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Review of geological study about part of caspian depression in territory of Kazakhstan

According to review of geological study about part of Caspian Depression in territory of Kazakhstan showed that the history of researching this area lasts approximately a half of the centuries. In a huge number of production reports, scientific publications, monographs and reference books various questions about history of development of geological researches, stratigraphy, tectonics, oil-and-gas content and prospect of Caspian Depression are considered.

Key words: Caspian Basin, geological study, oil and gas potential, hydrocarbon deposits.

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Қазақстан аумағына қарасты Каспий маңы ойпаты бөлігіндегі геологиялық танымдық жұмыстар

Андатпа: Қазақстан аумағына қарасты Каспий маңы ойпаты бөлігіндегі геологиялық танымдық жұмыстар, бұл аймақтың бір ғасырдан астам уақыт бойы зерттелгендігін көрсетіп отыр. Көптеген өндірістік ғылыми еңбектерде, есеп берулерде, монографияларда, және анықтамаларда геологиялық зерттеулердің даму тарихы, стратиграфиясы, тектоникасы, мұнайгаздығы және Каспий маңы ойпатының келешегі туралы кең ауқымды сұрақтар қарастырылған.

Негізгі сөздер: Каспий маңы ойпаты**,** геологиялық танымдық мұнайгаздық, көмірсутек кен орындары.

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GEOLOGICAL STRUCTURE AND MINERALOGY OF ORES OF AYNAK COPPER DEPOSIT (AFGHANISTAN)

Abstract: This paper highlights the summary of geological information on the Aynak copper deposit which has been investigated by Afghan-Soviet geologists. The Aynak copper deposit represents one of the most important world-wide economic deposits of the sandstone-hosted copper deposit type, characterized by extensive multi-horizon mineralization and high ore quality.

Keywords: geological structure, mineral, stratigraphy, deposit, copper, formation, ore body.

The Aynak deposit was discovered on July 1973 during the first days of the republican regime. The discovery was made by the Adreskan group while carrying out a prospecting survey in the central part of the Kabul block and over 30 additional copper occurrences were identified during the survey.

The Aynak deposit is located 30 km SSE from Kabul near the settlements of Gulkhamid, Chenaray and Anorkhel in the Logar Province. The town of Barakibarak, in the centre of the Province, is situated 35 km SW from the deposit .The extent of the Aynak ore field (110 km^2) is delimited by coordinates: 34º12'–

34°18' and 69°13'30"–69°19'30". The Aynak deposit, which is divided into the Central area and the Western area, has a surface area of 6 km^2 (*Figure 1*).

The deposit is accessed by an asphalt road from Kabul to Gardez, leading to Kishlak Zaydabad (34 km) and then by an earth road (16 km) which is navigable throughout the year. Equipment and materials from the USSR were transported 400 km on asphalt road to Kabul from the river port of Shirkhan. The ore field extends to the central part of the watershed of the Logar and Butkhak Rivers at the foothills of the western offshoot of the Safedkokh range.

The Aynak deposit is situated on the northwestern margin of the mountain depression within Neogene molasse deposits. The relief of the region is characterized by hills and valleys with altitudes from 2275 to 2675 m. Some peaks are up to 2750 m high (Mt Sarvanday NE of the deposit). Relative altitude of the area varies between 50 and 200 m. A ring of mountain ranges with altitudes up to 3452 m rims the depression. The mountains are formed of metamorphosed Upper Proterozoic to the Vendian-Cambrian rocks, cut by small intrusive bodies. On the southern margin of the depression, Upper Permian sediments occur. On the west, towards the Logar River, an area of lower relief, between 1875 and 1900 m occurs.

The total reserve of copper in the western part of Aynak according to estimation of USSR geologists in industrial category is 4557.9 thous. тон (with average copper content 1.53 %) and in the central part, the total reserve of copper in industrial category has been estimated 6220.5 thous. ton (with average copper content 1.85 %)

Aynak copper deposit, as well as the other occurrences has a high metal content and a suitable geographic location and economic conditions. These factors resulted in a decision to carry out exploration work on the Aynak deposit, detailed prospecting work on the Darband deposit and distinguish the new copper-ore region in the central part of the Kabul block (managed by Chmyrev and G. I. Teleshev).

Comprehensive geological and geophysical research on the Aynak ore field commenced in 1974 with technical assistance provided by the USSR. Positive results, conclusions and recommendations from this research, provided by I.Z. Samonov, an expert-consultant of the Ministry of Geology, USSR, resulted in a detailed exploration project of the Central area and preliminary exploration of the Western area of Aynak deposit to be undertaken between 1975-1977.

Figure.1. Simplified tectonic map of Afghanistan showing major block and faults and location of Aynak copper deposit

Geology of Aynak

Afghanistan sits astride the collision zone of the Indo-Pakistan and Asian crustal plates, which has given rise to the Himalayas. It has a very complex geological history, with a number of small blocks or 'terranes' which split off around 250 million years ago from the margin of the Gondwana supercontinent. These terranes then successively accreted on to the southern margin of the Asian continent. The Kabul Block is interpreted to be a one of these fragments and is bound by two major faults, on the west by the Pagman Fault

and on the east by the Altimur Fault *(Figure 1)*, in which the Aynak copper deposit is situated in this tectonic block.

The structure at Aynak is dominated by the Aynak anticline. The anticline is asymmetrical and approximately 4 km in length and up to 2.5 km wide. The south-eastern limb dips gently to the south-east but the north-western limb is steeply dipping and, in places overturned, with dips of 45–70° to the south-east. The periclinal closure of the anticline at its western end is asymmetrical. Here, the southern limb is overturned and the axial plane is inclined towards the north-north-east. Several sets of later faults cut across the folds. The oldest rocks exposed in the area belong to the metavolcanic Welayati Formation**,** composed of gneiss and amphibolites, and are exposed in the core of the anticline. This formation is overlain by the thick metasedimentary sequence of the Loy Khwar Formation, which is a cyclical sequence of dolomite marble, carbonaceous quartz schist and quartz-biotite-dolomite schist and hosts the copper mineralization *(Figure 2)*. The Loy Khwar Formation is post-dated by basaltic to dacitic metavolcanic rocks of the Gulkhamid Formation, which are also of Edicarian-Cambrian age.

As a result of folding, the copper deposit is divided into two prospects, with Central Aynak located on the shallow-dipping eastern limb of the anticline and Western Aynak occurring in the area of the periclinal closure at the western end of the structure *(Figure 2)*.

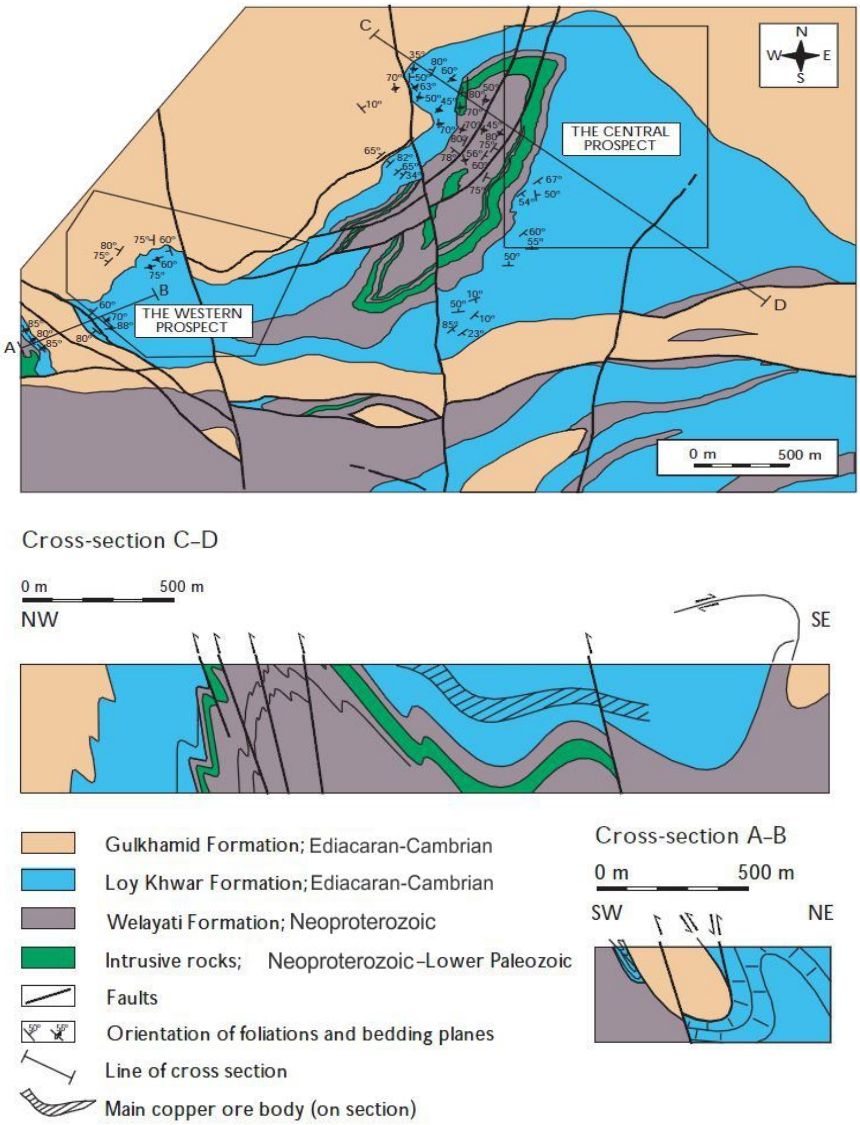

Figure 2. Simplified geological map and cross sections of Aynak copper mine.

Stratigraphy

The oldest rocks exposed in the Aynak area have been assigned to the Welayati Formation. Early exploration work at Aynak has been done in 1977 and investigated these rocks in detail and divided them into the following main lithological – structural units. The oldest unit is exposed in the cores of anticlinal structures in the south and north of the prospect and consists of garnetiferous gneisses, amphibolitic gneisses and schists, containing staurolite, andalusite and silliminite. This is overlain with angular unconformity by a sequence of metavolcanic rocks predominantly of basaltic to andesitic composition with intercalations of quartzitic and carbonates schists. These rocks have low-grade green schist facies metamorphic mineral assemblages and retain primary volcanic textures and fabrics. The uppermost, unit, is represented by quartzitic schists and carbonate schists that conformably overlie the metavolcanic unit.

The rocks assigned to the Welayati Formation are overlain by a thick metasedimentary sequence of the Loy Khwar Formation, which is the host to the copper mineralisation. This is a cyclical sequence composed of repetitive units, both on the macro and micro-scale, of dolomite marble, carbonaceous quartz schist and quartz-biotite-dolomite schist. Scapolite is also present within the schists. Fine rhythmic layering of schist and dolomite marble is common.

The Aynak ore field comprises metamorphosed Neoproterozoic and Edicaran-Cambrian rocks, Upper Permian and Neogene sedimentary rocks and Quaternary sediments, infilling a wide erosion-tectonic depression.

Neoproterozoic Erathem (PR_3):

Previous mapping at 1:100 000 by Shcherbina et al. (1975), distinguished the metamorphic rocks of the Neoproterozoic as Welayati Formation. The Neoproterozoic group is divided into six formations based on lithology and metamorphic grade. The age of the rocks is considered to be Neoproterozoic as they are unconformably overlain by lower grade metamorphosed carbonate-schists containing Ediacaran and probably Cambrian fossils.

1. Lower gneiss and crystalline schist formation (PR_3^1A);
2. Upper amphibolites and gneiss formation (PR_3^1B);
3. Metabasite formation (PR_3^2A)
4. Meta-andesite and metadacite formation (PR_3^2B);
5. Volcanic breccias formation (PR_3^2C);
6. Schist formation (PR_3^2D).

Ediacaran-Cambrian:

Carbonate schists occur at the base of the metamorphic section, unconformably overlying Late Proterozoic rocks. Previous research distinguished them as the Loy Khwar Formation (Slavin 1973; Shcherbina 1975). A Ediacaran-Cambrian age has been assigned to the formation based on fossils from the Kabul Block region. The best known section of the Carbonate-Schist Formation is about 400 m thick and occurs in the Central area of the deposit.

Permian system: Upper Permian

The Upper Permian rocks of the region are represented by the lower part of Khingil sequence. Three small outcrops occur in the western and the southern part of the Aynak ore field, unconformably overlying older rocks in the region. Conglomerate, gritstone and coarse-grained quartz sandstone occur at the base. The basal conglomerate contains well rounded pebbles of mostly quartz and quartzite and has a thickness of between 0.5 and 3 m.

The Permian rocks are predominantly finely crystalline thin-bedded limestone of varying colour: greyish-white, yellowish and bluish. Significant beds of massive, medium crystalline dolomite (about 30 %) with intercalations of phyllite, carbonaceous and chlorite schist occur in the upper part. The thickness of the Permian rocks attains 550–600 m.

Neogene system:

Neogene rocks in the Aynak ore field area are widespread. They infill intermontane depressions – Aynak in the east and Logar in the west and unconformably overly older rocks in the region. They are represented by terrigenous alluvium-proluvium sediments. A basal breccia, 1 to 40 m in thickness, frequently occurs infilling the lower parts of the older relief. The breccia is dominated by rock debris and poorly rounded blocks of underlying rocks cemented by clay-carbonate material. The Neogene deposits attain a thickness of 600 m with maximum thicknesses intersected in the Central area (borehole 87).

Quaternary system:

The extent of the Quaternary sediments in the ore field area is insignificant. They are bound to foothills and to the valleys of occasional streams. They are represented by different genetic types: prolluvial, delluvial, colluvial and technogenetic. The most common are delluvial-prolluvial Upper Quaternary (d.pl Q_{III}) and recent (d.pl Q_{IV}) sediments. Exposed thicknesses of Quaternary sediments do not exceed 13 m.

Mineralogy of ores

Approximately 60 primary and secondary minerals, including more than 30 ore minerals, have been distinguished in the Aynak deposit. The dominant ore minerals are bornite and chalcopyrite. Within the supergene zone of the deposit, chalcocite, native copper, cuprite and malachite dominate. Frequent, yet less abundant minerals include pyrite and sphalerite. Rare minerals include cobaltite, smaltite, pentlandite, molybdenite amongst others.

The most common rock forming minerals are dolomite, quartz, biotite and oligoclase-andesine in the wall rock. Bornite is the most abundant copper mineral within the deposit, in particular within the main ore body of the Central area. It occurs in rocks rich in quartz and feldspar although it can often be seen associated with dolomite. Bornite mainly forms compact linear or broken up aggregates with irregular margins, parallel to wall rock bedding. As a rule, the size of the aggregates does not exceed several millimetres; more rarely bornite can be seen as irregular disseminations or as layered disseminations. Quartzite is typically barren although rare disseminations of bornite and fine grains of isolated and isometric bornite (hundredths or tenths of mm) can occur. Disseminated bornite attains several mm in size or even cm in others rocks and its form is mostly irregular. Commonly, the grain size varies from 0.004 to 1.0–1.2 mm.

The copper mineralization at Aynak is stratabound and characterized by bornite and chalcopyrite disseminated in dolomite marble and quartz-biotite-dolomite schists of the Loy Khwar Formation *(Figure 3 A and B)*. The main zone of mineralisation at Central Aynak is dominated by bornite. Chalcopyrite occurs in only minor amounts in the middle and lower parts of the body, but increases in the upper parts.Cobalt concentrations are very low but, like zinc, increase peripherally in some parts of the deposit. The depth of the oxidised zone is variable with the deepest oxidation occurring 250 m below the surface in the northern part of Central Aynak, beneath thick Neogene deposits. The oxidized zone, with chalcocite and native copper, passes downwards into a mixed zone of oxidized and primary sulphides. No evidence for a supergene-enriched zone occurs.

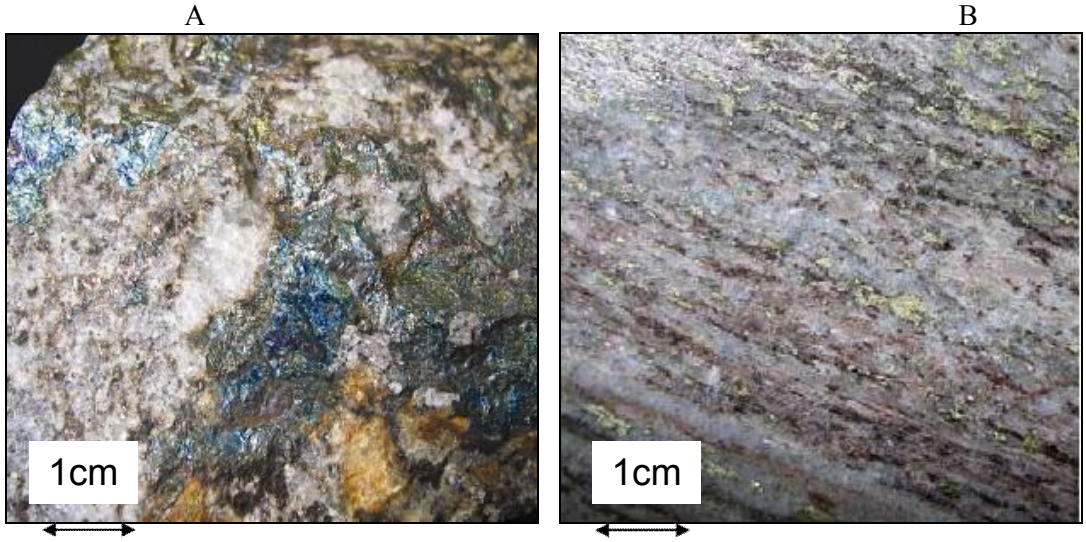

Figure 3: A) bornite mineralisation within dolomite marble of the Loy Khwar Formation; B) finely laminated biotite-feldspar-quartz schist with disseminations and stringers of chalcopyrite.

Rarely, in different rocks, brecciated bornite aggregates from 5 to 40 cm in diameter with an almost monomineralic bornite cement can be seen. Spectral analysis of bornite confirms the following admixture: Ni – 0.0001 to 0.0003 %, Co – 0.004 to 0.01 %, V – 0.001 %, Ag – 0.0002 %, As – 0.005 %, Zn – 0.0003 % and In – 0.001 %.

Bornite is frequently intergrown with chalcopyrite. Their contacts suggest that they formed contemporaneously. Supergene chalcocite can occasionally be seen as close intergrowths (sub-graphic) in the Central area. In addition to primary bornite, which displays a yellowish tint (as a result of forming in solid solution with chalcopyrite), supergene bornite occurs replacing chalcopyrite in the form of rims or veinlets.

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Ахмади Хемаятулла, А.Б. Байбатша

Геологическое строение и минералогия руд меднорудного месторождения Айнак (Афганистан)

Резюме: В данной работе рассмотрена геология меднорудного месторождения Айнак, приведены сведения о его стратиграфии, тектоническом строении и минералогии руд. Месторождение Айнак, расположенное в 30 км к югу от Кабула (Афганистан), был открыт афгано-советскими геологами в 1973 г. Обширные разведочные работы в 1974-89 гг. включали бурение скважин, проходку траншей и штольен. Выявлено несколько крупных рудных тел и меньшие линзы с ресурсами в 240 млн т с средним содержанием меди 2,3 % (ESCAP, 1995). Стратифицированная минерализация состоит из рассеянного борнита и халькопирита с циклической последовательностью в метаморфизованных отложениях позднего докембрия.

Ключевые слова: геология, медные минералы, стратиграфия, месторождение, руда.

Ахмади Хемаятулла, Ә.Б. Байбатша

Айнак (Ауғанстан) мыс кенорнының геологиялық құрылысы және рудаларының минералогиясы

Аңдатпа: Бұл жұмыста мыс рудалы Айнак кенорнының геологиясы қарастырылып, оның стратиграфиясы, тектоникалық құрылысы және рудаларының минералогиясы туралы мәліметтер келтірілген. Айнак кенорны Кабулдан (Ауғанстан) оңтүстікке қарай 30 км орналасып, оны 1973 жылы ауған-кеңес геологтары ашқан. 1974-89 жж. жүргізілген кең ауқымды барлау жұмыстарында орлар мен штольня да қазылған. Бірнеше ірі руда денелері және ұсақ линзалар анықталған, олардың жалпы ресурстары 240 млн т, мыстың орташа мөлшері 2,3 % (ESCAP, 1995). Стратификатталған минералдану метаморфталған түзілімдерде циклді орналасқан шашыранды борниттен және халькопириттен тұрады.

Түйін сөздер: геология, мыс минералдары, стратиграфия, кенорын, руда денелері.

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АНАЛИЗ И РАСЧЕТ НОРМ ВОДОПОТРЕБЛЕНИЯ И ВОДООТВЕДЕНИЯ НА ПАВЛОДАРСКОМ НЕФТЕХИМИЧЕСКОМ ЗАВОДЕ

Аннотация. Исследуется водопотребление и водоотведение Павлодарского нефтехимического завода, рассмотрен водный баланс предприятия, расчетный расход оборотной, свежей речной и хозпитьевой воды на выполнение технологических операций для производственных установок. Приведена методика нормирования расхода водных ресурсов , выполнены расчеты норм водопотребления и водоотведения по основному, вспомогательному производству и для хозяйственно-бытовых нужд завода, дана оценка достоверности расчета индивидуальных норм.

Ключевые слова: водопотребление, водоотведение, водный баланс предприятия, перерабатываемое сырьё, индивидуальные удельные нормы водопотребления, операционная технологическая норма, накопитель.