METALLOGENIC ZONES IN THE EASTERN BLACK SEA - MINOR CAUCASUS REGIONS AND DISTINGUISHING FEATURES OF THEIR METALLOGENY

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INTRODUCTION

Recognition of spatial zoning in the distribution of endogenic deposits, that originated during the Kimmerian - Alpine period of geosynclinal development within certain metallic belts, and relationships of these belts to tectonic zones in the Minor Caucasus area has been gradually accepted during the last three decades. The first ideas about tectonic and related metallogenic zoning belong to A.N. Pafengol'ts and I.G.Magak'yan, who during 1943-44 established the nucleus of recent metallogenic zoning in this area. The latter is one of the best known explorers of Minor Caucasus metallogeny and his zoning is well accepted (Magak'yan, 1960, 1962, 1963). Some of the most important results, i.e. in the Minor Caucasus metallogeny, may be pointed out as follows: proof of the tectono-magmatic evolution and its identification, in metallogenic sense, namely «B» -type of geosynclinal development and its features (Smirriov, 1962, 1963, 1968), characteristics of metallogeny and its zoning in the entire area (Tvalchrelidze, 1966), metallogeny of the Adjaro-Trialete zone (Nadiradze *et al.,* 1962), and similar.

Metallogenic investigation in the Eastern Black Sea area was developed in a different way compared to those in the adjacent Minor Caucasus. Here, such works were focused mostly on stratigraphy and tectonism on one hand, and various problems of ore deposits on the other. Among the main results in tectonic exploration the following may be pointed out: identification of the North Anatolian deep faults zone, that represents the border at certain places between inner zones or sectors of the Kimmerian - Alpine geosyncline and is the most important tectonic line (Ketin, 1969), the explanation of the so-called vergency of the Alpine orogeny (Klaus, 1958), etc. Notable results of investigation of numerous deposits in the Eastern Black Sea area that have, among others, definite metallogenic importance are: characteristics and genesis of some pyritic deposits (Maucher *et al.,* 1962; Pollak, 1961), classification and regional distribution of endogenic deposits (Ovalıoğlu, 1969), explanation of 1:2,500,000 metallogenic map (Gümüş,, 1970), distribution of trace elements in the Pb+Zn deposits (Bernard, in print).

Although some similarities of metallogeny concerning both the Minor Caucasus and the Eastern Black Sea areas as unique geostructure were periodically treated in some papers, any particular work that regards metallogenic zoning in this geostructure is non-existent at present. Some misunderstanding of adjacent metallogeny and its regional zoning in these metallogenic areas is caused, however, by different interpretation of tectonic zoning: many tectonic zones crossing the Minor Caucasus that produce related metallogenic zoning are distinguished, while the Eastern Black Sea area is still accepted as a single tectonic zone.

Extensive geological exploration that started few years ago in the Eeastern Black Sea area, particularly in its pyritic belt, brought new data on corresponding metallogeny. This exploration will be continued due to encouraging results and metallogenically promising nature of this area.

Thus, it is the purpose of this paper to review some features of metallogeny of the two adjacent units and the extension of metallogenic zoning from the Minor Caucasus through the Eastern Black Sea unit based on literature and personal observations during 1969-70 field seasons in the Eastern Black Sea area. In Figure 1, that illustrates contrasted regional zoning, only principal deposits are given and those from the Minor Caucasus are roughly located because their correct locations are omitted in literature.

THE EASTERN BLACK. SEA - MINOR CAUCASUS GEOSTRUCTURE AS METALLOGENIC UNIT OF FIRST ORDER

Mediterranean polycyclic geosyncline, a geologic and metallogenic unit of planetary scale, has been divided on the latest megacycle of tectono-magmatic evolution in two main parts, namely, the northern and the southern geosynclinal systems. Both of them were, in that megacycle, developed «autonomously» and separated by several median massifs. Through Balkan, Asia Minor and Iranids there are geological and metallogenic evidences of their separation, except in the Central Asia Minor where these systems seemingly joined each other. Henceforth, the Eastern Black Sea - Minor Caucasus geostructure as a folded and metallogenic unit proceeded from tectono-magmatic evolution of corresponding segment of the northern geosynclinal system in the Kimmerian - Alpine megacycle of development.

Distinct metallogenic zones in the Eastern Black Sea - Minor Caucasus region, that include mostly definite magmatic and related ore associations, may be accepted as zones formed by consolidation of parental tectonic zones in both intrageosynclinal and intrageoanticlinal sectors of the above-mentioned system. These metallogenic zones were gradually formed in different ages during large Kimmerian - Alpine orogeny. They passed over the region in a parallel arrangement, somewhere curved, but on the whole have «mediterranean» strikes. Some of the metallogenic zones, if not all, extend through North Iran and the Western Black Sea province and prolong westward as Carpathian-Balkan Arch.

Pre-Kimmerian stage of the Eastern Black Sea - Minor Caucasus region was subplatformic in character. It had been reached after long polycyclic development on Caledonian or perhaps Precambrian megacycle up to the end of Hercynian, when the region was consolidated and converted into subplatformic structure. A.G. Tvalchrelidze (1966) explained that Northern Minor Caucasus was converted at the end of Caledonian orogeny, White the Southern Minor Caucasus joined it at the end of Hercynian orogeny. The areas were parted by Echelon of deep-seated faults that recently traced the Black Sea ophiolitic - Sevano-Kurdistan zone.

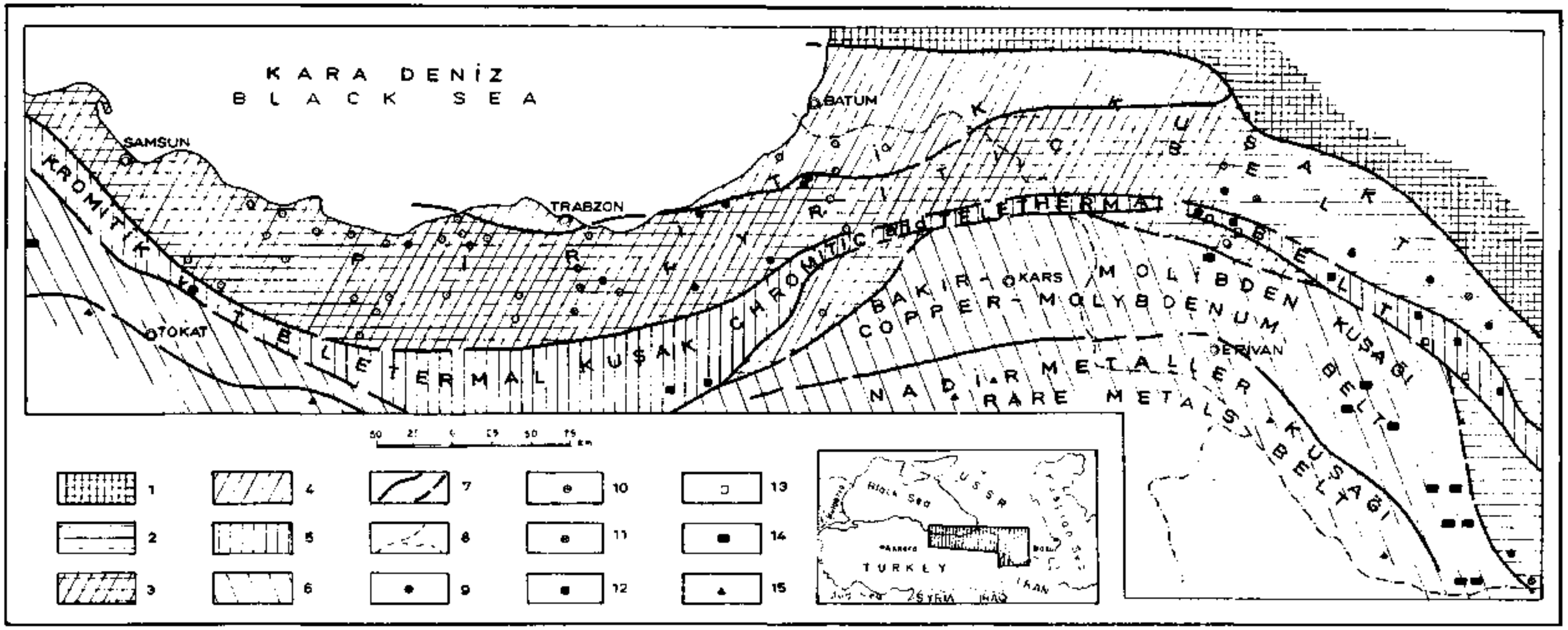

Fig. 1 - Metallogenic zones and related metallic belts in the Eastern Black Sea - Minor Caucasus region.
1 - Zacaucasus zone (median massif); Black Sea coastal Somkhito-Karabakh zone (2 - 3): *2 - Formed during the Kimmerian orogenesis; 3 - Formed during Kimmerian and Alpine orogenesis; 4 - Black Sea - Adjaro-Trialete zone; 5 - Black Sea ophiolitic - Sevano-Kurdistan zone; 6 - Tokat - Kars - Miskhano-Zangezur zone; 7 - Principal, mainly marginal deep faults; 8 - State boundaries;* Principal ore deposits (9 - 15): *9 - Pyritic deposits in the Kimmerian volcanic complexes; 10 - Pyritic deposits in the Alpine volcanic complexes; 11 - Skarn deposits; 12 - Chromitic deposits; 13 - Telethermal (Sb, Hg, As) deposits; 14 - Copper-molybdenum porphyry deposits; 15 - Rare metals (Au, As) deposits and Sb occurrences in the Tokat district.*

Some remains of subplatformic structure of still undetermined age of consolidation are known as relatively small crystalline massifs in the Eastern Black Sea area (SW of Gümüşhane, SE of Trabzon, SE of Artvin). Metallogeny of the pre-Kimmerian epochs is, however, various and related either to granitoids or other magmatic rocks. Such mineralizations are infinitesimal in value and therefore will not be further mentioned.

Decisive ore-bearing period within the given region (Fig. 1) started at the Early Alpine or maybe Late Kimmerian epoch (J1?-j2), when existing subplatform was destroyed by subsequent series of diastrophic tectono-magmatic motion. Since then, the region entered in the new geosynclinal environment which lasted up to Quaternary time when it became again a consolidated folded structure.

DEVELOPMENT OF THE EASTERN BLACK SEA - MINOR CAUCASUS REGION ON THE KIMMERIAN-ALPINE MEGACYCLE AND RELATED METALLOGENY

Geological environment during this megacycle was a geosynclinal one, when certain metallogenic zones generated from the corresponding sectors of geosynclinal system, the formation of which coincides with definite stage and/or substages of geosynclinal evolution whose magmatic and ore products largely constitute these metallogenic zones.

The list of metallogenic zones from north to south and their mutual relations as well as connection to certain sectors of geosyncline, in both the Eastern Black Sea and Minor Caucasus areas, are given in Table 1.

Although most investigators of the Minor Caucasus metallogeny agree about existence of the listed zones, their different names still exist; here, the classification adopted by A.G. Tvalchrelidze (1966) has been accepted.

Table - 1

The Eastern Black Sea area	*The Minor Caucasus area*
Outer (peripheric) sector	
1. Black Sea water basin	**1. Zacaucasus zone**
Inner (intrageosynclinal) sector	
2. Black Sea zone	**2. Adjaro-Trialete zone**
3. Black Sea coastal zone	**3. Somkhito-Karabakh zone**
4. Black Sea ophiolitic zone	**4. Sevano-Kurdistan zone**
Inner (intrageoanticlinal) sector	
5. Tokat-Kars zone	**5. Miskhano-Zangezur zone**

THE EARLY STAGE OF GEOSYNCLINAL DEVELOPMENT

The beginning of the Early stage may be dated as Lower Jurassic - Middle Jurassic, but due to the type of the geosyncline described in detail by V.I. Smirnov (1962) this stage can be divided into Early (a) and Early (b) subsequent substages.

The Early (a) **substage**

This substage started by strong tectonic motion when the areas of Black Sea coastal - Somkhito-Karabakh zone were lowered and became a geosynclinal trough. The paroxysm was accompanied by widespread spilite keratophyric magmatism which gradually passed into keratophyre porphyritic products and ended locally as andesite dacitic. In the Somkhito-Karabakh zone the initial basic magmatism evolved, principally, as follows: Spilite with pyroclasts-augite porphyrite-complex of extrusive and effusive mainly sodium quartz plagioporphyrite and albitophyre (Smirnov, 1962; Azizbekov, 1965). In the west, in the Black Sea coastal zone, the magmatic complexes of the Early (a) substage are mostly covered by magmatic and sedimentary series of the Early (b) substage. For instance, at Murgul district the sequence of the Early (a) substage is: Spilitic pyroclasts with terrigeneous intercalations-complex of extrusive and effusive quartz keratophyres-complex of mainly quartz porphyritic pyroclasts (Buser, 1970).

A great number of pyritic, copper-pyritic, polymetallic, barite-pclymetallic, hematitic and manganese deposits are enclosed into certain complexes of the Early (a) substage. Regarding relation between magmatism and metallization of this period N.A. Azizbekov (1965) concluded that «the commercial mineralization, for the most part, shows in cases when magma is differentiated up to acid and alkaline products». Among all listed types of mineralization of particular importance in the Black Sea coastal zone are the copper-pyritic of stockwork, impregnated and massive shapes (Anayatak, Çakmakkaya, Kilise Tepe) controlled by dome-like volcanogenous structure.

The Early (a) substage ended in the Upper Jurassic or Lower Cretaceous time when some plagiogranites were intruded into the axial part of the Somkhito-Karabakh zone. Some skarnic, not so important, mineralizations are related genetically to these intrusives. It is not certain whether some plagiogranites in the Black Sea coastal zone belong to this period or not.

The Early (b) **substage**

The beginning of the Early (b) substage is synchronous with the earliest phases of the Alpine orogeny and may be dated as Upper Cretaceous. It started just after partial inversion of the Black Sea coastal - Somkhito-Karabakh zone into a partly uplifted anticline-like structure. Tectonic and magmatic processes of the Early (b) substage involved all three zones of the intrageosynclinal sector, giving more or less proper magmatic and related metallogenic features in each.

Magmatism and metallization in the Early (b) substage played an exclusive role in the entire Black Sea - Adjaro-Trialete zone, which was, from the beginning up to the end of the substage, formed as an individual and definite metallogenic area.

The space of this zone, that is situated between the Zacaucasus median massif in the north and the partly inverted Black Sea coastal - Somkhito-Karabakh zone in the south, had been lowered as an oval geosynclinal trough. In this trough a strong basic and locally ultrabasic magmatism took place synchronously with lowering of this zone. Widespread diabase basalt andesitic formation was controlled in spatial distribution by marginal deep faults and intrazonal eugeosynclinal trenches. This volcanic formation, in general, was spilitized in a great degree due to the submarine media and nature of magmatic melt. Toward the end of the volcanic phase this association, as a whole, changed gradually, composition becoming more and more acidic and alkaline, and evolving finally into the andesite dacite albitophyric subformation. These two affiliations have, usually, normal superposition. Underlaying are spilitized diabase basalt andesitic rocks somewhere intercalated in the upper sequence by carbonate layers, and overlaying are andesite dacite albitophyric rocks in both lavic and pyroclastic forms. Meanwhile, such superposition can be locally repeated, but in general upper horizons are composed of rather acidic and alkaline rocks. An independent hornblende andesite volcanic phase took place, likely after a short interruption, containing in its upper sequence sedimentary flysch-like strata. It ended in the Upper Eocene, sporadically, as subintrusives.

All the above-listed volcanic activities were accompanied by various pyritic-type mineralizations (proper pyritic, zinc-copper-pyritic, copper-pyritic and manganese) similar to those as noticed in the Early (a) substage, except for barite-polymetallic representatives that are not typical here.

Quartz dioritic, gabbro dioritic, gabbro syenitic and similar usually minor intrusives took part in the zone subsequently after the hornblende andesites. It has been proved that some vein-shaped metallic occurrences are related in origin to these intrusives, as well as some less important pyritic and low-grade copper-pyritic mineralizations.

In the Black Sea coastal - Somkhito-Karabakh zone the equivalents of the initial basic magmatism of the Early (b) substage have, as a whole, rather different features compared to the previous zone. First, the eastern flank of the Somkhito-Karabakh zone stayed practically passive in that time and, second, the western flank of the zone and the whole Black Sea coastal zone were, in principle, contaminated by two varieties of contemporary volcanism: (1) in places of renewed and imposed eugeosyclinal trenches, both of which were seemingly of limited dimensions, volcanism similar to the one in the Black Sea - Adjaro-Trialete zone was basic in character and evolved similarly and, (2) in places being up to this time semi-uplifted, i.e. in predominant part of the zone the volcanism was from the beginning andesite dacitic in composition. Locally, in the uplifted parts of the Black Sea coastal zone, from the very moment of the substage sedimentary tuffogenous strata were deposited, often discordantly over previous stage's associations.

Andesite dacite rhyodacitic formation was introduced in the active part of the Somkhito-Karabakh zone and the Whole Black Sea coastal zone during the following volcanic phase. Lavic and pyroclastic products of this formation show from place to place variable participation in the principal rocks.

All volcanic rock associations in the Black Sea coastal - Somkhito-Karabakh zone are more or less contaminated by Various kinds of contemporary pyritic mineralization, but except the andesite dacitic subformation, where the most important mineralizations are concentrated, other associations contain mineralization of less importance. The andesite dacitic subformation contains numerous pyritic-type, discovered in this zone, including several commercial deposits as well. In prevailing cases such deposits are in pyroclastic horizons, being overlain by barren tuffitic strata.

There are two periods of intrusive magmatism in the Black Sea coastal - Somkhito-Karabakh zone: older plagiogranite, intruded probably in the end of Upper Cretaceous, and the relatively younger granite granodiorite intruded in Eocene age. Plagiogranites are, however, more characteristic in the bordering part of this zone close to the Black Sea ophiolitic - Sevano-Kurdistan zone in which these rocks are more typical. Here, such intrusives are not so large in size, having often an intrastratal position and elongated shape. Skarnic mineralization, mostly Fe-oxides (magnetite, specularite, hematite), sometimes with insufficient sulphides, relate in origin to the plagiogranites as contact and autoreactional mode.

Granite granodiorites occupy the axial part of the Black Sea coastal zone forming a row of intrusive bodies. Most of these intrusives are small in size and simple in composition. The largest İspir batholith in the row is an exception, according to its size and composition ranging from basic to ultraacidic varieties. The batholith was likely formed as a multi-stage intrusion during the Early (b) substage and the following Middle stage. Near the batholith some granite porphyritic rocks, whose dykes largely took place in the end of the Middle stage and are responsible for copper-molybdenum porphyry mineralization are found.

Great number of both pyritic and skarn mineralizations spatially and, probably genetically are related to the granite granodiorite. Former mineralization is pyritic or rarely copper-pyritic in composition and appears in the intersected volcanites around the intrusives in the form of low-grade diffused and disseminated but irregular-shaped bodies. As far as it is known, similar occurrences are of no value and should be separated from those related in origin to the above volcanites. Skarn occurrences are, however, more abundant than the pyritic ones. They appear, seemingly, around every intrusive as contact, autoreactional and distant also irregularly shaped bodies, showing often to be multiphase in formation. Multiphase in origin skarn mineralization, the greatest number of skarnic occurrences include pre-ore skarnoid mineral assemblage: garnets, various carbonaceous and magnesian contact minerals. Valuable part of ore association in these occurrences (pyrite; Gu, Zn, Pb sulphides with or without Fe-oxides) originated, however, from the hydrothermal, mainly sulphidic solutions. Meanwhile, it is not always clear whether this hydrothermal mineralization, that often has distinguishable telescoped or imposed position over the pre-ore skarnic assemblage, generated from the final skarnic (naturally hydrothermal) solution or was imposed during some later hydrothermal action in the Middle or the Late stages. Anyhow, some of multiphase occurrences may be of economic interest despite their usually small size, due to locally high Cu content ranging from few up to 10 %.

The narrow Black Sea ophiolitic - Sevano-Kurdistan zone of deep faults was also an active area during the Early (b) substage. In that time or even in the

Early (a) substage its deep faults were reactivated and followed by introduction of numerous lenticular ultrabasic, mainly peridotitic, intrusives. They were emplaced along the marginal deep faults and their second-order branches. Ultrabasites were obviously controlled in distribution by the above-mentioned deep faults, but are disputable in regard to the age of origin. The authors gave them different ages, from Paleozoic till Tertiary, but it is more logical to ascribe their origin to the Early stage, preferably to the Early (b) rather than to the Early (a) substage. Ultrabasites were, most probably, intruded by the end of the main phase of the Early (b) substage's basic formation.

Chromitic, principally, small-sized deposits are connected to the ultrabasites and they are more abundant in the Sevano-Kurdistan zone than in the Black Sea ophiolitic zone.

Ultrabasites were succeeded by the gabbroids, mainly minor intrusions, that are emplaced not only along the marginal ruptures but inside the entire zone. Copper-pyritic and copper mineralizations often attributed to the Black Sea ophiolitic zone can be, most probably, related in origin to the gabbroids.

At the end of the Early (b) substage the Black Sea ophiolitic - Sevano-Kurdistan zone was invaded by plagiogranitic plutonism. Some skarnic mineralizations similar to those at bordering lineament of the Black Sea coastal zone may occur in relation to the plagiogranites, but such manifestation is not personally known.

THE MIDDLE STAGE OF GEOSYNCLINAL DEVELOPMENT

The beginning of this stage coincides with main orogenic phase in the Upper Oligocene - Lower Miocene, when entire geosynclinal system was inverted into a stable folded structure. This inversion was accompanied by kinematic granite granodioritic intrusives emplaced in the intrageoanticlinal sector that inherited partially the anticlinal character from the previous megacycle.

This sector, including both Miskhano-Zangezur and Tokat-Kars areas, consists of laterally undulated anticlinoria; among them the Tokat-Ilgaz anticlinorium in the Eastern Black Sea area and the Pambak-Zangezur anticlinorium in the Minor Caucasus are of special importance. West of the Pambak-Zangezur anticlinorium toward the Erivan-Kars district and further to the west the intrageoanticlinal sector is represented by a downward median massif covered subsequently by thick basaltic flows.

The above-mentioned anticlinoria were saturated by kinematic granite granodioritic intrusives of the Middle stage, that may be expected in the buried part of the sector as, most probably, a continual plutonic row.

Kinematic plutonism was accompanied by a great number of various mineralizations (Cu, Mo, Zn, Pb, etc.) forming a distinct metallic belt in which copper-molybdenum porphyry mineralization plays a leading role; afterward the belt was named by I.G. Magak'yan as copper-molybdenum belt. According to him, copper-molybdenum mineralization is of first-class importance not only in the Miskhano-Zangezur zone but in the entire Minor Caucasus area.

Although the chance of discovering commercial porphyry ores inside this belt in Turkey is increasing due to resembling, geologic conditions and the discovery of similar mineralizations near Merzifon[1] in the Tokat-Ilgaz anticlinorium, this view cannot yet be accepted because the area of the copper-molybdenum belt in Turkey is the least geologically studied area and the behaviour of the commercial porphyry ores which are usually located in a selected part of anticlinoria. However, there is hope that systematic research in the metallogenically favorable anticlinoria may lead to the Magak'yan's view.

In the Miskhano-Zangezur zone copper-molybdenum porphyry ores are genetically related to the granodioritic porphyrytic dykes, small stock-shaped intrusions that were intruded subsequently to the kinematic granite granodiorites. The mineralization was deposited as veinlets in the shear zones, stockworks and disseminations mainly within granite granodiorites or subordinately within surrounding crystalline complexes. The ores usually show both vertical and horizontal zoning in the distribution of metals. Towards the periphery of main ore-bodies the content of Cu and Mo decreases, but the content of Zn and Pb increases; from top to bottom the content of Cu and Mo increases while the content of Zn and Pb decreases. In some deposits porphyry ore continued up to 700 meters in depth.

According to Ş. Taliç (oral communication), the copper-molybdenum mineralization near Merzifon appears in the granodioritic (monzonitic) intrusives as several outcrops that are in the form of quartz metallic veinlets and low-grade impregnation along the fractures in slightly altered host rocks. Metallogenically, this occurrence shows features resembling to those in the Minor Caucasus, except the low alteration of host rocks.

Other polymetallic mineralizations occur in the entire Tokat-Kars - Miskhano - Zangezur zone, in which Pb and Zn are predominant, but despite their frequency are not valuable as porphyry ores. Part of Zn and Pb occurrences can be useful for prospecting of the porphyry mineralization due to checked zoning in the copper - molybdenum ore-bodies.

THE LATE STAGE OF GEOSYNCLINAL DEVELOPMENT

This post-orogenic or final stage can be dated as Upper Miocene - Lower Pliocene in age, principally, not so long after the main orogeny and kinematic plutonism ended. Indeed, the Late stage, in a broad sense, is a posthumous tectono-magmatic phase of the main orogeny, inherited some still open tectonic sutures through which magmatic motion took place. Reactivated in that time, deep faults served as channels for penetration and distribution of the dacite andesitic volcanites and various minor intrusions of subvolcanic and plutonic modes. Their role in spatial distribution of all the above-mentioned igneous rocks, is conformable at the border between tectonic zones in the pyritic belt, and it is more clear at the border (suture line) between the Black Sea coastal and Black Sea ophiolitic zones and inside the latter, as well as through those in the Minor Caucasus. Here, volcanic chambers communicated with the surface and produced in many places the chains of elongated volcanogenic domes that dimensionally follow such channels and often overlie them.

In the area of the pyritic belt, subsequent to the main portion of effusives, subvolcanic minor intrusions were dominant and gradually were succeeded by plutonics, both of them in the form of stocks, dykes and intraformational lenticular bodies. Subvolcanic minor intrusions are: dacites, andesites, rhyodacites and their transitions while the plutonics are various granitoids (granites, granodiorites, quartz diorites, gabbro diorites, etc.). Polymetallic type of mineralization, monomineral or complex in composition, that is connected in origin to both volcanites and minor intrusions, are often multiphase in formation, showing locally spatial polyascendent zoning and more often monoascendent zoning in their ore-bodies. Tectonically they are controlled by different fissures (shear, brecciated zones, open fractures) or sometimes by volcanic tubes. Mineralization in the fissures is mostly isometric according to the lateral and vertical extensions—up to few tens of meters with an average thickness up to one meter, rarely larger.

Corresponding polymetallic mineralization that relates in origin to magmatism of the Late stage in the Black Sea ophiolitic zone and its Minor Caucasus counterpart is rather more enriched in Au. Ag, Sb, Hg, As and locally in Be, Te than those in the pyritic belt which also show such enrichment. All these trace elements appear in the polymetallic mineralization as admixtures, or own minerals not only in the low temperature but in the metasomatic bodies of mesothermal stage as well. Particular importance relates to Sb, Hg and As—the telethermal association—that forms own ore occurrences. The formation of telethermal, particularly mercury mineralization could occur not only from magmatic but also from the so-called transmagmatic hydrothermal solutions. This is why the connection between telethermal occurrences and magmatism can be paragenetical. Part of telethermal mineralization may be deposited in the adjacent areas of neighboring tectonic zones due to possible communication of parental solution through the common grid of deep faults.

Although telethermal occurrences are not so frequent, particularly in the Black Sea ophiolitic zone, they form own metallogenic shadow over the entire Black Sea ophiolitic - Sevano-Kurdistan zone, making with older chromitic mineralization common metallic belt.

Inside the intrageoanticlinal sector magmatism and mineralization of the Late stage were placed along intrazonal deep faults of second and third order. These faults of transverse and perpendicular position, particularly in the southern limbs of anticlinoria, are saturated with volcanogenic products and both polymetallic and rare-metals mineralizations. Former mineralization is not frequent as it is in the intrageosynclinal sector but latter, mostly Au-As mineralization, is very characteristic in the southern part of the intrageoanticlinal sector and had been separated by I.G. Magak'yan as the rare-metals belt. Au-As mineralization is already known in the corresponding areas of the Minor Caucasus as well as at the Kars district in the Black Sea province, -while at the Tokat-Ilgaz district instead of Au-As mineralization there is a Sb one.

In the Upper Pliocene-Quaternary period the entire Eastern Black Sea - Minor Caucasus region was attacked by metallogenically barren basaltic magmatism—dolerites, basalts, andesite basalts. In addition to numerous dykes and sills there are basaltic flows that sometimes covered large areas, as it is the case at the boundary between the Eastern Black Sea and Minor Caucasus areas making the impression that tectonic and metallogenic zones do not pass underneath.

COMMENTS ON THE LARGE-SCALE ORE ZONALITY IN THE REGION

The origin and spatial distribution of any discussed endogenic mineralization in the region was a result of interaction of numerous factors, the intensity and size of which change in the development of the entire region and individual tectono-magmatic zones as well. Consequently, all types of ore zonality are already established in the region.

Large-scale ore zonality which is characteristic throughout the whole region due to extention, lateral stability and mutual contrast—according to Smirnov's classification (1963)—belongs *to the regional metallogenic zoning or the zonality of ore belts.*

This type of zoning in the region— a segment of the Northern Mediterranean geosynclinal system—reaches, gradually, in time and space during its transformation into a stable folded structure. It was principally caused by partition of the geosynclinal system, or more correctly, its eugeosynclinal inner zone into the intrageosynclinal and intrageoanticlinal tectonic sectors and the tectonic zones of lesser order in these sectors.

Other two types of ore zonality, namely the polyascendent and monoascendent, or the zonality of ore districts and the zonality of ore-bodies, according to Smirnov's classification, often attributed to the region, were caused, in addition, by many other sometimes exclusively local factors.

Crossing the inner eugeosynclinal zone in the region from north to south, following metallic belts (as older of the regional metallogenic zonality) may be distinguished: *pyritic bell, chromitic ind telethermal belt, copper-molybdenum belt and rare metals belt.*

Pyritic and copper-molybdenum belts connecting the intrageosynclinal and intrageoanticlinal sectors, respectively, are leading belts in the region. Other two subordinate belts connect, however, particular tectonic zones of lesser order in these sectors. The narrow zone of long-lasting deep faults with the chromitic and telethermal belt in it is, actually, a part of the intrageosynclinal sector, while the plunging southern limbs of the anticlinoria with the rare-metals belt is a part of intrageoanticlinal sector.

Regional metallogenic zoning in the region is constant laterally over 1,000 km (Fig. 1). The frequency of characteristic ore associations in each belt changes, actually, up to total interruption. It was caused by some structural and endogenic factors during the main period of metallization. Similarly, if we take all belts as one unique belt we will see the same characteristics in ore frequencies, typical in each individual belt.

First position, for instance, due to frequency of appearrance and value of mineralization in the entire Minor Caucasus, belongs to the copper-molybdenum belts that gives own metallogenic shadow to this area. Meanwhile, toward the Eastern Black Sea area the copper-molybdenum belt loses such position, showing clear tendency of disappearance and henceforth pyritic belt takes the first position through the entire Eastern Black Sea area.

It is, further, characteristic that leading mineralization, particularly commercial deposits in the two main metallic belts occupy not all the space but certain parts only.

Commercial deposits of the Eastern Black Sea pyritic belt are spatially located at the bordering areas of both Black Sea and Black Sea coastal zone, especially in the limits of the latter zone, while skarnic deposits are related to the axial part of this zone following the intrusive row's extension. Spatial distribution of pyritic and skarn occurrences in the Black Sea coastal zone gives a picture of rough intrasectorial metallogenic zoning.

In the Minor Caucasus the main pyritic deposits, however, connect the axial parts of parental zones and show tendency to be outside the areas close to the Zacaucasus median massif.

Futrhermore, copper-molybdenum porphyry mineralization is, most intensively, concentrated at the axial parts of ore-bearing anticlinoria.

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