RESEARCH ARTICLE OPEN ACCESS

Geological-Structural Setting of Massif and the Levels of Quartz - Sulphide Mineralization in the Kaptina Gabbro Massif

Kaza Gj[1], Doda V[1], Naço P[1], Onuzi K[1], Gjeçi K[1], Vinçani F[1] & Gjonaj V[2]
[1]Institute of Geosciences, Energy, Water and Environment, Tirana, Albania
[2]Albanian Geological Survey, Tirana, Albania.

Abstract
Kaptina gabbro massif is placed in the northern half of the eastern Mirdita ophiolitic belt and is spreaded in a relatively large area. Petrology of Kaptina gabbro massif is very complicated as in view of the diversity of rocks that are spreaded within it as well in view of structurally construction.
In this region are exposed all components of the Mirdita ophiolitic Complex, as well as oceanic sedimentary cover, the Cretaceous one and the newer mollasic formations of Pliocene-Quaternary. Kaptina gabbro massif has an irregular shape, however is seen a certain extension in the meridional - submeridional direction. This massif is plunged in the South and the West under volcanogenic formations to come back in the small output in the lower Bisaku and to join more south with the Bulshari gabbro massif. The outputs of massif are expanded towards the north - northeast. In construction of gabbro massif take part a range of rocky types that stay in various reports regarding surface spreading. Greater spreading in all the massif have gabbronorite, in close connection with them stay norite and gabbro.
Gabbro rocks are generally mesocratic, but also meet the melanocratic, leucocratic types that have the gray-green colour to sometimes motley. Besides belted textures, in gabbronorite are often observed textures with gneiss presence. Belted gabbro represent the deepest parts of gabbro cutting, but while considerable spreading have also to other parts as follows above; the foliated and isotropic gabbro. Quartz sulphide mineralization has relatively large spreading in the region. It is localized mainly in gabbro rocks. In Kaptina gabro massif the main concentrations of quartz - sulphide mineralization meet in the Thirra, Gdheshta, Shëmri - Pista and Golaj-Nikoliq areas. In terms of spatial placement of ore bodies, they do not also belong to a certain horizon of gabbro rock, but represent a series of parallel bodies set in a potent belt of these rocks. This belt, may belong to lower parts, middle until middle-upper of Kaptina gabbro massif cutting, thus belong to deep levels (layered gabbro), middle and upper level of this belt (the foliated and isotropic gabbro).
Key words: Albania, Mirdita Ophiolites, Kaptina gabbro massif, quartz-sulphide mineralization, the isotropic gabbro, the foliated gabbro, the layered gabbro.

I. INTRODUCTION

Kaptina gabbro massif, the largest in ophiolites of Albania, has had and has the great interest not only for its geological - structural particulars but also for the high degree of its saturation with sulphide mineralization of copper - pyrite. This massif is characterized by a complete representation of all gabbro components as the layered gabbro, the foliated gabbro and the isotropic gabbro [12], [16].

Another very important aspect is even very emphasized development of shear zones with the presence of sulphide mineralization of copper - pyrite and also the quartz sulphide veins of gold content in some cases with its high values. This massif has been continuous subjected to geological and structural studies and scientific conclusions have supported the conducting of numerous research - exploration surveys for quartz - sulphides mineralization in many of ore showings of this massif.

Being a massif which is saturated with these mineralization is not yet given up to now that in which the rocky complex or level is focused this mineralization type. Although there is a numerous geological and structural material and for sulphide mineralization yet for a proper analysis of contemporary elements can not be claimed to have been performed.

Based on the above, this study was undertaken by analyzing levels of mineralization for the bodies of ore deposits as in Thirra deposit, and in other deposits of this massif as the most important representative of the Kaptina gabbro massif as to the quantity and the quality of detected reserves.

II. GEOLOGICAL - STRUCTURAL SETTING OF MASSIF

Kaptina gabbro massif, placed in the northern half of Mirdita Ophiolitic eastern belt and is spreaded in a relatively large area. Petrology of gabbro massif is quite very complicated as in view of the diversity of rocks that are spreaded within it as well in view of structurally construction (fig. 1).

In construction of the Kaptina gabbro massif take part a variety of rocky types that stay in various reports regarding the surface spreading. Greater spreading across the massif have gabbronorite, meeting almost in all sectors of gabbro outputs. In close connection with them stay norite and gabbro.

Gabbro rocks are generally mesocratic, but also meet the melanocratic, leucocratic types that have gray-green colour sometimes motley. Besides belted textures, in gabbronorite are often observed textures with gneiss presence, which is generally oriented in accordance with the orientation of belted textures [1], [3], [10]. Belted gabbro represent the deepest parts of gabbro cutting, but while considerable spreading have also to other parts as follows above; the foliated and isotropic gabbro [11], [18].

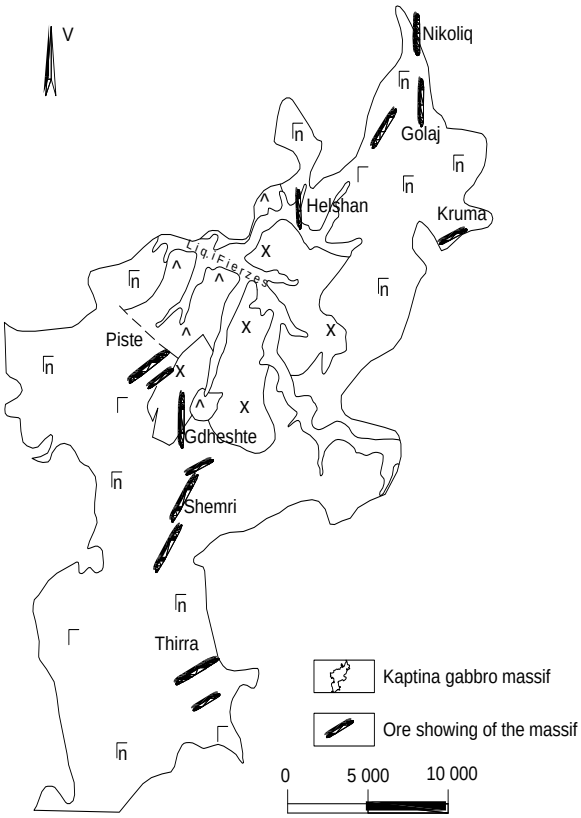


Figure 1. Geological map of the Kaptina massif

Photo 1. Meso-grained (Uka brook)

Photo 2. Gabbronorite with belted textures (Ballna brook), Thirra deposit

Gabronorite, norite and gabbro are usually of hipidiomorfo - grained gabbro structure more rare prismatic - grained and rare elements of sideronite structure. As the primary minerals in them usually meet: basic plagioclase 50-60% and rhombic pyroxene 10-20% and monocline 20-30%; as accessory mineral meets usually ilmenite.

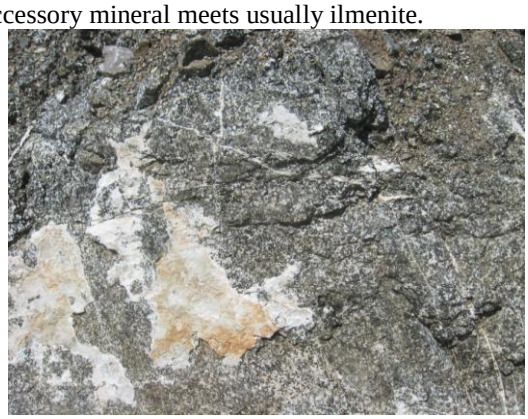


Photo 3. Amphibolitic gabbro (upper gabbbro level), Thirra deposit

Gabbro - pyroxenite and plagioclase - holder pyroxenite have the limited spreading in Kaptina gabbro massif. They meet in the eastern part of Massif (sector of Kumbulla brook - Ballna brook, fig. 1). In the Kaptina gabbro massif, rarely meet amphibolitic gabbro. Outputs of these rocks meet in different parts of the massif as its southern extreme (Xhuxha - Xhuxha Sangu) as in the southwestern one near the Hebe village (fig. 1), photo 3. Between the rocks of Kaptina gabbro massif, meet some distinctive rocky types that conventionally called "quartz gabbro" or "gneiss-gabbro-quartz" and rocks "metasomatic injection". Metasomatic rocks have the limited spreading and meet in Pista, in the middle part of Breu stream, in the sector between Uka and Heba streams (left coast near the village of Domgjoni Sangu), near the Megulla top etc..

4 

5 

Photos 4, 5. The view of pegmatite gabbro, Pista – Gdheshta and southeastern part of massif

Dike series in the Kaptina massif has a relatively large spreading and are of different types. More often meet the dike micro-grained rocks (microdiorite, microdiabase, microgabbro), more rarely meet medium-grain rocks (gabbro pegmatite, dikes of quartz plagioclase and plagioclase rock etc.) (Photos 4,5), [12], [13], [14], [15],[16]. In most cases the orientation of these dikes is transversal to the bealted texture as in the case of micro-grained and gabbro pegmatite types. More rare those oriented in accordance with the primary generation, where more typical is the case of pyroxene dikes (Photos 6, 7), [2], [11].

In massif is developed the intensive folded and disjunctive tectonics. Based on detailed analysis of data of the primary structural elements and postmagmatic tectonics earlier in the Kaptina gabbro massif, can be separated following folded structures: Fan anticline, Xhuxha anticline, Thirra anticline, Thia loop syncline, Black Peak anticline, Flet anticline, Mia saddle syncline (Korila Peak), Goska anticline, Kruma syncline. From what we have introduced above, it results that the Kaptina massif has in general an internal folded construction, the folded structures orientation seems consistent with the general morphology of the ceiling and the pan of gabbro massif.

6 

7 

Photos 6, 7. The view of dike series developed in gabbro massif

Regarding the time of formation of the folded structure, whereas the fact that such structural elements such as transversal dikes, which are indicators of continuity of magmatic process and the fact that quartz-sulphide veins are generally in accordance with the structure of the massif and sometimes form folds as the Medley Stone brachsyncline or Bulshari folded quartz vein, we can assume that folded formation of the massif has begun at the process of its petrification and has finished before the final closing of magmatic activity, namely before the formation of newer dike types. This structure may be complicated by later folded formation [18], [11].

III. QUARTZ-SULPHIDE MINERALIZATION AND THE MINERALIZATION LEVELS OF THIS MASSIF

This type of mineralization, has a relatively large spreading in the region, it is localized mainly in gabbro rocks. In Kaptina gabbro massif meet the main concentrations of quartz - sulphide mineralization in Thirra, Gdheshta, Shëmri - Pista and Golaj Nikoliq areas. Quartz - sulphide mineralization rarely encountered in other rocks as in plagiogranite, in ultrabasic rocks (within their or in tectonic contacts with gabbro rocks) and in the effusive rocks. So, for example in Shëmria area some quartz-sulphide veins meet in plagiogranite. In Helshan area face the quartz-sulphide veins between ultrabasic rocks or in their tectonic contacts with gabbro [17], [18].

Quartz-sulphide mineralization, generally presented in the form of quartz veins with different sizes from several centemeters to several meters and from a few meters to several hundred meters, in which observed sulphide different concentrations, mainly of pyrites and chalcopyrites, more rarely of pyrotine, in the form of nest and stipple. Besides quartz-sulphide mineralization, in gabbro rocks of the region, rarely noticed the other appearance of veiny type, such as barren quartz veins in view of sulphide mineralization and epidotic quartz veins with sulphides and hematite.

The first reach until the significant size, while the last ones are generally of small size. It should be noted that in gabbro rocks noticed the chloritized and quartzed areas of sulphide scattered stipple (pyritoze) that have generally limited extent [4], [6], [8].

IV. THIRRA ORE DEPOSIT

Thirra deposit is characterized by a relatively high concentration of quartz - sulphides ore bodies. Of these, the most important are bodies with no. 1, 6, 6^b, 6^c, 7, 7^d, 8/A quartz-sulphide, veins of Heba, Lugja Loop, Lugjata, Medley Stone (longitudinal secttion of figure 2, cross-secction of deposit of figure 3). In the terms of localization condition and composition, the mineralization divided into several types: the most widespread ore type is quartz - chalcopyrite, more less chlorine – chalcopyrite - pyrotine type, quartz – tiff -chalcopyrite and for the limited parts of ore bodies are chlorine – pyrite - epidot, quartz - chalcopyrite - arsenopyrite, quartz - chalcopyrite - sphalerite types.

These ores are involved in an ore field based on their likeness in terms of morphology, setting conditions, relations with the surrounding rocks, marginal changes, mineral composition etc. [7], [9].

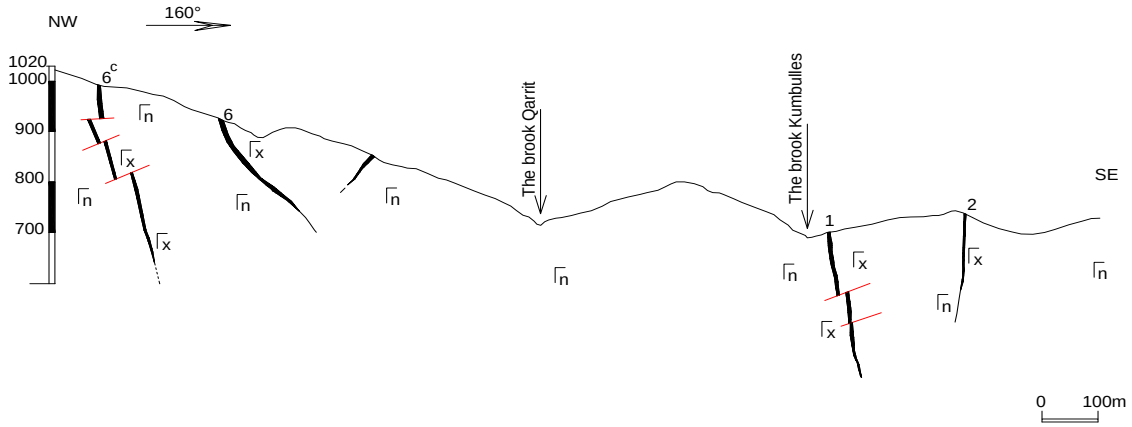
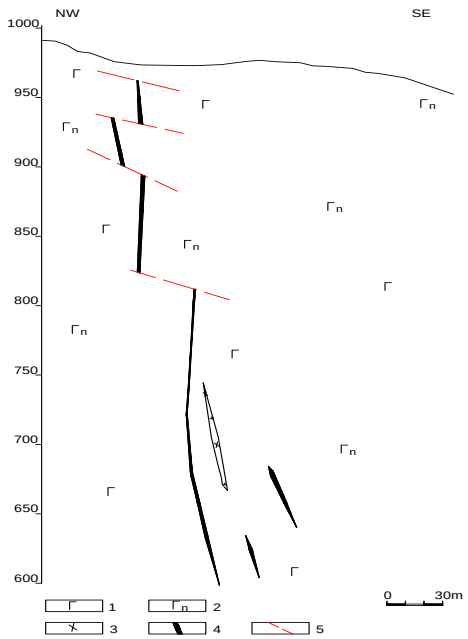


Figure 2. Cross-section A –A, Thirra



1. Gabbro rock 2. Gabbro-norite rock 3. Chlorite 4. ore body 5. tectonic fault

Figura 3. Profile +II, 6^C ore body of Thirra deposit

In terms of spatial placement of ore bodies, they do not also belong to a certain horizon of gabbro rock, but represent a series of parallel bodies set in a potent belt of these rocks. This belt, may belong to lower and middle parts of Kaptina gabbro massif cutting. In relation to each other, ore bodies have such a placement: the ore bodies of Uka brook, Kumbulla brook belong the deep levels of layered gabbro, while ore bodies of Medley Stone, Lugja Loop, Lugjata belong to the upper levels of this generation, the foliated and isotropic gabbro (fig. 4), [11].

Age	Lithology	Index	Description of formations
J U R A S S I C	+ + + + + +	γJ_2	Quartz diorite, plagiogranite
	Γ_a Γ_Q	υJ_2	Isotropic gabbro (Medley Stone, Loop Lugje, Lugjate, Pemez, etc.)
	Γ Γ	υJ_2	Foliated gabbro (Tr. $8^a, 7^d, 6^c$)
	Γ_n n	υJ_2	Layered gabbro (Tr. 1, 1^a, 6, 6^b)
	Γ_P P	υJ_2	Pyroxenite gabbro and pyroxenite

Figure 4. Thirra ore deposit

V. GDHESHTA – PISTA ORE DEPOSIT

In the terms of localization condition and composition, the mineralization of Gdheshta – Pista region divided into two main types:

1. Quartz - sulphide type, which is divided into two subtypes:
   a. quartz - chalcopyrite
   b. quartz - polymetallic
2. Serpentinite-sulphide type

Main minerals are chalcopyrite, pyrite, and pyrotine, where you can group these mineral accompaniment: 1. Quartz - chalcopyrite - pyrite, 2. Quartz - chalcopyrite - pyrotine - pyrite, 3. Quartz - pyrotine - pyrite - chalcopyrite.

The most widespread to the region's ore bodies is quartz – chalcopyrite – quartz - pyrite. In general, the mineralization of this genetic type has heterogeneous distribution. This heterogeneity observed in both extension and striking. Due to the heterogeneous distribution of mineralization is perhaps conditioned linear character of mineralization in the main body 1^a and 1^b of Pista. In Pista-Gdheshta area noticed a certain vertical zonality of mineralization distribution. Example, in comparison to the Pista-Gdheshta deposit, which is characterized by a mineral accompaniment of quartz - chalcopyrite - pyrite, the mineral accompaniment for Prujza is quartz chalcopyrite - pyrotine - pyrite, here pyrotine meet in substantial quantities, even in the gallery of slops meets until to the massive pyrotine; In Mgulla top meet the white quartz with some rare stipple of pyrite with little chalcopyrite, while in Srriqe river predominates quartz – pyrotine - chalcopyrite - pyrite, so rich in sulphide.

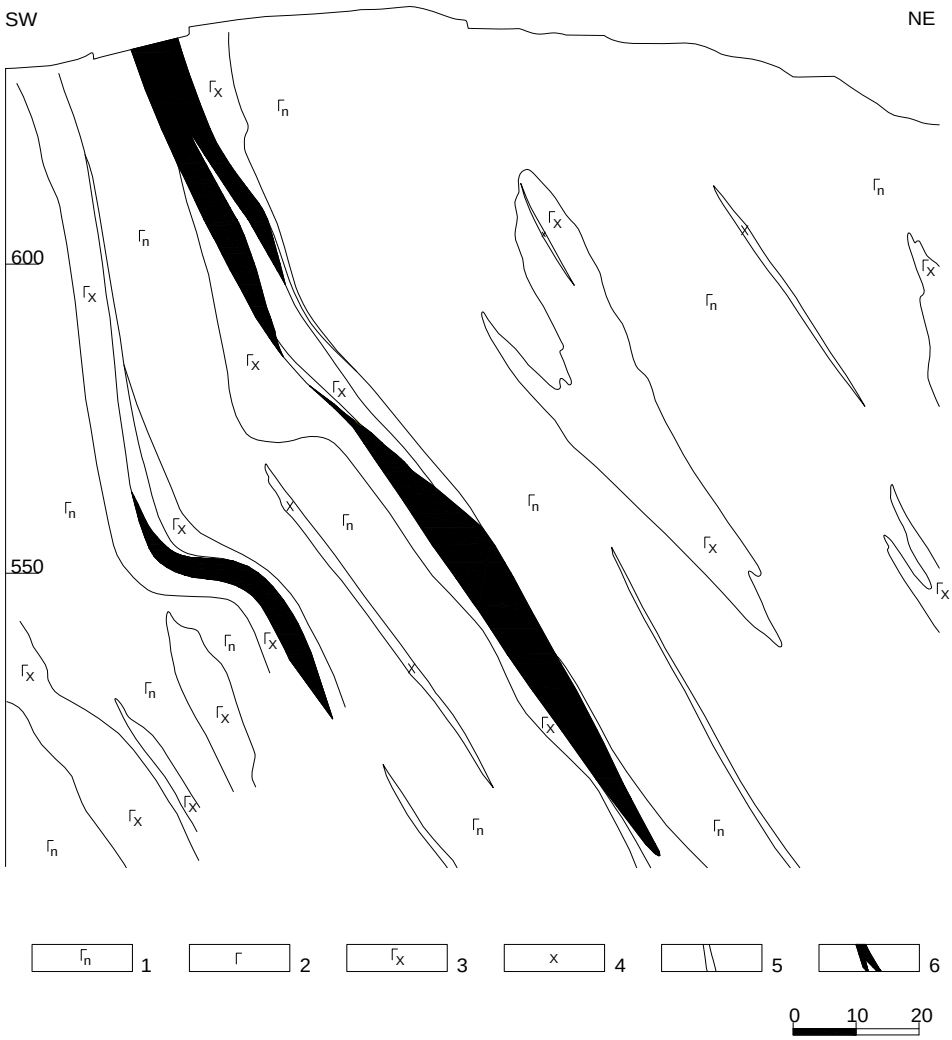
A such vertical zonality observed in Armira etc.. The body 1 with lines a, b, c, d; bodies 2, 3, 4 of Gdheshta and bodies 1, 2, 3, 4 of Pista, have typical veiny shape with distention and slimming as during the extension, as during the striking also have sub-latitudinal extension with azimuth of 80°, the south-eastern strike with the angle of 50°-60° sometimes greater than 60°. In the strike, observed its deviations from south-eastern position, in the vertical strike and even sometimes with the reverse strike. Bodies were followed during the extending with the surface works about 200 m and during the striking with drilling works of 220 m. Thickness ranges from 0.5 m to 8.4 m, while and copper content is 1.59 %. Have simple morphology, with rare ramifications, that opened and locked at certain intervals [4], [5], [7], [18]. In conclusion, quartz-sulphide and serpentine-sulphide mineralization of Pista-Gdheshta ore region related to tectonic fissures with later developing than the formation of other magmatic rocks of this structure. These levels belong to the middle and upper intrusive-gabbro cutting (fig. 5, 6, 7),[11].

Age	Lithology	Index	Description of formations
J U R A S S I C	+ + + + + +	γJ_2	Quartz diorite, plagiogranite
	Γ_a Γ_Q	υJ_2	Isotropic gabbro (Tr. 1, 2, 3, 4)
	Γ Γ	υJ_2	Foliated gabbro (Tr. 1, 2, 3, 4)
	Γ_n n	υJ_2	Layered gabbro
	Γ_P P	υJ_2	Pyroxenite gabbro and pyroxenite

Figure 5. Pista ore deposit

Age	Litholgy	Index	Description of formations
J U R A S S I C	+ + + + + +	γJ_2	Quartz diorite, plagiogranite
	Γ_a Γ_Q	υJ_2	Isotropic gabbro and in contact with quartz diorite (Tr 1^c,1^e)
	Γ Γ	υJ_2	Foliated gabbro (Tr. 1^a, 1^b ,1^d , 2, 3, etc.)
	Γ_n n	υJ_2	Layered gabbro
	Γ_P P	υJ_2	Pyroxenite gabbro and pyroxenite

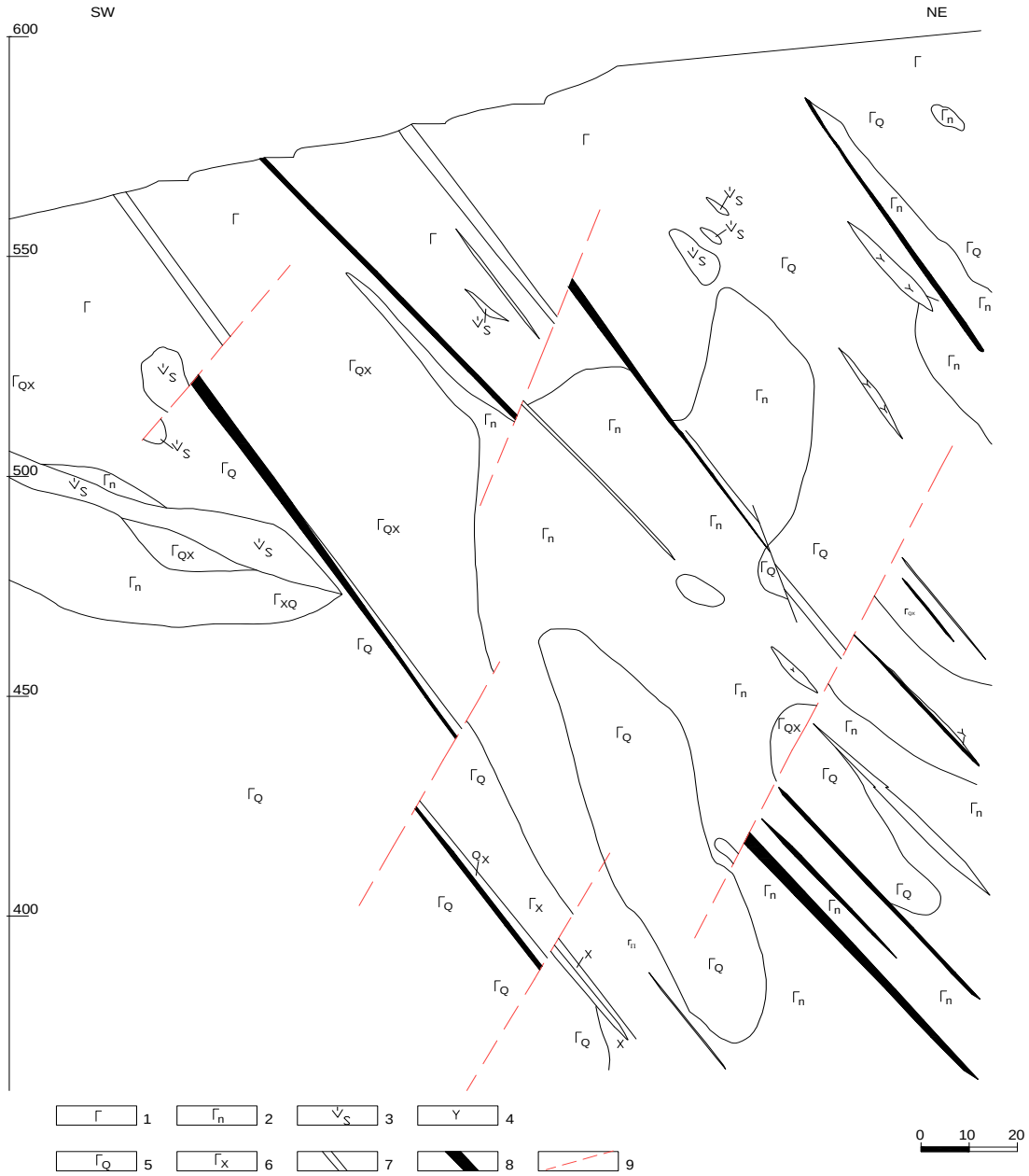
Figure 6. Gdheshta ore deposit



1. Gabbro-norite, 2. Gabbro, 3. Chloritized gabbro, 4. Chlorite, 5. Ore zone, 6. Ore body
Figure 7. Profili 0 – 0, Gdheshta – Pista ore deposit

VI. KRUMA – GOLAJ – NIKOLIQ ORE DEPOSIT

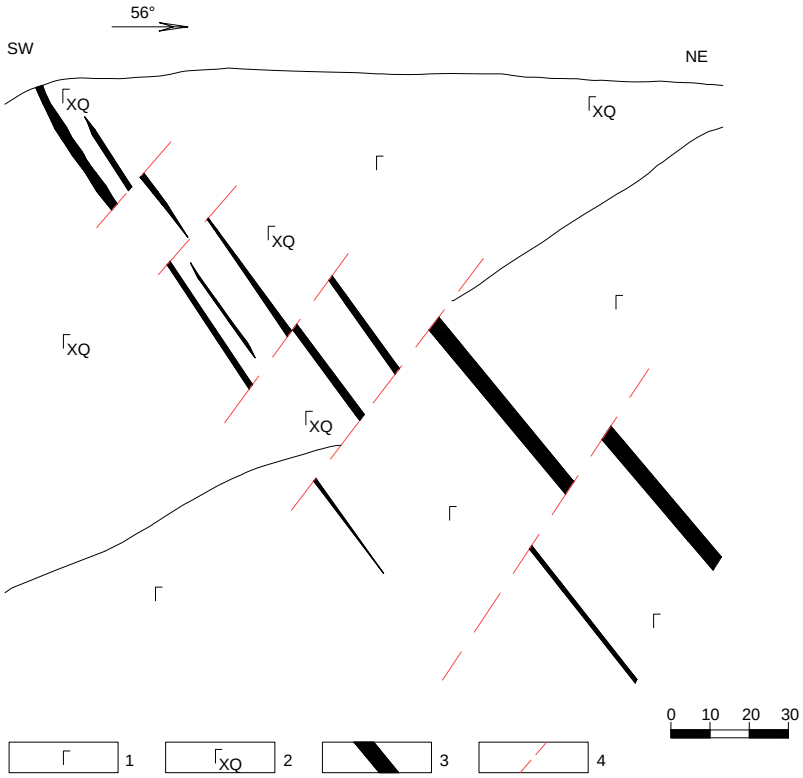
Bodies 1, 1a, 1^b, 2, 3, 4, 6 in Golaj and bodies 1, 2 in Zahrisht, bodies 1, 2 in Mirun, etc. and bodies 1, 2 in Nikoliq and Kruma, and generally mineralization of this type have different dimensions from a few meters to 600-700 meters. Overall, the strike of the bodies is equal to 2/3 of extension. Position of bodies in space is of the most different, however, two main directions are: - meridional or meridional direction with eastern strike, - latitudinal direction with northern striking. The prevalent structure of ore is granular allotriomorph, meet also cases of ksenomorfe structure, the dominant texture is with blotchy stipple and deism. Age of rocks and mineralization objects considered the same as all the Albanian ophiolites one, thus Jurassic. These deposits are veiny quartz-sulphide type, of filling of fissures by hydrotherms, mineralization is localized into tectonic fissures created as a result of action of a couple of normal and tangential forces after consolidating of basic and ultrabasic rocks. On the basis of the data and the conclusions that have been taken earlier, in the deposit of Golaj, we can say that we are dealing with these mineral accompaniment: quartz - chlorine, chalcopyrite, pyrotine, pyrite, serpentine, quartz, chalcopyrite, magnetite, pyrite, quartz-tiff, chalcopyrite, pyrotine, magnetite.



1. Gabbro 2. Gabbro-norite 3. Serpentinized dunite 4. Pyroxenite 5. Quartz gabbro 6. Chloritized gabbro 7. Ore zone 8. Ore body 9. Tectonic fault

Figure 8. Profile 11, Nikoliq ore deposit

These three mineral accompaniment, representing three mineralization stages from these the first stage is the most principal, the second stage and third stage in particular are auxiliary stages that associated with hidrotherm impulses with weaker mineralization potential. So, for this deposit meet two generations of pyrite, chalcopyrite, pyrotine, magnetite. The first generation represented by the dotted and blotchy texture, while the second generation from their veiny textures. The major measure of chalcopyrite is formed at the first stage and partly at the second stage [8], [11]. As a conclusion from the made analysis results that Kruma deposit is located on the upper levels of the gabbro cutting to isotropic gabbro, Nikoliq deposit is located on the middle and lower levels, in the foliated gabbro and layered gabbro, while Golaj deposit placed in the lower levels of gabbro cutting to the layered gabbro and piroxenite gabbro until piroxenite (fig. 8, 9, 10, 11, 12), [11].



1. Gabbro, 2. Quartz and chloritized gabbro, 3.Ore body, 4. Tectonic fault

Figure 9. Profile of Kruma ore deposit

Age	Lithology	Index	Description of formations
J U R A S S I C	+ + + + + +	γJ_2	Quartz diorite, plagiogranite
	Γ_a Γ_Q	υJ_2	Isotropic gabbro (Tr 1)
	Γ Γ	υJ_2	Foliated gabbro (Tr. 1)
	Γ_n n	υJ_2	Layered gabbro
	Γ_P P	υJ_2	Pyroxenite gabbro and pyroxenite

Figure 10. Kruma ore deposit

Age	Lithology	Index	Description of formations
J U R A S S I C	+ + + + + +	γJ_2	Quartz diorite, plagiogranite
	Γ_a Γ_Q	υJ_2	Isotropic gabbro
	Γ Γ_n	υJ_2	Foliated gabbro (Tr. 11, 12, 12^a)
	Γ_n n	υJ_2	Layered gabbro (Tr. 11, 12, 12^a)
	Γ_P P	υJ_2	Pyroxenite gabbro and pyroxenite

Figure 11. Nikoliq 2 ore deposit

Age	Litology	Index	Description of formations
J U R A S S I C	+ + + + + +	γJ_2	Quartz diorite, plagiogranite
	Γ_a Γ_Q	υJ_2	Isotropic gabbro
	Γ Γ	υJ_2	Foliated gabbro
	Γ_n n	υJ_2	Layered gabbro (Tr. 1, 1^a)
	Γ_P P	υJ_2	Pyroxenite gabbro and pyroxenite (Tr. 1, 1^a)

Figure 12. Golaj ore deposit

VII. CONCLUSIONS AND RECOMMENDATIONS

1. Kaptina gabbro massif in which is localized Thirra deposit at SW direction and other deposits to Nikoliq at NE direction characterized by the presence of three gabbro components: the stratified gabbro that constitute the deepest parts of gabbro profile, the foliated gabbro that comprise middle part of the profile and isotropic gabbro that constitute the upper parts of gabbro profile.
2. The structure of the massif and the deposits result folded, these structures have the sub-meridional to sub-latitudinal orientation. Folded structure of massif is complicated by a regional disjunctive fault that was attributed to two main systems, sub-meridional relatively more early one and the sub-latitudinal relatively more new one.
3. In the Thirra region and in all ores areas of said are exhibited a considerable number of quartz - sulphide weins with sulphide mineralizitain belonging three gabbro ingredients, and quartz - sulphide weins without mineralization. These mineralized quartz - sulphide stay into the middle and upper gabbro profile.
4. Quartz-sulphide mineralization is mainly characterized by para-genetic quartz-pyrite-chalcopyrite accompaniment more principal, which is the genetic hydrothermal type formed in replacement metasomatic way of gabbro rocks or in the way of filling the gaps in the weakened areas conciliatory with the massif structure.

We recommend: - Based on all the information we have available from the exploration surveys and based on very large spreading of gabbro to the lower,

middle and upper parts, linked with these mineralizations, think that Kaptina gabbro massif represents a very important formation for research - discovery of copper sulphide deposits without output or with output in the surface that at first glance seem unimpressive.

We believe that a detailed airborne geophysical surveys will highlight the important data that would lead to the discovery of other important deposits in this massif.

REFERENCES

[1] Aleks V., 1972. *Report on geological construction and calculation of reserves to Thirra deposit*, state 1.01.1972.

[2] Aleksi V., Konomi N., Cina A. 1969. *Morphological and mineralogical characteristics of the ore bodies in a copper deposit of Fan area*. Summary of studies, No 12.1969.

[3] Bajo L., Konomi N., 1967. *Report on the results of geological of exploration works to Thirra deposit* (calculations of reserves up to 1.01.1967).

[4] Bytyçi H., 1983. *Report of reserve calculations to Leproi deposit*, the state 01/01/1983.

[5] Çaushi R., 1976. *Report of reserve calculations to Pista - Gdheshta deposit*, the state 1976.

[6] Çina A., 1977. *Mineral paragenetic accompaniment of hydrothermal ore vein (Mirdita Zone).* The publication of Tirana University, Mineralogy-Petrography Department, 1977.

[7] Çina A., 1979. *Communities of hydrothermal veiny mineralizations of Mirdita structural-facial area*. Summary of studies No 1, 1979.

[8] Hysenaj R., 2008. *Quartz - sulphide mineralization in the Has region, the genetic and spatial relation with ultramafic and diorite - plagiogranite intrusions*. Bulletin of Geological Sciences No.2/2008.

[9] Imami S., Pjetri F., 1979. *Geological report on the geological setting and calculation of reserves of Thirra deposit*, state 1.01.1979.

[10] Kaza Gj. etc., 1992. *Report on the results of expoloration surveys and calculation of geological reserves of Thirra deposit*, state 1.09.1992. Archive of Rubik regional geological branch.

[11] Kaza Gj. (2012) *The structure of quartz sulphide mineralization located within the massif rocks gabror chapter and the prospect of further exploration (Dissertation).*

[12] Milushi I., Meshi A., Neziraj A., Deda T., 2003. *Sheeted dyke complex of Mirdita, an excellent Geological site. 4th European Geoparks Meeting, Anogia - Crete, Greece*, 2-5 October 2003.

[13] Milushi I., Meshi A., Hoxha I., Deda T., Marto A., Gurabardhi L., 2004. *Sheeted dyke complex of Mirdita ophiolite (Albania): structural evidence*, 5th International Symposium on Eastern Mediterranean Geology, Thessaloniki, Greece, 14-20 April 2004. Proceedings, Volume 1, pp. 267-270.

[14] Milushi I., Imami S., Meshi A., Hoxha I. (2002). *Structural study of the complex of parallel dikes*.

[15] Nicolas A., 1989. *Structures of ophiolites and oceanic lithosphere of Dynamics*. Kluwer Academic Publishers, pp. 367.

[16] Nicolas A., Boudier F., Meshi A., 1999. *Slow Spreading accreation and Mantle denudation in the Mirdita ophiolites (Albania)*. Journal of Geophysical Research.

[17] Shallo M. and Dilek Y., 2003. *Development of the ideas on the Origin of Albanian ophiolites*. In Dilek Y., and Newcomb S., eds., Ophiolite concept and the evolution of Geological thought. Bouldes' Colorado, Geological Society of America Special Paper 373, pp. 351-363.

[18] Shallo M., Spiro (Qirinxhi) A., Çina A., Kote Dh., Konomi N., Çaushi R., 1970. *Assessing of the prospects for quartz-sulphide ores in Kaptina gabbro massif*. Results of research-thematic works conducted during 1968-1970 in Kaptina gabbro massif.