COLOUR AS A MARKER FOR THE EARLIEST FORMS OF METALLURGICAL PROCESSES[1]

ფერი – უძველესი მეტალურგიული პროცესების მთავარი ინდიკატორი[2]

NINO KALANDADZE
PhD. Restoration-Conservation Scientific Institute of Georgian National Museum
Address: Rustaveli Avenue 3; Tbilisi 0105
Email: ninokalo@gmail.com
Orcid: https://orcid.org/0000-0003-4931-859X
Tbilisi, Georgia, Tel: +995 577245577

MIKHEIL TSERETELI
PhD. Student at Georgian Technical University
Address: 77, Kostava Str., Tbilisi 0160
Email: mishatsereteli@hotmail.com
https://orcid.org/0009-0003-7291-0310
Tbilisi, Georgia; Tel: +995577500597

TEA KINTSURASHVILI
PhD. Restoration-Conservation Scientific Institute of Georgian National Museum
Address: Rustaveli Avenue 3; Tbilisi 0105
Email: teakintsurashvili@yahoo.com
https://orcid.org/0009-0006-1377-2853

TEIMURAZ PARJANADZE
PhD. Restoration-Conservation Scientific Institute of Georgian National Museum
Address: Rustaveli Avenue 3; Tbilisi 0105
Email: temo.parjanadze@yahoo.com
https://orcid.org/0009-0005-5639-2300

Abstract. Early metallurgists had profound understanding of natural properties, enabling them to extract ore and obtain desired metals and various alloys. This empirical knowledge was acquired through a cognitive process, in which various materials and events, along with their significant properties, were observed and learned. In addition to taste, smell, and sound, colour should also hold a prominent position in the perceptual process. Colour served as a primary indicator for identifying and extracting valuable ore, ultimately allowing for the acquisition of desired metals and alloys. This article presents metallurgical processes on the territory of Georgia that are associated with the production of colourful metalwork. The colourful effects of studied materials shows the following picture: in the 6th-4th millenniums BC- monochromic metal production; 3rd millennium BC (second half) – bi-chromic production appears for the first time; first half of the 2nd millennium BC – polychrome of precious metals production; second half of 2nd millennium BC – precious

[1] This paper is written within the project "Colourful Prehistory" supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) Grant No FR-21-17354

[2] სტატია მომზადდა შოთა რუსთაველის ეროვნული სამეცნიერო ფონდის მიერ დაფინანსებული პროექტის „ფერადოვანი პრეისტორია“ გრანტი N FR-21-17354 ფარგლებში

metals polychromic production is replaced with non-ferrous metal (copper alloys) bi-chrome and polychrome; second half of 1st millennium BC – colour is not dominant any more in metalwork decoration and is replaced with other ornamentation methods (granulation, engraving, relief ornament); colourfulness returns with its amazing finesse to the goldsmith of Iberia in the Late-antique period. Studies indicate that colour plays a significant role in metallurgical processes, both in terms of functionality and aesthetics, as well as symbolically.

Keywords: Archaeology; colour; early metallurgy; Georgia; metal mining;

ნინო კალანდაძე
ისტორიის დოქტორი, საქართველოს ეროვნული მუზეუმის
რესტავრაცია-კონსერვაციის კვლევითი ინსტიტუტის ხელმძღვანელი
ელ-ფოსტა: ninokalo@gmail.com
Orcid: https://orcid.org/0000-0003-4931-859X

მიხეილ წერეთელი
საქართველოს ტექნიკური უნივერსიტეტის დოქტორანტი
მისამართი: თბილისი 0160, კოსტავას ქ. 77
ფოსტა: mishatsereteli@hotmail.com
თბილისი, საქართველო; ტელ: +995577500597
https://orcid.org/0009-0003-7291-0310

თეა კინწურაშვილი
ისტორიის დოქტორი, საქართველოს ეროვნული მუზეუმის
რესტავრაცია-კონსერვაციის კვლევითი ინსტიტუტის
ლაბორატორიის ხელმძღვანელი
ელ-ფოსტა: : teakintsurashvili@yahoo.com
https://orcid.org/0009-0006-1377-2853

თემურ ფარჯანაძე
ისტორიის დოქტორი, საქართველოს ეროვნული მუზეუმის
რესტავრაცია-კონსერვაციის კვლევითი ინსტიტუტის კონსერვატორი
ელ-ფოსტა: temo.parjanadze@yahoo.com
https://orcid.org/0009-0005-5639-2300

აბსტრაქტი. უძველეს ხანაში, როდესაც ადამიანმა დაიწყო ლითონის მოპოვება, ის დაეუფლა ცოდნას იმის შესახებ, თუ როგორ, სად და რა გზით მოეპოვებინა ბუნებრივი წიაღისეული. ადამიანმა ასევე შეისწავლა ის ბუნებრივი მახასიათებლები და თვისებები, რომლებიც მას ეხმარებოდა მადნის დამუშავებასა და სასურველი ლითონების და შენადნობების მიღებაში. ეს პროფესიული ცოდნა კი იმ კოგნიტიური პროცესის შედეგი იყო, რომლის დროსაც ხდებოდა ამ თუ იმ მასალის თუ მოვლენის ცალკეული თვისების აღქმა და გაცნობა. ბუნების რესურსების

სხვადასხვა დამახასიათებელი თვისებების შეცნობისას, – იქნებოდა ეს გემო, სუნი, ჟღერადობა თუ სხვა მახასიათებლები, ფერს ერთ-ერთი უპირატესი ადგილი უნდა დაეკავებინა. სწორედ ფერი იყო ის ერთ-ერთი მთავარი მაჩვენებელი, რომლითაც ხდებოდა შესაფერისი მადნის იდენტიფიცირება, მოპოვება და სავარაუდოდ, სასურველი ლითონის და შენადნობების მიღება. სტატიაში განხილულია საქართველოს ტერიტორიაზე მოპოვებული არქეოლოგიური მასალა, უძველეს ხანაში მიმდინარე მეტალურგიული პროცესები, რომლებიც დაკავშირებულია ფერადი ლითონის ნაკეთობების წარმოებასთან. მიმდინარე მეტალურგიული პროცესები, ფერადოვნებასთან მიმართებით სქემატურად შემდეგნაირად ხასიათდება: ძვ.წ. VI-IV ათასწლეულები – მონოქრომული ლითონის ნაწარმი; ძვ.წ. III ათასწლეულის მეორე ნახევარი – პირველად გვხვდება ბიქრომიული ლითონის ნაწარმი; ძვ.წ. II ათასწლეულის პირველი ნახევარი - ძვირფასი ლითონების პოლიქრომიული ნაწარმი; ძვ.წ II ათასწლეულის მეორე ნახევარი – ძვირფასი ლითონების პოლიქრომიულ ნაწამს ანაცვლებს ფერადი ლითონების (სპილენძის შენადნობები) ბიქრომია და პოლიქრომია; ძვ.წ I ათასწლეულის მეორე ნახევარი – ფერადოვნება თითქოს კარგავს ლითონწარმოების დეკორირების დომინანტობას და გზას უთმობს დეკორირების სხვა საშუალებებს (გრანულაცია, გრავირება, რელიეფური ორნამენტაცია); ფერადოვნება საოცარი სინატიფით ბრუნდება გვიანანტიკური იბერიის ოქრომჭედლობის ნიმუშებში. კვლევები აჩვენებს, რომ ფერი მნიშვნელოვან როლს თამაშობს მეტალურგიულ პროცესებში, როგორც ფუნქციონალური, ასევე ესთეტიკური და სიმბოლური მნიშვნელობით.

საკვანძო სიტყვები: არქეოლოგია; ფერი; ადრეული მეტალურგია; საქართველო; ლითონის მოპოვება;

Introduction:

Discussing and arguing about the early labour organisation in ancient societies from a modern perspective can be challenging. However, an exception can be made for the specific labour of early metallurgists. It is highly probable that these individuals have acquired expertise in both the management of metallurgical processes and the specialised field of metal mining.[3]

The early metallurgists clearly demonstrated a profound understanding that allowed them to extract ore and create specific metals and diverse alloys. This empirical knowledge was obtained through a cognitive process, in which different materials and events, along with their significant properties, were observed and learned. Colour should be given equal importance alongside taste, smell, and sound in the perceptual process. Colour functioned as a fundamental marker for discerning and extracting valuable ore, ultimately enabling the procurement of desired metals and alloys. In the Georgian language, numerous colour names are linked to particular materials or the properties of those materials. Notably, the colour denoting terms, which are explicitly associated with metallic substances, serve as excellent illustrations. For example – ‘*spilendzispheri*’ (colour of copper), *“Okrospheri”* (colour of gold, golden),

[3] Metallurgy, a term which is derived from the ancient Greek word μεταλλουργός, unites two concepts – ore mining and metalwork.

"kalispheri" (colour of tin), *"tkviispheri"* (colour of lead), *"rkinispheri"* (colour of iron), *"vercxlispheri"* (colour of silver, silver), *"Jangispheri"* (colour of rust), *and etc.*

Methods:

All information about the metallurgical processes in Georgia from 6th millennium BC until the 1st Millennium BC was collected and analyzed according to the color to understand what kind and color ores were used for manufacturing the colourful metal and metal alloys artefacts.

Results and discussion:

6th millennium BC

Acquiring expertise in metalworking begins by becoming acquainted with native copper. Native copper, also known as virgin copper, exhibits a red coloration and possesses exceptional malleability, making it an ideal material for jewellery crafting. Originally, beads and small dimes were made using native copper through the process of cold forging. Archaeological evidence from that time period suggests that natural copper was unsuitable for tool forging due to its malleable and pliable properties (Inanishvili, 2014: 47).

Several artefacts are examined to acquire additional insights into the discovered metal material and its technological advancements. The limited distribution and lack of established metallurgical practices for native copper restrict its utilisation. However, these factors also drive the advancement of metallurgy (Forbes, 1950: 19).

The initial discovery of metal artefacts in Georgia has been verified to originate from the Merneuli region, specifically from the archaeological sites associated with the Shulaveri-Shomutefe culture. The most ancient artefacts originate from the Khramis Gora Settlement, consisting of a half ring, a knife, two beads, and one amorphous piece. These artefacts are crafted from native copper using the cold forging technique. They are dated back to the VI millennium BC. (Kiguradze, 1986).

Colour of the native copper: red
Original colour of the artefact: red (colour of copper).

5th-4th millennia BC.

The period between the 5th and 4th millennium BC in the Caucasus region is notable for significant advancements in non-ferrous metallurgy. Representative artefacts of that time include small objects such as knives, needles, hooks, arrowheads, and spiral bracelets, which are commonly found in the inventories of Kura-Araxes and Maykop cultures. The copper alloys (As = 1.0-2.0%) are formed using the cold and hot free forging technique. The extraction of local copper oxide ores, such as cuprite and tenorite, which are known for their easy reducibility and uncomplicated smelting properties, became prominent during this period.

Ore colour: red and black
Original colour of the artefact: red (colour of the copper).

4 th-3rd millennia BC.

The period between the end of the 4th millennium and the first half of the 3rd millennium BC in Georgia was marked by the development of copper-bronze metallurgy. The metallurgical economy has expanded. During that time, the mining operations are focused on extracting various types of copper ores, including copper carbonates (such as malachite, which is green, and azurite, which is blue), copper silicate (such as chrysocolla, which can be green, blue, or pastel blue), and arsenic copper ores (such as tennantite, which is grey or black, and enargite, which is dark grey or metallic black).

Copper was widely used in metallurgy throughout the entire region of Georgia during the 3rd millennium BC. This process exerted a substantial influence on the economic and cultural advancement of the region. Archaeological sites in Georgia have yielded a substantial quantity of artefacts from that time period. These copper artefacts exhibit arsenic concentrations varying from 3 to 10%. Notably, there are small silver and lead jewellery items discovered at the Kura-Araxes culture site. Amirani Gora and Kvatskhela archaeological sites contain jewels like spiral bracelets and pendants. Polymetallic ores were a source of silver, which could also be extracted by employing the cupellation method to separate it from lead. The product was designed using the free hot forging method. Silver is a type of metal that has been extensively utilised since ancient times. The earliest silver artefacts discovered in Georgia have been dated to the first half of the 3rd millennium BC.

Copper ore colour: Green, blue, pastel blue, grey, black, red
Native gold colour: yellow (golden)
Colours of the gold bearing ores – quartz vein ore colours are various; it can be either yellow, pink, crimson, grey, black, brown, with iron colour shade incrustation.
Silver and lead polymetallic ore colours: silver, grey or black.

4 th-3rd millennia BC.

Artefacts' colour: golden, silver (gold, silver and lead artefacts).

Arsenic copper alloy artefact original colour (probable): 3-10% arsenic copper alloy colour is changing from red to light pink.

The origin of bi-chromic metal products can be traced back to the early kurgan culture period, particularly during the latter part of the 3rd millennium BC. This type of metalwork is produced through the fusion of precious metals, namely gold and silver. The Ananauri N2 kurgan contains a silver pin with openwork design, adorned with a gold double wire. On the other hand, the Bedeni N11 kurgan provides a silver pin with a gold head decoration (Lordkipanidze, 2016: 60-61). This bi-chrome artefact can be regarded as a precursor to the polychromic style of the Trialeti culture, which is highly significant in the context of precious metal jewellery art.

2nd-1st millennia BC.

Polychromy

The primary focal point of Trialeti Culture lies in the refinement of precious metals for the creation of exquisite artwork, particularly in the field of jewellery. This artistic tradition has been greatly influenced and advanced through the shared cultural accomplishments of the ancient Eastern civilizations. The gold artefacts of the Trialeti Culture are encrusted with vibrant hues. These objects are dated back to the beginning of 2nd millennium BC.

The Trialeti gold goblet and necklace-pectoral are essential when discussing polychromic metal products from the first half of the 2nd millennium BC.

A gold goblet is a unique exemplification of the craftsmanship of goldsmiths during the first half of the 2nd millennium BC. The object is fully embellished with gemstones and decorative elements. Five different colours can be found in Trialeti golden goblet: golden (gold alloy), brownish-red (carnelian), black (agate), amber (Amber stone) and royal blue (azurite). (Fig .1).

The Trialeti pectoral-necklace is composed of 14 spherical beads made of gold, along with central pendants. Beads vary not only in size but also in decoration. The necklace exhibits four distinct colours: golden, brown-reddish (carnelian), dark brown, and cream (the colour of the aqate). (Fig.2).

The bimetal pins discovered in the Trialeti Kurgans (XVII, XXXVI) are adorned with carnelian and rock-crystal. A gold pin adorned with carnelian and rock-crystal has been discovered at the Mravalstkali cemetery, dating back to the 2nd millennium BC. It is worth mentioning the bi-chromic and bimetal pins from Irganchai N9 kurgan. These pins have a silver body and a gold head, and they are adorned with carnelian gems (Lordkipanidze, 2016: 82-85).

Bichromic metal artefacts remained relevant during the first half of the 2nd millennium BC. An exemplary artefact is exemplified by a silver bucket discovered in the Trialeti N17 Kurgan dating back to the Middle Bronze Age. The bucket is constructed from a silver sheet, with the bottom and rim of the object embellished with a gold hoop. Additionally, a gold twig is adorned along the seam of the sheet. (Fig.3)

Second half of 2nd millennium is characteristic of cultural development in many fields; new achievements in non-ferrous metallurgy emerge and are distributed. The most utilised method in that period is considered mining and processing copper sulfidic ores.

Metallurgical smelting charge is composed propositionally on copper, arsenic and antimony ores. With Arsenic (As= 4,0-12%) and antimony (Sb= 3,0-15%) raw material is composed of three components (Cu/As/Sb) alloy, with low melting eutectic and increased casting characteristics. At that period arsenic and antimony was being mined at very rare mines of the known ancient world; these mines are located in Racha. Those mines were presented with orange réalgar, lemon-colour Aurum Pigmentation and yellowish mining passages due to the antimony (Inanishvili G, 2014: 32).

Artefacts made on arsenic copper are found at Bornighele (Meskheti). Along with spearheads, daggers that are made on arsenic copper, are confirmed also some ritual object made on the same alloy: rython with 21 % of antimony, mace head (2) with 12% and 10% of antimony, 3 Colchis axe with 9%, 10% and 12% antimony.

Such products like mace head, rython and axes did not have practical utilisation and it would have been impossible to have such function, which is reinforced further with aspects of material science. For example, alloy of arsenic and antimony of 10-20 % drastically lowers the smelting temperature, which is very good for the casting, however material becomes very brittle. Early metallurgist surely noticed that too (Georgien - Schätze aus dem Land des Goldenen Vlies, Bochum 2001: 150-155).

Scientists are sure that antimony was utilised for its aesthetic reasons. This metal is light silver in colour and when it is added to the copper, objects made from it gain very nice silver polish.

During the late 2nd millennium BC, the practice of incrustation became widespread. Copper alloys were adorned with various decorative materials. Concrete evidence of glass and paste incrustations has been confirmed at Brili cemetery, including standards, pendants, and axes.) (Sulava, Kalandadze, 2006: 11-16).

The findings at Brili cemetery can be categorised into three distinct groups: arsenic alloys, arsenic-antimony alloys, and antimony-arsenical alloys. Incorporating antimony into the alloys was discovered to augment the fluidity of the metal, consequently facilitating the production of casts with meticulous surface and relief. Antimony is renowned for its capacity to improve the viscosity of alloys. (Investigation of non-ferrous metal alloys, Volume I, Moscow, 1955: 48). The abundance of artefacts with antimony composition suggests a deliberate incorporation of this element into the object.

The chemical-technological properties of material from Brili cemetery are being examined in the laboratory of the Georgian National Museum, as reported by Abesadze in 1958. According to the authors, the presence of antimony in the alloys can be attributed to the following circumstances: "It is established that arsenic-antimony alloys possess an aesthetically pleasing bronze hue, they exhibit a shiny appearance reminiscent of silver. Therefore, it is plausible to assume that antimony in such compositions is utilised for decorative purposes. However, it should be noted that this metal is quite fragile and extremely challenging to forge." It is evident that an axe made from this type of metal is ineffective for both combat and agricultural uses. Antimony is added to provide coloration in the stylized representation of a sheep sculpture (Abesadze, Bakhtadze, Dvali., Japaridze, 1958: 34). Additionally, it is noteworthy to mention the observation made by Otar Japaridze. According to his belief, antimony was the primary commodity exported in that area, whereas tin was imported. Hence, the industry had an abundant supply of tin raw material. The artefacts found in Racha contain tin copper as a constituent. "It is challenging to explain why arsenic was not widely used in a region abundant with that ore, and the same can be said about tin." The author's conclusion suggests that the primary factor behind this phenomenon may have been the dominance of metal as the primary export during that period.

Early metallurgists utilised antimony and arsenic in order to produce alloys that possessed a lustrous appearance and closely resembled silver. This phenomenon can be attributed to the scarcity of silver in those regions and the high demand for it.

Arsenic-antimony and antimony-arsenic copper alloys were primarily utilised in the Brili cemetery material to achieve the desired colour of the object.

A buckle with the depiction of a rider found in tomb N65 of the Threli burial ground, dated to the 13th-12th centuries BC is characterized by very interesting color effect. Here, the coloring is achieved with variation of silver (arsenic copper alloy) and red (enamel?) colors.

When we discuss the colourfulness of that period one must definitely include the archaeological artefacts from Mtskheta Archaeological Museum. These are two daggers, one (#7232) from Tserovani The first sample is a Bronze Age cemetery, while the second sample is an accidental discovery (N11220) (Kebuladze, Kalandazdze, 2021: 32-51). According to the latest analyses, dagger N7232 is adorned with polychrome decoration on its surface that is embedded with glass. The incrustation is formed using an undisclosed technology, where a combination of glass-like material and metal grids are utilised. Authors regard the technique as the precursor of vitreous encrustation.

The second dagger (N1220) features a handle crafted from two distinct alloys of different colours. The handle and blade of the dagger possess distinct chemical compositions. The copper content in both cases is 85.35% in the handle and 84.5% in the blade. The amount of arsenic is nearly the same, around 5%. The composition of tin, lead, and antimony is distinct. The handle of the composition contains nearly the same amount of lead (5.25%) as arsenic (5.63%). The blade contains 0.352% lead. The tin content in the handle has decreased by nearly a factor of ten (1.194%), compared to the blade (10.047%). Based on the analyses and the composition of the dagger, it can be determined that the blade of the dagger was originally golden in colour, while the handle had a more silver appearance.

The distribution of tin in non-ferrous metallurgy had a significant impact on various aspects of the ancient world, leading to a revolution in different fields. The addition of tin to copper resulted in the creation of a new material known as bronze. Bronze has gained significant popularity and has become widely disseminated. However, in the region of Georgia, the transition from arsenical and antimony copper alloys to tin bronze occurred at a sluggish pace. Despite changes in the compositions of antimony and arsenic, such alloys have been continuously utilised for many centuries.

Cu-As-Sn alloys are mainly yellow. Cu-As-Sn 5% composition of arsenic has reddish and yellowish shades. Added more than 5% arsenic to the alloy, the colour is changed to silver. Adding up to 5% tin (Sn) to copper (Cu) material colour changes to light pink shade, though 5-20% tin addition increases the yellowish shade of alloy.

Incrustation technique with different metal and glass material is widely used in non-ferrous production decoration already at the end of 2nd millennium BC. This tendency continued to exist in the 1st millennium BC.

Generally, at that time period material used for incrustation the metal products are presented as with metals itself like iron and different copper alloys, also with glass. The bronze surface features specially curved settings that incorporate metal and glass. As an illustration, the Ude treasure features four bronze buckles adorned with animal imagery. Animal bodies are covered with a layer of glass. Regrettably, the original colour could not be discerned. Al. Javakhishvili and T. Chubinishvili state that the surfaces of four bronze buckles are adorned with animal figures. Two of them have a total of nine dog cravings arranged vertically, with four on top and five below. The dog figurines are adorned with an encrusted paste, the original colour of which is uncertain. Based on the three fragments of the last - eights buckle, it is evident that the surface of the buckle was encrusted with deer and a dog. The carved dog sculptures are adorned with intricate metal filigree. The lines were perceptible as chromatic dots, specifically the colour red was perceptible (Javakhishvili, Chubinishvili, 1959: 59-64).

Buckles similar to those found in the Ude treasure have been discovered throughout the Koban cemetery in the North Caucasus region. Currently, Koban buckles are housed in various museums worldwide (Uvarova, 1900: 50). The accuracy of this data should be verified, as the information provided by P. Uvarova dates back over a century.

A buckle encrusted with a black and greenish substance is documented in Vani (Charkviani, 2002: 58). The analysis of the glass-like substance from that buckle is highly intriguing. The investigations focused on the composition of the main elements involved in glass production, including flinty soil, calcium, aluminium, lead, and sodium (Na). (Abesadze, Bakhtadze, Dvali, 1961: 174).

The buckles from the Natsargora and Tsiteli Shukura cemetery are intriguing due to their vibrant colours. (Ramishvili, 2001: 148-156, tab. VIII-1361), (Trapsh, 1969: 115).

One of the bronze buckles from Natsargora cemetery is decorated with engraved dog images; they are represented on the background of engraved spirals. Edges of the buckles are ornamented with craved triangles, also presented on the background of spirals. Engraved images are incrusted with iron (Fig. 4).

The second bronze buckle recovered from the same cemetery is adorned with depictions of a deer and a dog. These images are arranged in a vertical sequence using the carving technique. The animals are depicted against a backdrop adorned with intricately carved spiral motifs. The surface of the décor is encompassed by an intricately engraved frame with curved lines (Fig.5). The presence of red material is clearly discernible in the borders of zoomorphic engraved shapes.

Another buckle from grave N44(30) at Tsiteli Shukura has incrusted dark grey figures on its surface. Figures resemble swans. Engraved bent lines are carved around the borders of the buckle

(Трапш. М., 1969, 118, Tab.E XXVI-12). At the same cemetery, in the grave N70(107) a buckle is found. It has wedge-like cravings on its surface, which is incrusted with metal – possibly with iron. (Trapsh, 1969: 133).

Precious metals with Polly chromic accents from 1st millennium BC are confirmed only in few cases, mostly on the central territory of Colchis: Spherical bead with germs incrusted in gold frames are found in pit grave N2 from Tsaishi. Material is dated back to first quarter of 1st millennium BC. Gold adorns of dagger handle decorated with dew drops and incrustations are confirmed in pit-grave N1 of Tsaishi – material is dated back to 7th century BC. Silver strap of an iron dagger handle is decorated with carnelian gems – artefact is coming from pit-grave N5 of Ergeta I cemetery. Other artefact from the same cemetery, coming from pit-grave N9 is presented with iron dagger, which has silver strap adorned with amber gems. Other iron dagger with silver handle, which is incrusted with carnelian gems is found at Egreta III cemetery, pit-grave N4 (Kobalia N., 2023: 12-15).

Incrustation technique on bronze products is almost completely diminished engraved decoration technique by 7th century BC.

Conclusion:

According to the results, presented above, the metallurgical processes that take place on the territory of Georgia involved in creating colourful effects can be described in a simplified and systematic way.

- 6th-4th millenniums BC- Monochromic metal production
- 3rd millennium BC (second half) – bi-chromic production appears for the first time.
- First half of the 2nd millennium BC – polychrome of precious metals production.
- Second half of 2nd millennium BC – precious metals polychromic production is replaced with non-ferrous metal (copper alloys) bi-chrome and polychrome.
- Second half of 1st millennium BC – colour is not dominant any more in metalwork decoration and is replaced with other ornamentation methods (granulation, engraving, relief ornament).
- Colourfulness returns with its amazing finesse to the goldsmith of Iberia in the Late-antique period.

Colour played a significant role in both the functional and aesthetic aspects, as well as the symbolism, of early metallurgical processes.

Fig. 1

Fig.2

Fig. 3

Fig. 4

Fig. 5

გამოყენებული ლიტერატურა

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