Geology

Phanerozoic Metallogeny of the Caucasus Region during the Tethys Ocean Subduction and at the Post-Collision Stage

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ABSTRACT. The interrelation of geodynamic development, volcanic activity and metallogeny of the Caucasus region is determined by subduction at the pre-collision stage, as well as by synorogenic magmatic activity at post-collision setting. Pre-collisional development at the normal subduction stage includes island arc setting, calc-alkaline volcanism and gold-copper-base metal mineralization. Transformation of subducting slab (roll back, break off, detachment and delamination) was related to mantle diapir and spreading revealed in back/inter-arc settings. It resulted in tholeiite-alkali olivine basalt and shoshonitic volcanic activity and in copper-zinc-pyrite mineralization as well. In the course of a strengthening the diapir incursion the back-arc transformed into a small ocean basin, where ophiolite volcanism and copper-pyrite mineralization occurred. Transformation of subducting slab (TSS) took place along its dip and laterally as well, which mainly manifested itself in modes of geodynamic development, volcanism and metallogeny. The post-collisional development commenced after the closure of the ocean and is characterized by high grade of gold and low grade of base metals associated of rare metals (Sb, W, Mo and Hg). The high geochemical background of rare metals is a geochemical indicator for post-collision setting, unlike the pre-collision setting. At the same time this association is a prospecting guide to gold mineralization. *© 2016 Bull. Georg. Natl. Acad. Sci.*

Key words: pre-collision setting, island arc, back-arc, inter-arc, gold-copper, base metals

The Caucasus region has been the part of Eurasian active margin. Its geodynamic development was related to subduction, collision and closing of the Tethys Ocean during ongoing convergence of Eurasian and Afro-Arabian continents.

In response to pre/post-collisional events the distinct metallogenic episodes occurred that are examined in detail in V.Gugushvili's monograph [1] as well as in a number of publications [2-10].

It is established that at pre-collisional stage, transformation of subducted slab (TSS) was responsible for specific linkages between geodynamic settings, magmatism, and metallogeny. In the course of normal subduction (without TSS) the island arc setting, calc-

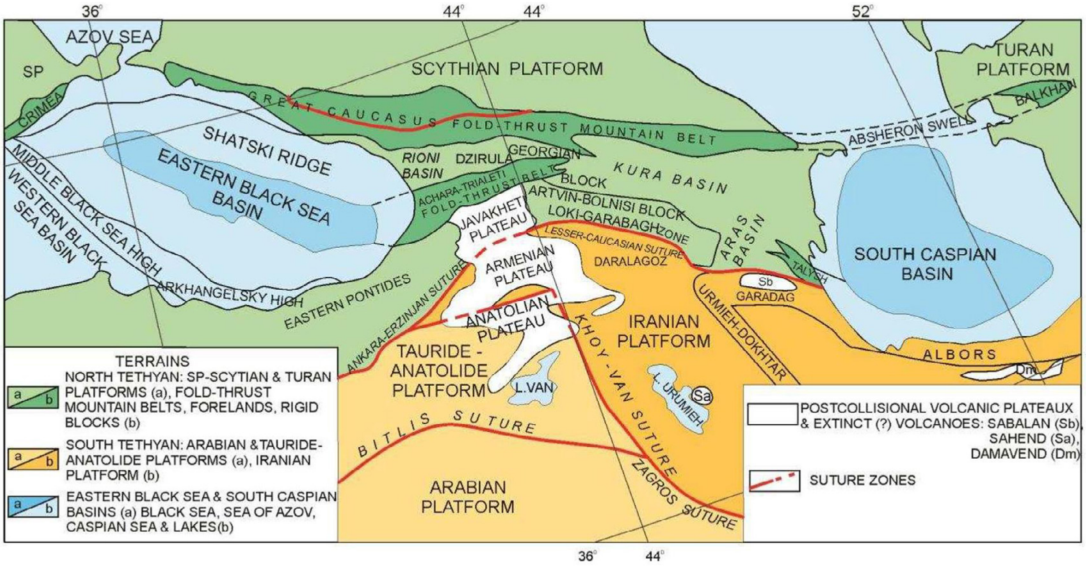

Fig. 1. Schematic map of the main tectonic units of the Caucasus and adjacent areas, after Sh. Adamia

alkaline volcanics and gold-copper base metal mineralization were formed. The TSS resulted in mantle diapir incursion, enrichment of magma with mantle components, spreading, and back/inter-arc rifting. At the first stage of rifting, when diapir incursion and mantle influence were comparatively weak, the volcanism was characterized by shoshonitic-trachyandesitic compositions. Further continuation of these transformations led to the intensification of diapir incursion and spreading, which in turn caused tholeiitic, alkaline olivine basaltic and picrite basaltic volcanism as well as formation of zinc-copper sulfide mineralization. At this stage the mantle influence is more conspicuous by geochemical and petrochemical indicators. The farther intensification of diapir incursion and spreading caused conversion of back-arc in the small ocean setting with ophiolite volcanic activity, ultramafic dunite-peridotite magmatism and Cyprus type copper-pyrite mineralization.

The pre-collisional stage continued until collision and formation of ophiolite sutures. In the central segment of Eurasian active margin, including Iran, Caucasus, Turkey and Balkan–Carpathians, the subduction commenced in the Late Proterozoic and continued up to Late Eocene suturing [1]. The closure of Tethys Ocean in the Oligo-Miocene and stressing African-Arabian continent on the Eurasian initiated the stage of post-collisional development. It resulted in formation of the fold-thrust structures as well as in synorogenic intrusive activity. These events contributed to the specific metallogenous features characterized by high grades of gold and low grades of copper-lead-zinc mineralization in close association of rare metals – Sb, W, Mo, Hg. This association is a geochemical indicator of post-collisional situation, but is unlike to pre-collisional setting [1].

So, the both pre-collisional and post-collisional developments are tightly related to TSS.

The geodynamic development of the Caucasus is the distinct example of interrelationship between pre/post-collisional processes and metallogeny controlled by TSS.

In the Caucasus, the island arc setting related to normal subduction, temporary and spatially alternated with the back/inter-arc settings, which were formed due to TSS and diapir incursion. The TSS took place along its dip from south to north, as well as laterally from west to east. The pre-collisional stage in the Caucasus started in Paleozoic and lasted until Late Eocene, before formation of suture zones.

Normal subduction gave rise to the calc-alkaline andesite-basalt-dacite suite in the Paleozoic Dizi series at the southern slope of the Great Caucasus [2]. To the north, the TSS and incursion of mantle diapir caused formation of inter-arc rift in the Fore Range zone of the Great Caucasus. This event resulted in formation of Paleozoic tholeiitic and rhyolitic volcanism and copper-zinc-sulfide mineralization of the Khudes group of deposits (Khudes, Urup, Daud) (Fig. 2-I). According to iron fractionation the tholeiites belong to abyssal tholeiites, whereas by Ti content and K/Rb ratio they correspond to island arc tholeiites [11]. Such geochemical dualism is typical of basalts of modern inter-arc rifts of New Georgia and Hebrides [11]. The mineralization of Khudes group of deposits does not contain the lead, so sialic crust material did not participate in the mineralization process. The source of zinc here might be the subducted basaltic slab, as well as basaltic crust in the process of spreading, but copper might be derived from the mantle diapir [1].

Fig.2-I presents a relation between volcanism and metallogeny in normal subduction setting and in the regime of TSS. The normal subduction is responsible for calc-alkaline volcanism of andesite-basalt-dacite–rhyolite composition of the Dizi series, but the northvergent transformation of dipping slab is a key for the inter-arc rifting with tholeiite volcanic activity and zinc-copper sulfide VMS type mineralization.

In the Caucasus region the northvergent TSS also occurred during Early Jurassic time (Fig.2-II). The normal-subduction-related calc-alkaline basalt-andesite–dacite volcanics are known in the Loki-Garabakh zone of the Lesser Caucasus [3]. Volcanic activity here started in the Liassic (Hettangian-Sinemurian) and lasted until Neocomian stage. To the north, in the Caucasian intermountain region (the Georgian Block) the normal-subduction-related calc-alkaline volcanic activity is established in the Liassic (Hettangian-Sinemurian) and lasted until Aalenian age. Here the Paleozoic Loki and Dzirula salients are overlain by calc-alkaline rhyodacitic volcanic suites [2]. At the same time, the northward-subducting slab subjected to transformation that manifested itself in incursion of mantle diapir and spreading, as well as in formation of the back-arc basin (marginal sea), where turbidite sedimentation, tholeiite volcanism and related VMS type pyrite-chalcopyrite-sphalerite-pyrhotite mineralization (with minor lead and gold) occurred (at the southern slope of the Great Caucasus). This mineralization is represented by Filizchai group of deposits (Filizchai, Katsdag, Kizildere, Adange). The bottom of Lower Jurassic marginal sea at the stage of spreading was partly underlain by sialic crust. Its relics on the basaltic crust are fixed up to date [12]. Presumably, this sialic crust was a source for gold and lead of these deposits, whereas copper is probably derived from mantle diapir, and zinc might be sourced from subducting slab and/or basaltic crust in the process of spreading [1]. The tholeiites here are characterized by back-arc geochemical indicators: low REE contents, normal chondrite characteristics of Ni and Ti [10].

The northvergent transformation of normal subduction is fixed as well in the Middle-Upper Jurassic (Fig.2-III). The andesite-basalt-dacite-rhyolite calc-alkaline volcanic series in the Loki-Garabakh zone of the Lesser Caucasus formed due to the normal subduction processes. Significant gold-copper-base metal porphyry, epigenetic, and Kuroko-type VMS deposits (Shamlug, Alaverdi, Gedabek, Karadag, Chovdar etc) are related to these volcanic series. To the north, in the Georgian Block, the subducting slab experienced the transformations to stipulate formation of Upper Jurassic (Kimeridgian, Tithonian) alkaline-olivine basaltic and trachytic suite intersected by monchiquite and camptonite stocks [13]. On the base of drilling materials in the Rioni river depression of the Georgian block, M.Lordkipanidze [14, 15] defined a thick (2200m) volcanic series of tholeiitic, high-Ti olivine basaltic and trachytic compositions and interpreted the series as the products of interplate rifting. We suppose that formation of the back-arc setting in the Georgian Block was related to TSS, incursion of mantle diapir and spreading.

In the Caucasus similar situation also occurred in Cretaceous (Fig. 2, IV). In the Artvin-Bolnisi and

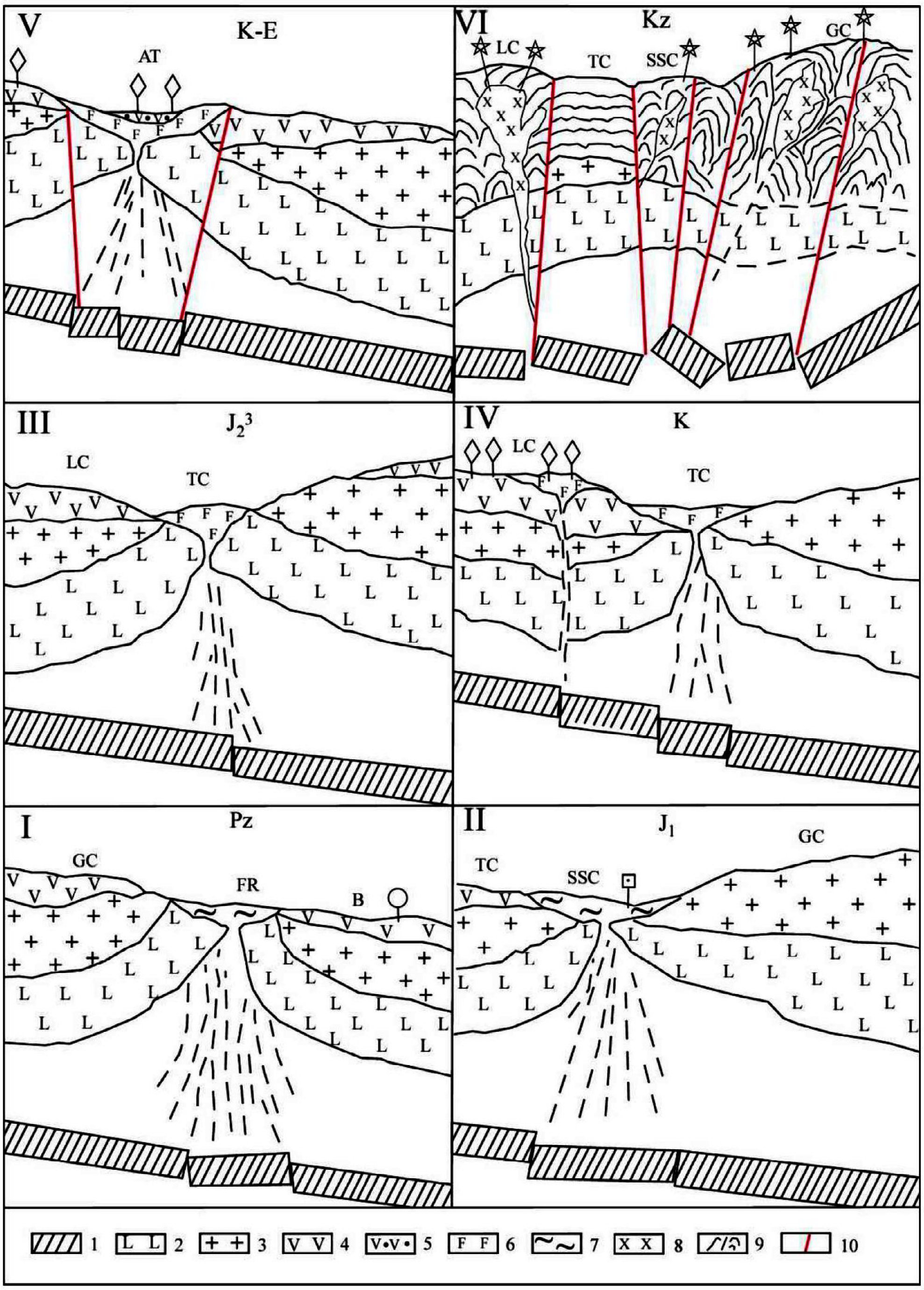

Fig. 2. Precollision and postcollision development and metallogeny excmplified on the Caucasus region. mineralization 1. subducted slab, 2. basaltic crust, 3. sialic crust, 4. calc-alkaline volcanic series, 5. shoshonite series, 6. tholeiite and alkali olivine basalt series, 7. VMS mineralization, 8. granodiorite porphyry, 9. fold-trust zone, 10. faults.
Precollision mineralization: ◇ -Au, Pb, Cu, Zn; ○- Pb, Zn; □ - Zn, Cu; - Zn, Cu, Pb;
Postcollision mineralization: - Au, Cu, Zn, Pb assocated Sb, W, Mo, Hg; Mo, Cu, Au.

Somkhit-Garabakh zones of the Lesser Caucasus the normal subduction-related calc-alkaline island-arc-type volcanic activity occurred. In the Bolnisi ore district (the eastern part of the Artvin-Bolnisi zone) the Senomanian-Santonian andesite-basalt-rhyodacite volcanics host the gold-copper-base metals mineralization that are related to porphyry mineral system [1]. In Campanian, in response to deformation of this subducting slab, the island arc setting transformed in the incipient stage of back-arc structure resulted in mantle diapir incursion, as well as in formation of high-Ti and high-Mg alkali olivine basalts and trachyandesites of the Shorsholety suite (Fig. 2-IV). This suite has geochemical and petrochemical characteristics distinctly diagnostic of back-arc setting [1]. According to TiO_2/P_2O_5 ratios, G. Nadareishvili [16] referred the Shorsholety suite to a volcanic formation of continental rift, which is controlled by deep faults.

$^{87}Sr/^{86}Sr$ ratios of normal-subduction-related Turonian-Santonian volcanic formations of the Bolnisi ore district range from 0.710 to 0.715 and are more consistent with that of island-arc-type volcanics, and $^{208}Pb/^{204}Pb$ ratios are around 38. $^{87}Sr/^{86}Sr$ ratios of the Shorsholety suite that is related to Campanian TSS and mantle diapir incursion do not exceed 0.705.

The similar situation was described in the Panagyurishte ore district (Bulgarian Srednegorie), which is also a part of the same Eurasian metallogenic belt [4]. Here the Upper Cretaceous volcanism and mineralization were also controlled by two stages of subduction: (i) calc-alkaline volcanism was related to normal subduction, whereas (ii) transformations of subducted slab (roll back and detachment) led to incursion of mantle's material and transition of island arc situation to incipient stage of back-arc.

In the Bektakari ore cluster of the Bolnisi ore district the transformation of subducted slab and diapir incursion are manifested in the hydrothermal alteration and metallogeny. At the first stage the alkali-carbonate hydrothermal fluids resulted in the potassium feldspar alteration and silicification, as well as in non-sulfide gold mineralization. The second stage involves the intensification of mantle diapir incursion and high temperature hydrosulfide fluid activity to generate gold-copper-base metal mineralization and ore wall rock high temperature epidote-zoisite propylitization. It is noteworthy, that here sulfide mineralization cemented quartz-K-feldspar breccias, but the epidote-zoisite propylitization is superimposed on the quartz-K-feldspar metacomatites [1].

The more intensive transformation of subducted slab occurred in the Georgian Block area (Fig. 2-IV), where the Turonian–Santonian Mtavari suite is cropped out. This suite consists of picrite-basalts, alkali olivine basalts, trachyandesites and trachytes. They are intersected by numerous phonolite ultra alkaline extrusions [13, 17]. The Mtavari suite shows a back-arc-related signature, based on petrochemical and geochemical data and is characterized by high contents of TiO_2, MgO, P_2O_5, V, Co, Ni and Cr [17]. It should be noticed that in this suite the high temperature epidote-zoisite-actinolite regional-scale propylitization is recognized, presumably associated with mantle diapir incursion.

Transformation of the subducted slab and related mantle diapirism continued in Eocene. It is strongly exemplified in rifting that initiated in Cretaceous in the Achara-Trialeti zone of the Lesser Caucasus (Fig. 2-V). The Cretaceous volcanics are represented here by calc-alkaline andesite-dacite volcanic series including shoshonitic volcanics [15]. In the western part of Achara-Trialeti zone the Eocene volcanic series of tholeiitic and alkaline olivine basaltic compositions are exposed. The series thickness exceeds 5000m. Geochemical and petrochemical peculiarities of these rocks are diagnostic of back-arc magmatism that is governed by slab transformation and mantle diapir incursion [15]. It is known as Chidila suite. Chidila suite is underlain by Nagvarevi suite represented by shoshonites and trachyandesites. By petrochemical characteristics they are comparable to magmatism of the incipient stage of back-arc setting. Chidila suite is overlained by Upper Eocene series

(Adigeni suite) including shoshonites, trachyandesites and dellenites. They differ in some petrochemical and geochemical features from the normal-subduction-related calc-alkaline volcanics [14, 15]. We suggest that formation of this Upper Eocene series occurred in response to a slackening of processes of TSS and diapir incursion at the waning stage of late back-arc system.

In the western part of the Achara-Trialeti zone both Middle Eocene olivine basalts and Upper Eocene shoshonites are intersected by granosyenitic and syenitic-dacitic stocks (Merisi, Namonastrevi and Uchamba intrusives). These stocks were the main fluid flow pathways from deep magmatic chambers and control both porphyry copper-gold and low sulfidation epithermal gold mineralization.

The deformation of subducted slab caused formation of the interarc setting of the Achara-Thrialety. Southern of Achara-Trialety in the Turkish Pontides and Artvin-Bolnisi zone Cretaceous calcalkaline and Eocene shoshonitic volcanic activity occurred. So here, also, normal subduction from south to north alternates with TSS.

Besides that the lateral TSS is established to the north from the Izmir-Ankara-Erzincan-Sevan suture zone, in the limits of Lesser Caucasus, namely in both Eastern Black Sea-Achara-Trialeti and Talish-South Caspian zones (Fig. 1 and 3) [14, 15]. In the biography of both zones there were distinctly readable lateral conversions of back/inter-arc paleorift structure into small ocean basin: (i) Achara-Trialeti paleorift transformed to Black Sea small ocean basin to the west, and (ii) Talish paleorift transformed to Caspian Sea small ocean basin to the east. Presumably in either direction an intensification of the TSS process and diapir incursion took place.

Furthermore, in the western part of the Achara-Trialeti zone (the Achara-Guria region) the Middle Eocene tholeiitic-basaltic volcanic series is laterally changed eastward to shoshonitic-trachyandesitic-dellenitic series (Akhaltsikhe region) further eastward to calc-alkaline andesitic-dacitic series (around the Achara-Imereti and Trialeti mountain ridges) [14, 15, 18]. This picture might be determined by a lateral slackening of the processes of TSS and diapir incursion, as well as by eastward transformation of back/inter-arc rifting to normal subduction. Consequently, mantle's influence is gradually *decreased to the east. In particular,* tholeiitic-basaltic volcanic series is higher in magnesium and titanium than the shoshonitic-trachyandesitic-dellenitic series. MgO concentration in tholeiitic-basaltic volcanic series is in the limits of 7-8%, TiO_2 mainly varies from 0.6 to 0.8% sometimes exceeding 1.5%; SiO_2 ranges from 44 to 48%; whereas in the shoshonitic series SiO_2 is up to 54-70%, MgO is less than 3%, TiO_2 varies from 0.2 to 0.4%. Besides that Shoshonitic-trachyandesitic-dellenitic series is characterized by high contents of alkalies: sum of Na_2O+K_2O is about 10-12%, whereas that in calc-alkaline andesite-dacites is less than 4% [14, 15, 18].

It is noteworthy that ratio of $^{87}Sr/^{86}Sr$ in the rocks of shoshonitic series is 0.7041-0.7045 [19], whereas that in calc-alkaline series is definitely higher - 0.708-0.715.

The interarc tholeiite-basaltic series of the Achara-Thrialety regionally are substituted by high temperature epydote-zoisite-actinolite propylitization [20], whereas the shoshonitic series volcanics are alkali altered and substituted by lower temperature chlorite-albite and zeolite propylitization. Thus, intensity of diapir incursion and mantle influence revealed as on the magmatic trend, so on the character of fluid activity.

Transformation of SN dipping subducted slab resulted in the Tallish backarc formation, which is bordered by Eocene trachyandesite-shoshonite volcanic series southwards (Fig.3). The latter overlies controlled by normal subduction Cretaceous calc-alkaline andesite-dacite volcanic suite. During the Eocene the subducted slab transformation firstly was manifested in the formation of shoshonite volcanic series. Further strengthening of transformation and diapir incursion revealed in the formation of Talish backarc with related alkali olivine basalt-phonolite series. Petrochemical and geochemical background of Talish bacark volcanics is similar to those of the Achara-Thrialeti.

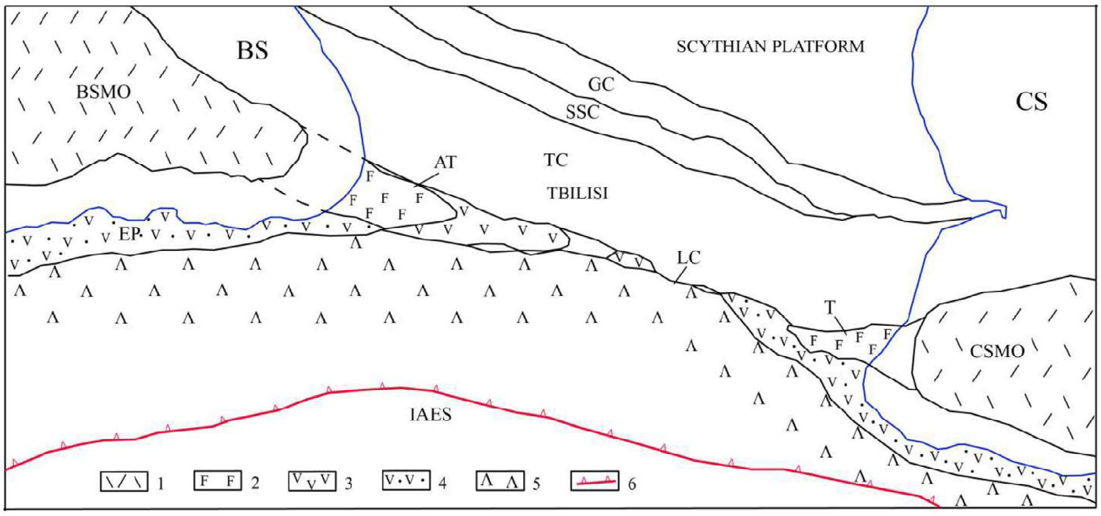

Fig. 3. Schematic map reflects the E-W lateral geodynamic transformation of subducted slab above IAES suture , shown the character of the Eocene volcanic series in the East Pontides and Lesser Cauacasus. BS-Black Sea, CS-Caspean Sea, GC-Great Caucasus, SSC-Southern Slope of Caucasus, TC- Transcaucasus, AT-Achara-TRialety, LS-Lesser Caucasus, EP-East Pontides, BSMO-Black Sea Minor Ocean, T-Talysh 1-ophyolites, 2-alkaline olivine basalts and tholeiites of bakarc settings.3.- Eocene calc- alkaline volcanic series of island arc, 4-Shoshonite series, 5-Cretaceous calc-alkaline series of island arc.

In the Talish backarc setting the Middle Eocene basalts are overlain by Upper Eocene volcanic-sedimentary suite, dissected by peridotites, gabroperidotite and picrite stocks and complex of dikes [21]. It is noteworthy that in the Achara-Thrialeti mantle influence is weakening till Upper Eocene and formation of shoshonite series takes place in Upper Eocene. On the contrary, in the Talish backarc setting the mantle influence strengthening is evidenced by intrusion of ultramafic peridotite stocks.

Thus, in the Caucasus, at precollision stage of geodynamic development, magmatism and metallogeny are controlled by character of subduction and transformation of dipping slab. The normal subduction revealed in calc-alkaline volcanism and gold-copper base metal mineralization, whereas transformation of subducted slab revealed in the formation of backarc-interarc and minor ocean settings. The backarc and inter-arc settings are characterized by tholeiite and alkali olivine basalt volcanism and mainly by zinc-copper sulfide mineralization, where gold and lead are known as a traces. The exclusion is the stage of backarc setting, where sialic crust participates in the mineralization. Here in ores occurs the subordinate amount of gold and lead (Filiz-chai group of deposits). In case of slab transformation and diapir incursion strengthening the backarc setting transforms into the minor ocean stage of the Black and Caspian seas basins, so as in the associated Кьre complex represented by ophiolites ultramafic dunite-peridotite intrusive bodies and Cyprus type copper- pyrite mineralization [1].

The closure of Tethys Ocean and stressing the Afro-Arabian continent on the Eurasian margin led to postcollisional stage of development of the Caucasus region accompanied by the formation of gold-copper base metal and lowsulfidation epigenetic gold mineralization. The postcollisional metallogeny distinctly differs from precollisional one. It is characterized by high grade of background gold and the low trend of base metal mineralization in the proper sulfide ores, whereas low-and nonsulfide gold mineralization is represented mainly by gold-antimony and gold-sheelite quartz veins and stockworks. At the same time postcollision proper sulfide and low sulfidation gold mineralization coincides with rare metals (Sb, W, Mo, Hg) association, which is not characteristic for similar precollision mineralization [1]. Among them the only exclusion is molybdenum, which participates in the precollision island arc ores. The association of rare metals is characterized for postcollision setting as in ores, so in ores wall rock altered zones, so generally in hostrocks.

The investigation of postcollision setting in the Eurasian active margin area along the border of Iran, Caucasus, Turkey and Balkans exhibited, that postcollision setting commenced in the Oligo-Miocene and everywhere is characterized by above mentioned criteria [1]. The similar situation is evidenced in postcollision settings of the various ages worldwide [22-24] and is characterized by mentioned rare metals association which represents the geochemical background of the settings.

It is well known that different settings of the precollision stage of development are characterized by distinct geochemical criteria - $^{87}Sr/^{86}Sr$, $^{208}Pb/^{204}Pb$ ratios, grades of chondrite and REE etc. On the contrary the postcollision setting, which comprises various rocks of the precollision stage, lacks any distinct geochemical criteria. The geochemical indicators of the precollision setting were established in the unaltered magmatic and volcanic rocks, whereas geochemical indicators of postcollision setting is represented by rare metals association (Sb, W, Mo, Hg) formed as a result of hydrothermal alteration of the hostrocks. Accordingly this association is generally regarded as the geochemical indicator for postcollision settings.

The postcollision development of the Caucasus (the Main Range and Southern Slope) and of the Megri-Ordubad zone of the Lesser Caucasus is shown below (Fig. 2, VI).

In the Megri-Ordubad Cenozoic magmatic province, significant gold-molibden mineralization is related to the Oligocene-Miocene granodioritic stocks (Kajaran and Agarak deposits) associated with minor Sb, W and Hg quantity. In the Sevano-Akera suture the dacite porphyry stocks control substantial gold mineralization in quartz-antimony veins and stockworks (Zod and Merhadzor deposits). Ores and orewall rocks are associated with presense of Sb and W [1].

The postcollision gold mineralization coincides with Sb, W, Mo and Hg association widespread in the fold-thrust zone of the Caucasus (Fig.2,VI). Here gold and above mentioned rare metals mineralization is related to the orogenic stage of postcollision setting development. The most significant among them is the Zopkhito deposit, represented by epithermal low sulfidation quartz-antimonite veins and gold-copper base metal mineralization. High gold grade in Zopkhito deposit occured on the low trend of base metals. Synore quartz-sericite zone is goldbearing as well and is characterized by high grade of antimony. The goldbearing veins cross-cut lower Jurassic shales. The gold grade in the veins is 4.35 ppm, silver-4.15 ppm. The gold resource of the deposit is 34.110 t., Sb – 41223 t., silver -39.241 t.

In the fold-thrust belt of the Caucasus are known numerous goldbearing rare metals ore manifestations controlled by Oligo-Miocene dacite extrusive domes and granodiorite stocks (Avadhara, Akhey, Notsarula etc.). Another orogenic vein type deposit is the Lukhumi where gold-antimonite-arsenopyrite mineralization is controlled by faults and shear zones. The deposit is hosted by Upper Leassic shales and limestones and is presented by quartz-antimonite-carbonate-realgar-orpiment veins and quartz-carbonate and quartz-sheelite stockworks. The gold grade in the veins is 5.10 ppm, As-6.7%, Sb-7.37%. The ore reserves 483000 t consist of Au-14.04 t, Sb-2580 t, As -1800 t.

Abundant rare metals occurrences are known in the fold-thrust zone as well: Carobi molybdenum deposit with Mo grade 9.8% (Mo reserves 50 t.), Notsara sheelite mineralization with grade of W-35%, Au-2.3 ppm. Mineralization is controlled by Cenozoic granitoid stocks. Here, also, occur mercury occurrences associated with Sb: Akhey - 0.34% Hg (reserve2564 t.), Avadhara-Hg – 0.29% (1353 t.), Akhahcha Hg- 0.5% (2200 t.). The mineralization is localized in the Lower Jurassic shales and controlled by fault zones.

In the Caucasus to the regional fault is related Hokrila–Achapara ore manifestation. Gold is associated to Sb and W here. The mineralization is hosted by goldbearing quartz- sheelite, quartz-pyrite, quartz-polymetallic and quartz veins. The gold grade in the ores reaches 3-4 ppm [25].

So, postcollision mineralization is characterized by high grade of gold and low trend of base metals. Gold is associated by the rare metals (Sb, W, Mo, Hg) which represent the prospecting criteria for the gold mineralization. At the same time these rare metals participate in antimonite, sheelite, wolframite and mercury deposits.

The genesis of gold and rare metals in postcollision settings is related to transformation of the subducted slab in the depth and incursion of high temperature fluid flows in the lithosphere. The fluids were leaching gold and rare metals from thick sialic crust of the orogene and depositing them as porphyry and epigenetic mineralization with the high grade of gold and rare metals and low trend of base metals.

Postcollision setting is characterized by high geochemical background of indicator rare metals (Sb, W, Mo, Hg). Accordingly this complex of rare metals is the geochemical indicator of the postcollision setting and they are absent in precollision situation.

Thus, investigation in the Caucasus region exposed following tendencies in the interrelation of geodynamic development with magmatism and metallogeny:

– At the precollision stage of development the island arc setting spatially and temporary is controlled by normal subduction, evidenced by interrelation of calc-alkaline volcanism and gold-copper base metal mineralization. Transformation of subducted slab and mantle diapir incursion initiated spreading and therefore backarc-interarc settings revealed in the olivine basalt tholeiitic and shoshonitic volcanic activity followed by zinc-copper-pyrite VMS mineralization. The intensification of slab transformation and diapir incursion caused further transition of the backarc into Minor Ocean setting accompanied by ophiolite volcanism, ultramafic dunite-peridotite magmatic activity and Cyprus type copper-pyrite mineralization.

– The metallogeny of the island arcs with gold-copper base metal mineralization is conditioned by participation of the sialic and basaltic crusts and the mantle material. The metallogeny of backarc-interarc settings (without participation of the sialic crust) revealed in the zinc-copper-pyrite mineralization. The oceanic setting, where neither sialic, nor basaltic crusts take part in the mineralization processes, is characterized by copper-pyrite ores. Thus, the source of gold and lead is the sialic crust, source of zinc - basaltic crust, whereas source of copper is the mantle, which participates in all above mentioned settings.

– On the postcollision stage, during subduction and slab transformation, as along the slab dipping, so laterally, island arc - backarc-interarc transition occurred. Reinforcement of diapir incursion and spreading in Minor Ocean setting revealed in coherent magmatism and metallogeny.

– The postcollision setting distinctly differs from precollision one, as by metallogeny, so by geochemical indicators. It is characterized by high grades of gold at the low trend of copper-base metals, in contrast to precollision settings, here mineralization always coincides with association of rare metals – Sb, W, Mo and Hg spread in the ore wall rocks as well as in the host rocks. Postcollision setting is characterized by high background of these rare metals association which could be regarded as the geochemical indicator of the postcollision setting. The geochemical characteristics of the precollision setting incorporated in the fresh volcanic and magmatic rocks, whereas the postcollision indicators are the products of hydrothermal alteration. They were leached from thick orogenic sialic crust by the protracted high temperature fluids.

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გეოდინამიკის ურთიერთდამოკიდებულება ვულკანიზმთან და მეტალოგენიასთან პრეკოლიზიური განვითარების ეტაპზე განპირობებულია სუბდუქციით, ხოლო პოსტკოლიზიურზე — ოროგენეზისით და სინოროგენული მაგმატიზმით. პრეკოლიზიური განვითარება ნორმული სუბდუქციის ეტაპზე უკავშირდება კუნძულთა რკალურ ვითარებას, კირტუტე ვულკანურ აქტივობას და ოქრო-სპილენძპოლიმეტალურ გამადნებას. სუბდუცირებული ფილის ტრანსფორმაცია მანტიური დიაპირის შემოჭრით სპრედინგს განაპირობებს და ბეკარკ-ინტერარკულ ვითარებაში ვლინდება, ტოლეიტ-ბაზალტური და შოშონიტური ვულკანიზმითა და თუთია-სპილენძის მინერალიზაციით. დიაპირის შემოჭრის გაძლიერების შედეგად ბეკარკი ჩაინაცვლება მცირე ოკეანური ვითარებით ოფიოლიტური ვულკანიზმით და სპილენძ-კოლჩედანური გამადნებით.სუბდუცირებული ფილის ტრანსფორმაცია ხდება როგორც სუბდუცირებული ფილის დაძირვის მიმართულებით, ისე ლატერალურად ფილის დაძირვის მიმართ. იგი ორივე მიმართულებით გეოდინამიკური ვითარების და მაგმატიზმისა და მეტალოგენიის ხასიათის მონაცვლეობაში ვლინდება.

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