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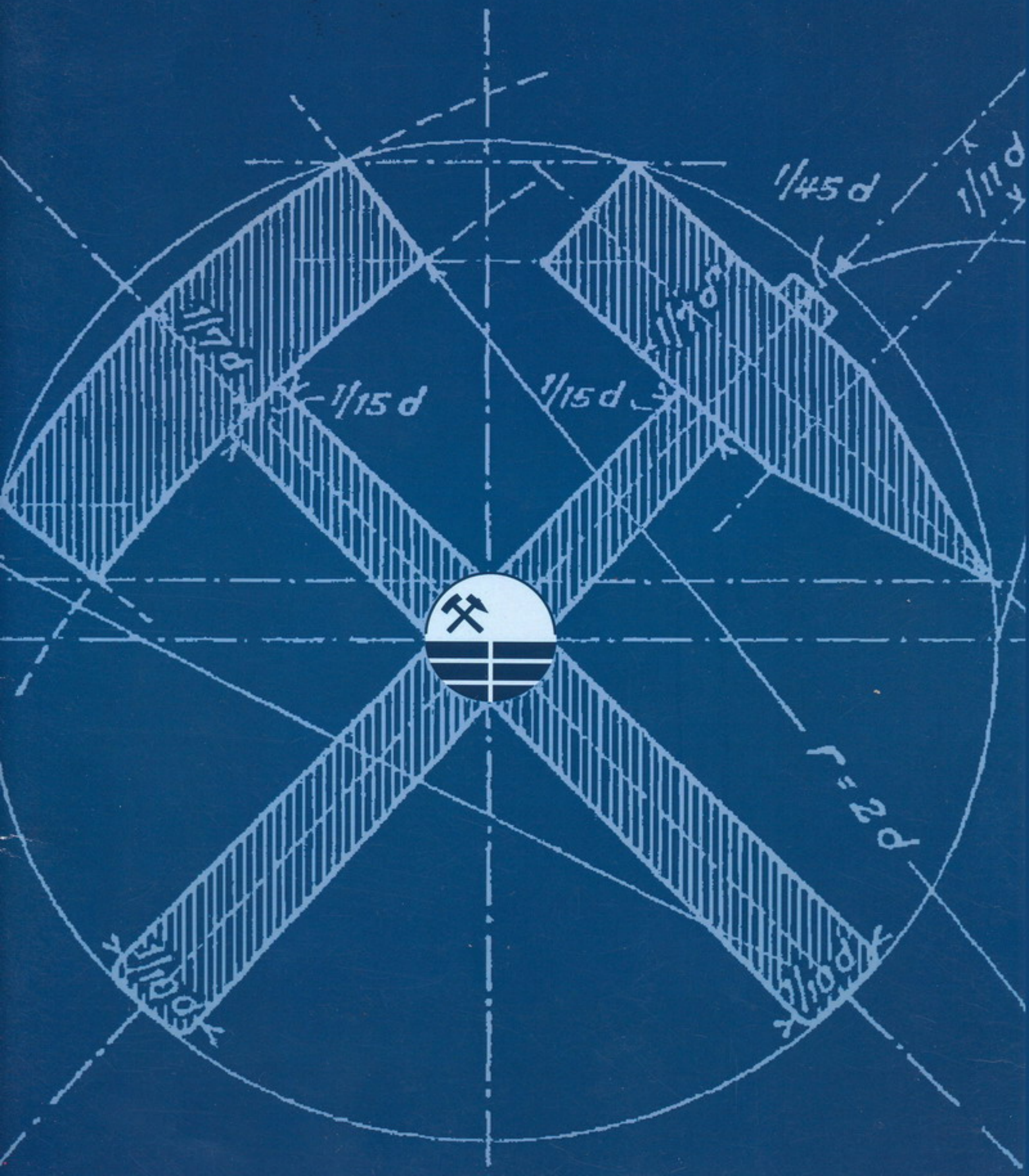

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Archaeometallurgical researches on the early beginnings of metallurgy (VIth-IIIrd millennia BC) in the Caucasus: an example of interdisciplinary studies

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Situated between the Caspian and Black seas, the mountains of the Caucasus are not a barrier but give access to Anatolia and beyond to Mesopotamia through several passes.

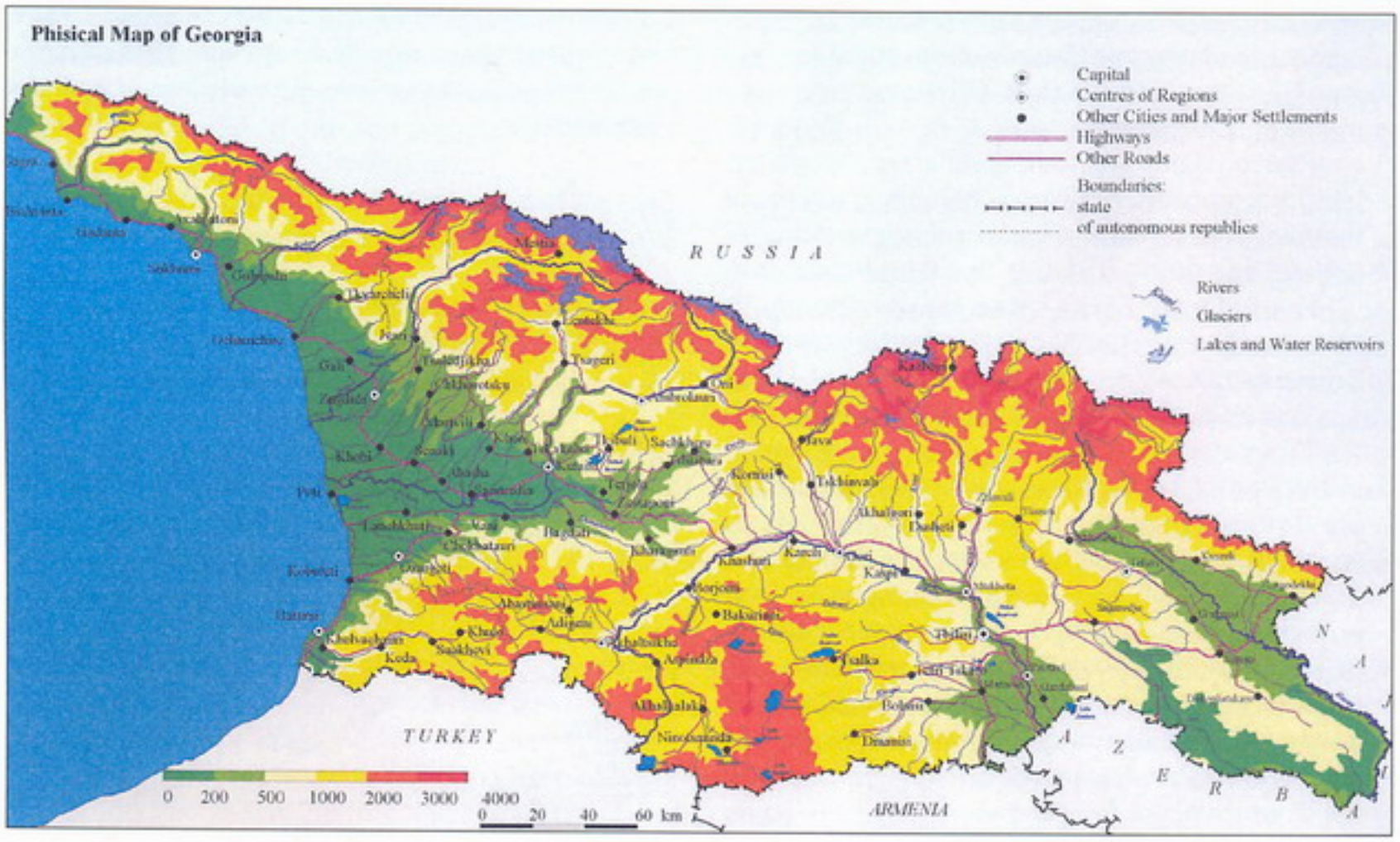
Influences and exchanges have always been a significant feature of the different ancient cultures. Among the various materials that explain these cultural interactions metal played an important role. The beginnings of metallurgy (VIth-IIIrd millennia B.C.) corresponds to a technological and conceptual revolution (radical transformation of the material) which had important cultural implications. In order to understand the importance of metal the definition of metallurgy is taken in its largest meaning: from the ore to the objects including their recycling. The aim is to explain the technical aspects of extractive and manufacturing metallurgies and the cultural consequences of the apparition of a new material – metal – in the cultures of the Caucasus and beyond. This problem is approached by several studies combining archaeology, geology, metallogeny and metallurgy.

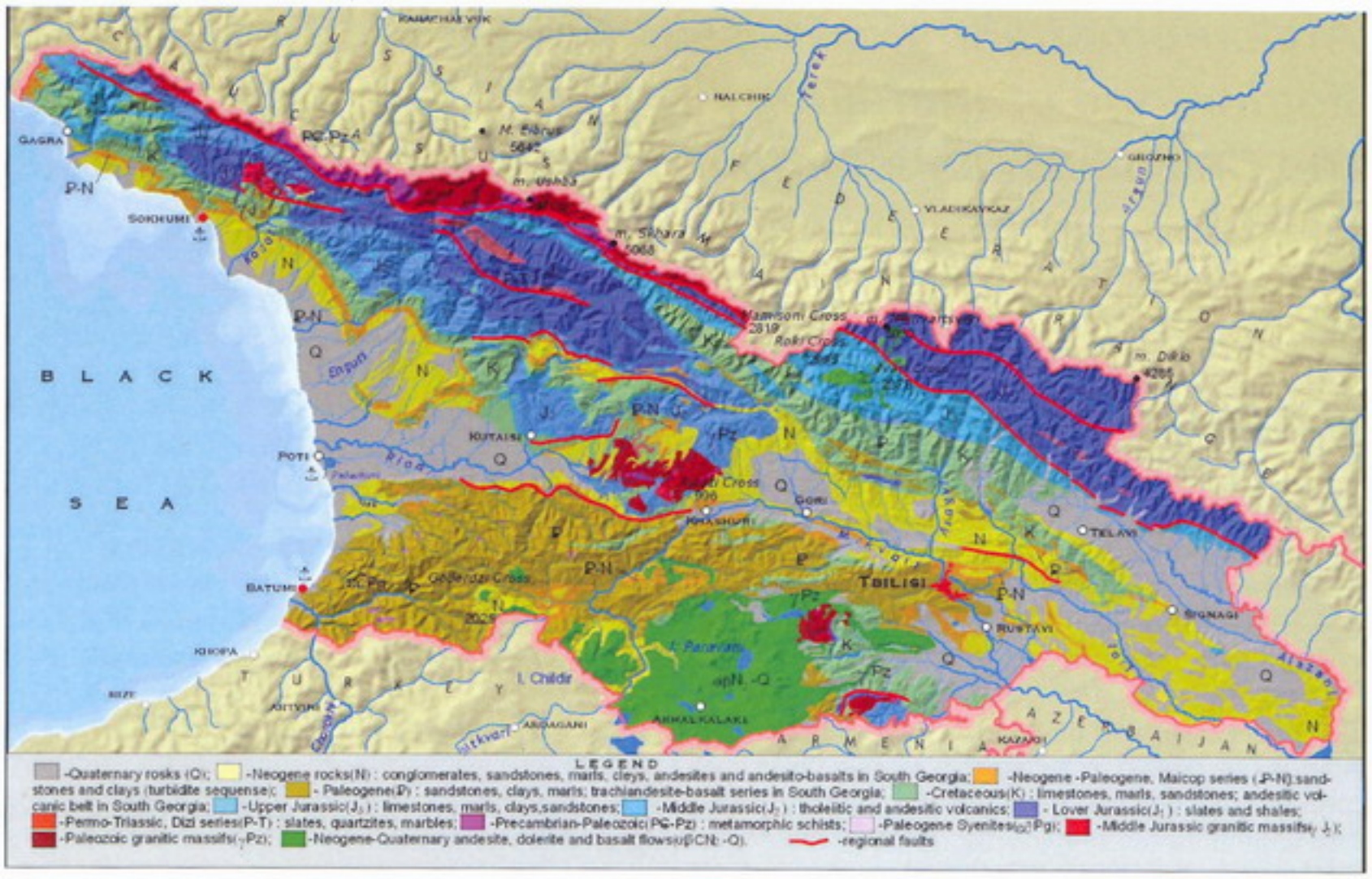
The main geological and metallogenic features in the Caucasus

Geology and metallogeny in Georgia

The relatively small territory of Georgia (Map 1) is rich in a variety of mineral deposits (Map 3). This is primarily due to the complexity of the geological situation - the existence of various geological complexes (Map 2) explainable by the nature of their emergence

Map 1: Physical map of Georgia (Kuparadze 2008).





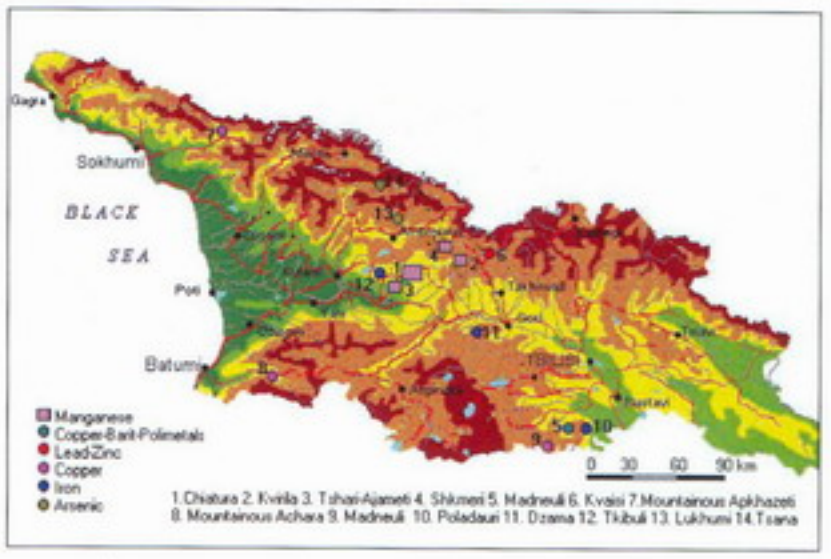
Map 2: Sketch geological map of Georgia (Kuparadze 2008).

and composition of the clusters of rocks, as well as in the variety of tectonic events and mineralization processes that took place on the territory described. Almost all the now known manifestations and deposits of minerals are linked to certain stratigraphic formations, geotectotonic units and cycles of volcanic activity. This huge factual material makes it possible to determine the genesis of most deposits of Georgia with great precision, except for a few cases.

Analysis of the data (Tvalchrelidze 2006) for nonferrous and precious metals allows us to draw a number of conclusions:

1 Non-ferrous and precious metals are clearly isolated in a number of ore areas belonging to various metallogenic zones and various time-periods.
2 On the southern slope of the Great Caucasus (Chkhalta-Laylin zone), three areas - Adangei in Mountainous Abkhazia, Low Svanetia-Racha and Artana in mountainous Kakheti - bear specific polygenic copper-pyrrhotine mineralization formed in the Cimmerian era.
3 In the Somkhito-Karabakhian metallogenic zone, the Bolnisi ore district is clearly singled out. Its specific feature is a set of kuroko-type Early Alpine gold-bearing sulfur-polymetallic deposits. However, it presents a number of characteristic features.
4 In the west of Adjara-Trialetian metallogenic zone, late Alpine copper - porphyry together with a veined gold polymetallic mineralization in the Merisi mining area, is attested, the resource potential of which is not fully known.
5 In Gagra-Djava metallogenic zone, in addition to small deposits, an Early Alpine lead-zinc mineralization, concentrated mainly in two areas - Dzishra-Brdzishkra in Abkhazia and Kvaisa in South Ossetia (Samachablo) is known.
6 Finally, there are also two separate areas of gold concentration the accumulation of which is not connected with nonferrous metals: in the western region, more recent placers along the river Enguri; in the second ore area (Svaneti-Racha) the accumulation of gold is associated with the deposits of rare elements.

Map 3: Sketch metallogenical map of Georgia (Kuparadze 2008).



The major geotectonic units of Georgia are: the bow areas of the Great Caucasus and Adjara-Trialeti, the intermediate zone (Georgian Massif) and Artvin-Bolnisi massif.

Below we will try to describe some areas and deposits in more detail.

The bow area of the Greater Caucasus

The exclusive place with respect to the abundance of mineral deposits in Georgia is the bow area of the Greater Caucasus, which, therefore has attracted researchers' attention.

Almost all the ore deposits located in this area, are the result of hydrothermal processes that had occurred here, and, as a consequence, are linked to geotectonic elements and to cycles of volcanic activity.

Within the metallogenic province of the main ridge we can identify four major ore zones:

- copper-pyrrhotite – from Devdoraki copper deposit (east) to the upper coast of the river Tskhenis-Tskali (west),
- antimony - within the Zopkhito ore field tungsten - including a number of small deposits,
- mercury, involving a number of fields,
- and manifestations of cinnabar, mostly linked to the argillaceous slates of Lias.

The metallogenic province of the flysch zone, located to the south of the first, is less developed in Svaneti and Abkhazia, while it is widely represented in Racha and East Georgia. Within this zone the most relevant ore areas are:

- the copper-pyrrhotine zone of Northern Kakheti related to other metals (cobalt, lead, zinc),
- the Lukhumi ore field of arsenic deposit in Racha,
- and some arsenic-pyrite and complex ore manifestations in Upper and Lower Svaneti,
- as well as the gold-bearing quartz veins of the Lasili river basin in Upper and Lower Svaneti.

The Southern periphery of the bow area is rich in deposits of complex ores and, in particular, barytes. South Osetian (Samachablo) and Abkhazian ore regions deserve attention, especially Kvaisa in the volcanogenic stratum of Bajocian, Amtkheli in granitoids of the Kelassuri massif, Brdzishra in the limestone of upper Jurassic. Barium veins, occurring in eastern Abkhazia, Upper Imereti, Lechkhumi and South Ossetia, are basically linked to the volcanogenic stratum of Bajocian. This sub-area is also known for its manifestations of arsenic-pyrite, molybdenum and tin (?). They are mostly associated with neo-intrusions of Jurassic time.

There seem to be some relations between Jurassic intrusions and manifestations of tin(?) and molybdenum in the Kelassuri district (Central region of Abkhazia) and gold-scheelite mineralization in western Svaneti.

Most of the ore deposits of the Greater Caucasus bow area has a clear genetic link with Cenozoic intrusions: its seems that Cenozoic volcanic activity played a far greater role in the process of ore formations than any other geological cycles.

It should be noted, however, that not all the geologists agree with this point of view. For example, G. Kharashvili considers that copper-pyrrhotite mineralization is genetically associated with the magmatic formations of Bathonian age.

The bow area system of Adjara-Trialeti ridge

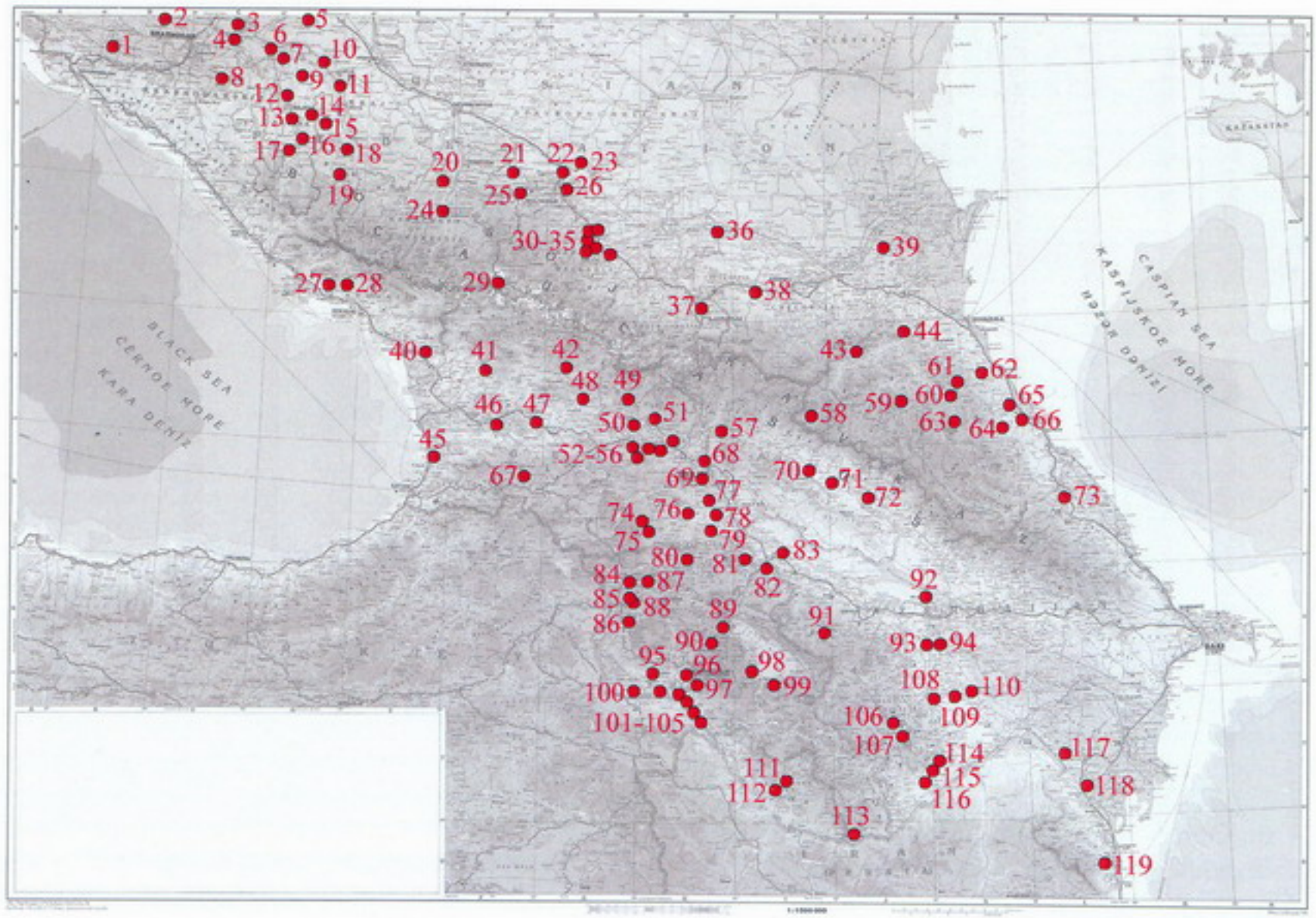
In the areas of the bow area of Adjara-Imereti and Trialeti ridges, effusive prevail over intrusive and veined formations, hence the relatively weak ore of the system.

Effusive rocks of the described zone are not ore-bearing, and the metallogenic importance of intrusive and hypabyssal formations, as a whole, is not fully clarified. Within the bow area three main ore centers are identified: Adjara, Guria and Dzama.

In Adjara, the link of mineralization with the Merisi group of syenite-diorite intrusions is evident. All more or less large deposits and mineralized zones are located among silicified volcanogenic rocks of the middle Eocene. According to the nature of ores, the deposits of this region belong to polymetallic, and according to the prevalence of major minerals, they can be divided into copper and lead-zinc, though the first group is essential (Varaza, Kanly-Kaia and Obolo deposits). Besides copper-polymetallic mineralization, a small manifestation of molybdenum is known near the village of Namonastrevi and a significant mineralization of pyrites at Uchampo, Tsablana and Skhalta.

In Guria, the genetic link of minerals with the intrusions of syenite composition that are uncovered in the vicinity of the villages Vakis-Djvari and Gomi, is none the less clear. Here attention is drawn to pegmatite lodes (Chkhikva terrain and Chachuas-gele) with rare-earth mineralization with magnetite, apatite and less frequently molybdenum. At some distance from the exits of intrusions, there are a number of small-scale magnetite and copper- polymetallic deposits (Koris-bude, Uchkhobi, Pampaleti).

From a metallogenic point of view the region of Dzama magnetic iron deposit is very interesting. It is typically contact-metamorphic and is chronologically linked to the skarn strip of Kvirana (Dzama) intrusion and Upper Cretaceous limestones. Close to Kvirana intrusion is the Kodman manganese deposit of hydrothermal type. The link between these fields is not clear.



Map 4: Settlements mentioned in the text: 1- Anastasevskaja, 2- Staromyshastovskaja, 3- Ust'Labinskaja, 4- Krasnogvardejskoe, 5- Zissermanov, 6- Sturbino, 7- Ulskij, 8- Psekups, 9- Kelermes, 10- Mikhajlovskaja, 11- Kontantinovskaja, 12- Majkop, 13- Apcheronskaja, 14- Makhocheskaja, 15- Kostromkaja, 16- Novosvobodnaja (Klady), 17- Meshoko, 18- Andrukovskaja, 19- Psebaj, 20- Ust'Dzheguta, 21- Vozdvizenskaja, 22- Inozemtsevo, 23- Aleksandrovskaja, 24- Kubina-Aul, 25- Kislovodsk, 26- Pjatigorsk, 27- Kistrik, 28- Guad Ikhu, 29- Elbrus (région d'), 30- Kyzburin III, 31- Lenchinkaj, 32- Kishpek, 33- Nal'chik, 34- Chegem I et II, 35- Dolin, 36 Galugaj I, 37- Vladikavkaz, 38- Bamut, 39- Germenchik, 40- Pichori, 41- Grotte de Belaja-Peshara, 42- Samele Klde, 43- Galgalatli I, 44- Chirkejskogo, 45- Ispani, 46- Tetri-Megvime, 47- Sagvardzhile, 48- Tsartis Gora, 49- Natsar-Gora, 50- Khizanaant Gora, 51- Medzhvriskhevi, 52- Yalbuzi, 53- Gudabertka, 54- Berikleedbi, 55- Kulbakeli, 56- Kvatskhelebi, 57- Tianeti, 58- Hutrah, 59- Rugudza, 60- Karlabko, 61- Mekegi, 62- Karabudahkent, 63- Gapshima, 64- Habaz-Kutan, 65- Gemetiube I, 66- Velikent, 67- Amiranis Gora, 68- Zemo-Avchalskaja, 69- Tbilisi, 70- Tsiteli-Gorebi, 71- Kviriastskaki, 72- Muraddayi, 73- Serkertepe, 74- Simonian Khevi, 75- Dmanisi, 76- Tsiteli-Sopeli, 77- Marneuli, 78- Arukhlo, 79- Khramis Didi Gora, 80- Alaverdi, 81- Brdadzori, 82- Baba-Dervish II, 83- Gargalar Tepesi, 84- Leninakan, 85- Karmir Banka, 86- Arich, 87- Keti, 88- Ganlidzha, 89- Sevan, 90- Dzagovit, 91- Khachbulag, 92- Mingechour, 93- Borsunlu, 94- Kortepe, 95- Echmiadzin, 96- Ajgechat, 97- Garni, 98- Elar, 99- Zolak'ar, 100- Dzhrashen, 101 Tekhut, 102 Kyul Tepe (Mokhra Blur), 103 Shengavit, 104- Aigevan, 105- Ararat, 106- Stepanakert, 107- Kaçincaj, 108- Khyndyrystana, 109- Leila-Tepe, 110- Kul'tepe II, 111- Chalagan-Tepe, 112- Kul'tepe I, 113- Megri, 114- Karaköpektepe, 115- Kul'tepe III, 116- Garakepek Tepe, 117- Alikemektepesi, 118- Misharchaj I, 119- Tel'ma Kend (Courcier 2008).

Other major deposits of copper are attested in the western part of the lesser Caucasus, in the Adjara-Trialeti plicate system (Adjara and Guria).

a) The Adjara ore region is the westernmost ore-bearing area in the Lesser Caucasus and is isolated from the other metallogenic areas (South Georgia and Armenia). This is due to the existence of young volcanogenic formations in the vast territory between Adjara and other regions of the eastern part of the Lesser Caucasus that create unfavorable geological conditions for the formation of mineral deposits.

   The Adjarian ore area covers nearly the entire territory of Kedi and Khulo districts, mainly made up of volcanogenic andezit-tuff rocks of middle Eocene.

   Almost all the ore manifestations of the region have a clear genetic link with the formations of syenite-diorite present in the vicinity of the villages of Merisi, Namonastrevi, Uchambo and others. The main deposits are located at some distance (3-5 km) from the syenite–diorite diastrophic massifs and the surrounding usually pyritized zones.

   Among major ore manifestations of the area, copper deposits are the most prominent. Lead-zinc minerals occur either in conjunction with copper or form independent low-capacity lodes.

b) The Gurian ore area, located in the western part of the Adjara-Trialeti system presents the same geological conditions as the previous one. The metallogenic importance of this area in relation to copper or other metals is not fully determined yet. However, the multiplicity of ore manifestations indicates the existence of ore hearth in the area. Along with the deposits of iron, lead and zinc near the Vakis-Djvari intrusion, are several manifestations of copper.

Intermediate zone (Georgian Massif) and Artvino-Bolnisi boulder

The metallogenic importance of magmatic formations occurring within the intermediate zone, have been hitherto negatively estimated.

The Bolnisi District, which is a part of Somkhity rocks, is of great interest. Here, from a metallogenical point of view, in the northern part of the Loki massif several deposits are known: the iron deposit of Chatakhi, Dambludi deposit of polymetalls (gold and copper), Kamyshlo copper deposit and Madneuli barite-polymetallic deposit, etc. A similar mineralization complex exists in the area of the Khrami massif. In the latter, the manganese hydrothermal mineralization is particularly singled out. Acid intrusions and especially dacites play a major role in the metallogeny of these regions.

Sulphide-gold (barium sulphate-polymetallic and attendant vein-rocks of gold-polymetallic) and copper-porphyritic deposits of Georgia belong to the early Alpinian metallogenic era. They are concentrated within the mining area of the Bolnisi district in the Somkhito-Karabakhian metallogenic zone.

Within the zone of the Main Caucasus Mountain Range on the territory of Georgia, the most significant and explored are: (a) the copper-pyrrhotite zone of North Kakheti, (b) the Kazbegi ore area and (c) some copper-pyrrhotite deposits of Racha and Upper Svaneti.

a) The copper-pyrrhotite zone of North Kakheti, is located in the highland area in the upper course of the Alazani river; it stretches in a narrow band (230 km × 10-20 km) along the southern slope of the Main Caucasus, up to the Belokani copper-pyrrhotite deposits in Azerbaijan and further to Southern Dagestan (upper course of the r. Samur and r. Akhty-chai).
   Among the numerous manifestations of deposits of copper ores in Kakheti, the best known and studied are Atani, Loduani and Shilda.
b) The ore zone of the Kazbeg area is located on the northern slope of the Main Caucasus range, within the flysch deposits. As far as metallogeny is concerned the area is characterized by numerous manifestations of non-ferrous metals, among which lead is the most important while copper-zinc is rather rare. Among the known deposits, Devdoraki, Chachskoe, Mtskhrobi, Gveleti and Bogumchi should be mentioned. Devdoraki is of crucial importance.
c) The copper mineralization in Upper Svaneti and Racha is represented by numerous copper-pyrrhotite or copper-polymetallic manifestations. They are located mainly in the same lower Jurassic slates of the Main Caucasus ridge, within the zone of the flysch deposits. In general, the geological conditions of deposit bedding and the mineralogical composition of the ores are the same as those of the Kazbeg area. It is characterized by the prevalence of lead and zinc minerals while pyrrhotite is less important. In many cases, the deposits are more polymetallic, than pure copper ones.

Out of the numerous manifestations of copper ores in these regions, the more or less studied ones are: Mamisoni, Didveli and Kodnaruli (Upper Racha, zone of rare metal mineralization), Zeskho deposit (Svanetia, in the immediate vicinity of the Tsurungali intrusion) and Tsana (Svanetia) arsenic deposit. Further to the west, in mountainous Abkhazia, along the main ridge, a number of copper ore manifestations represented by copper-polymetallic or predominantly copper-pyrrhotite formations are known.

Thus, copper mineralization linked to the zone of the flysch deposits, is found in a vast area from eastern Georgia to Abkhazia.

To the South of this area, along the southern periphery of the bow area of the Greater Caucasus many (Lachepiti, Mekvena, Opitari, Khopuri, Logurashi, etc.), but smaller copper deposits related to slates and tuff-porphyry rocks of lower and middle Jurassic period are known.

The copper deposits of the Bolnisi area (Artvin-Bolnisi block mass) are located to the north-west of the well-known deposit of copper of Alaverdi (Armenia), and are in similar geological conditions. Geographically they are all linked to Locki and Khrami arrays and their intermediate zone. The most significant deposits in this group are: Madneuli, Tsitelsopeli, Dambludi and Sakrdrisi; less important deposits are Balichi, Tamarisi, Bektakari, Mamulo, Tsikhnari, Kamyshlo, Djaraera, etc. Genetically, the deposits of the Bolnisi group are mostly linked with the dacite and rhyolite intrusions available. The ore lodes are of hydrothermal type of medium depths. The ore formations are distinguished by high content of noble metals (silver, gold), which greatly increases their value. A detailed study of the identified fields is certainly needed. Deposits of gold placers (Kldeisi, Bedenka, upper and lower Khrami, Mamulo, Pinazauri, Lokchai, Arakhlo, Hachkovi, etc) are also attested here.

The metallogeny of Azerbaijan and Armenia

As above, we will mainly concentrate on non-ferrous and precious metals.

a) Azerbaijan

Greater Caucasus

Copper mineralization is extensively developed on the southern slope of the Greater Caucasus in the Belokani-Zakatala ore area (immediate continuation of the eastern part of the Georgian ore zone) and in copper-sulphide and copper-polymetallic deposits (Mazimchay, Jhihih, Kekhnamed, etc.).

Lesser Caucasus

Industrial copper deposits are known mainly in the lesser Caucasus (Kedabek and Ordubad ore areas). They are mainly represented by copper and molybdenum-porphyry ore deposits in two ore areas: Kedabek (Karadag, Kharar and Djagirchay deposits) and Ordubad (Misdag, Geydag, Diakhchay, Geygel, etc), as well as copper-sulphide ores (Kedabek, Bittibulag, etc.).

The deposits and manifestations of copper sandstones of the Asadkaf group in the Nakhichevan Autonomous Republic (Khalhal, Sirab, Yaydjhi, Kagat, etc.) are particularly noteworthy. Mineralization is detected on three horizons with the capacity of 3-5 m within the strip of development of oligocene deposits. The content of copper is on average 0.3-0.5 % and in some areas, ranges from 0.5 to 1.5 %.

In the southern part of the Lesser Caucasus, the Gyumushlugi ore field stands apart together with prospective ore manifestations (Danzik, Sadarak, Agdara, Kvanuts, etc.). The most promising is the Mehmaninsi field. Over 20 fields of sulphide - polymetallic ores have been identified. Most of them are located within the Belokani-Zakatala ore district. Ibid is located in the Filizchai deposit (unique according to the estimated amount of mineral reserves). The content of the useful composition in the ore is: Cu- 0.27-1.03 %; Zn- 1.01-3.69 %; Pb- 0.21-1.58 %; Ag- 15.65-45.41 %. Solid copper-pyrrhotite ores, constituting 2 % of the total ore volume, also participate in the structure of this deposit.

Large stocks are also explored in Katsdagi, Katekhi, Mazymchay, Sagatori and other fields. Over ten monometallic mercury deposits (Agyatag, Shorbulakh, Agkaya etc.), as well as antimony (Elizgel) antimony-mercury (Levchay) deposits are also attested. In the Araza zone the Darrydagi, Salvartini, Ortakendi and Bashkend deposits and manifestations of arsenic ores are known.

The Bitti-Bulakhi deposit of copper-arsenic (enargite) ores in the Kedabek ore district is of special interest. In the basins of the Tutkhun and Levchay rivers antimony ores linked to siliceous limestone have been identified. In this ore deposits arsenic, copper, silver and gold have been recorded.

Recently, in the northern part of the Dashkesan ore area and in the Kyurakchay river basin (Chovdar and Kyapaz) sources of epithermal low-sulphide ores with gold were discovered.

Gold deposits and mineral occurrences in the south Lesser Caucasus are concentrated in the aureoles of the Meghri-Ordubad bathylite (Agyurt, Bashyurt, Mundundara, Pyazbashi, Shakardara, Kalyaki, Kvanuts, etc).

Important is a group of gold-bearing sulphide deposits containing sufficient quantities of gold to classify it as the main component of mineralization (Kedabek, etc.). Gold in the form of impurities is present in all the fields of copper-porphyry formations of the Lesser Caucasus.

Gold-bearing placers of alluvial deposits are numerous (Akstafachay, Tauzchay, Kyurakchay, Asrikchay, Dzegamchay, Shamkirchay, Terterchay, Apindjachay, Vanadchay, etc). Signs of gold mineralization of molasses have been identified in Nakhichevan, and several river basins of the Lesser Caucasus.

Armenia

The reserves of ores and metals in Armenia are attested in 22 deposits of copper, molybdenum, lead, zinc, gold, silver and iron. Most deposits consist of complex ores: copper- molybdenum or gold-polymetallic (Bgdasarjan 2007: 20-23). The main ore reserves are concentrated in the upland parts: Kadjaran, Agarak and Tekhuti (copper-molybdenum), Tandzuk, Mgart and Sotksk (gold). The Shaumyan gold-polymetallic deposit is represented by ore of a vein type, with a high content of gold, zinc and copper. Those of Kapan are represented by stockwerks and veins located in a mountainous area. The veins are characterized by a higher content of copper. The Alaverdi district copper ore deposits also deserve attention (very thin ore veins, up to 0.8 m).

Besides the above mentioned deposits, there is a number of promising deposits of non-ferrous and precious metals in Armenia.

Mains features about the beginnings of metallurgy in the Caucasus

The end of Neolithic – beginnings of Chalcolithic (from the end of the VIth – to the 3rd quarter to the Vth mill.)

In the northern part of the Caucasus, metal appeared in very small quantities in few settlements dated to the beginnings of the Chalcolithic: one copper bead and three pendants respectively in Svobodnoe and

Figure 1: Silver and gold artefacts coming from the Majkop kurgan (Korenevskij 2004 Pl. VI).

Figure 2: Gold and silver necklaces found at Majkop, arsenical copper and gold animal figurines coming from Staromyshastovskaja (Korenevskij 2004, Pl. VII).

Vesjolaja Roshcha (Chernykh 1991: 584-585, figs. 3 n°19 (Svobodnoe) and n°22-24 (Vesjolaja Roša)) (Map 4). According to the analyses, the composition of these artefacts corresponds to "pure copper" with lower traces of impurities (Chernykh 1991: 591, tab 1). This particularity suggests an import of the ores from the Balkans, where the deposits contain mainly copper (Chernykh 1991: 585; Chernykh 1992: 158). The presence of sherds characteristic for the Skelya culture – which is known in the North of the Azov sea – within the ceramics of Svobodnoe seems to confirm the hypothesis of contacts with the Carpatho-Balkan metallurgical centre (Rassamakin 1999: 75 sq, 108 sq), the oldest one known up to now (Chernykh 1992: 49).

In Meshoko, a settlement similar to Svobodnoe but slightly later in date, several metal artefacts (pendant, fragment of awl, complete awl and a short blade) were discovered. Only the blade was made of non-alloyed metal (Chernykh 1966: 101-102, Tab. II). The other objects contain arsenic (1 % to 1.2 % As) (Chernykh 1966: 98-99 and 102-103, Tab. I and II). And this suggests another extractive place than the Balkans.

It seems that the early beginnings of metallurgy in the cultures of the northern part of the Caucasus, at the end of the Neolithic and the beginnings of the Chalcolithic, could have been stimulated by the Carpatho-Balkan metallurgical centre – then at its apogee – through steppic cultures like Skelya. This last culture was probably the link between the Danube entities, the Kuban area and the wooden steppe along the Volga. Furthermore, during the Skelya culture an independent metallurgical centre also existed, which was developed under the influence of the south-east Europe regions (Rassamakin 1999: 104).

Nevertheless, we cannot exclude, that a local metallurgical centre had appeared in the North Caucasus because of the composition of the Meshoko metal artefacts. Unfortunately, the data on metallurgy in this area give no support to this hypothesis.

In the southern Caucasus, several artefacts (stone hammers, slags) suggesting ancient extractive activi-

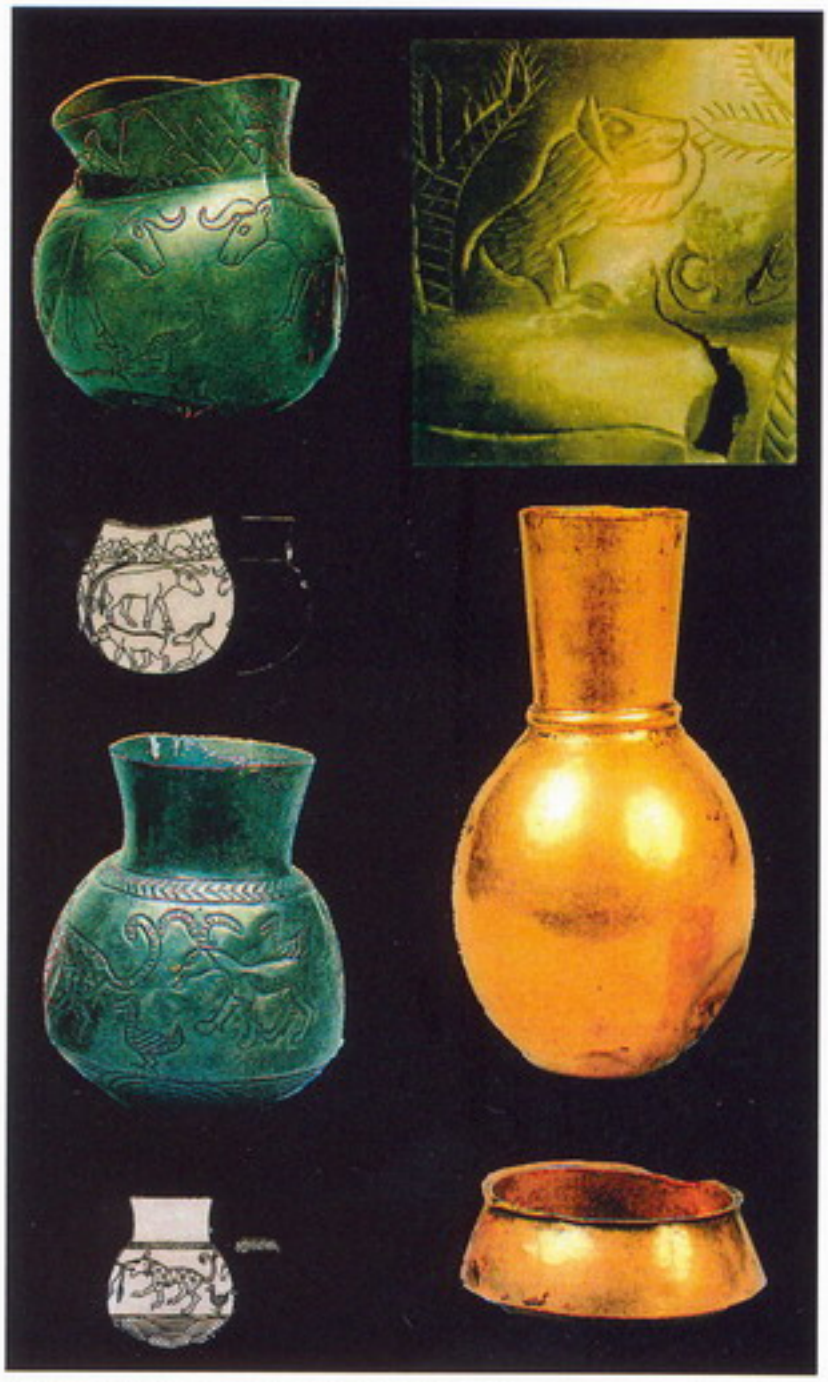


Figure 3: Gold and arsenical copper wares coming from Galugaj I, Alikovovskoe and Majkop (Korenevskij, 2004, Pl. III).

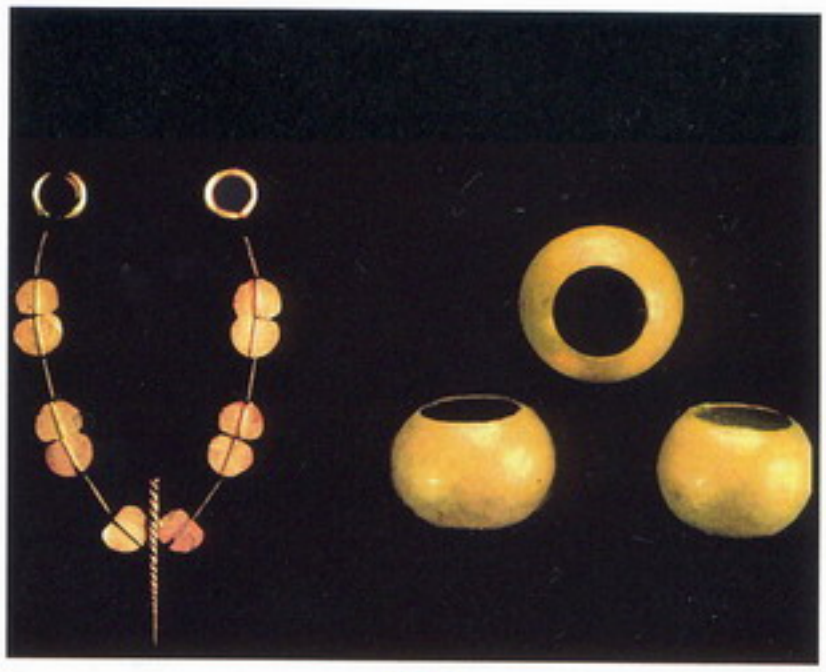


Figure 4: Jewellery ornaments found at Novosvobodnaja (Korenevskij 2004, Pl. VIII).

ties were found at Tsiteli-Sopeli, Arukhlo and Kul'tepe (Kavtaradze 1999: 72), all close to copper deposits. Difficulties in dating these evidences do not allow to verify these presumptions.

The first metal objects discovered in settlements are dated to the end of the Shulaveri-Shomutepe culture (rings and undefined object coming from Khramis Didi Gora (Kavtaradze 1999: 69; Menabde et al. 1978: 27-46) and Arukhlo (Gogelija et al. 1985)). The most ancient metallurgical center on the Georgian territory is therefore probably the Bolnisi Region (Gzelishvili 1967:247-251).

During the next chronological period – not well characterized and where different types of settlements including shelters under caves are grouped together (Sagvardzhile, Tsiteli-Gorebi, Natsar-Gora, Gargalar-Tepesi, Chalagan-Tepe, Chikhori, Samele Klde and Alikemektepesi) – metal objects are more numerous and few evidence for metal production (crucible, mold) has been found (Kavtaradze 1999: 69-73; Akhundov 2004: 426; Chataigner 1995: 131-132).

The manufacturing technique frequently used seems to be an alternation of cold hammering and annealing of a metal sheet. The forms are simple: rings, awls, small blades and arrowheads. Some artefacts, as the awl found at Sagvardzhile, were made in "pure copper" (Kavtaradze 1999: 73). But in this case, there is no sign of a possible importation from the Balkans. On the contrary, suggestions are made of an exploitation of local deposits (Kavtaradze 1999: 71; Chernykh 1991: 60). Arsenical copper is also attested quite early in Transcaucasia, as shown by the composition of objects from Kul'tepe and Tetri Mgvime (Kavtaradze1999: 73 (Tetri Mgvime); Chernykh 1992: 72 (Kul'tepe); Kushnareva et al. 1970: 130-131, Tab. 1 (Kul'tepe); Selimkhanov 1960a (Kul'tepe); Selimkhanov 1962 (Kul'tepe); Akhundov 2004: 426 (Kul'tepe)). The nature of this alloy (anthropogenic or natural) is difficult to estimate because of the peculiar composition of most copper deposits in the Caucasus, where arsenic is intimately associated with the mineralization of copper. In some cases, the composition of objects comprises nickel (Selimkhanov et al. 1969

(awl found at Kul'tepe)). This led to suppose an importation of these objects or of the ores from Iran or Anatolia. But it is more likely that nickel is linked with the ophiolite belt that crosses the Caucasus.

The end of Chalcolithic – beginnings of Early Bronze Age (IVth mill. B.C.)

This period corresponds to the collapse of the Balkan metallurgical centre and to the emergence of the "Circumpontic" one which includes the Caucasus (Chernykh et al. 2002: 83). Two main cultural groups characterize the end of the Chalcolithic/beginnings of the Early Bronze Age: the Maikop (composed of two partly overlapping phases, Maikop and Novosvobodnaja) (Lyonnet 2000: 300-301; Lyonnet 2004: 93-95; Lyonnet 2007a, 2007b), Berikldeebi-Leilatepe, and the Kuro-Araxe culture.

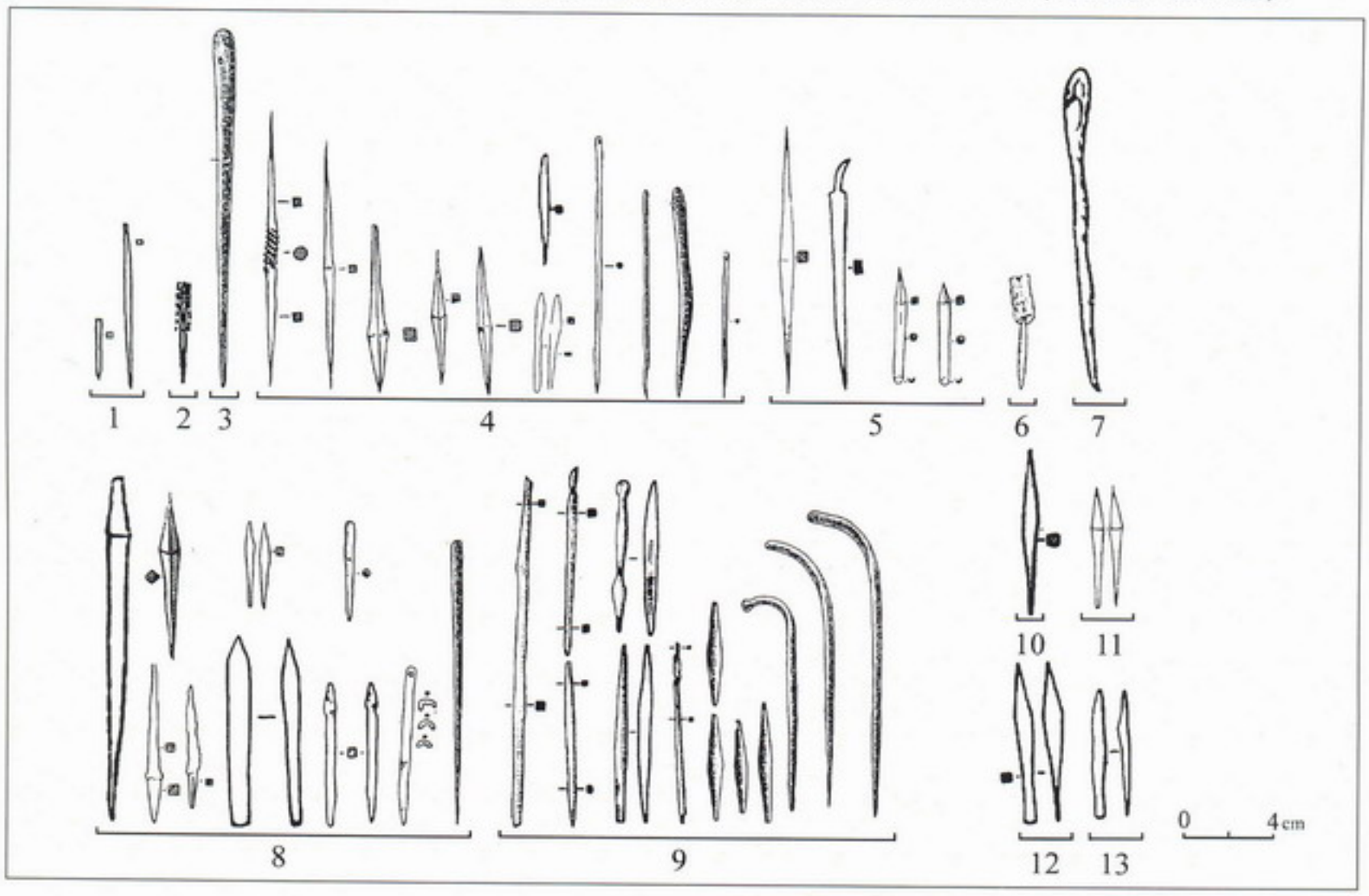
In the North Caucasus, metallurgy develops remarkably during the first half of the IVth millennium (Maikop phase).

The pendants, rings, beads, zoomorphic figurines, applied ornaments, rods, vessels in gold and silver, which were found at Staromyshastovskaja (Munchaev 1975: 225; Chernykh 1992: 71-72), Kostromskaja (Munchaev 1975: 257-259; Munchaev 1966: 98, 100-101) and more particularly at Maikop (Munchaev 1975: 212-222; Munchaev 1992: 67), illustrate the high level reached by the metallurgy of precious metals (Figs. 1, 2 & 3). During the next phase (Novosvobodnaja, from the middle of the IVth millennium), this metallurgy continues, but seems less important (Novosvobodnaja, Kishpek, Chegem I - II and Bamut ; Fig. 4) (Munchaev 1994: 195; Betrozov et al. 1984: 37, 39; Chechenov 1984: 170, 200; Chernykh 1992: 69, 75; Miziev 1984: 92; Munchaev 1975: 241-253).

The metallurgy of copper was characterized by an important increase in the number of the artefacts and by a diversification of the types (for more details, Courcier 2007), as shown by the awls (Fig. 5). New tools appeared in settlements belonging to the Maikop phase: flat axes, hollow chisel, adzes (Galjugaj I, Psebaj, Maikop Kourgan, Konstantinovskaja), pic-axe (this tool is similar to an adze-pic, but with a probably different function) (Maikop), Ust'Labinskaja). The latter is generally associated with ore extraction activities (Kuftin 1944: 303; Khanzadjan 1964).

During the Novosvobodnaja phase, other new tools appear, like forks (Fig. 6 ; Novosvobodnaja, Pse-

Figure 5: North Caucasus metal awl, bradawl, and needles coming from settlements attached to the Majkop culture (phases I & II). **Majkop phase I***: 1- Galugaj 1 (Korenevskij 1995: 169), 2- Psekups (Lovpache 1985: 33);* **Majkop phase II***: 3- Bamut (Chernykh 1966: 98, 100-101), 4- Chegem I (Betrozov et al. 1984: 42,46, 71; Munchaev 1994: 195), 5- Chegem II (Betrozov et al. 1984: 42, 71; Munchaev 1994: 195), 8- Kishpek (Betrozov et al. 1984: 37,39, 92; Chechenov 1984: 176,183,191), 9- Novosvobodnaja (Chernykh 1966: 98, 100-101; Munchaev 1994: 195), 10- Kuban area (Chernykh 1966: 98), 11- Kyzburum III (MIZIEV 1984: 99, 101), 12- Nal'chik (Korenevskij 1984: 256), 13-Timashevskaja (Chernykh 1966 98, 100-101);* **Daghestan settlements attached to the Kura-Araxe culture***: 6- Chirkejskogo (Gadzhiev 1991: 140), 7- Karabudakhent (Gadzhiev 1991: 138).*



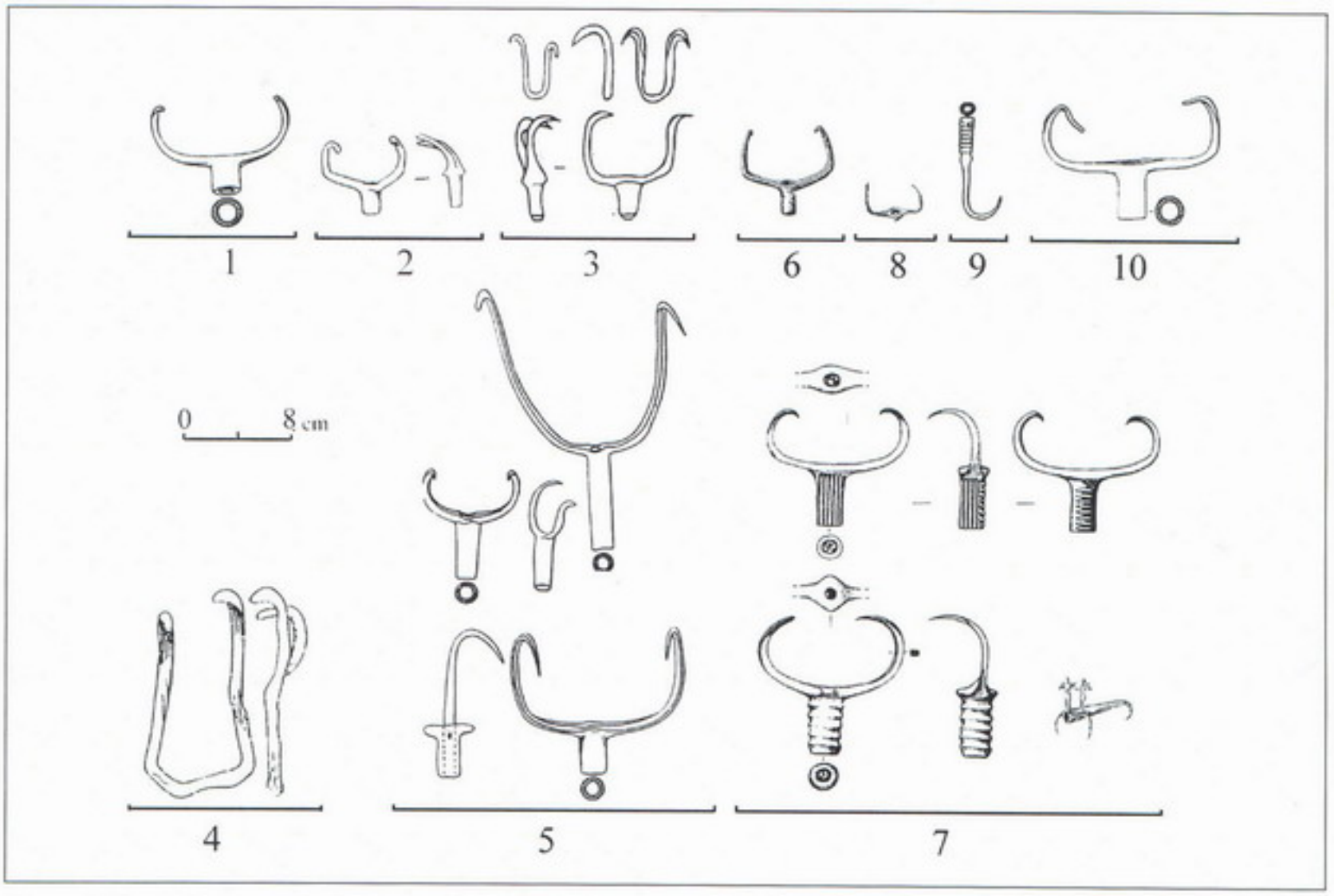


Figure 6: North Caucasus, forks coming from settlements attached to the Majkop culture (phase II): 1- Bamut (Chernykh 1966: 100; Munchaev 1994: 207), 2- Chegem I, 3- Chegem II (Betrozov et al. 1984: 42; Munchaev 1994: 207), 4- Dag-Ogni (Gadzhiev 1991: 192), 5- Kuban area (Chernykh 1966: 100), 6- Makhocheskaja (Munchaev 1994), 7- Novosvobodnaja (Chernykh 1992: 75; Munchaev 1994), 8- Psebaj (Chernykh 1992: 75; Munchaev 1994), 9-Timachevsk (Chernykh 1966: 100), 10- Vozdvizhenskaja (Chernykh 1966: 100).

baj, Makhoshevskaja, Inozemtsevo, Vozdvizhenskaja, Chegem, Bamut, Dag Ogni and chance find in the Kuban area) and pic-axes in the Northern part of the Caucasus (at Kabaz-Kutan, Mikhajlovskaja, Lechinkaj, Elbrus area, Velikent, Vladikavkaz, and Rugudzha). Similar artefacts are known in contemporaneous sites linked to the Kura-Araxe culture (Alaverdi, Dmanisi, Tianiti, Dzhrashen (chance find (Elbruskij treasure), Martirosjan et al. 1973. Tools dated probably Kura-Axe culture, Chernykh 1992: 64-65)). Two influence sources for these pic-axes are possible: one, in the Near-East and Iran (at Tepe Hissar, Tepe Gawra, Tepe Sialk, Gisarlyk and Sé Girdan) where the same tools have been found (Kuftin 1944: 303; Khanzadjan 1964; Muscarella 2003: 124), the other in the Carpathes-Balkan (shapes similar to those of Ust'Labinskaja and Rugudzha) (Ryndina 2003: 17).

The shaft-hole axes, which can also be tools, testify the important rise of metallurgy both because of their number and because of the various types (Courcier 2007: 200). Daggers with a flat blade are principally linked to the Maikop phase, whereas those with a ribbed blade are more characteristic of the Novosvobodnaja phase (Courcier 2007: 201).

Two types of spearheads have been distinguished. The javelin type, with a square section, has been found in only one settlement in the Northern Caucasus (Verkhnij Gunib). However, this type is well-known in the Kura-Araxe culture. The tripartite spearhead is more frequent in the North Caucasus (Psebaj, Novosvobodnaja, Psekups, Sigitma et Chirkejskogo) and illustrates clearly contacts between cultures: similar artefacts have been discovered not only in Kura-Araxe contexts (Amiranis-Gora grave, Osprisi, Zemo-Avchalskaja, Tbilissi, Sevan, Tel'ma-Kend), but also in Syria (Tell Selenkahije, Tell Qara Hassan) (Graham 1989: 530, 538), in Mesopotamia and Anatolia (Arslantepe VIA and VIB, Tell Qara Quzaq, Carchemish, Tell udaida = Amuq H phase, Tell Qara Hassan, and Birecik cemetery) (Frangipane & Palmieri 1983; Montero-Fenollos 2001: 255, 290-292; Watkins 1974; Chernykh 1992: 64; Graham 1989: 69) as far as Turkmenia (Sumbar) (Khlopin 1983: 69, fig. 17).

According to a chemical point of view, the metal artefacts manufactured during the Maikop culture are made of arsenical copper. The composition is comprised between 0.5-0.7 % and 9-10 % As (See for more details about the compounds Courcier 2007: 201-202) and in some cases includes also nickel (< 0.1 % Ni until 4.4 %). This characteristic, combined with both to the supposed absence of nickel within the copper

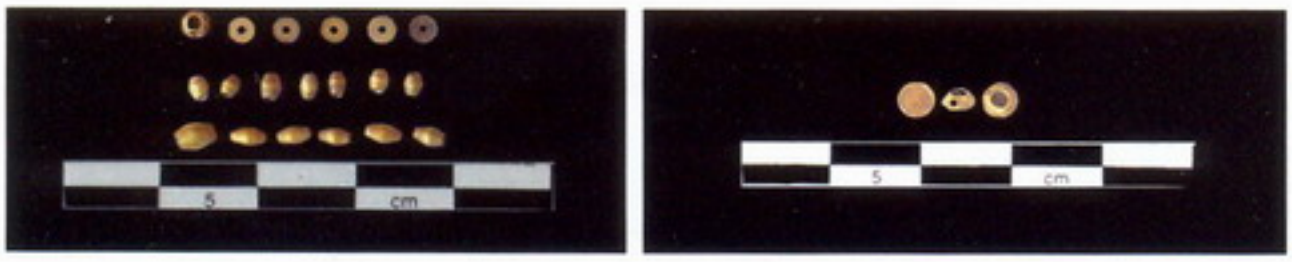


Figure 7: Gold beads found in the kurgan 1 at Soyuq Bulaq (Courcier 2007).

ore deposits and the absence of alteration levels in these deposits in the North Caucasus, have led to the hypothesis that this culture was dependent on the Kura-Araxe metallurgy and acted only as an intermediary between Transcaucasia and the Northern Steppes which were devoided of any ore (Chernykh 1992: 73, 74, 121, 156).

Because of insufficient excavation of settlements, neither hearths, nor tools or waste linked to metallurgy have been discovered so far. Nevertheless, it is difficult to exclude the existence of a metallurgical centre in the North Caucasus which could have exploited local ores (Korenevskij 1988; Ravich *et al.* 1995: 5).

In the south Caucasus, during the first half of the IVth millennium, metallurgical activities have been identified in several settlements with Mesopotamian features (Lyonnet 2007b), (Leilatepe, Berikldeebi, Boyuk Kessik, Soyuq Bulaq). The evidence suggests the use of the smelting process and the manufacturing of object in arsenical copper alloy (ŽavaxiŠvili A. I 1988 (Berikldeebi); Gasan et al. 2001: 135, Tab. XL (Leila Tepe); Akhundov 2004: 427 (Leila Tepe)). Furthermore, recent researches at Soyuq Bulaq confirm the high level reached by the cuprous metallurgy (arsenical copper) and show a joint development of metallurgy on precious metals (gold, auriferous-silver alloy) (Courcier et al. 2008). In the funeral chamber of kurgan 1 at Soyuq Bulaq, 164 beads, of which 33 beads in auriferous-silver alloy (10 barrel-like, 12 ring-shaped, 3 tubular, 8 biconical) and 23 beads in gold (16 biconical, 6 flat rings, 1 crimp; Fig. 7), have been found. Furthermore a dagger made of arsenical copper has been discovered in the lower part of the grave. In kurgan 4, three rings in auriferous-silver alloy and one arsenical copper have been also discovered (Courcier *et al.* 2008).

From the middle of the IVth millennium, north-Mesopotamian features began to disappear while regional characters intensified progressively and gave rise to different cultures: Novosvobodnaja followed by "North Caucasus" in the North-Western part, Velikent in the North Eastern part and Kuro-Araxe in the South and South-Western part of the Caucasus (Lyonnet 2007a: 17).

From this time on, which coincides with the emergence of the Kura-Araxe culture, there is an important rise of metallurgy. Most metal objects (awls, axes, flat axes, pic-axes, javelin-spearheads, tripartite spearheads, daggers) are similar to the products of the Novosvobodnaja phase. These parallels illustrate

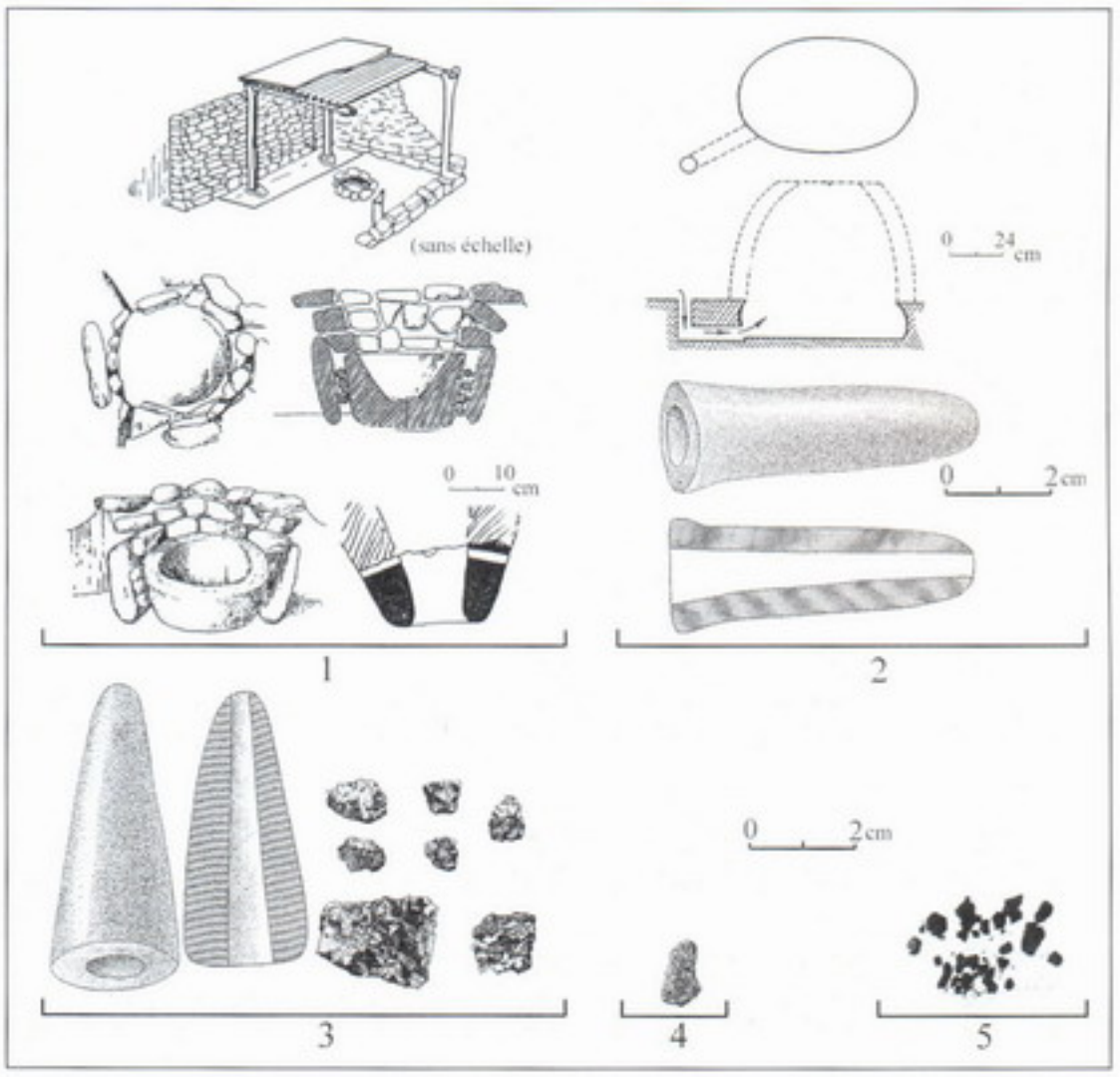


Figure 8: Metallurgical "workshops" attached to the Kura-Araxe culture. **Kura-Araxe culture***: 1- Amiranis-Gora (Kavtaradze 1999: 75), 2- Baba-Dervish II (Kavtaradze 1999: 75), 3- Kul'tepe II (Makhmundov et al. 1968: 17-19), 4- Kul'tepe III (Makhmundov et al. 1968: 17-19);* **pré Kura-Araxe culture***: 5- Leila Tepe.(Narimanov et al. 1990: 7).*

probably the importance of metal within the relationships on both slopes of the Caucasus. Besides the circulation of metal or metallurgical techniques, the exchanges seem to also include the ores. Indeed, the composition of several artefacts found at Arslantepe VIA and VIB suggest the import of polymetallic ores from Transcaucasia (Palmieri et al. 1998: 41-42; Hauptmann et al. 2000: 80); typological similarities of the ornaments discovered in the "Royal tomb" support the hypothesis of contacts between this site and the Kura-Araxe culture (Kushnareva et al. 1970: 119; Frangipane 2000: 451). Needles (Serkertepe, Elar, Kul'tepe II, Kul'tepe I/level 3) and sickles (Amiranis-Gora, Khizanaant-Gora, Tekhut, Garni) make their appearance also during the Kura-Araxe period.

Contrary to the situation on the Northern Caucasus, some ingot-moulds (Gudabertka, Baba-Dervish, Kul'tepe II, Karaköpek) and moulds for artefacts (Amiranis-Gora, Brdadzor, Kvatskhelebi, Garni, Shengavit, Kul'tepe II, Baba-Dervish II, Shortepe, Karaköpek, Geoj-Tepe (levels K1 et K3) were discovered in Kuro-Araxe settlements.

Furthermore, at Baba-Dervish II, three firing structures have been identified, two of which were equipped with a fanning canal (Kavtaradze 1999: 74; Makhmudov et al. 1968). Presence of fragments of charcoal, tuyeres and furnace led to suggest that this was a metallurgical workshop (Kavtaradze 1999: 74) (Fig. 8). Some evidences (slags, tuyeres, fragments of furnace) found at Misharchaj I, Geoj-Tepe (levels K1 et K3), Yanik-Tepe, Tebriza, Kul'tepe II, Khizanaant-Gora and Mokhra Blur (Kyul-Tepe) confirm the dynamism of the manufacturing metallurgy (Makhmudov et al. 1968 ; Kushnareva 1997: 197 (Misharchaj I, Geoj-Tepe (levels K1 et K3), Yanik-Tepe, Tebriza, Kul'tepe II); Kushnareva et al. 1970: 114; Chubinishvili 1971: 102 (Khizanaant-Gora); Kushnareva 1997: 52, 57 (Mokhra Blur)).

The Kuro-Araxe metal artefacts were made of arsenical copper. In most of alloy, arsenic reaches 2 % to 4 %. Some rare objects have a composition with up to 6 % or even 22.7 % As (See for more details, Courcier 2007).

In East Georgia the oxide-bearing and carbon-bearing copper ore deposits of Kvemo Kartli (Marneuli and Bolnisi regions), were presumably, used for the raw materials. Remains of ancient mountain extraction stones and of stone-hammers used for the ore benefication were found in the same region. Of great interest is the original combined tool found in Simoniantkhevi (Dmanisi region), which, on the one hand, looks like an axe handle and, on the other, like rhomboid thinning. Most likely this instrument was used for extracting ores (Koridze 1958).

The composition of Kuro-Araxe metal artefacts suggests the use of polymetallic ores particularly rich in arsenic. The deposits of Ankadzor, Antonovskoe, Zangezur, Megri River, Darridag and Kafan

Figure 9: Gold earrings coming from Martkopi settlement (obligingness Kuparadze 2008).

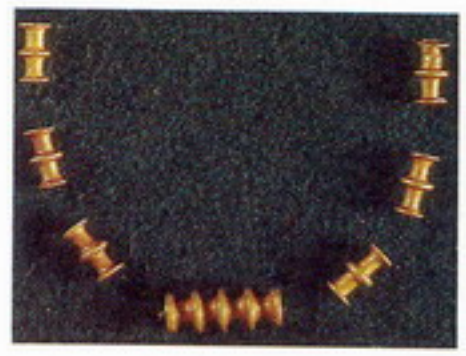


Figure 10: Gold beads coming from Martkopi settlement (obligingness Kuparadze 2008).

could have been exploited (Gevorkjan 1980: 21-33; Chernykh 1992: 60; Palmieri et al. 1993: 594-595). At the end of the Kuro-Araxe culture, the extinction of altered copper ores could have led to extract sulphurous copper ore in the districts of Abkhazia, of Svanetia and of Ratcha (Kushnareva 1997: 211).

In south eastern Daghestan, the settlement at Velikent (3600-1900 B.C.) seems to be a "variant" of the Kura-Araxe culture. In the early levels of mound II (Trench IIC: 3365-3317 (1); 3494-3100 (2) cal. B.C.; trench IIE: no ^{14}C but chronologically similar to the IIC, see Gadziehv *et al.* 2000: 72 and 106), stone hammers equipped together with cupules, fragmentary blades and points, remains of a two-part clay mould for casting a shaft-hole axes have been found. They illustrate both extractive and manufacture metallurgy (Kohl *et al.* 2002a: 115-119; Kohl *et al.* 2002b: 166). However, no research has been engaged yet about the exploitation of local ores deposits. Metal artefacts are in arsenical copper, with an amount in arsenic fluctuating between 0.1 % and 5 % As. In the collective catacomb tombs, dated from the early to the mid of the IIIrd millennium B.C., many metal objects were made in bronze (copper and tin). Recent analyses suggest that this new alloy was not made in Velikent but imported in an already alloyed state probably from Western Asia (Kohl et al. 2002a: 126; Kohl et al. 2002b: 181; Kohl 2003: 19-21).

From the beginnings of the IIIrd millennium B.C., for reasons still not well understood, an important migration of transcaucasian communities started towards the Levant, Susa and the East. At the same time, metallurgy seems to spread everywhere. Later on, contacts between the Caucasus and the Near-East seem to disappear to the profit of those with Western Asia (Lyonnet 2007b: 17).

Around 2500/2300, the Kura-Araxe culture has disappeared, life in the lowlands fades and foothill and highland areas develop more intensively. Early kurgans are found in Martkopi, Bedeni, Trialeti, Samgori, and in the Alazani valley. Some advances are visible in economic and social life, as well as in the development of metallurgy (Abesadze 1969) now mostly bronze (copper and tin) (Kushnareva 1997: 203) and in jewellery (Figs. 9 & 10). Cultural contacts with other areas are also evidenced probably because of the tin trade (Lyonnet 2005).

Conclusion

In the North Caucasus, the metallurgy had known a strong development since the Majkop "phase I" (eponym phase), in the beginnings of the IVth millennium (around 3800 B.C). This tendency went on during the Majkop "phase II" (Novosvobodnaja phase). This phenomenon could be concomitant with a rise of the extractive metallurgy. The metalliferous potential in the northern part of the Caucasus subtends this hypothesis. So, a local metallurgy (extractive and manufacturing) could have spread out in the North Caucasus since the beginnings of the IVth millennium B.C. It is also at this time that an intrusion of north-mesopotamian features is observed both in the North Caucasus (Majkop "phase I") and in Transcaucasia (Leilatepe, Berikledeebi, Boyuk Kesik, Tekhut, Soyuq Bulaq). In some of these settlements, metallurgical activities (cuprous and precious metal) were proved. At this time, the Carpathian-Balkan Metallurgical Province declines.

Around the middle of the IVth millennium B.C., the Kura-Araxe culture appeared. It was contemporaneous and had some affinities with the Majkop "phase II". At that time, it was the apogee of the metallurgy in the Caucasus. Several metallurgical workshops attest this technological spreading. The metalliferous potential was fully exploited and had probably become a centre of interest for the adjacent cultures. Metal should have at that time contributed to the intensification of the exchanges between the Caucasus and the adjacent countries like Mesopotamia.

Nevertheless, because of a lack of excavations and research about extractive metallurgy in the North Caucasus, numerous data are missing. In Transcaucasia, though studies have been done on ancient metallurgy, the question of extractive metallurgy has not been treated, nor that of the ancient metallurgical processes (smelting/co-smelting, melting, cold/hot work and recycling).

However, we hope to be able to make with our colleagues of Georgia a Caucasus GIS which collect geological/metallogenical and archaeological (particularly about the ancient metallurgy, since the beginnings of the IVth millennium until the first half of the IIIrd millennium B.C.) data of the Caucasus. The combination of these, according to the precise problem, could allow successful answers about the ancient metallurgy in the Caucasus.

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metallum, i, n:
Grube, Bergwerk (oft pl.)
Metall, auch Gestein, Mineral

μεταλλον, το:
Grube, Stollen;
bsd. a) Bergwerk (meist pl.)
b) Steinbruch

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