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New Data on Copper and Silver Ore-Occurrence Sigurd in West-Spitsbergen Island, Svalbard archipelago

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Abstract:
One of the largest in the archipelago silver-copper mineralisation at Mount Sigurdf'ellet in West Spitsbergen Island was found in 1990 by Russian geologists. Firstly genesis was caused exclusively with hydrothermal ore migration of a substance from the enclosing sandstone and siltstone of the Devonian age. But subsequent work on the ore and nearest rocks of the basement gave a new factual material on the geochemical characteristics of potential sources of metals and found new for this mineral occurrence - gold mineralization. Similarity of geochemical associations of Sigurd ore occurrence with nearby upper Proterozoic marble as the first likely source of ore substance and the second - caused by carbonate-containing streaks in Low Devonian sediments. Ore-formation, probably due to repeated hydrothermal processes and was completed in a period of tectono-magmatic activity in Jurassic-Cretaceous time.

Keywords: Svalbard, Sigurd, copper, silver, gold, geochemistry.

Introduction

The Arctic islands represent ledges of continental crust over the surface of the seas. Svalbard archipelago located in a northwest frame of the Barents Sea treats them also. One was opened by us in 1990 in the north of the central part of West Spitsbergen Island (fig. 1) is the ore-occurrence of copper and silver Sigurd [1]. It is situated on the southern slope of Mount Sigurdfyellet. Sigurd has excess from 400 to 900 m above sea level and is the largest on the area from all found on the Svalbard archipelago.

As a result of the subsequent exploration works the resources of metals estimated in total on several nearby ore objects of this area give the grounds to speak about existence here the deposit with industrial conditions tipe of it [4].

It was necessary to execute more detailed studying of geological structure, regularities of his placement, mineralogical structure and geochemical features of definition of geological and industrial type of mineralization, for localization of the source of substance of "Sigurd" ore-occurrence.

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Figure 1. Svalbard archipelago and ore-occurrence Sigurd (rectangle) position.

Geological structure of Sigurd ore-occurrence

The ore-occurrence is located along sub meridian zone of breaks Breybogen. This zone is framing the western flank of large graben structure of the same direction. The graben formation was caused by the Caledonian tectonic events during which the similar to a rift structure has been filled with conglomerates, sandstones, aleurolites and thin carbonate deposits. The Russian geological mapping of this site of the West Spitsbergen Island have allowed to find some more small ore-occurrences of sulfides of copper and lead, barite, fluorite, rhinestone that has allowed to allocate a metall-genic zone with a number of ore fields within terrigenous deposits of the Devonian age and rocs of crystal basement framing a graben [5] here.

Upper-Proterozoic crystal slates and marble are on the western flank of a ore-occurrence Sigurd. The central and east parts of it are put by a terrigenous complex of Early-Devonian sandstones and aleurolites with pro-layers of carbonates (fig. 2). Contact between Proterozoic and Devonian deposits is tectonic, it is fragmentary carbonated and deployed with formation of brekchiya.

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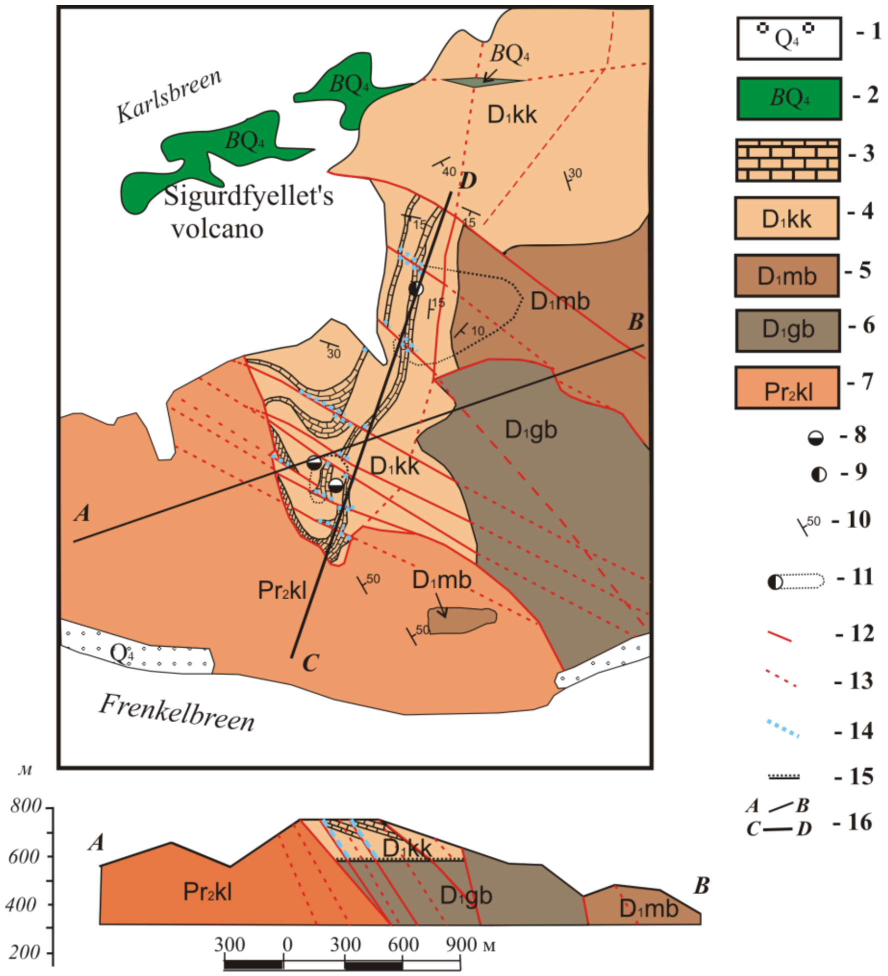

Figure 2. Scheme of a Geological Structure of a Silver-copper ore-occurrence Sigurd, where:
1 – the modern thin deposits of glaciers Frenkelbreen and Vonbreen (Q_4);
2 – alkaline olivine basalts of a Quarternary age (Sigurdfyellet's volcano – $Q_{4\beta}$); 3 - carbonaceous structure interlay of gray-green color in the Devonian terrigenous deposits; 4 – sandstones of red color, aleurolites with pro-layers of gray-green limestones of the Early Devonian age, Kap-Kyeldsen subsuite of Vud-Bey series (D_{1kk}); 5 – sandstones thin-grained gray-green and conglomerates of the Early Devonian age, Monakobreen, the Red-Bey series, the Lower Devon ($D1_{mb}$); 6 – conglomerates gray, polymictic, strata Germaniyabekken, the Lower Devon (D_{1gb}); 7 – marble and crystal slates of the Krossfyord series, Kollerbreen suite, by Rify
($Pr_{2\ kl}$); 8 – a copper mineralization in bed rocks; 9 – a lead-copper mineralization in deluvial deposit; 10 – elements of bedding of rocks; 11 – halo of dispersion of a copper-silver mineralization; 12 – the established tectonic disturbance; 13 – estimated breaks; 14 – manifestations of a vein ore mineralization; 15 – geological limits of discordant bedding; 16 – positions of profiles: AB – geological and CD – geochemical in fig. 4.

It is important to mark, that the ore mineralization is generally located in the tectonic cracks which are breaking off significantly carbonate interlay in the Devonian sandstones. At the same time ore substance spreads as well on bedding of carbonate stratas that says about what carbonate interlay served as geochemical barriers to unloading ore hydrothermal solutions.

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The magmatic activity on the next removal from ore bodies was shown during the Neogenic and Quaternary periods. In Neogenic time layers of basalts were created in close proximity to the ore-occurrence, however the genetic linkage of this mineralization with Neogenic volcanism isn't noted.

In the Quaternary Period the tubes of explosion and dikes of alkaline olivine basalt composing Mount Sigurdfyellet top are formed. It is the most southern of four volcanic centers on the archipelago. By estimates of various authors of eruption of volcanoes of Spitsbergen occurred and has come to the end not later, than 10 thousand years ago [2]. Now only hydrothermal springs located in several kilometers to the north of Mount Sigurdfyellet near Sverrefyellet's volcano on the seashore of Bokk-fyord work. The geological bases on influence of Quarternary volcanism on formation of ore substance aren't observed.

The ore-occurrence Sigurd is presented by a series of the veins which are carrying out cracks in terrigenous Devonian deposits and consisting of sulfides of copper and lead: faded ore, chalcopyrite, galenite in association with a barytic mineralization. The main vein minerals are calcite, quartz, dolomite, magnesite. Veins carry out fracture spaces, as a rule, plumaging the main sub meridian direction of a zone of breaks Breybogen. As ore veins breaks cut Low Devonian layers, it is obvious that ore formation happened already in the Post-Early Devonian time. However on finds of sulphidic mineralization in Precambrian metamorphic breeds of the archipelago B. Flud in 1969 [8] assumed the Pre-Devonian stage of ore genesis in similar veins caused by the Caledonian tectonic activity.

Authors of the Spitsbergen chapter in the monograph devoted to Solid minerals of the Arctic Islands of Eurasia [4] don't exclude probability of the beginning of copper sulphidic genesis in Early Rifeian time in the western part of Lifde-fjord, Bokk-fjord and Wood fjord where the group of the shows of copper connected with the stratified bodies of Early Rifeian breeds metamorphosed in the Amfibolitic facies is known.

Geological age of ore formation

Analyzing isotope composition of sulfur from T.V. Sigalstad sulfides and coauthors [10,11] have established that inclusions of hydrogen sulfide in sulfides of ore-occurrence in the Mount Sigurdfyellet in West Spitsbergen Island and the Island Bearnow have equally low values of content of isotope of sulfur 34, same, as in evaporita of the Permian age. Earlier publication A. Hardly, in 1962 contains the assumption of tertiary age of ore-occurence on the western coast of Spitsbergen [9]. Have given definitions of isotope ratios of lead from galenite samples from our collection Late Triassic age – 210 $\pm$ 10 million years [1]. Considering essential errors of this method which are admissible when determining absolute age, it is only possible to claim that dating confirms the post-early Devonian Period of ore formation on the Mount Sigurd-fjellet, already in actually post-Caledonian time. A probable tectonic-magmatic event with which paragenetic final phases of hydrothermal activity could be connected is an intrusion of dikes of the alkaline and ultrabasic breeds in D3-C1 time in Svalbard.

Thus, the age of sulphidic vein mineralization on the archipelago is estimated in quite wide range, beginning from Early Rifeian [4] and finishing the beginning of the Late Paleozoic. However, the age of a ore-occurance Sigurd, proceeding from geological relationship with the containing breeds is limited to the Devonian time. Geological data of all zone of the Devonian graben of West Spitsbergen specify the Middle and Late Devonian time as a time interval of ore formation.

Correlation between macro and micro- components of ore

Correlation relations between macro and microcomponents of ore substance reflect schemes of isomorphism in crystal lattices of ore minerals, their paragenetic associations and tendencies of secondary changes also. The correlation analysis has been made on group of 53 samples of ore substance and also the containing breeds and near ore metasomatic changed minerals. The results are given in the scheme of classification of positive correlation relations (fig. 3.).

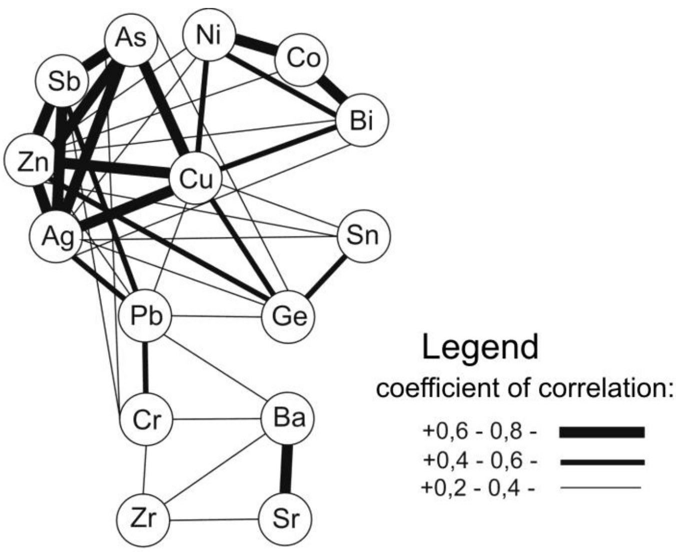

Figure 3. The scheme of positive correlative connections between macro - and micro-elements of ore-occurrence Sigurd.

The strongest connections between elements are shown by fatter lines. On this sign the six-element association is distinctly allocated: Cu, As, Ag, Sb, Zn and Pb. It’s formation is connected with prevalence of the main ore

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mineral of copper here - the tennantit, the extreme arsenical member of an isomorphic row tetrahedrite-tennantit. Tennantit is copper and arsenical sulfosalt – $Cu_{12}As_4S_{13}$ with impurity Sb, Bi, Fe, Zn, Ag, Hg, Co, Pb.
The relationship of ore minerals in polished samples have shown that tennantit was allocated in association with chalcopyrite ($CuFeS_2$), pyrite (FeS_2), a galenite (PbS) and blende (ZnS) were generated at the earliest stage of mineral genesis. So stable correlation relations between the listed elements were established as a result. These minerals carry out the main ore lot of the occurence, formed primary hypogene mineral complex.

Other associations of elements are connected with main ore association weak and moderate positive correlation relations and steady in each group of elements. It is possible to carry association to: Ba, Sr, Zr, Cr, Pb characteristic of barytic veins ($BaSO_4$) and the accompanying mineralization, including an argentiferous galenite, a tselestin ($SrSO_4$). Zirconium and chrome isomorphically replace cations of these minerals. Barytic and carbonate veins with a galenite, as a rule settle down in the top part of a vertical section of a ore occurence that will quite be coordinated with the general regularity of geochemical zonality in hydrothermal deposits of metalls.

In general, here it is necessary to pay attention to two important features. First, it is weak relation of Cu and Pb that is characteristic of all ore occurrences in a zone of the Devonian graben. It can say about existence of two or more stages of ore formation in which these elements played sharply various role. Secondly, it is weak relation of Cu and Ba that is the important instruction on the fact that barytic occurrences are created in a separation from silver - copper, it is probable realized later and together with fluorite. It can also be the indirect instruction on existence of different sources of substance for ore and nonmetallic occurrences.

The third association forms group of four elements at the heart of which strong relation between Ni and Co and also Bi and Cu, is connected with concentration of chalcosine (Cu_2S) replaced kovelliny (CuS). Isomorphic impurity elements in chalcosine: Ag, Co, Ni, As and Au. This association occupies the lowermost level in the vertical zonality of hydrothermal mineralogenesis established by V. Emmons and S.S. Smirnov [6,7].

The fourth association is presented by positive relations between concentration: Zn, Ge, Cu and Sn. Germany is in the majority of silicate minerals and as isomorphic impurity contains in blende in certain cases up to 1000 g/t. There are sulfides of SnS tin and SnS_2 and natural connection with copper and zinc in the form of sulfide of copper, zinc and tin, mineral kesterit – Cu_2ZnSnS_4. It is represented that this association of elements is related to the first - tennantite, but it is connected with a blende paragenesis of chalcopyrite.

Sequence of ore mineral’s crystallization

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The structural relationship of ore minerals in polished slides from various sites of a ore occurrence and the real positive correlation between base elements of the minerals, the following sequence of crystallization of the main ore minerals is planned.

The first faded ores in association with chalcopyrite, blende and a galenite crystallized. In the second stage bornitic ores with the subordinated amount of pyrite, chalcopyrite and chalcosine were formed significantly. At the third stage of mineralogenesis were formed chalcosine, chalcosine-kovelline of ore of secondary sulphidic enrichment where chalcosine is replaced with copper indigo. The fourth stage has no strict temporary binding concerning the first three as in different parts of ore occurrence, especially close with marble of Riphean age form the veins executed by barite, and to a lesser extent celestine and calcite, cutting the vein interspersed ores of all three first stages of mineralogenesis. The fifth and final stage of ore generation are the processes of a zone of oxidation which are expressed in azurite formation - $Cu_3(CO_3)_2(OH)_2$ and $Cu_2CO_3 (OH)_2$ malachite (fig. 4), respectively both secondary minerals of copper don't form an independent complex of correlation between ore elements. There is also a limonite (Fe_2O_3 x nH_2O) which develops on pyrite and chalcopyrite in an oxidation zone.

Figure 4. Oxidation zone minerals: $Cu_3(CO_3)_2(OH)_2$ azurite – blue and $Cu_2CO_3 (OH)_2$ malachite – green.

The greatest coefficient of concentration in the Sigurd ore occurrence is Cc silver = 218. It’s maximum grade estimated by method of the semi-quantitative spectral analysis has made 500 and 617 g/t, and by method of atomic and issue spectroscopy – 450,6 g/t. Continuous strong correlation of silver and copper in all geochemical groups of associations is noted. The most large amount of silver is revealed in a burnonite ($PbCuSbS_3$) – 3920 g/t, it is less in a galenite (PbS) – 1940 g/t, and in faded ores

($Cu_{12}(AsSb)_4S_{13}$), bornite (Cu_5FeS_4) and Cu_2S chalcosine) from 488 to 1900 g/t. Average content of silver and copper has been calculated according to analytical works of different years and taking into account different types of analyses, spectral semi-quantitative and atomic and issue. Average concentration of Ag = 124,9 g/t, Cu = 2,87%.

Geological and industrial type of mineralization

The ore occurrence Sigurd has been carried [5] to sulphide -polymetallic geological industrially type by a number of signs.

The typical representatives are fields in Ore Altai and Kazakhstan: Oryol, Irtysh, Maikan and others. Characteristic signs of geological and industrial type are:

a) confinedness to the steeply dipping zones of crushing and a cleavage connected with deep faults;

b) localization in trailing boards of large ruptural deformations;

c) contrast of the containing complexes (metamorfogenny, volcanogenic and sedimentary);

d) pre-ore formation of hydrothermal -metasomatic alteration of breeds and three subsequent stages: chalco pyritic, with formation of pyrite, the chalcopyrite, blende and seldom a galenite; the second – polymetallic with barite, carbonates, chalcopyrite, pyrite, a galenite and faded ore; the third vein of quartz - sulphidic or barite - polymetallic. The majority of these features of a geological structure, mineral structure and the sequence of formation was shown in the ore occurrence Sigurd.

V. Emmons [7] connected mineralogenesis zones with temperature condition and subsequently has undergone criticism from S.S. Smirnov who allocated the intrusive specialized on ores formations [6]. On the example of a number of fields the following sequence of concentration of elements in aureoles from over ore to sub ore parts has been established: Sb - As - Ba - Ag - Pb - Zn - Cu - Bi - Sn - Co – Ni.

The irregular network of approbation of the ore occurrence Sigurd executed because of complexity of a mountainous terrain where the corner of a slope makes from 20 to 80° has been counted in regular according to the Serfer program and designed on the vertical plane focused on an azimuth of 20 degrees NE. As a result we have received a picture of distribution of abnormal maintenance of ore elements in the range of heights from 450 to 700 meters above sea level (fig. 5).

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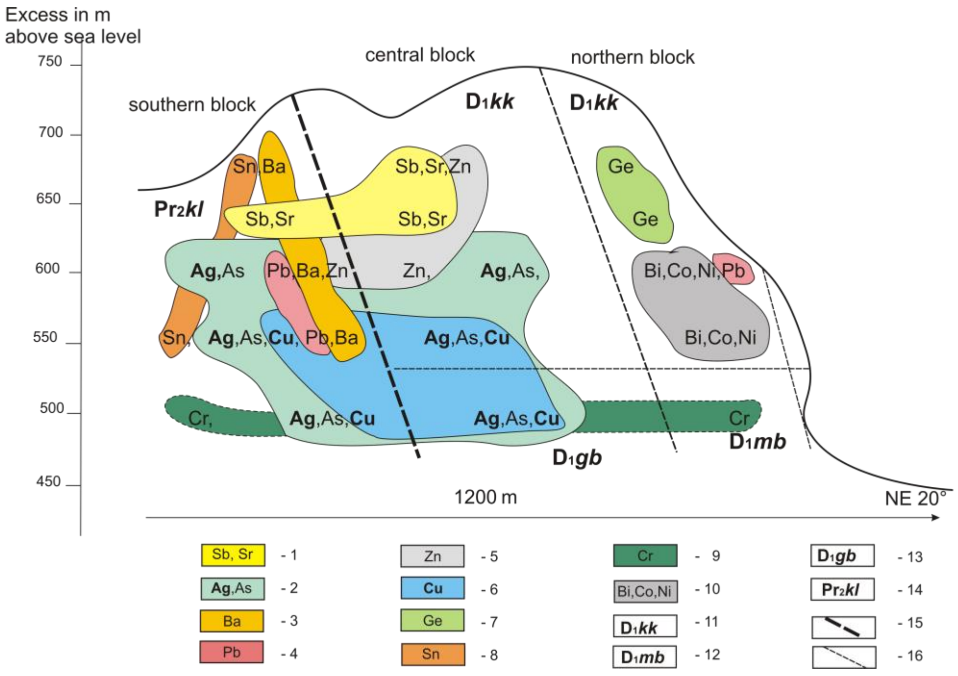

Figure 5. Geochemical zonality of a ore-occurrence Sigurd on a vertical and on direction 20 ° NE, where the abnormal concentration: 1 – antimony(Sb) and strontium(Sr); 2 – silver(Ag) and arsenic(As); 3 – barium(Ba); 4 – lead(Pb); 5 – zinc(Zn); 6 – copper(Cu); 7 – germanium(Ge); 8 – tin(Sn); 9 – chrome(Cr); 10 – bismuth(Bi), cobalt(Co) and nickel(Ni); 11 – sandstones and limestones Kap-Kyeldsen suite, the Lower Devon; 12 – sandstones and aleurolites Monakobreen suite, the Red-Bey series, the Lower Devon; 13 – conglomerates of polymictic strata Germaniyabekken, Lower Devon; 14 – marble and crystal slates of Kollerbreen suite, the Upper Proterozoic; 15 – a deep break Breybogen – tectonic contact of Proterozoic and Devonian deposits; 16 – tectonic dislocations in the stratas of the Devonian sediments.

The section consist of three blocks of breeds divided by breaks. The Southern block is represented of the crystal slates and marble of the basement. It is penetrated by ore-bearing veins and is separated from the central block by a zone of breaks Breybogen focused on an azimuth 330 ° by NW. The central block is put by sandstones, aleurolites and carbonate pro-layers of suite of Kap-Kyeldsen of the Lower Devon. The main ore substance are connected with carbonate pro-layers and zones of a breccia. The third – the northern block is a part of also terrigenous and carbonate deposits of the Lower Devon, including a complex of small ore-bearing veins, peripheral to the ore occurrence, small one, in the first centimeters thickness.

The results of the spectral semi-quantitative analysis of different years and also X-ray-fluorescent in number of 270 samples have shown good degree of convergence that has allowed to use them for creation of trend surfaces of distribution of the main and minor ore elements in the plane of the section focused in the direction 20 ° by NE. The subsequent comparison

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of provisions of maximum contents of the analyzed elements has given on the generalizing scheme which is submitted in fig. 5.

Geochemical zonality of Sigurd ore occurrence

The general large copper bearing zone which is settling down in the lower part of Southern - Precambrian and Central – Devonian blocks, designated in blue color is allocated for fig. 5, it is a kernel of larger abnormal zone of content of copper, silver, arsenic.

The zone under silver-copper anomaly is enriched with chrome that is connected with confinedness of ore occurrence to a zone of a deep break. Enrichment by chrome is noted both in breeds of the basement, and in the Devonian breeds that testifies to a deep source of ore substance. It was delivered in a mineralization zone along this break and the subsequent distribution on fracture dislocations of mélange type on the corner to the Breybogen break, in common direction 50 – 70 ° NE.

Existence of anomaly of chrome can be caused also in general by the increased content of chrome in all terrigenous thickness of red-color sandstones with chrome minerals at heavy fraction: chromic spinel, chrom-diopside and also an olivine -product of destruction of the ultramaphic rocks located in the form of thin dykes on the southern continuation of a zone of breaks Breybogen in Ekmanfyord [3]. The anomaly of content of chrome is recorded during of earlier geological mapping in a zone of a deep break on east flank of the Devonian graben, near the Pyramid mine, in the valley Mimerdallen where come to the surface the layers of the top Devon. They contain the increased concentration of minerals of heavy fraction of the ultramaphic paragenesis. Besides, it is impossible to exclude the imposed nature of chromic anomaly caused by post-magmatic processes of redistribution of minerals of quarternary age volcanic rock.

The special position is taken by anomalies of content of bismuth, cobalt and nickel in the basis of an ore zone of the northern block of a Sigurd ore occurrence. It is designated on the scheme in gray color. This association of elements is caused significantly by chalcosine type of a mineralization and, to a lesser extent, chalcopyrite, pyrite and tennantite ($Cu_{12}As_4S_{13}$).

Chrome, nickel and cobalt anomalies are typical for sub ore parts of any copper hydrothermal mines. Here, in the northern block these anomalies can be caused by rather big removal from a zone of a deep break as they are focused sub parallel to a zone of breaks Breybogen.

The zinc anomalies above on a section are distinctly dated for a zone of a deep break. They are caused by blende (ZnS) location thear. At the same level, the strontium anomalies is closer on to contact with Proterozoic marble of distribution and are connected with antimony location. The first is caused by a celestine ($SrSO_4$) mineralization which associates with barite ($BaSO_4$), and the second is caused by the isomorphic Sb impurity in arsenopyrite (FeAsS) replacing arsenic.

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The germanium enrichment zone is allocated in the north of the section. It is an isomorphic impurity in blende structure. This zone is located at the same stratigraphic level, as anomaly of zinc in the central and southern blocks of the ore occurrence.

The distribution of geochemical zonality corresponds in general established earlier on fields of hydrothermal genesis, known in the world. It is observed the variability of compositions of ores on lateral, in process of remoteness from the main ore moving deep break Breybogen. The northern block differs in structure of anomalies from the central and southern blocks on typical sub ore association: bismuth, cobalt and nickel.

There were numerous movements of separate blocks down to formation of zones of a breccia sites of mutual crossing of ore veins in the history of tectonic events of the region of Sigurd ore occurrence. Therefore the northern block quite could test a relative raising so that the zone of a chalcosine mineralization from the lower level has been raised together with the block of the containing sandstones of Devon on the level of the main ore zone of the central block. By the second, and perhaps more probable cause of concentration of bismuth, cobalt and nickel in the northern block Low Devonian adjournment of suite of Kap-kyeldsen it is connected with process of a propillitization during which Ni and Co are a part of the first stage of pyrite formation. It’s allocations at a late stage have xenomorphic character and a lesser extent contain impurity elements.

The lateral geochemical zonality of Sigurd ore occurrence gives the grounds to claim that the main break Breybogen according to whom Proterozoic marble and the Devonian sandstones (350 °NW) contact is ore bring, and plumage, with pro-deletings in northeast points, – the containing ore break.

The southern and central blocks are characterized by auras of distribution of very similar ore elements: Ag - Pb - Zn – Cu, at the same time the top part of a section is enriched with minerals of lead, barium and arsenic.

Source of ore substance

One of the most debatable in hydrothermal ore formation is the problem of a source of ore elements. Earlier [1] we considered a source of copper and silver and also lead, zinc and other elements the containing terrigenous thicknesses of the Devonian age with manifestation of a copper mineralization like medisty sandstones were. However, later works [4, 5] demonstrate probability of Precambrian sources of ore elements which are widely shown in points of a mineralization of metamorphic breeds of the crystal base.

The approbations and results of chemical analyses of primary ore substance of the Sigurd ore occurrence presented by generally faded ore and chalcopyrite have been involved to the solution of this task. Minor ore minerals are: the galenite, blende, barite associating with calcite and quartz.

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Secondary minerals are widely presented by malachite and azurite, as shown in fig. 4. As potential sources of ore substance data of chemical and microelement compositions of red and gray sandstones and aleurolites of the Lower Devon, ore-bearing marble of metamorphic breeds of suite Koller-breen of Rify age, the ore occurrences of polymetals in other areas of the archipelago have been attracted.

By results of analyses of maintenance of the main and accompanying ore elements in the breeds mentioned above: Ag, Cu, As, Sr, Ba, Ti, Cr, Co, Ni, Mo, Sn, Pb, Zn, have been counted their average quantities and the correlation analysis between structures of potential sources of ore substance and composition of ore of Sigurd ore occurrence is made. The result is placed in table 1.

Table 1.

Results of the correlation analysis of geochemical features of ore substance with his potential sources in the containing rocks.

Name of rocks	Number of tests	Correlation coefficient				
		Sigurd - ore substance	Limestone D_1kk	Sandstone green D_1rb	Conglomerate D_1rb	Marble with the ore substance Pr_2
Sigurd - ore substance	31	1				
Limestone D_1kk	33	0,80	1			
Sandstone green D_1rb	28	0,66	0,95	1		
Conglomerate D_1rb	10	0,69	0,97	0,99	1	
Marble with the ore substance Pr_2	15	0,90	0,49	0,32	0,34	1

The maximum size of coefficient of correlation between composition of ore substance of Sigurd ore occurrence is 0,90 with the composition of marble of Proterozoic age enriched with ore minerals. The second for extent of decrease in correlation with ore is limestone from pro-layers in suite of Kap-Kyeldsen of the Lower Devon – 0,80. It is noted that doesn't allow to eliminate terrigenous thickness of the Devonian age of sources of ore minerals. The Devonian conglomerates and sandstone of green color, are correlated on structure with ore substance to a lesser extent – 0,66 and 0,69, than carbonate interlay for which mineralization is dated.

Conclusion

The main impact on result of the correlation analysis is exerted by the ratios of maintenance elements sizes and not their absolute values. Especially it should be noted the concentration of Sr, Ba and Ti increasing in the listed order in all studied breeds. High titan is caused by such minerals as rutile, anatase, sphene and leucoxene, present at heavy fraction even carbonate Proterozoic and Devonian beds. Sr and Ba are a part of the minerals which are carrying out cracks and all deposits penetrating also, calcite - barytic with tselestiny veins.

The minimum coefficients of correlation between compositions of marble of Proterozoic age both the Devonian conglomerates and green sandstones. It says about their formation occurred not only and not just due to destruction of nearby Rify metamorphic rocks.

Factors which influence needs to be considered for reconstruction of ore-occurrence Sigurd history of a becoming: 1 - probable process of multistaging of ore deposition and 2 – influence on dynamics of migration of ore substance of geochemical features of each of the considered elements.

It is important a detection of free gold in ore-occurrence Sigurd. It is determined by the atomic and adsorption method in test of XII/-42-6 in number of 0,36 g/t. Availability of gold is confirmed when studying polished slide, in an exemplar 540/3 grain of gold, 0,015 mm in size in association with bornite, tenanted is noted, chalcosine, chalcopyrite and indigo copper. A grain of free gold, 0,4 mm size is in VII/36 polished slide along with rich chalcopyrite – tenanted – chalcosine – indigo copper ore in quartz - a carbonaceous part.

It is interesting to note that 6 fine grains (about 0,01 mm) diagnosed as kyustelit (Ag18Au – Ag 2,5Au) were found in similar association, in sample XII/-40-2 in a tenanted.

Considering these facts, it is represented that an ore-occurence Sigurd can have also gold specialization. Justification of this conclusion will demand carrying out padding sampling works on all area of the ore-occurrence.

It is possible to draw a conclusion on preferred similarity of geochemical associations of ore substance of ore-occurence Sigurd with nearby marble of the Late Proterozoic as first probable source of ore substance on the basis of the above. The second source, caused a carbonate containing pro-layers in Early Devonian layers. Circulation of ore-bearing solutions on a deep zone of breaks Breybogen happened a lot of times and came to the end probably at a boundary of Devonian and Carboniferrouse periods.It was during the tektono-magmatic activity on the archipelago expressed by formation of fields of dikes of the alkaline and ultramaphic structure and D_3-C_1 age.

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