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SHALES OF THE SOUTH PISTALI GOLD MINERALIZATION AREA (NORTHERN NURATA MOUNTAINS)

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Abstract. *Relevance.* The Northern Nuratau Range is considered one of the promising metallogenic regions due to its favorable geological environment and widespread occurrence of hydrothermal alterations. The South Pistali area has attracted particular attention because of the occurrence of metamorphic rocks associated with gold mineralization. *Method.* Geological field investigations were carried out in the South Pistali area, including detailed geological observations, structural analysis, and systematic sampling of representative rocks. Collected samples were subjected to petrographic and mineralogical examinations under laboratory conditions to determine the lithological composition, mineral assemblages, hydrothermal alterations, and ore mineral distribution. *Results.* The geological structure of the study area is dominated by metamorphosed rocks

belonging to the Suvliksay (R_2sv) and Kansay (O_{2-3}kn) formations, with the Suvliksay Formation occupying the largest part of the area. Magmatic rocks are represented by lamprophyre, diorite, and granodiorite dikes. Laboratory analyses identified chlorite, clay, and sericite schists as the predominant rock varieties. Quartz veins and oxidized rocks occurring as veins and small boudins within metamorphic rocks were formed during hydrothermal activity and subsequently modified by supergene oxidation. Ore minerals are represented mainly by pyrite, iron hydroxides, hematite, and ilmenite, which occur in quartz veins, veinlets, and altered shale rocks, especially within oxidation zones. *Conclusion.* The obtained results indicate that gold mineralization in the South Pistali area is closely controlled by the interaction of sedimentary, metamorphic, and hydrothermal geological processes. Metamorphic shales served as favorable host rocks, whereas hydrothermal fluids played a decisive role in the formation and redistribution of ore minerals. The identified mineralogical, lithological, and structural characteristics provide reliable exploration criteria for recognizing promising gold-bearing zones and contribute to a better understanding of ore-forming processes in the Northern Nuratau Range. The findings of this study can be applied in future geological exploration, mineral resource assessment, and the development of scientifically based exploration strategies for similar geological environments.

Keywords: Pistali deposit, Southern Pistali section, shales, chlorite, sericite, clay minerals, quartz

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ОҢТҮСТІК-ПІСТАЛ АЛТЫН КЕНДІ ТЕЛІМІНІҢ ТАҚТАТАСТАРЫ (СОЛТҮСТІК НҰРАТАУ ТАУЛАРЫ)

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Аннотация. *Кіріспе.* Солтүстік Нұратау жотасы қолайлы геологиялық жағдайы мен гидротермиялық өзгерістердің кең таралуына байланысты перспективасы зор металлогендік аймақтардың бірі саналады. Алтын кенденуімен байланысты метаморфтық тау жыныстарының кездесуіне орай, Оңтүстік Пістәлі аумағы ерекше назарға алынды. *Әдістері.* Оңтүстік Пістелі ауданында геологиялық далалық зерттеулер жүргізіліп, оның барысында егжей-тегжейлі геологиялық бақылаулар, құрылымдық талдау және типтік тау жыныстарынан жүйелі сынамалар алынды. Литологиялық құрамын, минералдық ассоциацияларын, гидротермиялық өзгерістерін және кен минералдарының таралуын анықтау мақсатында жиналған сынамаларға зертханалық жағдайда петрографиялық және минералогиялық зерттеулер жасалды. Зерттеу ауданының геологиялық құрылымында Сувликсай (R_2sv) және Қансай ($O_{2–3}$kn) свиталарына жататын метаморфтанған тау жыныстары басым, оның ішінде аумақтың басым бөлігін Сувликсай свитасы алып жатыр. Магмалық жыныстар лампрофир, диорит және гранодиорит дайкаларынан тұрады. Зертханалық талдаулар басым тау жынысы түрлері ретінде хлоритті, сазды және серицитті тақтатастарды анықтады. Метаморфтық жыныстар ішінде желілер мен ұсақ будиндер түрінде кездесетін кварц желілері мен тотыққан жыныстар гидротермиялық белсенділік кезінде пайда болып, кейіннен супергендік тотығуға ұшыраған. Кен минералдары негізінен пирит, темір гидроксидтері, гематит және ильменитген құралған, олар кварц желілерінде, желішелерде және өзгеріске ұшыраған тақтатастарда, әсіресе тотығу белдемдерінде кездеседі. *Нәтижелері.* Алынған нәтижелер Оңтүстік Пистали алаңындағы алтын минералдануы шөгінді, метаморфтық және гидротермальдық геологиялық процестердің өзара әрекеттесуімен тығыз байланысты екенін көрсетеді. Метаморфтық тақтатастар қолайлы сыйыстырушы тауыныстар болса, кен минералдарының қалыптасуы мен қайта таралуында гидротермальдық флюидтер шешуші рөл атқарған. *Қорытынды.* Анықталған минералогиялық, литологиялық және құрылымдық ерекшеліктер перспективалы алтынды белдемдерді анықтауға арналған сенімді іздеу-бағалау критерийлерін қамтамасыз етеді әрі Солтүстік Нұратау жотасындағы кен түзілу процестерін тереңірек түсінуге ықпал етеді. Бұл зерттеудің тұжырымдары болашақта геологиялық барлау жұмыстарын жүргізуде, минералдық ресурстарды бағалауда және осыған ұқсас геологиялық жағдайларға арналған ғылыми негізделген іздеу стратегияларын әзірлеуде қолданылуы мүмкін.

Кілт сөздер: Пистали кен орны, Пистали оңтүстік учаскесі, тақтатастар, хлорит, серицит, сазды минералдар, кварц

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СЛАНЦЫ ЮЖНО-ПИСТАЛЬСКОГО ЗОЛОТОРУДНОГО УЧАСТКА (СЕВЕРНЫЕ НУРАТИНСКИЕ ГОРЫ)

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Аннотация. *Актуальность.* Северный Нуратау является одним из перспективных металлогенических регионов благодаря благоприятному геологическому строению и широкому распространению гидротермально изменённых пород. Особый интерес представляет Южно-Писталинский золоторудный участок, в пределах которого золотое оруденение пространственно связано с метаморфическими породами, кварцевыми жилами и зонами гидротермальных изменений. Изучение состава, строения и минералогических особенностей сланцев имеет важное значение для выявления закономерностей локализации оруденения и обоснования поисковых критериев. *Цель.* Определить литологические, минералогические и структурные особенности сланцев Южно-Писталинского золоторудного участка и оценить их значение как поисковых признаков золотого оруденения. *Материалы и методы.* На Южно-Писталинском участке проведены полевые геологические исследования, включавшие детальное геологическое картирование, структурный анализ и систематический отбор представительных образцов пород. Отобранные образцы исследованы петрографическими и минералогическими методами для определения литологического состава, минеральных ассоциаций, характера гидротермальных изменений и особенностей распределения рудных минералов. *Результаты.* В геологическом строении исследуемой территории

преобладают метаморфизованные породы сувликсайской (R_2sv) и кансайской (O_2–$_3kn$) свит, при этом отложения сувликсайской свиты занимают большую часть площади участка. Магматические породы представлены дайками лампрофиров, диоритов и гранодиоритов. Установлено, что основными литологическими разновидностями являются хлоритовые, глинистые и серицитовые сланцы. Кварцевые жилы, прожилки и окисленные породы, залегающие в метаморфических толщах в виде небольших линз и будин, сформировались в результате гидротермальной деятельности и впоследствии подверглись супергенному окислению. Рудная минерализация представлена преимущественно пиритом, гидроксидами железа, гематитом и ильменитом. Эти минералы приурочены к кварцевым жилам, прожилкам и гидротермально изменённым сланцам, особенно в пределах зон окисления. Полученные результаты свидетельствуют о тесной связи золотого оруденения с комплексным воздействием осадочных, метаморфических, тектонических и гидротермальных процессов. Метаморфизованные сланцы служили благоприятной вмещающей средой, а гидротермальные флюиды играли важную роль в переносе, локализации и перераспределении рудного вещества. *Выводы.* Выявленные литологические, минералогические и структурные особенности могут использоваться в качестве поисковых критериев при выделении перспективных золотоносных зон Южно-Писталинского участка. К основным признакам относятся распространение хлоритовых и серицитовых сланцев, развитие кварцевых жил и прожилков, наличие зон гидротермального изменения и супергенного окисления, а также приуроченность рудных минералов к изменённым сланцам. Полученные результаты могут применяться при дальнейших геологоразведочных работах, оценке минерально-сырьевого потенциала и разработке поисковых моделей для сходных геологических обстановок Северного Нуратау

Ключевые слова: месторождение Пистали, Южный участок Пистали, сланцы, хлорит, серицит, глинистые минералы, кварц

Introduction. Gold exploration and extraction in the Northern Nuratau Mountains began many years ago. This is evidenced by the work carried out in areas such as Konsoy, Sentob, Karovulkhona, Korakuduk, Uzunsoqol, Davlatkho'ja, Ko'ng'oraut, and others. The Pistali site was first studied as an independent object in 1988 during exploration work at the Tandir site (V.B. Zholtkevich, 1985-1991) and was deemed to have low prospects. In 2001, the projected resource data of the Samarkand State Geological Exploration Expedition were reassessed, and work was carried out within the framework of the evaluation stage from 2001 to 2012. As a result of these works, the Pistali ore field and its individual promising sections were identified. The South Pistali section was considered a separate promising part of this ore field and was delineated as a distinct area.

Since late 2020, preparatory work for development and initial assessment has

begun at the Pistali deposit in the region. Within a short period, Navoi Mining and Metallurgical Complex commenced excavation work at the site. Geological exploration is also actively continuing in promising areas surrounding the deposit. Additionally, extensive research is being conducted by scientists from various organizations to study the stages of mineralization and the processes of gold ore formation in the ore field. Pirnazarov M.M., Zavyalov G.E., Khamroev I.O., and Koloskova S.M. have concluded that gold and arsenic ores in the region are controlled by structural, magmatic, and lithological factors (Pirnazarov et al., 2003). Abduazimova Z.M., Aleksandrova N.V., Tabatchenko L.M., Shaykurov N.B., and Rakhimov A.D. have noted that zones of intense fracturing at the intersections of tectonic structures also play a significant role in the accumulation of gold and other minerals (Abduazimova et al., 2007). Additionally, in the region, researchers such as Glux A.K., Mavlonov J.J., Mirkamalov R.Kh., Chirikin V.V., Nurkhodzhaev A.K., Asadov A.R. (Asadov et al., 2021), Riskidinov J.T., Ubaydullaeva Sh.A., Ishbaev Kh.D. (Ishbaev et al., 2025), Ganiev I.N., Shukurov A.Kh., and others have conducted studies in various directions and drawn conclusions related to mineralization. However, ongoing debates surrounding gold mineralization in the area indicate that the study of gold mineralization and related processes in the region requires a distinct approach. It is worth noting that such controversial issues are observed throughout the territory of the Republic of Uzbekistan, which is rich in gold deposits. Mirusmanov M.A., Zakhidov A.R., and Zhuliev M. concluded that the Lower Paleozoic quartzite schists play a key role in the localization of hydrothermal gold mineralization at the "Shirotny" deposit in Southern Uzbekistan (Mirusmanov et al., 2022). In the geological-genetic model of gold formations on the northern slopes of the Chaqil-Kalon Mountains, the development of gold-bearing quartz veins in strongly silicified quartzite schists of the Lower Paleozoic has been noted (Mirusmanov, 2015). In a study focused on the processes of gold mineralization formation in the Okzhetpes ore field (Bukantau Mountains), Khaydarov Z., Mirusmanov M., Tangirov A., and Sodikov S. concluded that "ore concentrations of gold and silver in zones 2, 3, and 5 of the Okzhetpes ore field are formed based on sedimentogenic resources of metals and sulfur. The ore resource of such objects is determined by the scale of the metal-bearing environment and its transformation processes, and the identification and assessment of these systems acquire important practical significance" (Khaidarov et al., 2025). In an article by T.B. Ishbobayev et al., dedicated to the oxidation zone of ores in the Okzhetpes ore field, attention was drawn to the presence of secondary enrichment zones in gold ores and the importance of considering such situations during field work (Ishbobaev et al., 2023).

Taking the above into consideration, we focused particularly on gold mineralization in the region and its relationship with shales, the connection between rocks formed during metamorphism and hydrothermal solutions, and the variability in their mineralogical composition. The article provides brief information on

the geological structure of the South Pistali area, the structure, composition, and ore minerals of the shales that predominate in the region, as well as the formation processes of these ore minerals.

Materials and methods. Data on the geological structure of the area was compiled using the report of geological survey work conducted by R.S. Khan in the Northern Nuratau Mountains in 2007, as well as the project for preliminary assessment of ore bodies in the southern and northeastern wings of the Pistali deposit by A.R. Normuminov and M.K. Shirinov in 2023.

In general, numerous gold deposits and placers, as well as multiple geochemical gold distribution halos, are associated with the sediments of the Suvliksoy and Besapan suites in the western part of the Northern Nuratau Range (Abdullayev et al., 1977). Many occurrences of gold ores are observed in this area. Structurally, the Pistali ore field is bounded by the western periclinal closure of the Yombosh-Ustuk brachyanticline, which has a length of 70 km and a width of up to 15 km. The azimuth of the anticlinal axis is 280-290°, and the dip angle of the hinge is 10-30° (Pokrovskiy, 1988; Pokrovskiy et al., 1988;).

The geological structure of the area includes metamorphosed rocks of the Suvliksoy (age equivalent of the Suvliksoy suite) (R_2sv) and Kansay (O_{2-3}kn) suites (Figure 1).

The *Suvliksoy Suite* (R_2sv) forms the base of the section in this area and is the oldest suite in the Tamdytau-Nuratau subzone. Its lower boundary remains unexposed, while the upper boundary is located in the upper part of the quartzite horizon. The suite consists of bodies and layers of metamorphic schists, quartzite, dolomite, and marbled limestone. The schists are composed of quartz-mica and muscovite-sericite schists with varying carbon content, along with relatively thin packages of meta-siltstone and meta-sandstone. Within the metamorphic schists, quartzites and carbonate rocks (limestones, dolomites) occur as densely interbedded layers and bodies, ranging in thickness from one to ten meters and extending up to several kilometers in length (Pokrovskiy, 1988; Pokrovskiy et al., 1988; Shodmonov et al., 2025).

Quartzites (phtanites) appear as gray and dark gray fine-grained, layered or massive rock formations. Their structure is granoblastic, mosaic, and sometimes granolepidoblastic, while their texture is massive. These rocks are composed of carbonate rocks, dolomites, and various marbled and dolomitized limestones. The color ranges from brownish-gray to brown.

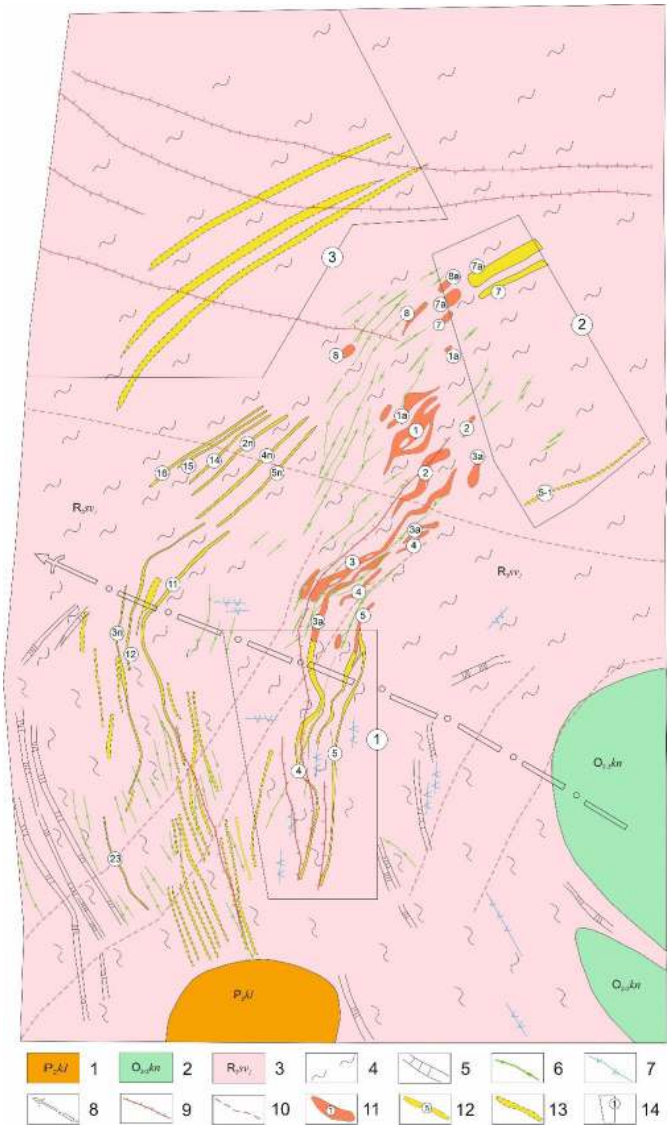


Figure 1. Geological structure diagram of the Pistali gold deposit. (Compiled using data from A.R. Normuminov and M.K. Shirinov).

1 - Middle Paleogene. Kultaban Formation. Alternating layers of clays, marls, sands, and sandstones; 2 - Middle and Upper Ordovician. Konsoy Formation, Lower Member. Micaceous schists, siltstones with interbedded albite-micaceous sandstone layers; 3 - Upper Riphean. Suvliqsoy Formation, Lower Member. Micaceous schists, metasandstones with layers and lenses of meta-siltstone and quartzite, dolomites, and limestones; 4 - schists; 5 - quartzites and quartzite-like rocks; 6 - lamprophyre dikes; 7 - quartz veinlets; 8 - Axis of the anticlinal structure; 9 - observed fractures; 10 - incompletely observed fractures; 11 - ore bodies and their serial numbers (reserves of category C2); 12 - predicted resources of category P1 and their serial numbers; 13 - predicted resources of category P2; 14 - Contours and numbers of plots: 1) South Pistali plot, 2) East Pistali plot, 3) North Pistali plot.

Kansay Suite (O_{2-3}kn). Suite deposits are widespread in the Gatchasoy basin. The lower part of the section consists mainly of shales. The color of the rocks ranges from greenish-gray to dark gray, with silky luster on the cleavage surfaces. In terms of composition, quartz-mica and quartz-mica-sericite-chlorite schists are distinguished among them. They are metamorphosed siltstones and pelites, forming stilpnomelane-chlorite-muscovite subfacies. The majority of the rocks are mica-quartz schists, while a smaller portion consists of sericite-chlorite schists.

Paleogene deposits have been identified in wells drilled in the northern part of the area.

The deluvial-proluvial deposits of the Quaternary period belong to the *Mirzachul complex* (Q_3gl), covering the upper part of the existing deposits in the area with varying thicknesses.

Igneous rocks. The igneous rocks of the area are represented by dikes of diorite and granodiorite composition, forming a zone up to 1400 meters wide and a Pistali stock of quartz syenite-diorites directly in the deposit area. The orientation of the dike zone generally corresponds to the orientation of the host rocks. The dikes are mainly composed of lamprophyre-like diorite porphyries of the spessartite and kersantite types, as well as granodiorite-porphyries. Spessartites are considered the earliest members of the series and are cut by kersantites. Granite dikes are very rare.

Tectonic structures. Longitudinal structures are more often noted, usually associated with the formation of brachiomorphic folds. From a morphological point of view, the main faults are sharply vertical faults (sbros) and uplifts (vzbros). These fracture zones are filled with milonitization products, represented by quartz veins (Abdullayev et al., 1977; Shoyokubov et al., 1998).

The largest longitudinal faults in this area include the North-Nuratau deep fault and adjacent faults. These faults extend along the northern foot of the mountain range and connect with the young platform crust. On the Earth's surface, the slope of the faults lies at an angle of 60-800 to the north, northeast, and southwest. Fault zones are represented by milonitization, brecciation, and predominantly iron deposition. As a result of these structures, the displacement of Mesozoic-Cenozoic deposits along the faults is clearly observed (Figure 1).

The Suvliksoy Suite is represented by two sub-slices: lower and upper. The rocks of the lower subsuite make up a large part of the area of the South Pistali section and its slopes.

The rocks of the Suvliksoy Suite of the area and its surroundings are metamorphosed at the level of the green schist facies of regional metamorphism.

The mineralized gold zones of the Pistali deposit are associated with metasomatically altered rocks. The degree of metasomatism is significant, covering almost the entire Suvliksoy Suite at depths of hundreds of meters. The manifestation of metasomatism along fractures and fissures is very uneven and inconsistent. The distribution area of metasomatically altered rocks increases in the northern direc-

tion. At some points, metasomatism is observed, encompassing the entire surface (Pokrovskiy et al., 1988; Shodmonov et al., 2025).

The geological structure of the South Pistali area consists of metamorphosed terrigenous-sedimentary rocks from the Suvliksoy Formation of the Upper Proterozoic. These rocks are intersected by intrusions of the Kattaich (Middle to Upper Carboniferous) and Gatcha (Late Carboniferous to Early Permian) magmatic complexes (Figure 1) (Pokrovskiy et al., 1988; Shodmonov et al., 2025).

The Suvliksoy Suite consists of two subsuites: lower *(R_2sv_1)* and upper (R_2sv_2).

A large part of the area is composed of rocks from the *lower subsuite (R_2sv_1)*. This subsuite includes quartz-mica, mica-quartz, and carbonaceous schists, meta-siltstones, and meta-sandstones. Among them are layers and horizons of carbon-rich and green chlorite-epidote schists, metasiliceous quartzites, and dolomites with thicknesses ranging from 1-5 meters to 20-40 meters. The total thickness of the subsuite reaches up to 2600 meters.

The deposits of the *Upper Subformation* (R_2sv_2) are distributed in the western part of the area. The main component of this subformation consists of numerous layers of metasiliceous quartzites, marbled limestones, and dolomites, ranging in thickness from a few centimeters to tens and hundreds of meters. The thickest layer is developed at the base of the subformation, consisting of alternating layers of limestones, quartzites, and dolomites. In its widest part, its thickness reaches up to 150 meters. The subformation is composed of albite-porphyroblastic mica-quartz, crystalline muscovite-feldspar-quartz schists, gneiss-like rocks, green quartz-epidote-chlorite (metatuffs) and albite-clinozoisite-chlorite-amphibole (metabasalts) schists. The total thickness of the formation is 1500 meters.

The deposits of the Golodnostep complex of the *Quaternary period* (Q_3gl) lie unconformably on the deposits of the Suvliksoy Suite with an angular discordance. Their thickness ranges from 1-5 meters in the southern mountainous part of the territory to 10-60 meters in the northern part. These are deluvial-proluvial deposits by origin. In terms of composition, they consist of loamy soils mixed with sand and gravel material, while the northern part of the territory mainly comprises sand-clay-gravel deposits with gravel and boulder material. The modern Quaternary alluvial-deluvial deposits consist of gravel, crushed stone, siltstone, sandy loams, and loess-like loams and clays.

Magmatic formations are represented by intrusions of the Kattaich and Gatcha complexes and their dike analogs (Zel et al., 2020).

Intrusions of the Kattaich Middle-Late Carboniferous gabbro-diorite complex ($\xi\delta\ C_{2-3}kt$) are represented by diorite and granodiorite dikes, as well as stock-like outcrops of quartz syenite-diorite intrusions. The dikes (lamprophyre-like diorite porphyrites, granodiorite porphyries) (Ishbaev et al., 2025) form a belt up to 500-700 m wide in the Pistali deposit area and southeast of it. The elongation of this belt generally corresponds to the orientation of the surrounding rocks (20-60° northeast). The thickness of the dikes ranges from the initial tens of centimeters to

20-30 m, with predominantly vertical dip, often inclined to the west at an angle of 60-80°, and sometimes to the east at an angle of 20-30°.

In the eastern part of the territory, intrusions of the Late Carboniferous-Early Permian two-mica granite complex (γC_3-P_1g) are represented by the Temirkabuk biotite-muscovite granite massif with a total area of 35 sq. km and a series of aplite-pegmatite dikes. The thickness of the dikes ranges from 0.1 to 1 m, and they are predominantly oriented in the northwestern and sublatitudinal directions.

According to gravimetric data, two "hidden" intrusive bodies with granitic composition have been identified in the study area: the Pistali massif to the northeast of the Pistali deposit and the Kulkuduk massif to the west of the deposit. Both massifs are considered to be continuations of the Temirkabuk intrusive, located at a depth of 500-700 m below the Earth's surface.

The main *plicative* structure of the area is the Yambosh-Ustuk brachianticline, formed during the Hercynian period, which was observed during geological mapping (Usmanov, Startsev et al., 1984) between Kulkuduksoy and Gatchasoy, extending for 10 km up to the village of Ulus. The eastern part of the anticline is intersected by the granites of the Temirqobuq intrusion.

The most clearly identifiable structures among *fractures and faults are longitudinal structures*, usually associated with the formation of brachiform folds. Morphologically, these consist of steeply dipping faults and uplifts. These fault zones are characterized by mylonitization, vein quartz formation, and iron mineralization.

The following methods were used in the research process:

1) Reviewing the materials of previous work carried out;

2) During fieldwork, lithological sections were compiled in the South Pistali area;

3) A total of 10 samples were collected using the channel sampling method: 6 samples from the intervals of 148.5-149 m, 149-149.5 m, 149.5-150 m, 150-151 m, 151-152 m, 152-153 m, and 4 samples from the intervals of 166-167 m, 167-168 m, 168-169 m, 169-170 m along the 2nd trench of the 7th exploration line (Rl-7) in the South Pistali area. The first 6 samples were taken from the fourth ore body, and 4 from the fifth ore body (gold occurrence points). These ore bodies have been studied in the eastern and northeastern parts of the area.

Results and discussion. Based on the analysis of samples taken from different points of the study area under laboratory conditions, it was established that the following types of shales are present in the area: chlorite shales, clay shales, sericite shales. Chlorite schists are rocks that are often found in basic, sometimes intermediate and acidic rocks, where colored minerals are replaced by chlorite during metamorphism and recrystallized. Clay shales are quickly disintegrating rocks formed during the initial stages of metamorphism, resulting from the compression and layered crystallization of clay rocks. Sericitic schists are rocks formed by the metamorphism of layers composed of fine particles of colored mica minerals and small quartz veins (Milovskiy, 1973).

Chlorite schists are found in almost all areas of the field. This main type of schist, being the predominant rock distributed in the surface layers, indicates the widespread occurrence of metamorphism in the region. Under the Quaternary cover, it can be observed that the primary rocks are schists of this type. At some points, outcrops that have emerged on the surface can also be observed. Chlorite schists are distributed in a layer-like form in a specific sequence with quartz, and observations show that during the intensive metamorphic process, quartz veins penetrated the schist layers. The intersection surface of quartz and chlorite schists is strongly oxidized and partially weathered. Schists are very easy to identify by their greenish glossy color. Occasionally, crystalline chlorite schists are encountered. In such cases, the stratification characteristic of shales is rarely observed. Most commonly, layered chlorite schists are encountered. In this type of schist layers, fractures, small cracks, and the penetration of thin quartz veins can be observed. Around these quartz veins, fractures, and small cracks, an intensification of oxidation is noticeable. The fractures are predominantly parallel to the direction of the layer, though occasionally perpendicular veins and cracks are also found. Ore minerals are more prevalent along the parallel fractures, which is evidenced by the presence of oxidation processes along the direction of these cracks or fractures (Figure 2). When examining particle sizes in thin section samples, it was determined that fine-grained particles measure 0.01-0.03 mm, while medium-sized particles range from 0.05-0.09 mm (Table 1).

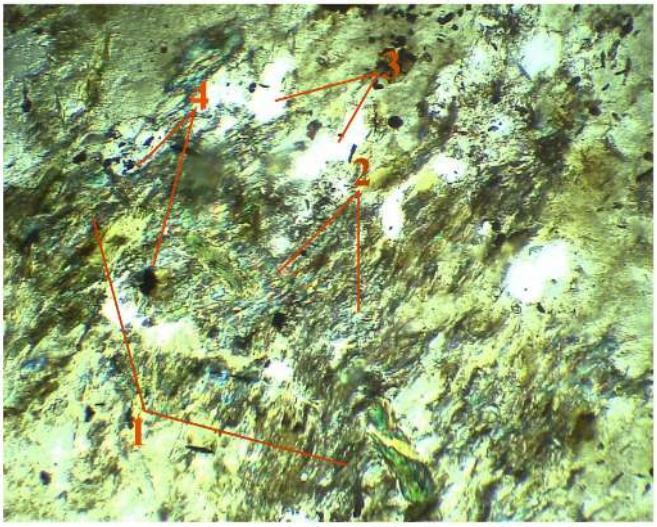
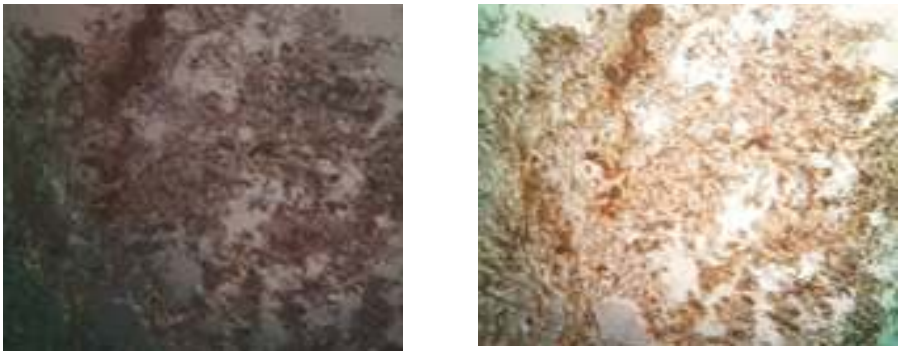


Figure 2. Chlorite schists and the quartz and sericite minerals contained within them. Thin section №1. Magnification 50x with analyzer. 1 - chlorite; 2 - sericite; 3 - quartz; 4 - ore minerals.

As particle size increased, a rise in the content of ore minerals was observed. The oxidation process is widely evident both in quartz and in the chlorite schists

surrounding them. When exposed to sunlight, chlorite schists reflect light and shine similarly to sulfide minerals. It is around these shiny points that sulfide mineral particles such as arsenopyrite, pyrite, and occasionally chalcopyrite can be observed.

Clay shales, which are less common in the area compared to chlorite shales, are mainly composed of fine-grained particles and are less frequently observed with quartz. They are mainly composed of fine-grained particles. Analysis of the obtained samples leads to the conclusion that among clay shales, quartz occurs in the form of lenses 2 cm and smaller, while lenses larger than 2 cm and quartzite layers are mainly observed in chlorite shales. Ore minerals are less common among the layers of clay shales, primarily occurring as small strata of hematite and limonite. The composition of clay shales is very complex and difficult to distinguish accurately. The particles are very fine-grained, which makes it challenging to observe them clearly in thin sections (Fig. 3).



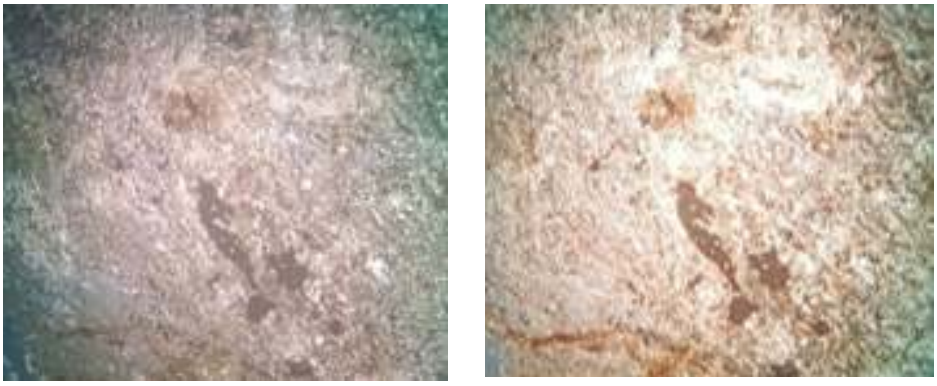
a) b)

Figure 3. Clay shales and the ore minerals contained within them (black dots). Thin section №4. Magnification 25x: a) without analyzer, b) without analyzer.

Analysis of the samples reveals that in areas where clay shales are present, thin layers with a thickness of 0.1-0.2 mm can be observed. Along these layers, fine cracks are visible. When sample fragments are broken, iron oxide minerals and other oxidized mineral accumulations can be seen in the spaces between layers. Among the shale layers, small lenticular quartz veins up to 0.01 mm thick and quartzite layers can be observed. The particle size of clay shales ranges from 0.01 to 0.02 mm and is infrequently observed (Table 1). During the process of metamorphism, ore minerals accumulated between layers of shale, forming various concentrations. As a result, in the existing layers of clay shales in the area, almost no ore minerals are observed. Some thin interlayers are entirely covered with oxide minerals. Oxide minerals are particularly widespread around fractures and small veins of quartz.

Sericitic schists. Chlorite schists also contain a large amount of sericite miner-

al, but in some areas, sericite forms the main component of the schist composition. This type of schist is also among the widely distributed schists in the region. In the samples, it can be observed that small particles of mica minerals and quartz, present in small quantities, form the basis of the schist layers and have developed as a separate layer, visible in sunlight. As mentioned above, the foundation of this type of schist consists of sericite and quartz (Figure 4).\



a) b)

Figure 4. Sericitic schists and the ore minerals contained within them (black dots). Thin section №5. Magnification 25x: a) without analyzer, b) without analyzer.

Table 1. Mineralogical composition of rocks observed in thin sections.

Grinding order number	Quartz content in the grinding wheel (%) (particle size mm).	Content of chlorites in the grinding (%) (particle size mm).	Sericite content in the grinding wheel (%) (particle size mm).	Content of clay minerals in the grinding (%) (particle size mm).	Content of ore minerals in the grinding (%) (particle size mm).
JP-1	20-25 (0,3-1)	55-60 (0,03-0,1)	5-10 (0,01-0,03)	-	3-5 (0,05-0,5-1)
JP-2	20-25 (0,2-1)	35-40 (0,03-0,05)	15-20 (0,01-0,03)	-	5-10 (0,05-0,09)
JP-3	50-55 (0,07-0,5)	15-20 (0,03-0,1)	10-15 (0,02-0,05)	-	5-10 (0,01-0,5)
JP-4	-	15-20 (0,02-0,2)	45-50 (0,07-0,09)	5-10 (0,01-0,02)	15-20 (0,07-0,7)
JP-5	30-35 (0,07-0,1)	30-35 (0,03-0,07)	15-20 (0,03-0,05)	3-5 (0,02-0,05)	3-5 (0,02-0,2)
JP-6	75-80 (0,1-1,5)	3-5 (0,07-0,1)	5-10 (0,01-0,09)	-	3-5 (0,01-0,3)
JP-7	50-55 (0,2-1,7)	5-10 (0,01-0,02)	5-10 (0,01-0,07)	3-5 (0,01-0,02)	15-20 (0,01-0,4)
JP-8	50-55 (0,03-1)	10-15 (0,04-0,2)	5-10 (0,01-0,02)	5-10 (0,02-0,04)	5-10 (0,01-0,1)
JP-9	50-55 (0,05-0,8)	30-35 (0,01-0,09)	3-5 (0,01-0,04)	-	3-5 (0,02-0,4)
JP-10	45-50 (0,02-1,2)	35-40 (0,02-0,1)	3-5 (0,02-0,04)	-	3-5 (0.05-0,6)
∑	43-48 (0,1-1)	23-28 (0,03-0,1)	11-16 (0,02-0,05)	4-8 (0,02-0,03)	6-10 (0,03-0,5)

The average particle size in sericites is 0.02-0.05 mm, while in quartz it is 0.1-1 mm (Table 1). Quartz veins (or veinlets) are almost not observed around the layers of sericitic schists. Small cracks are present, running parallel to the layers. Ore minerals are rarely observed with this type of schist. From observations, it can be concluded that this type of schist may have formed due to the accumulation and recrystallization of mica mineral particles and quartz particles at a single point.

The main representatives of sulfide minerals present in the region are pyrite and arsenopyrite, which are widespread in rocks and quartz veins. The oxidation process is more pronounced at the interface between quartz veins and schist layers. In addition to pyrite and arsenopyrite, the schists contain hematite, ilmenite, and magnetite. Primary minerals have been transformed into limonite and various other secondary minerals.

Conclusions. The rock formations in the area were primarily formed through sedimentary, metamorphic, and hydrothermal processes. Initially, the existing sedimentary rocks underwent metamorphism, which resulted in the formation of certain types of slate.

In the strata of the Suvliksoy Formation, which constitute the main part of the mine section, chloritic, argillaceous, and sericitic varieties of shale are primarily observed. Microscopic studies indicate that the majority of these shales are metaterrigenous rocks, with a very small amount of metamorphosed carbonates also present.

In the structure of the shales, the alternating sequence of several types of microlayers, each up to a few mm thick, was identified. By assessing the quantitative proportions of the main minerals in these shales, it was possible to distinguish between chloritic, argillaceous, and sericitic types.

In the placement of ore zones, their tendency to associate more frequently with chloritic shales and, to a lesser extent, with sericitic shales was observed.

The quartz and oxidized rocks, which formed as veinlets and small boudinages within metamorphic rocks, are products of hydrothermal processes and have undergone various alterations due to surface oxidation.

The ore minerals within the rock formations have undergone significant changes, primarily in the oxidation zone, and were observed in quartz veins and veinlets, as well as in shales. These minerals consist of pyrite, which is rarely observed in quartz; various iron hydroxides observed at the contact surfaces between quartzites and shale rocks and in oxidation zones; and hematite and ilmenite, which are found as isolated occurrences within the shales.

The continuation of future research, through a thorough study of metamorphic schists, will enable the identification of the facial-lithological factors governing gold ore deposits. Furthermore, studying vein and ore minerals will allow for the determination of the geochemical-mineralogical factors of these deposits.

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