MINERALOGICAL SOCIETY OF GEORGIA
G. TSULUKIDZE MINING INSTITUTE
GEORGIAN TECHNICAL UNIVERSITY
INSTITUTE OF HYDROGEOLOGY AND ENGINEERING GEOLOGY

THE DEVELOPMENT OF MINING AND GEOLOGY IS THE PRECONDITION FOR THE REVIVAL OF ECONOMY

BOOK OF ABSTRACTS

9th International Scientific-Practical Conference on Up-to-date Problems of Mining and Geology

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Tbilisi

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Correction – **Elene Akhmeteli**

TABLE OF CONTENTS

POST-COLLISIONAL GEODYNAMICS, TECTONICS AND SEISMISITY OF GEORGIA

SH. ADAMIA, N. SADRADZE, V. ALANIA, O. ENUKIDZE, N. KVAVADZE, G. SADRADZE
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Georgia, the westernmost part of the southern Caucasus, represents an unique area where the Tethys Ocean was closed in the Late Cenozoic as a result of prolonged convergence between the Eurasian and Africa-Arabian plates. The lithosphere of Georgia represents a collage of Tethyan, Eurasian, and Gondwanan terranes.

Regional geological, geophysical, paleobiogeographical, and paleomagnetic data indicate the existence of several tectonic units in the regions. These are the Cavcasioni and Achara-Trialeti fold-and-thrust mountain belts, the Rioni and Kura (Mtkvari) intermontane depressions-forelands, the northern Transcaucasian rigid platformal units, the southern Transcaucasian terranes and the Javakheti and Keli-Kazbegi volcanic highlands and extinct volcanoes [1, 2].

Within the Main Range Zone (MRZ) of Cavcasioni, the basement rocks build up the Crystalline Core of the Alpine anticlinorium. The basement of the Cavcasioni was dismembered by Alpine tectonic events into several megaslices–salients separated by Alpine (Jurassic) tectonic depressions: 1. Chugush Salient; 2. Sofia salient; and 3. Teberda-Digori salient separated by Arkhiz-Klich depression from each other; 4. Shkhara-Adaikhokh salient separated from Teberda-Digori salient by Shtulu-Kharesk megaslice.

Lower–Middle Paleozoic basite-ultrabasite metamorphic comlexes represent the southernmost strip of the mafic series along the southern edge of the crystalline core. This complex is the largest pre-Upper Paleozoic oceanic unit in Cavcasioni. It is composed mainly of diverse tectonic slices of paleo-oceanic lithosphere. Lower-Middle Paleozoic age of the complex is appreciated by paleontological data.

Magmatic zircons indicate Early–Middle Paleozoic age. The age of regional metamorphism is accepted as Late Paleozoic 320±5Ma. The detrital zircons selected from quartzbiotite schist of the same locality yielded four groups of values: 2394–1929, 669–483, 425–405, and 355–325 Ma. The granites and various granitoids, granite-gneisses, migmatites and crystalline schists are characterized by rejuvenated K/Ar ages c. 300 Ma. The true age of the Darial massif is considered to be Early Carboniferous c. 340 Ma, by analogy with microcline granitoids of the Main Range.

Within the MRZ, Upper Paleozoic sedimentary cover is composed of rocks accumulated under subaerial and shallow-marine environments. Continental molasse, locally coal-bearing contain Middle Carboniferous floral fossils. The higher horizons of the section constrained according to brachiopods to the Upper Carboniferous–Permian.

The Dizi series crops out in the cores of two (Enguri and Tskhenistskali) Alpine antiforms of the Southern Slope Zone. The presence of Devonian, Carboniferous and Triassic deposits (phyllites, slates) is proved on the basis of paleontological findings. Black slate, terrigene-turbiditic, and volcanogenic formations of the Southern Slope Zone unconformably rest upon Paleozoic and Triassic rocks. Two, en-echelon type flysch basins were formed during the Callovian-Eocene: (1) Eastern (Chiauri -Dibrar) and (2) Western (Novorossiysk and Abino-Gunai) ones.

Most part of the Cretaceous flysch of Kakheti is hidden under Neogene-Quaternary subaerial molasse deposits of the Alazani piggyback basin, and only uppermost part of the section crops out along the right bank of the r. Alazani, where it forms the NW-SE Tsivgombori (Kakheti) narrow ridge.

The key structural characteristics of the Main Range and the Southern Slope Zones of Cavcasioni is imbricate structure of the Paleozoic basement and sedimentary cover and en-echelon arrangement of the structures. The MRZ and SSZ are characterized by complete penetrative, intensive, linear, often isoclinal folding with mainly south-vergent imbricated thrusting, close joint cleavage, boudinage etc. During the Alpine time, basement rocks and sedimentary cover together underwent tectonic deformations. Thus, the present-day structure of Cavcasioni represents a thick-skinned imbricated fold-and-thrust mountain belt. At the Southern Slope, nappe structures have not been recognized.

The Achara–Trialeti tectonic unit submerges east of Tbilisi under Oligocene–Neogene molasses. The system of the northern frontal faults of Achara–Trialeti overlaps the northerly lying stable (rigid) tectonic unit of the Georgian Block.

The structure of the Transcaucasian intermontane troughs - forelands are deformed: linear folds, reverse faults, strike–slip faults. Rock deformation is especially strong within the boundary zones between the Kura and Rioni forelands and fold-and-thrust belts of the Cavcasioni and Minor Cavcasioni. The theory on the presence of nappe structures in Transcaucasian Basins is based on analysis of the data derived from large scale geological mapping, drilling and seismic profiling.

Georgia is an earthquake-prone region where devastating earthquakes have repeatedly caused significant loss of lives and damage to infrastructure and buildings. The large seismic event was the Mw 6.9 Racha earthquake on 29 April 1991. Its epicenter was located in the Southern Slope zone of the Cavcasioni. This earthquake, the strongest ever recorded in Georgia, took about 200 human lives and caused great destructtion within densely populated areas. The main shock was followed by numerous aftershocks, lasted for several months, the largest ones of which were Ms = 5.4 on April 29, Ms = 5.3 on May 3, and Ms = 6.2 on June 15, causing additional damage. Data on the Racha aftershocks for a month period (May 15–June 15) reveal a few clusters of shocks, trending respectively to W-E 270°, WNW 290°, and NW 310°. Most of them show that nodal planes were orientated to WNW or NW. All the shocks were shallow, with focal depth varying from 2 to 32 km.

Structurally, the epicenter region represents a boundary zone between two main tectonic units: the Cavcasioni fold-and-thrust mountain belt and the rigid Georgian Block. The northern periphery of the Georgian Block is dissected by a system of active W-E– and NW-SE–trending faults. The overwhelming majority of strong shocks (including the main shock) were associated with the southern branches of these seismoactive structures – Racha-Lechkhumi-Kakheti.

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CONDITIONS FOR THE FORMATION OF THE LUKHUMI GOLD-ARSENIC-ANTIMONY DEPOSIT

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On the Southern slope of the Greater Caucasus, mercury, arsenic-mercury, arsenic-antimony-mercury, arsenic-antimony, antimony and tungsten-antimony mineralizations, which are combined into a single mercury-arsenic-antimony ore formation, are widespread.

In the spatial distribution of deposits of this formation in the central part of the Southern slope of the Greater Caucasus, horizontal zoning is observed: antimony deposits (Zophito, Sagebi, Edena, Kvardzakheti) are located along the Main thrust and are localized in keratinized clay shales of the Lower Liassic and in Paleozoic granitoids; sandy-clayey deposits of the Upper Liassic and Middle Jurassic are ore-bearing for monomineral mercury deposits (Talakhiani, Boko, Mamisoni, Tibi, etc.); arsenic-mercury deposits (Kodis-Dziri, Chichkhva, Zrugskoye, and others) gravitate towards the lower levels of the carbonate flysch strata of the Upper Jurassic, and in the flat-leaf deposits of the Cretaceous there are deposits of antimony-arsenic ores with gold of Lukhumi and others.

The Lukhumi deposit consists of several ore bodies, the main place among which is occupied by the main ore body, which is a steeply falling column with an eastern declination.

At the first metamorphic stage of the region, quartz-calcite veins of the Alpine type crystallized. The temperature of the formation of these veins is averages 250-180°C and the formation of rhinestone in these veins occurred at a temperature of

170-100°C. Directly within the Lukhumi deposit, the temperature of the formation of metamorphogenic veins also did not exceed 250°C.

At the second stage, sulfide mineralization was formed, represented at the deposit by several associations:

a) Disseminated gold-bearing pyrite-arsenopyrite, localized mainly in clay shales and less often in quartzed limestones;

b) Vein antimonite, with a subordinate amount of scheelite, or realgar;

c) Realgar-auripigment.

The change of mineral associations is subject to an indistinct vertical zoning and corresponds to a drop in the temperature of homogenization of fluid inclusions from 360±35°C (in quartz of thin veins in the zone of development of disseminated arsenopyrite mineralization) to 260±40°C for antimonite-containing conductors and 180-30°C for realgar-auripigment mineralization.

Fluid inclusions of the metamorphogenic stage are two-phase, gas-liquid. In contrast, the inclusions of the ore stage are represented by single-phase with liquid carbon dioxide, two-phase gas-liquid, three-phase with liquid carbon dioxide and four-phase with a crystal-prisoner of needle arsenopyrite [2].

The latter type of inclusions is characteristic only of quartz veins from zones of gold-bearing arsenopyrite mineralization. The estimated minimum concentrations of iron, arsenic and sulfur in fluids are 2-3 g/l.

Ore-bearing fluids were characterized by a bicarbonate-chloride sodium-calcium composition with a salinity of up to 80 g/l in terms of NaCl.

The gas saturation of the fluids that formed the Lukhumi field is 20-30%. As the temperature dropped, the solubility of the gases decreased, which led to the heterogenization of the fluid into essentially aqueous and essentially gaseous components. Evaluation of pressure from PVT data for the CO_2-CH_4 system indicates that at temperatures of 150-200°C, the minimum pressure in the system was not less than I kbar.

Gold as an impurity is present in needle-like arsenopyrite, where its average content according to chemical and X-ray microanalysis is 300-400 g/t, and with spot microanalysis in enriched areas of crystals it reaches 15 kg/t.

According to isotopic studies, the primary source of sulfur sulfides from the Lukhumi deposit was deep emanations (δ34S=-1±3‰). Carbonate carbon was mainly borrowed from sedimentary deposits.

It is difficult to assess the primary source of water due to its intensive interaction with the rocks δDH_2O (fluids) = -80±10‰, $\delta 18OH_2O$ (fluids)=+12±2‰. δDH_2O (modern water) = -85‰).

Fluid inclusion studies carried out by us together with Z.Y. Tsertsvadze and M.I. Kucher (3) on a number of antimony-arsenic and mercury deposits in Upper Racha and Mountainous Abkhazia showed that the physical-chemical parameters of their formation are very close to the parameters of the formation of the Lukhumi deposit.

Thus, at the Zophito and Kvardzakheti deposits, crystallization of antimonite occurred at temperatures of Z00-140°C. At the Achey mercury deposit, productive ore deposition occurred at temperatures of 235-110°C. At the Kodis-Dziri deposit, antimonite crystallized at temperatures of 260-220°C, and the realgar-auripigment association with quartz and calcite at 200-120°C.

The chemical composition, salt concentration, carbon dioxide content and pressure in these ore-deposited systems are also close to the parameters recorded at the Lukhumi deposit.

Geochemical anomalies of gold are noted in the overwhelming majority of deposits of the mercury-arsenic-antimony formation of the Upper Racha in Georgia, however, the lack of data on the form of its location in the ores hampered prospecting work. At present, it can be considered proven that one of the main gold concentrates in the deposits under consideration is needle arsenopyrite.

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CONDITIONS FOR THE FORMATION OF DASHKESAN SKARN-IRON ORE DEPOSIT

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The Dashkesan skarn-iron ore deposit is located in the Somkhito-Karabakh zone of the Lesser Caucasus within the Dashkesan-Kyapyaz syncline.

In the central part of the Dashkesan syncline, the Jurassic deposits are broken through by the eponymous intrusive massif of the Cretaceous age. Its formation took place in the process of four successive phases of intrusion: gabbroid, adamellite-granodiorite, leucocratic vein; intrusive activity ends with the emplacement of basic dikes

Iron ore mineralization in the Dashkesan ore region is associated with skarn bodies developed in the northwestern, western, and southern endocontacts of the Dashkesan intrusion. According to the mineral paragenesis, the skarns of the Dashkesan deposit belong to the pyroxene-garnet and garnet-epidote facies. The first is the most high-temperature 500-600°C [1]. Lower temperature (400-500°C) skarns of garnet-epidote facies (pyroxene epidosites) are spread only in the northern areas.

For pyroxene-garnet skarns of Dashkesan, the distribution constant of iron between pyroxene and garnet is 0.22 that corresponds to strongly alkaline conditions of crystallization. The subsequent occurrence of epidote in association with garnet indicates an increase in acidity at a high activity of calcium in the fluid. A further decrease in the temperature and alkalinity of the fluid led to the precipitation of iron oxides with an insignificant admixture of sulfides. At the same time, the imbalance in the skarn-fluid system was accompanied by the replacement of primary skarn minerals with magnetite, calcite, epidote, quartz, garnet and other minerals.

Superimposed on skarn-magnetite deposits, sulfide mineralization with pyrite, chalcopyrite, cobaltite, less often with sphalerite and galena, is often associated with dikes of basic rocks of the fourth intrusive phase.

The study of inclusions in transparent minerals (garnet, quartz, apatite, fluorite, sphalerite, calcite, epidote) showed the presence of two and multiphase inclusions with prisoner crystals of silicates, sulfates, carbonates, chlorides, as well as pyrite, magnetite and hematite.

Primary inclusions in amethysts (from nests in magnetite ore) are most saturated with crystals-prisoners of halite, sylvine and magnetite. They are homogenized at temperatures of 420-350°C. The same homogenization temperatures characterize inclusions in garnets and calcites associated with magnetite.

The crystallization temperatures of pyrite and chalcopyrite can be judged by imaginary-secondary three-phase inclusions in amethysts with crystals-prisoners of halite and pyrite with a homogenization temperature of 320-200°C.

Homogenization of two and three-phase with NaCl primary and imaginary-secondary inclusions in fluorites occurs at 310-260°C. Primary and imaginary-secondary two- and three-phase inclusions with halite in post-sulfide calcites of the Northern area are homogenized at temperatures of 250-220 and 270-240°C, respectively. If green sphalerite is present in geodes, the homogenization temperature of primary two-phase inclusions is 200-180°C. Post-sulfide calcites contain only two-phase primary inclusions with a homogenization temperature of 200-160°C.

Thus, at the post-skarn, oxide-sulfide stage of the formation of the deposit, the temperature of the fluids gradually decreased from more than 420 to 200-180°C. However, the temperature drop was not smooth. Periodically, high-temperature fluids entered the level of ore deposition, as a result of mixing with which the temperature of the system increased by at least 30-50°C.

Cryometric studies in primary two-phase inclusions of garnets revealed eutectics of systems containing calcium, magnesium, and iron chlorides. Eutectics of calcium and iron chlorides are also recorded in primary and pseudo-secondary, two- and multi-phase inclusions in amethysts and early calcites.

The essential chloride, calcium-sodium composition of the fluids is also confirmed by the chemical analysis of aqueous extracts. According to the calculated data, the concentration of iron, taking into account its amount in the liquid phase, is ~60 g/kg of solution. The total content of Na, K, Ca and Mg chlorides in the fluid at the stage of formation of Dashkesan magnetite ores reaches 86 wt%. The minimum pressure at a temperature of ~400°C in this system is estimated at 700 bar with a periodic drop to 200 bar.

Crystallization of the pyrite-chalcopyrite-polymetallic association occurred at a temperature of 310-200°C and a pressure of at least 200 bar from a solution of similar salt composition, diluted to a concentration of 3 wt.% in terms of NaCl.

The fluid inclusions studied by us in quartz phenocrysts of diorite-porphyrites and granodiorites of the Dashkesan intrusive showed very high iron contents. Consequently, the fluids separated from the melts in the intermediate magma chambers were potentially ore-bearing, which, however, does not exclu de the presence of additional sources of iron.

The sulfur of the fluids had a deep source. Only the late generation of sulfides is characterized by light sulfur, which we explain by its oxidation with the formation of sulfate mineralization of the Zaglik alunite deposit, located in close proximity to the Dashkesan deposit.

Fluid carbon, according to isotopic studies of calcites of the ore and post-ore stages, also had a deep genesis. At the same time, the predominant form of carbon in the system at elevated temperatures (>250°C) was bicarbonate ion, and at low temperatures, carbon dioxide.

According to isotopic studies of hydrogen in water of inclusion fluids and oxygen of quartz and calcites, the water of ore-forming solutions at the early stages of the Dashkesan deposit formation came from the depths, and at later stages it mixed with meteoric waters of deep circulation.

Using the example of the Dashkesan deposit and the literature data, it is established that the presence of magnetite-bound minerals in fluid inclusions is a typomorphic feature of the prevailing majority of skarn-iron ore deposits in the world. Therefore, such inclusions can serve as a search criterion when predicting deposits of a given ore formation.

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SECONDARY QUARTZITES FROM TWO LEVELS OF THE MADNEULI DEPOSIT

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Rich Metals Group

As you may know, the Madneuli ore deposit has been undergoing open-pit operations for five decades. Even before that, the entire Bolnisi ore area was known and worked by different people at different times, evident from the old mining in its vicinity[1]. Over time, with technological advancements, we have gained a better understanding of the geological processes that led to the current situation in the region.

Gold is an element that has held value throughout the development of Homo sapiens and continues to be relevant today. Aside from its value, gold exhibits various noble qualities during its evolution.

The Madneuli ore deposit contains a type of gold (and not just gold) ore rock represented by secondary quartzites. These quartzites are found in the Madneuli deposit in the form of two lenses: the central lens (Fig. 1) and the eastern lens (Fig. 2).

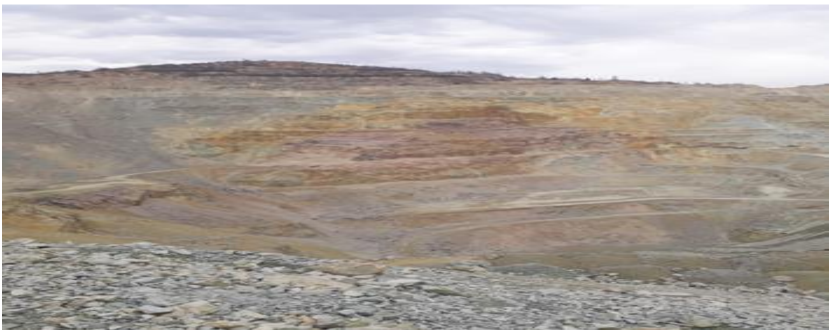

Fig. 1. The central lens.

Fig. 2. The eastern lens.

Due to its complex and diverse structure, the Madneuli ore deposit has been a subject of interest for many geologists, researchers, and scientists for several decades. It has been discussed in numerous articles and works [2, 3]. In one such article, V. Gugushvili and M. Apkhazava presented a well-defined scheme of ore production processes (Fig. 3). However, as the quarry expands, different criteria and opinions emerge (Fig. 4).

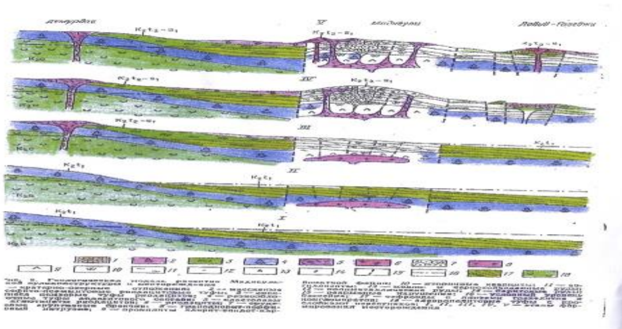

Fig. 3. Scheme of ore production processes according to V.Gugushvili.

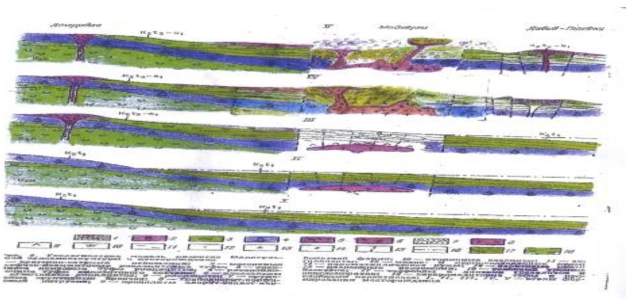

Fig. 4. Ore formation scheme – corrected.

Gugushvili and Abkhazava consider the genesis of secondary quartzites as a one-period process. However, as you may know, volcanism is cyclical and repeats processes rhythmically. In our case, the situation is similar: the central lens is relatively old, while the eastern one is young. The geological criterion known as the "Kazreti suite" supports this assumption. In one case (central lens), the sequence is covered with secondary quartzites (Fig. 5), while in the other case (left lens), the sequence is at the bottom of the secondary quartzites (Fig. 6). Based on this, we can conclude that the central lens was formed first, followed by the sedimentation of the Kazreti suite, and finally, the quartzites of the "eastern lens" overly the top of the Kazreti suite in the eastern part of the deposit.

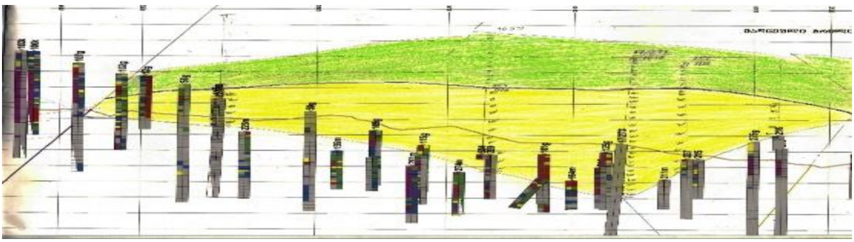

Fig. 5. Sections of the central lens.

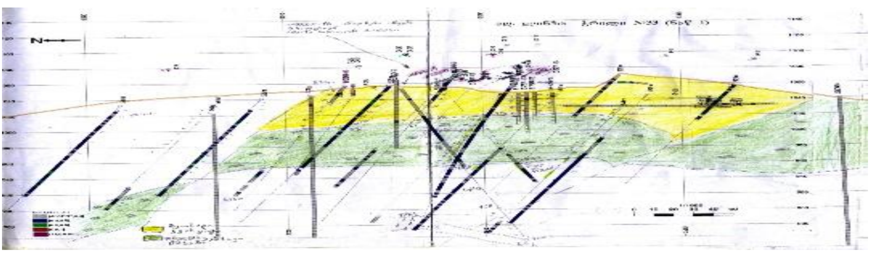

Fig. 6. Sections of the eastern lens.

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DETECTION OF IODINE CONTENT IN MINERAL WATERS OF KASPI REGION AND ITS IMPORTANCE

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Among the mineral wealth, in contrast to solid minerals, the most important is recognized as underground fresh waters. Georgia is one of the richest countries in terms of water resources, suitable for drinking and with the highest quality indicators. On its entire territory, drinking water accounts for 95% of the huge, but unevenly distributed groundwater. To date, only a third of the identified water resources have been studied in detail and approved by the state commission on reserves (4.2 billion M^3 / year).

The Caucasus fold system is a kind of natural laboratory, in which one can follow the processes of mineral water formation related to the geological development of the Caucasus region. By establishing a regularity, it becomes possible to trace the processes involved in the development of the Earth's crust of this or that region [1].

Such important physicochemical and partly geological indicators as: anionic, cationic and gaseous composition, common mineralization, temperature and conditions of their placement in different geotectonic units, allow many new hydrogeochemical and often geological detailed studies [1].

Today in Georgia more than 40 water resources have been studied. Of these, 17 occurrences are medicinal waters. Part of it is for external use (baths), part is for dual use – for on-site drinking cures and for industrial casting purposes.

Evaluation of the therapeutic activity of mineral waters and the mechanism of action on the human body is determined by the following characteristics of water: ionic salt and gas composition; temperature; specific microelements.

Chemical trace elements (iodine, bromine, boron, manganese, lithium) in the composition of mineral waters are essential for human animal activity. For the Prevention of diseases of any organ caused by a deficiency of one or another micronutrient, the consumption of mineral water can allow the body to regain and restore the concentration of the necessary microntrient.

Georgian mineral waters contain tens and hundreds of mg/L of iodine. In surface waters it ranges from 1.4 mcg/L - 24 mcg/L. High concentrations of iodine (10-59 mg/L) are characteristic for the accompanying waters of the Georgian Oil. For example, the drinking water of Tbilisi (Aragvi filtrate) contains 5–18 μg/L iodine.

From a geochemical point of view, iodine is an element of a complex nature. Despite its Clark number (400 mg/t), it is highly dispersed.

During oxidation, it is actively involved in sorption and biochemical processes in the environment, the forms of its content (iodide, iodate, molecular iodine, organic, etc.) are easily changed. Therefore, it is difficult to determine the regularity of its dynamics in time and space. Despite the difficulties, it has been established that waters in contact with sedimentary and oil-bearing rocks are distinguished by an increased iodine content [2].

Iodine is one of those microelements without which the normal functioning of the human body is not possible. It serves as a constantly filling building material for the thyroid cell. The process of its metabolism is carried out continuously, the main purpose of which is the unhindered work of hormones. It is absorbed into the body and up to 20-25 mg (the average day-night norm) of iodine accumulates.

The concentration of iodine in the blood of a human being is maintained at a constant level (10-5-10-6) - iodine mirror. 2-3 g of iodine is a lethal and dangerous amount. However, it is safe to take it in the form of iodide. When taken internally, iodine is rapidly oxidised, reacting with proteins, carbohydrates and lipids to form complex organic compounds. Still when taken artificially, with iodine preparations, during long-term treatment of iodine deficiency, an excessive amount of iodine accumulates in the body, leading to the development of iodism [3].

The prevalence of diseases caused by thyroid pathologies is quite high, according to the data of the last 10-15 years in Georgia.

The consumption of iodized salt is a common method for the prevention of diseases, that is accompanied by the peculiarity of the assimilation of iodine in solid form, the accumulation of excessively salt crystals in the body. The quality of salt decreases and loses its beneficial properties, depending on the storage conditions and heat treatment.

Water, as well as iodine, participates in the vital processes of the body. The advantages of iodised water are: iodine does not evaporate during heat treatment, does not lose its properties during storage, iodine acts as a water preservative, has no age contraindications and can be consumed up to 3 litres a day. This is the reason why iodised water is a much more effective way of compensating for iodine deficiency in the human body.

The chemical composition of the water in the six selected springs in the Kaspi district was analysed using ISO standard methods. According to the results of the analysis, the waters of the study region are practically neutral (pH=7.48-7.69) and mineralised within the norm (average number of major ions 406 mg/L, total amount of potassium and sodium 50-147 mg/L) in waters.

In the same waters, a kinetic method was selected to determine the iodine ion during all four seasons, which was based on the oxidation of the rhodanide ion with a mixture of nitrate and nitrite ions by photometric end while catalyzing iodide-ions [4].

According to the results obtained (see. Table) the iodine content varies in the limits of 16-48 mcg/L and averages 32 mcg/L.

Such iodine levels in water are considered a positive indicator.

From a scientific and practical point of view, the discovery of iodine-containing underground drinking water in the Kaspi district has increased interest in other mineral drinking water sources in the district and in geochemical studies of minerals and soils in their vicinity.

Table 1

Seasonal dynamics of iodine content, mcg/L

	Spring	Summer	Autumn	Winter
1	27	21	32	48
2	25	21	42	48
3	30	24	37	54
4	20	17	16	48
5	15	-	32	43
6	16	-	32	39

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USE OF THE "TORCO" PROCESS, THE SAME SEGREGATION METHOD, FOR THE PROCESSING OF THE OXIDIZED GOLD-BEARING COPPER ORES OF THE BOLNISI REGION OF GEORGIA, AS WELL AS THE RESIDUES FROM THE AUTOCLAVE PROCESSING OF THE CHALCOPYRITE CONCENTRATE

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Rational complex processing of mineral raw materials using production wastes is an actual problem in mining. It is to solve this problem that our researches on the use of low-quality, difficult-to-enrich gold-bearing copper oxide, mixed ores and their processing residues of the Bolnisi region. For the processing of such ores, it is promising to use the segregation method, which can ensure their effective complex processing.

The segregation method was discovered in the 1920s and found practical use 30 years later by the Anglo-American group as a "TORCO" process (Treatment of Refractory Copper Ores). The segregation method has found application in countries: Peru, Mauritania, USA, Canada, South Africa, Kazakhstan, etc. This method ensures high quality and ecological safety of the extraction of non-ferrous and noble metals.

The segregation method on the first stage implies high temperature (750-900^0 C) burning of ores in neutral or weak-reduced area in the presence of coal and sodium chloride. Chlorides copper and noble metals, obtained after the burning, are reduced on the surface of carbon with hydrogen, which is formed by the interaction of water vapor with carbon. Metallic copper and noble metals particles are collected around the carbon. The second stage of the processing is carried out by flotation enrichment of the segregation product. As a result of this flotation copper and noble metals are extracted together with coal in the concentrate.

Chemistry of the segregation process of copper oxidized ores generally accepted view [1-4] is that the segregation process consists of three sequential stages:

Stage I - Hydrolysis of metal chloride in the presence of ore components to form hydrogen chloride:

$$2NaCl + SiO_2 + H_2O_{(steam)} = Na_2SiO_3 + 2HCl\uparrow \qquad (1)$$

Stage II - Interaction of oxidized compounds of copper with hydrogen chloride to form volatile monovalent copper chloride. This process is accompanied by the release of water vapor involved in the hydrolysis of metal chloride:

$$3Cu_2O_{(solid)}+6HCl_{(gas)}=2Cu_3Cl_{3(gas)}+3H_2O_{(gas)} \qquad (2)$$

Stage III - Recovery of copper chloride on the surface of a carbon regenerator by hydrogen, generated by the interaction of water vapor with carbon. As the result metallic copper is obtained, particles of which accumulate around the carbon reducer:

$$2Cu_3Cl_{3(gas)}+3H_{2(gas)} = 6Cu+6HCl_{(gas)} \qquad (3)$$

The hydrogen chloride produced by this reaction re-participates in the chlorination of copper oxidized minerals.

The gold and silver chlorides are recovered by the same mechanism and together with the copper surround the carbon regenerator. As a result of flotation of the segregation product, these metals are removed together with the coal in the concentrate, where their content is much higher than the initial one.

The segregation roasting process has attracted the attention of many researchers of the world, and it has been introduced in several countries: Mauritania, USA, South Africa, Zambia, Peru.

We used this method for copper oxide ore (Cu-3.6%, Au-0.5g/t, Ag-2g/t) and secondary quartzites of the oxidation zone (Cu-0.02%, Au-2,0g/t, Ag-1.5g/t), as well as residues of joint autoclave leaching of Madneuli (Bolnisi region) chalcopyrite copper concentrate and Chiatura low-quality floatation concentrate - iron cakes (Cu-1.3%, Au-3.8g/t, Ag-38g/t) for processing. These residues contain iron oxide and calcium sulfate in increased amounts. Anthracite-250 μm in size was used for experiments, which contained: C-91.12%, H-2.16% and sodium chloride - quality "pure for analysis" - size -100 μm.

Experiments have established that for successful segregation roasting, pre-oxidizing roasting of iron cakes is required, because copper is in sulphide form in the residue.

The devise for segregation roasting was a quartz reactor, which was heated in an electric furnace. It was rotated by a special drive device. The reactor could hold a weight of 150-200g. Nitrogen was supplied from the cylinder at a small rate (30 cm^3/sec) during furnace heating, working temperature and cooling of the cask to remove air oxygen from reaction area. The gases were expelling by a rubber tube in the hydroshutter. The reagents were mixed with the cake in a cold state or heated to the temperature given in the reactor. Rotational speed of reactor is 10rot/min, and furnace heating speed is 10 grade/min.

After cooling, the flotation enrichment of the segregation product took place without crushing under the following conditions: Pulp pH – 8-11; Collector - potassium butyl xanthogenate (100 g/t); pine oil (50 g/t); Duration of main and control flotation is 15 and 10 minutes.

Experiments are carried out on cakes after pre-oxidizing roasting (at 850 – 900^{0}C in a muffle furnace or quartz rotating reactor). Determined the optimal conditions for segregation roasting of iron cakes: temperature - 850^0C, consumption of coal - 1.5% of cake mass, and consumption of sodium chloride - 1% and duration of segregation roasting - 30 - 60 min. The degree of removal of metals from the concentrate under these conditions is: Cu – 91.6%, Ag – 85.8%, Au – 93.3%.

Studies using the segregation method were also carried out on the copper oxide ore (Cu-3.6%, Au-0.5g/t, Ag-2g/t) and secondary quartzites (Cu-0.02%, Au -2.0g/t, Ag-1.5g/t) of Bolnisi region. These ores were also subjected to segregation roasting after preliminary oxidizing roasting. The experiments were carried out under the optimal conditions selected for iron cakes. Under these conditions the degree of extraction metals in the flotation concentrate of copper oxide ore segregation product was 86-93%, and in the case of secondary quartzites it was within 80% that was probably caused by the low copper content in quartzites (0.02%).

As a result of the segregation of copper oxide ores metallic copper accumulates around the coal, and in the case of iron cakes, the recovered metallic copper accumulates around the coal, then it gradually passes into chalcosine - (Cu_2S) at the expense of sulfur of calcium sulfate, present in the cakes. It is advisable to continue research on copper oxide ores in order to refine the segregation roasting technology.

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RESEARCH ON THE STABILITY OF COMPOSITE MATERIAL REINFORCED WITH STEEL WIRE UNDER THE INFLUENCE OF DIFFERENT DIAMETERS AND VOLUME CONTENT OF REINFORCING ELEMENTS

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In recent years, composite materials have been actively used for the production of separate units of machine-building and special equipment. The production of composite materials by traditional welding and rolling methods has certain disadvantages, which are related to the structural change of the reinforcement materials due to the high temperature during the welding process. The latter causes a change in the physical-mechanical characteristics of the composite [1]. In order to solve the mentioned problems, the use of explosion energy for the production of composite materials has certain advantages [2, 3]. Explosion welding is one of the advanced methods for obtaining high strength and high modulus fiber reinforced metal materials. Due to the lack of comprehensive studies, it is not possible to establish physical bases for predicting the structure and physical-mechanical properties of reinforced composite materials.

Optimum use of explosion energy to obtain composite material with reinforcing elements is particularly topical. The mentioned physical process is related to the generation of impulse voltages in a short period of time, accompanied by a fast physical process in time, which complicates the final definition of the physical-mechanical properties of the reinforcing element of the composite material.

When producing reinforced composite materials, first of all, it is necessary to preserve the initial mechanical properties of the steel matrix and the reinforcing wire as closely as possible. At this time, it is necessary to have minimal diffusion interaction on the separating surface. Methods of manufacturing reinforced composite materials, associated with temperature rise during the reinforcement process, should be minimized.

As is known from the literature, in all studies carried out to date on the production of a heterogeneous reinforced composite material, titanium and aluminum are used as a matrix both in dynamics and in statics.

In accordance with the existing schemes for producing reinforced composite materials by explosive welding, matrix layers and steel wires are alternated. Obviously, characteristics such as the diameter ratio of the matrix plates and the steel wires and the pitch (distance) between the steel wires determine the volume content of the reinforcing phase. At the same time, the geometry of the steel wire arrangement should ensure all-round contact of the steel wire with the matrix, because it is on the dividing surface that the bonding between the matrix and the steel wire is formed. Therefore, the bond must be made not only along the matrix-steel boundary, but also along the matrix-matrix boundary in the wire space. The analysis of the structural characteristics of the matrix-wire and matrix-matrix boundaries of the bond made it possible to reconstruct the picture of the interaction of the elements of the steel wire reinforced composite material along the collision boundaries. An important characteristic of reinforced composite materials is the volumetric content of steel wire. Taking this into account, the volume of the explosion welding schemes of reinforced composite materials is determined by two factors - the ratio of the matrix plates and wire diameters and the pitch (distance) of the steel wire arrangement. Under the conditions of the location of the steel wire with different pitches (distance), different physical conditions are realized that ensure the interaction between the matrix plates and the steel wire.

Ammonite 6 ЖВ was used as an explosive material in the experiments during explosion welding and reinforcement. Explosion welding and reinforcement were carried out with a flat welding scheme. In the experiments, steel wires with diameters of 0.8 mm and 0.33 mm were used, the tensile strength of which were 1225 MPa and 1600 MPa, accordingly. The height of the explosive charge was also chosen different, particularly 11 mm and 12 mm. This difference is clearly visible in the results obtained from the experiments. When the height of the explosive charge was 12 mm, the surface of the reinforced composite material experienced more deformation than when it was 11 mm.

Figure 1 shows a composite material reinforced with 0.8 mm diameter steel wire, where the wire arrangement pitch (distance) is 50 mm.

Fig. 1. 0.8 mm steel wire reinforced composite.
Pitch (distance) - 50 mm.

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CLEANING OF MINING PRODUCTION WASTE USING THE BACTERIAL METHOD (ON THE EXAMPLE OF THE CHIATURA REGION)

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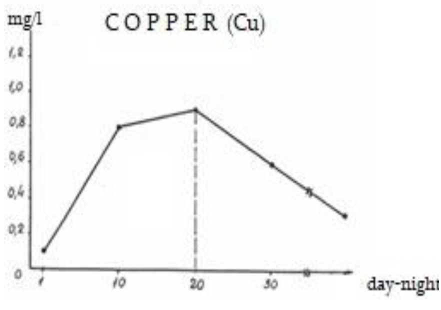
The exploitation of the Chiatura manganese deposit has more than 150 year history. Anthropogenic impact on the environment has reached a critical limit in the region. A large area of the city Chiatura is covered with the manganese ore enrichment residues, and their washing surface waters flow into the river Kvirila, which retains a specific grey-black color for a considerable distance due to the content of a large amount of manganese (10 - 12%) [1].

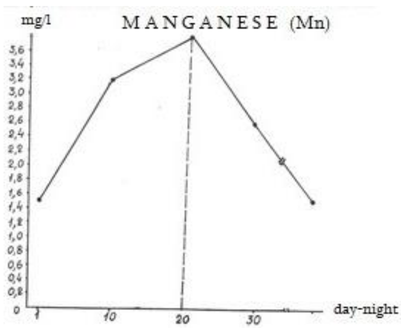
Mining production waste is excessively accumulated in the ore placement area, it is understood that this is a great danger to the local population.

Therefore, to improve the ecological situation, it is necessary to improve the technology of ore processing, so that production waste is less in volume, and contains fewer toxic metals, which will contribute to the improvement of the ecological situation of the Kvirila river and also make it possible to provide the population with clean drinking water.

Long-term studies have confirmed the importance of biochemical depletion as one of the leading geological factors. The advantage of using the bacterial method lies in the fact that different physiological groups of microorganisms use mineral mass as food in the process of animalization. It breaks down the crystal matrix of minerals, releases such chemical elements that are necessary for the vital process, while the inert elements for this process remain in solution in one form or another, and there is a real possibility of their removal from biological water soluteons.

According to the method developed by us, the bio-organic complex (contact solution) necessary for removing chemical elements from production waste is prepared based on natural peat, the deposits of which are abundant in the Black Sea coast of Georgia. Before the extraction, an energetic material is added to the peat's bio-organic complex, which helps activate the microorganisms' vitality. The intensity of activity of microorganisms involved in bacterial excretion is directly related to environmental conditions, especially temperature. Experiments have established that the peak of the intensity of animal activity corresponds to the interval of the ambient temperature of 26-28 C^0 when there is a transition to high concentrations of elements in the solution. Based on multiple studies, it was determined and established that the maximum effect of removing metals in the contact solution is observed in an acidic environment (pH=5.5 - 5.6) when it seems that the conditions are suitable for the activation of animalization process of microorganisms. The optimal time required to reach the maximum concentration of elements in the contact solution is 20-25 days [2].





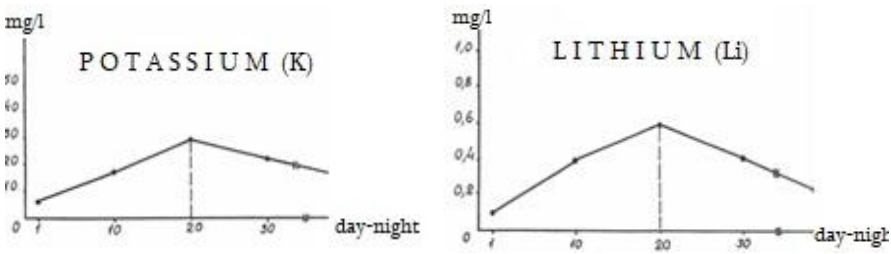


Fig. 1. Dependence of the intensity of leaching on the duration of contact with the solution.

The advantage of the proposed method compared to the methods known to date lies in the fact that the leaching of metals is not carried out by one particular artificial strain of bacteria, the isolation and reproduction of which is a time-consuming and expensive procedure, but by the community of bacteria present in the peat under natural conditions and multiplied by methodical support under optimal conditions and easily available.

With the method developed by us, it is possible to remove metals from bulk, production waste, and even loose rocks, which leads to significant decontamination of three ore production wastes, which will contribute to the cleaning of the surface and underground water and maintaining the ecological balance of the environment [1].

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STUDY OF NATURAL ROCKS OF GEORGIA AS THE MAIN RAW MATERIAL FOR THE PRODUCTION OF VITREOUS MATERIALS

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In Georgia, due to the lack of high-quality raw materials for glass production, the search and study of such complex natural raw materials, which simultaneously contain several glass-forming oxides, is topical. As a result, it will become possible both to simplify the process of glass synthesis, as well as to save scarce raw materials.

From this point of view, it is interesting to study the easily accessible rocks of Georgia in order to use them in the production of vitreous materials.

These circumstances served as the basis for specific studies: the researches of waste from the processing of rocks of both neutral and basic composition (basalts, andesites, ignimbrites of various deposits) as non-traditional raw materials.

After establishing the stability of the chemical, mineralogical compositions and reserves of these rocks, basalts were especially distinguished; they are ready-made raw materials, which, without any adjustment in the temperature range of glass melting (1450-1500°C), pass into a glassy state and form a high-quality homogeneous glass mass. Their fusibility is due to the presence of an optimal ratio of various fusible oxides, which makes it possible to exclude unnecessary processing steps (grinding, dosing) and batching from the technology. The study of the technological and physical-chemical properties of the obtained glasses revealed the effectiveness of basalt glasses, both for the manufacture of black facing tiles with a mirror surface by casting, and for the production of fibrous materials from mono-charge.

Studies have shown that the use of basalt for the production of fiber makes it possible to simplify the technological cycle, since the preliminary melting of glass and the production of granules from it are excluded, therefore, instead of the tradetional two-stage fiber production, a filament is obtained after one stage, which leads to significant energy savings.

The laboratory study of the basalts Chiatura, Akhaltsikhe, Marneuli, Tejisi, Aspindza and Kosalari established their suitability as a mono-charge for the production of fibrous materials. Based on their physico-chemical and technological parameters, the preference was given to Marneuli basalt. It features high stability of the fiber spinning process. A wide processing interval makes it possible to reduce the diameter of a filament to 9 μm, and the resulting material is characterized by high thermal stability, tensile strength and alkali resistance.

Based on the results obtained, technological lines for the production of continuous and staple fiber using Marneuli basalt were launched in Rustavi and Tbilisi.

The investigated rocks were also studied to obtain glass-ceramic materials. Research has established that a slight adjustment of rocks significantly increases their crystallization ability, which is a decisive factor for the synthesis of glass-ceramic materials.

By correcting Marneuli basalt with the help of barium sulfate and dolomite, a technology was developed for obtaining glass-ceramics of a fine-grained structure, which were distinguished by high wear resistance and heat resistance.

In order to obtain coarse-grained cast stone, andesite was successfully used, the use of 60-70% of which made it possible to obtain heat-resistant and alkali-resistant compositions.

In addition to the studied rocks of basic composition with high iron content, rocks of acidic composition with low iron content were also investigated in order to obtain container glass.

The study of quartz-adular metasomatites, trachyrhyolites, ignimbrites and rhyolites showed the possibility of their use as a partial replacement (30-40%) of the main components for container glass (quartz sand, soda) and a reduction in the number of standard components.

The use of the studied rocks made it possible to completely exclude alumina-containing raw materials. The obtained experimental container glasses meet the requirements of the standards.

The study of these materials proved that the above-mentioned rocks, in terms of their chemical and mineralogical composition, technical characteristics and technological parameters, can be used in the production of glass tiles, fibrous and glass-ceramic materials. All of the above makes it possible to turn the waste of stone-working quarries into cheap raw materials for the production of vitreous materials.

USE OF CHLORIDE SYSTEMS IN THE PROCESS OF ELECTROCHEMICAL LEACHING OF GOLD REFRACTORY SULFIDE ORES

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Of great interest as a source of noble metals are the tails of the enrichment of non-ferrous and rare metal ores, which mainly belong to the category of refractory sulfide ores. The problem of processing gold-bearing refractory sulfide raw materials, including technogenic residues, is also relevant for Georgia. Over the course of its long operation, a huge amount of flotation tailings of enrichment has been accumulated on the territory of the Madneuli mining and processing plant, which contains tens of tons of gold and several hundred tons of silver and create an environmentally dangerous situation. Currently, their processing is not carried out due to the lack of effective technologies, while being a source of air basin and water reservoirs pollution.

In the world practice of gold mining, the main method of extracting gold from ores and concentrates is the cyanide method [1], which, when applied to refractory sulfide ores, does not provide economically viable indicators. The disposal of cyanide solutions also remains a serious problem. The use of non-traditional methods for processing these ores is characterized by complexity, multi-operation, energy intensity and does not always provide high rates of gold recovery. Therefore, the problem of finding environmentally and economically acceptable methods for processing refractory sulfide minerals will make it possible to solve the problem of increasing the completeness of the use of natural resources while reducing the ecological burden on the environment.

The object of our research was the flotation tails of the primary enrichment of gold-bearing sulfide concentrates (quartzites, barite-polymetallic and chalcopyrite) of the Madneuli deposit.

Instead of the well-known method of hydrochlorination, we chose the method of electrochemical oxidation of sulfides in ore pulp using various chloride systems as a method for processing gold-bearing tailings from the enrichment of refractory sulfide concentrates. The advantage of the electrochlorination method over hydrochlorination is the simultaneous regeneration of the oxidizing agent, molecular chlorine, at the anode.

Studies have shown [2, 3, 4] that the Cl_2-NaCl-HCl-H_2O system is characterized by the highest Red/Ox potential at 0.5M HCl, which was used by us for processing gold-bearing refractory sulfides by electrochlorination. The use of this method gives a high degree of extraction of gold from quartzites containing highly dispersed nuggets of metallic gold. However, it does not give the desired results in the leaching of flotation tailings of the enrichment of refractory sulfide ores. The reason for the low degree of gold recovery in this system is the incomplete opening of the sulfide layer covering the disseminated gold in the sulfide mineral during electrolysis.

In search of ways to increase the recovery of gold and simplify the processing technology of sulfide mineral, research was carried out in the direction of applying the method of direct electrochemical leaching using a non-toxic electrolyte based on alkali metal chlorides in the presence of an organic complexing agent that gives a cationite complex with gold.

The method provides electrochemical treatment of a refractory sulfide mineral (in the form of a suspension or pulp) in a chloride electrolyte containing an organic complex-forming agent-thiourea in a potentiostatic mode at room temperature. The introduction of thiourea into the chloride solution reduce the Red/Ox potential of the system from 0.8–1.2 V to 0.35–0.45 V, which helps the electrochemical leaching process under “soft” oxidizing conditions without the release of molecular chlorine at the anode and environmental pollution. This method was successfully applied by us in the processing of gold-bearing flotation "tails" of enrichment of barite-polymetallic, chalcopyrite and antimony gold-bearing concentrates after vacuum heat treatment.

In the process of leaching, under the influence of electrochemical reactions, the electronegative metal of this system will be the first to dissolve. As a result of the electrochemical dissolution of sulfides in the anode space, the mineral is destroyed and finely dispersed gold mineralization is exposed. Under the influence of the selective complexing agent of noble metals, free thiourea, contained in the electrolyte, gold will go into solution in the form of a cationite complex $[Au(TiO)_2]^+$ with instability constant K-10^{-23}(pK-22) according to the reaction:

$$Au+2ThiO+Cl^- \rightarrow [Au(TiO)_2]^+Cl^-+e^-$$

At the cathode, the discharge of these complexes and the deposition of metallic gold will occur. The catholyte, after extracting gold and adjusting, returns to the anode space.

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IMPACT OF ORGANIC FERTILIZER-STIMULATOR ON SOILS AND POSSIBILITIES OF RECULTIVATION-REMEDIATION

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The organic fertilizer-stimulator presented by us can be used for all types of soils, both in solid and liquid form. Soil recultivation-remediation is possible in the conditions when the soil fertility rate is studied in advance and in case of pollution the degree of toxicity of heavy metals, solubility coefficient, valency, forms, distribution area and pH must be studied. Organic fertilizer-stimulator is a vital food source for microorganisms. It regulates oxidation-regeneration processes in the soil, improves soil porosity, which in turn affects the quality and quantity of obtained products. The production of fertilizer is simple and waste-free. It is distinguished by its high quality and is economically profitable. If the type of soil and the rate of fertility are determined correctly, the result will not be delayed, the quality and yield of products will increase accordingly. A visual image of the organic fertilizer is given below (Fig. 1).

Fig. 1. Solid organic fertilizer.

As for the liquid stimulant, it is also prepared for special cases considering the degree of heavy metal contamination in the soil. For example: if the concentration of lead, cadmium, arsenic, copper, zinc, etc., exceed MPC a certain amount of stimulator is poured per square meter, which ensures the accumulation of heavy metals up to MPC [1]. This approach will prevent the transfer of heavy metals into products from agricultural soils.

EPA test methods [2] were used to leach mobile soluble forms of heavy metals. In the second stage, the process of soil recultivation was carried out in order to determine the amount of solid fertilizer needed for application and identify the optimal conditions.

In Georgia, 50% of soils are barren, eroded, and podzol. The relevance of the topic lies in increasing the fertility rate of this type of soil (Fig. 2).

Fig. 2. Cultivated soil.

In the case of industrial areas of Georgia, we consider it necessary to study fill-up soils as well; to provide mobile-soluble forms of heavy metals and their subsequent accumulation process with the help of our liquid stimulator. Soil recultivation was carried out with solid organic fertilizer.

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CONDITIONS OF FORMATION AND SOURCES OF ORE SUBSTANCE OF THE MAYSKOYE GOLD DEPOSIT

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The Mayskoye gold deposit is located on the periphery of the Okhotsk-Chukotka volcanogenic belt and is one of the richest objects of the gold-arsenic-antimony formation in the northeast of Russia.

The ore field is composed of dislocated sandy-shale rocks of the Triassic, broken through by numerous dikes of medium and acidic composition [1].

At the field, two complexes of dike bodies successively replacing each other are distinguished. The first, associated with the Kukenei intrusion, includes granite-granodiorite-porphyries, which compose large bodies of the northeastern strike, with a thickness of 1-5 to 50-60 m, with a southeastern fall at angles of 50-70°. To the second, dikes of rhyolite-porphyries of the subvolcanic complex that are widely spread in the field and have relatively even distribution. The length of individual dikes reaches 1-2 km, and the thickness varies from 1 to 60 m.

The age of the igneous rocks of the deposit corresponds to the boundaries of the Early and Late Cretaceous. An important structural feature of the deposit is the development of bodies of explosive vein-shaped breccia within its limits. The general strike of the breccia bodies is submeridional, the fall is eastern at an angle of 60-75°, and thickness is 1-10 m, with a spread to a depth of more than 700 m.

In the central part of the deposit, quartz-sericite rocks are spread. The contour of metasomatites has the shape of an oval, elongated in the northeast direction and expanding downwards. Ore-deposition-related metasomatosis is characterized by a weak transformation rate and responds to the argilisite formation. At the Mayskoye deposit, about 20 ore bodies with a capacity of 2-4 m and a length of 200-1100 m with an average gold content of 12 g/t were identified. The established vertical mineralization span is 800 m, estimated to be more than 1200 m [2].

The lithological factor plays an important role in the placement of mineralization. The most favorable for ore formation are essentially siltstone strata of the central block of the deposit.

Ore bodies are represented by mineralized crushing zones mainly with distinct geological boundaries and are composed of metasomatically altered, vein-quartzed, weakly sericitized and kaolinized rocks (siltstones, clayey shales, fine-grained sandstones, in some cases dikes of quartz porphyries), impregnated by interspersed with gold-bearing sulfides.

At the deposit, gold-arsenic-sulfide mineralization is superimposed on all types of igneous rocks and explosive breccias.

Gold is evenly distributed with a coefficient of variation of 40-60%. The main mass of gold is contained in sulfides – needle-like arsenopyrite and pyrite. A smaller part of gold is represented by interspersed grain sizes from hundredths to the first mm. Silver is contained in the form of impurities in sulfides.

A two-stage formation of the deposit is assumed - the first rare-metal with cassiterite, wolframite, scheelite, arsenopyrite, bismuthin and gold, and the second productive with arsenopyrite-pyrite-quartz, stannin-quartz, gold-sulfoantimonite-quartz, gold-antimonite, and gold-arsenic-kaolinite-quartz associations [2].

According to the analysis of needle-like crystals of arsenopyrite on the X-ray microanalyzer, the gold content in them ranges from 0.3 to 10 kg/t, averaging 0.8 kg/t.

The chemical composition of ore-forming solutions according to the analysis of aqueous extracts indicates a bicarbonate-sulfate, sodium-potassium composition with a mineralization of no more than 120 g/l.

The study of fluid inclusions showed that the formation of the deposit occurred with a gradual decrease in the temperature of ore-forming solutions from 380 to 160^{0}C. At the same time, rare-metal ores were formed at high temperatures of ~380^{0}C and below and pressures of ≥140-100 MPa, arsenopyrite - containing associations from 330 to 200°C and pressures from 80 to 20 MPa, and antimony and arsenic minerals at temperatures from >280 to 150^{0}C and pressures from >45 to 15 MPa.

Isotopic studies of sulfides have established a deep source of sulfur in the fluids of the ore-forming system. Isotopic studies of carbonate carbon establish their facilitation by 5±2‰, which may be due to the isotopic specificity of the parent melts or to the partial removal of carbon dioxide from deep fluids as they move to the level of mineral deposition [3].

Isotopic studies of fluid inclusions hydrogen water in minerals of productive and post-productive associations record only the meteoric component, but the presence of high-temperature fluid inclusions with minerals in pre-productive mineral associations indicates the presence of a magmatogenic component in the hydrothermal fluids.

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DETERMINATION OF THE MASS OF LOAD CARGO TRANSPORTED BY AERIAL CARGO ROPEWAY

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The paper considers the issue of determining the mass of loose, bulk cargo transported by a cargo cableway. A new automated system for weighing cargo without stopping the trolley is proposed. To achieve this goal, it is necessary to change the design of the cable car trolley.

Aerial cargo ropeways (ACR) are used in many industries: ferrous and non-ferrous metallurgy, chemical, mining, forestry, building materials industry and other industries, as well as in agriculture, because they successfully compete with rail, road and other types of industrial transport. [1].

The most widespread use of ACR was found for the transportation of bulk cargo - minerals from mining sites to processing sites and shipment to consumers. For example, at the enterprises of the manganese industry, in many cases the ACR is the only transport for delivering ore from quarries and mines to processing plants, as well as for transporting waste rock to the dump [2, 3].

Accounting and control of the amount of goods transported by the ACR can be solved by several methods. The simplest is to determine (and register) the number of ore-loaded trolleys.

The simplest device of this type consists of a short piece of overhead rail with a counting device. The counter turns on only under the influence of the weight of the trolley with a full load. Empty and under loaded trolleys are not taken into account. However, such an indirect determination of the mass of bulk cargo transported by the ACR, taking into account the carrying capacity and capacity of the trolley, is approximate and cannot take into account the grain size composition, particle shape and moisture content of the cargo, which determines the actual weight of the trolley with cargo.

At mining and processing enterprises, the difference between the actual mass of cargo and the mass of the determined indirectly amounts to several tens of tons per shift.

For weighing trolleys, ACR use suspended scales, which are included in the overhead track. The section of the rail cut out from the overhead track, sufficient to place a trolley on it, is suspended with the help of shoes to a rectangular scale frame, which rests on four levers that transmit pressure to the bar with a movable load.

However, this method has a significant disadvantage: when weighing, it is impossible to get rid of the action of the mass of ropes, and therefore it is impossible to accurately determine the mass of the load in the trolley.

The trolleys with a carrying capacity of 2.0 and 3.2 tons, with a cargo capacity of 0.63 to 2.0 m^3 (types of trolleys 2,000; 2,000R, 2,000U) and depending on the type of cargo, the weight of cargo in trolleys can be different [2, 3].

Based on the above, the non-stop determination of the mass of bulk cargoes of each ACR trolley and the receipt (calculation) of total data on the mass is a very urgent task.

To ensure the possibility of determining the mass of the loaded trolley during its movement, without stopping, a trolley of a new design and an automated system for determining the mass of the cargo transported by the ACR are proposed.

In the suspension of the trolley of the new design, grooves are provided that will enable the tipping trolley body to move in a vertical plane. In other words, it is possible to run into the weighing platform and for a certain time to get rid of the mass of ropes and the trolley.

The presented automated system makes it possible to obtain a measurement error of not more than 0.5% in the measurement range from 500 to 2,000 kg. ACR trolleys of a new design and an automated system for determining the mass of bulk cargoes should find application in the transportation of mass bulk cargoes: minerals (coal, gravel, crushed stone, manganese), chemical raw materials, as well as waste rock in the dump.

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THE USE OF AERIAL CARGO ROPEWAY TRANSPORT AT MINING-ENRICHING ENTERPRISES

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The paper deals with the use of aerial cargo ropeway (ACR) for the transportation of goods in mining and processing enterprises. A scheme for transporting ore with the use of ACR is proposed.

Freight aerial ropeways are one of the types of industrial transport for the transportation of bulk minerals.

ACR is most widely used in mountainous, rugged, hard-to-reach, densely populated areas and the location of mining and processing enterprises, where they provide transportation with the highest speed and lowest cost.

Comparison of the main technical and economic indicators of road and rail transport and the ACR revealed that the ACR has a number of strategic advantages over other types of transportation of minerals, especially for mountain regions. It has been proven that the use of ACR reduces the cost of transportation by 10 times or more.

In Georgia, at the end of the 20th century, not only passénger, but also unique ACR operated in the most difficult mining conditions that indicate the presence of a certain engineering and technical potential in Georgia.

The main advantages of ACR are:

- ✓ Independence from the terrain profile;
- ✓ The possibility of laying the route along the shortest distance between the points of loading and unloading;
- ✓ Independence from atmospheric conditions;

It should be noted that in recent years, ACR have become, under certain conditions, a fairly serious competitor to road transport.

Currently, none of the existing traditional modes of transport (railway, road, air, river and sea) meets modern requirements. The introduction of cargo cableways into the transport system allows creating a completely new type of transport that is cheap in construction and operation.

Freight aerial ropeways (ACR) are most widely used in mountainous, rugged, hard-to-reach areas, where they provide transportation over the shortest distance and at the lowest cost. Freight aerial ropeways are one of the types of industrial transport for the transportation of bulk minerals.

The main factors determining the advantage of ACR in comparison with other modes of transport (road, rail) include:

- A significant reduction in the transportation distance, since the routes are laid along the shortest path between the end points with an allowable slope of 45 °;
- Uninterrupted operation regardless of weather conditions (except for very strong winds);
- A relatively low volume of one-time capital investments and operating costs required for the construction and operation of the ACR;
- Reduction of land allotment and prevention of cutting down large areas of forest;
- Stimulating the development of high-mountain regions;
- Exclusion of environmental pollution;
- Reduction of noise from machines.

Aerial cargo ropeways ACR are mainly used for intrafactory transportation of bulk cargo, especially in rough and mountainous terrain.

In the process of work, a classification scheme for industrial transport, as well as special-purpose transport, was drawn up. The place of ACR in the technological process of the mining and processing plant is shown.

The classification features of the ACR were determined and a scheme for the transportation of manganese ore from the mining sites to the shipment of the products to the consumer was developed.

It can be confidently said that ACR are the most modern and technologically advanced type of transportation of bulk cargo (ore) and there is a great future for cargo aerial ropeways

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SYNTHESIS OF A NEW HIGH ENERGETIC COMPOUND BASED ON TNT

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In nature, explosives are mined in extremely small quantities. Their absolute majority is produced by synthesis.

Today, many explosives of various functions and types are produced in the world, but the requirements for them are growing and becoming more stringent. In particular, mass-produced explosives for industrial use, together with many positive factors, they have strong disadvantages that are most often expressed in energy, environmental, expertise and economic indicators.

So, in order to get rid of these negative sides, as well as to reduce risks during production and use, is absolutely relevant topic of the development of new methods for the synthesis of explosives and their improvement.

The main goal of the work was to research and perfect the methods of synthesis of high energetic substances. Research focused on recycling expired compounds and increasing efficiency. Through chemical transformations of expired TNT, in particular, its interaction with resorcinol, a new compound was obtained. The explosive transformation ability and energy characteristics of the synthesized material were investigated. It was determined that the brisance of the synthesized material was 12% higher than the brisance of expired TNT.

EXPERIMENTAL LABORATORY STUDY OF UNDERGROUND GASIFICATION OF TKIBULI-SHAORI DEPOSIT COALS

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In the 21st century, coal still remains one of the main sources of world energy generation [1]. The coal mining industry is growing in the world, but the development of rational, safety and break-even coal mining technologies remains an unsolved problem. Mentioned problems are also relevant for the Tkibuli-Shaori coal deposit, the main energy resource of Georgia, which is characterized by difficult mining-geological conditions, rock bursts and sudden eruptions, explosive concentrations of dust and gas generated during extraction, self-igniting coal layers and endogenous fires, labor safety complexity leading to frequent accidents [2].

In recent years, intensive research has been carried out in the coal-producing countries of the world on the development of technologies for underground coal gasification (UCG) [3], the rationality of using which in the development of the Tkibuli-Shaori deposit has been repeatedly noted by the scientific community of Georgia [4].

The paper presents the results of the experimental works carried out at the G. Tsulukidze Mining Institute on the laboratory UCG georeactor (Fig. 1) created for the experimental study of underground gasification of coal from the Tkibuli-Shaori deposit. The laboratory georeactor is a physical model of the shaft area conditionally allocated for gasification, where the experimental work of studying the UCG process is carried out.

Fig. 1. Laboratory georeactor for UCG study -
1. Injection well, 2. Ignition window, 3. Gasification chamber,
4. Production well.

As a result of the experiment, the necessary temperature characteristics of coal flames and the gasification process were established. Syngas was obtained under the conditions of using atmospheric air as an injection agent, the ignition (burning) characteristic was assessed and the composition of the syngas was determined.

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THE IMPACT OF GLOBAL SOCIO-ECONOMIC CHALLENGES ON GOLD PRICE DYNAMICS

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In recent years, the world has faced many challenges, between them the global coronavirus pandemic, which started in 2020. That year, the global economy has contracted sharply, at least by 3 %, which is worse than the global crisis of 2008-2009. The world economy, affected by the pandemic, could not fully recover from the crisis, when in 2022 a new serious disaster hit the world - this is the large-scale Russian invasion of Ukraine, which in various ways (supplying weapons, humanitarian aid, accepting refugees, imposing sanctions, etc.) All leading states are involved. Obviously, this war has a great negative impact on the world economy, reduces the rate of growth of the world economy and therefore hinders its development [1].

As for the price of gold, the observation of the change in the price of gold in recent decades (see diagram № 1) allows us to say that when the modern world entered into political or economic crises, or suddenly the circumstances changed the development trajectories, gold was a metal that reacted sensitively to political-economic concerns and its price rose instantly. An example of this is the jump in the price of gold after the terrorist attacks of September 11, 2001 year, as well as the increase in the price of gold during the so-called American mortgage crisis of 2008.

Diagram № 1 shows the gold price peaks on August 7, 2020, when it amounted to \$2,034/oz (oz-31.1 gr.) and on April 15, 2022, at \$1,974/oz, respectively.

At the moment, the price of gold remains at a fairly high level of 1982.81 $/oz (2023.04.23), although the panic on the gold exchange has already stopped [2, 3].

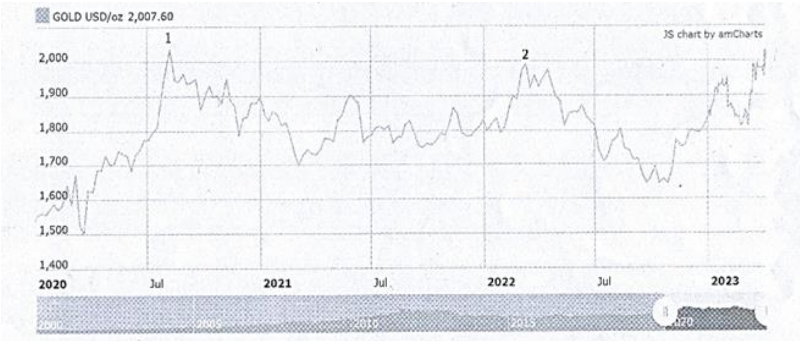

Fig. 1. Gold price dynamics from January 1, 2020 to March of 2023
Price peaks: 1. August 7, 2020 - $2034/oz.
2. March 11, 2022 - $1,991/oz.

What makes gold the safest investment even in the most difficult times is, on the one hand, its close historical connection with the beginnings of capitalism, free trade, the development of the banking system and, subsequently, the financeialization of already global structures, and on the other hand, its physical characteristics – the scarcity of reserves, the extraction process complexity and accompanying large-scale socio-ecological problems, the rustlessness of the metal itself, resistance to time, as well as its color and shine.

Gold is a solid investment that never loses value and successfully resists inflation. Therefore, the price of gold and the demand for it worldwide are increasing tremendously. It still remains the most demanded and expensive metal, which guarantees the financial stability of the rich and wealthy class in times of crisis or political instability [4].

From all of the above, we can conclude that the negative cataclysms occurring in the world "positively" affect the price of gold and increase the demand for it.

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PHYSICO - CHEMICAL STUDY OF INDIVIDUAL BENTONITES DEPOSITS OF GEORGIA AND SOME FOREIGN COUNTRIES

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The areas of application of bentonite clays are very diverse and at present the demand for high-quality bentonites is not decreasing, which is mainly due to their specific physical and chemical properties.

The purpose of the study was to determine and evaluate some of the main physical and chemical properties of bentonites.

The objects of study were bentonite clays from deposits in Georgia (Vaniskedi, Tsikhisubani, Ozurgeti, Chiatura), and bentonite clays from foreign countries (from England, Yugoslavia, Japan, Bulgaria, Hungary) were used as objects of comparison, as well as a standard sample of bentonite molding clay K 11 [1]. Bentonites are represented by Ca-montmorillonite; as impurity minerals they contain: Ca-Na-feldspar, mica, quartz, calcite and α-cristobalite.

For the studied bentonites, such indicators as the content of the mineral montmorillonite, swelling, colloidality, bentonite number, water absorption were determined, on the basis of which their technological assessment is usually carried out. The results of determining the physico-chemical parameters are presented in table 1; it should be noted that the assessment of the mass fraction of montmorillonite, colloidality and water absorption was carried out according to the classification of molding bentonite clays [2].

Table 1

Physical and chemical indicators of bentonites

№ №	Bentonite sample and country	Bulk share montmorillonite, %	Swelling, cm^3	Colloidality, %	Bentonite number, %	Coefficient of water absorption, K
1	Vaniskedi section1 – Georgia	72,0	10,0	28,0	30,0	2,3
2	Vaniskedi section2 – Georgia	69,0	13,0	33,0	33,5	2,72
3	Tsikhisubani – Georgia	64,0	14,0	97,0	98,0	5,4
4	Ozurgeti – Georgia	78,0	17,0	85,0	-	6,05
5	Chiatura sample №2 – Georgia	16,0	6,0	13,0	13,0	1,2
6	England	20,0	5,5	47,3	-	2,3
7	Yugoslavia	35,0	2,5	10,0	-	-
8	Japan	32,0	2,5	11,0	-	-
9	Bulgaria	97,0	2,13	13,0	-	1,2
10	Hungary	83,0	18,5	60,0	74,75	5,45

Thus, among the bentonites of Georgia, the samples of Ozurgeti (78,0%) and Vaniskedi section 1 (72,0%), have a high content of montmorillonite - the samples of Vaniskedi section 2 (69,0%) and Tsikhisubani (64,0%), and for bentonite-like clay from Chiatura - it is below the permissible norm. Of the bentonites of foreign countries, the samples from Bulgaria (97,0%) and Hungary (83,0%) are characterized by the highest content of montmorillonite, while in the rest it is low and even beyond the norm.

According to the classification [2], bentonites from Tsikhisubani and Ozurgeti show high colloidality (97,0% and 85,0% respectively), samples from Hungary and England have medium colloidality, and the rest have low colloidality.

Of all the studied bentonites, the samples of Ozurgeti, Tsikhisubani and Hungary have a medium water absorption (respectively 6,05; 5,4 and 5,45), in the remaining samples it is low (2,3 – 2,72) and below the permissible norm. A very high value of bentonite number was obtained for bentonite from Tsikhisubani (98,0%), and bentonite from Hungary also has a high value (74,75%).

The study of swelling showed that all the studied bentonites in their natural form exhibit low swelling ability; at the same time, samples from Ozurgeti and Hungary are slightly distinguished. In order to improve the swelling ability, several samples were modified with the optimal combinations of chemical reagents previously established by us, which made it possible to increase their swelling to one degree or another. It should be noted that of the studied combinations of chemical reagents, the combination of 0,2 g Na_2CO_3 + 0,1 g CaO turned out to be the most effective for the samples of Tsikhisubani and Vaniskedi section 1, which led to an increase in their swelling ability ~ by 6.5 times, the same effect is obtained using 0,2 g Na_2CO_3, and the combination of 0,1 g Na_2CO_3 + 0,05 g MgO that improved the swelling capacity ~ by 5 times. The impact of all combinations turned out to be less effective for the sample from Hungary, the swelling capacity of which increased only 1,8-2,8 times.

The paper also assessed the adsorption capacity of bentonite clays with respect to methylene blue (MB); the determination of MB adsorption was carried out according to the method of the German Foundry Society [3].

The adsorption activity of the samples dried at t = 105-110^{0}C was preliminarily determined, and then the effect of heat treatment of the studied bentonites at t = 500^{0}C on the adsorption activity of MB was studied and the coefficient of thermal stability was calculated. As the results show, in terms of MB adsorption value, bentonites from Georgian deposits (with the exception of bentonite-like clay from Chiatura) are much superior to bentonites from foreign deposits.

Thus, the assessment of the physico-chemical parameters of the studied bentonites showed, in general, the superiority of Georgian bentonite clays; among bentonites from foreign countries, the sample from Hungary turned out to be the best.

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ORGANIZATION AND SAFETY OF PREPARATORY WORKS FOR DRILLING ON POLYMER DEPOSITS

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Detailed exploration of the Bolnisi polymer deposit was carried out by drilling column wells. First of all, a network of wells was installed, then access roads were laid, the main site was prepared, and temporary housing was arranged for the workers. The mast and the necessary equipment were installed [1]. The well was washed with a solution made with a special polymer powder, which simultaneously performed the functions of lubrication and cooling of the drill gun. With the removable core receiver, the core material was removed without loss and quickly [2].

During drilling operations, there was a high probability of injuries caused by mechanical, thermal, vibration, and high-intensity noise. In this regard, strict compliance with labor safety rules was considered at all stages of the work [3].

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NATURAL ZEOLITES IN THE ADSORPTION PROCESS OF WASTEWATER TREATMENT FROM PHENOL AND PHENOL DERIVATIVES

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Providing water to the population, industry, energy and agriculture is a priority for all countries, including Georgia [1]. In addition, surface water pollution issues are part of Georgia's National Environmental Action Program.

Recently, Governments and scientists have expressed concern about the effects of chemicals in the environment (in water) on humans and animals. Phenolic compounds are problematic in this regard. The anthropogenic source of phenols in water is domestic and various industrial wastewater. The United States Environmental Protection Agency (USEPA) and the European Union (EU) have listed Phenol and its derivatives as major hazardous pollutants due to their toxicity. The maximum permissible concentration of phenols in water is 1 μg/l [2].

Phenol is a component of household chemicals, medical and pharmaceutical products (disinfectants and anesthetics, antiseptics, lotions, soaps, dyes, varnishes, etc.). Consequently, their direct or indirect penetration into the wastewater of these enterprises leads to water pollution by phenol derivatives. This problem is especially noticeable in a pandemic, because the amount of contaminated water from medical facilities is high, and the purification plants in Georgia cannot provide biological treatment. The treatment plants in Tbilisi-Rustavi, Kutaisi, Tkibuli, Gori and Batumi are operated only by mechanical stages, and some of them have not even been completed. Therefore, the problem is urgent and requires proper attention.

Many wastewater treatment methods have been developed to minimize the adverse effects of phenolic compounds. These methods include adsorption, extraction, polymerization, biological and other methods.

Adsorption is considered oneof the most promising methods of removing phenolic compounds from water, as it is a fairly simple process, and its technology does not produce toxic waste. During the adsorption process pollutants accumulate on the surface of the adsorbent. Therefore, the efficiency of the process is determined by the adsorbent properties.

Natural zeolites are mineral raw materials with a unique spectrum of physico-chemical and adsorption properties and are of great interest for use in sorption processes [3]. Efficient organomineral adsorbents and ion-exchangers, which will possess new specific properties and can be used for effective wastewater treatment from phenolic compounds can be created on their basis in a simple way.

The paper presents the preparation of some natural zeolites and their nanomodified forms, the development of adsorption and quantitative chromatographic analysis methods and optimal chromatographic conditions for phenol and its chlorine derivatives.

Natural zeolites from Georgia – clinoptilolite (Khandaki region) and mordenite (Bolnisi-Ratevani region) - were used for theex periment. The obtained nanomodified forms were studied by I.R. Spectroscopic and X-ray Diffractometric Analysis methods .

Infrared Spectrometric Analysis was carried out on an Agilent Cary 630 FTIR Spectrometer in the range of 350-

5000cm^{-1} (USA). The IR spectra of the zeolite were recorded in the region of vibrations of the aluminosilicate framework of the middle and far regions. X-ray Diffraction (XRD) Analysis was performed by X-ray diffractometer - Drone-4 (Russia). The X-ray diffractometer connected to a personal computer via the USB port multimeter AX-18B and the corresponding PC software-PC-Link, which allows the processing of experimental data in Excel format. All the measuring equipment was appropriately calibrated.

The chromatographic analysis was performed using LC-20AD Prominence Shimadzu HPLC System (Japan).

HPLC analytical methods for the quantitative determination of phenol and phenol derivatives were developped using HPLC columns - Agilent SB-C18 4.6 x 250 mm, 5 μm (USA). Analysis was performed in isocratic mode; the flow rate of MP was 1.0 mL/min; the wavelength of the detector was 220 nm; the sample volume was 20 μL; the temperature of the chromatography column was maintained at 40°C.

The developed HPLC methods were validated with respect to robustness (standard solution stability, PVDF membrane filter compatibility test, critical factors effect study using design of experiments - DoE) system suitability test (SST), specificity, linearity-range, accuracy, precision, limits of detection (LOD) and quantitation (LOQ) according to methodologies and ICH Q2 guideline requirements.

Figure show the chromatogram obtained from the mixed solution of phenol and phenol derivatives (phenol, o-chlorophenol, 2,6 dichlorophenol, 2.3 dichlorophenol and 2.5 dichlorophenol), respectively.

New, rapid, selective and effective analytical procedures were developed and validated for the quantitative determination of phenol and phenol derivatives in aqueous solutions.

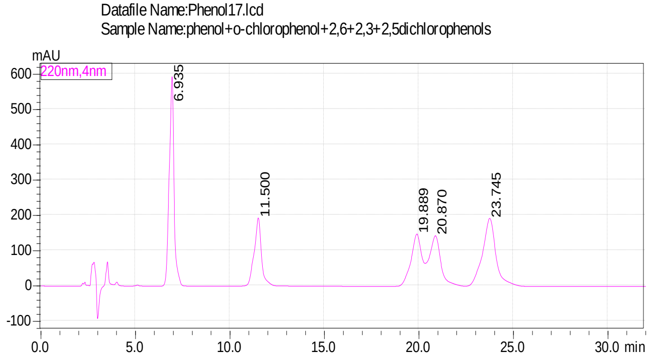

Fig. 1. Chromatogram of the model mixtures solution of phenol and phenol derivatives (phenol, o-chlorophenol, 2,6 dichlorophenol, 2.3 dichlorophenol and 2.5 dichlorophenol).

Based on the results, an adsorption method of wastewater treatment was developed and an effective sorbent was selected to solve the problem of pollution of the ecosystem with phenol and phenol derivatives at lower cost.

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THE IMPACT OF EARTHQUAKES ON THE REGIME OF THE BORJOMI MINERAL WATER DEPOSIT

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Georgia and the regions adjacent to the Black and Caspian Seas are part of the global seismic belt. Several earthquakes of magnitude M6 and above have occurred in Georgia and neighboring countries. The table shows a list of earthquakes that occurred between 1902 and 2011 [1].

Table №1

M≥6 earthquakes within Georgia and adjacent countries in 1902-2011

Location	Date	Epicenter	Magnitude	Depth (km)
Kartli (Georgia)	20.02.1920	42.02, 44.1	6.2±0.3	11
Erzurum (Turkey)	13.09.1924	40.0, 42.0	6.9±0.1	15
Tabatskuri (Georgia)	07.05.1940	41.7, 43.8	6.0±0.2	19
Chkhalta (Georgia)	16.07.1963	43.25, 41.58	6.4±0.2	5
Narmar (Turkey)	30.10.1983	40.330, 42.187	6.8	15
Spitak (Armenia)	07.12.1988	40.987, 44.185	6.9	5
Racha (Georgia)	29.04.1991	42.453, 43.673	7.0	17
Georgia	23.10.1992	42.589, 45.104	6.4	30
Georgia	07.09.2009	42.660, 43.443	6.0	15
Van (Turkey)	23.20.2011	38.721, 43.508	7.1	18

Borjomi mineral water deposit is situated in the central part of the Lesser Caucasus, in seismic active region, where earthquakes of magnitude 3-4 are recorded several times a year. Due to the high seismicity of the Borjomi region, the earthquake factor should be taken into account when analyzing the deposit exploitation.

From the beginning of the study of the deposit (30s of the 19th century) to the present day, in which many Georgian and foreign scientists took part, as a result of the research it was established that “Borjomi” is a carbonate, hydrocarbonate-sodium mineral water and the content of its constituent chemical elements, despite the high seismicity of the Borjomi region, are stable and their fluctuations are insignificant. This is confirmed by the following facts recorded as a result of earthquakes that occurred in the late 19th and early 21st centuries:

- After the Akhalkalaki earthquake (magnitude 6.2) of December 19, 1899 the output of the Ekaterininski spring increased up to 10000-12000 buckets (1 bucket = 12.3 liters) without changing its chemical composition (before the earthquake the output was 7000 buckets) [2];
- On October 29 of 2018, a magnitude 4.3 earthquake was recorded in the village of Rveli of Borjomi municipality. The response to the earthquake in the Vashlovani-Kvibisi wells was more significant than in the Central site, as it was located closer to the earthquake epicenter. As a result of the earthquake, levels in the Central site dropped by 0.2-2.2 m, while levels in the Vashlovani-Kvibisi wells recovered by 2.5-47.8 m. In contrast to the Central site, peaks in the Vashlovani-Kvibisi site were detected asynchronously, indicating the existence of different fracture systems within the boundaries of this site. Nevertheless, there were no changes in the chemical composition of water obtained from wells in these sites [3].
- On February 6 of 2023, a M7,5-7,8 magnitude earthquake that happened in southeastern Turkey, had some impact on the hydrodynamic regimes of the Borjomi mineral water

wells. Debits and mineralization of mineral waters in wells throughout the deposit have not changed (Table 2). The effect of the earthquake on the deposit was manifested in the level changes in some of the wells. Particularly, level rise within a range was observed in wells of the Central site (№103, 41, 131, 132), in wells of Vashlovani-Kvibisi site (№38, 25, 47, 70) and in wells of Zanavi site (№39, 143, 144); in Well №54 of Likani site the level continued to fall. The chemical composition and general mineralization of mineral water in wells throughout the deposit have not changed [4].

Table №2

Data reflecting the impact of the February 6, 2023 earthquake on the wells of the Borjomi deposit

Well №	Data before the Earthquake 06.02.2023			Data after the earthquake 10.02.2023			Level change rise/ drop	Depth of well, m
	Output m^3/day	Level. m	Salinity g/l (January)	Output m^3/day	Level. m	Salinity g/l (March)		
Central site								
103	30.50	-50.86	5.0	30.00	-48.74	5.0	+2.12	821,56
41	180.80	-8.93	5.9	181.10	-7.65	5.9	+1.28	155
131	124.50	-9.21	5.9	124.50	-8.50	5.8	+0.71	282
Likani								
54	104.50	-52.00	5.6	101.50	-53.18	5.6	-1.18	1400
Vashlovani-Kvibisi								
38	36.00	-36.80	6.6	39.20	-21.22	6.7	+15.58	1370
25ე	138.00	-21.87	7.2	136.00	-10.84	7.1	+11.03	1500
47	100.00	-35.27	6.9	100.00	-21.22	7.1	+14.05	1350
70	60.50	-27.33	7.0	61.30	-22.38	7.1	+4.95	1300
Zanavi								
39	30.40	-23.45	3.0	30.40	-12.49	3.1	+10.96	1400
143	11.10	-25.53	2.6	17.60	-0.53	2.7	+25.00	1600
144	30.20	-21.96	3.0	30.30	-14.62	3.2	+7.34	1800

It should be noted that in 2015, in all Borjomi mineral water wells, below the separation depth of gas and mineral water, at a depth of 80-100 meters, automatic devices were installed (measuring flow rate, level, temperature and total Salinity), which continuously measure these parameters and then they are transferred to the electronic database. The received information is processed using special computer programs, which makes it possible to determine the impact of an earthquake on a well with great accuracy.

Finally, we can conclude, throughout the long history of studying the chemical composition of the mineral water "Borjomi", the results of analyses carried out by various researchers show that the content of chemical elements in the water is stable and their fluctuation is insignificant, the total salinity of water has not changed. The circumstance mentioned above is one of the main factors in increasing the useful resources of the Borjomi mineral water deposit.

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CLAYS OF THE DARBAZI DEPOSIT FOR CERAMIC APPLICATIONS

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The clays of Darbazi are acid vulcanite products of the Late Cretaceous era. The clay is in contact with hydrothermally highly altered acid tuffs, trachytes and subvolcanic rhyolites.

Argillization appears in the vertical section of the hill. The 100 m long and 30-40 m thick altered zone is covered with alluvium and vegetation (Fig. 1). Outcrops of similar kaolinic clays may be traced in other areas and gorges near Darbazi showing that the common zone extends for a considerable distance.

Fig. 1. Southern slope of the hill near the Darbazi village.

To have a preliminary idea of the potential for industrial ceramic applications of the Darbazi clay, we examined two samples representative of the deposit: Sample I (from the altered part), and Sample II (from the part containing harder material).

We conducted the following laboratory analyses of these samples in the R.M. Ricerche Minerarie Srl laboratory (Lozzolo, Italy).

200 g of Sample I sieved through a sieve (45 μm) and left overnight in humid conditions with the addition of sodium tripolyphosphate. Result: 81.1 wt.% >45 μm. That is, the fine-grained material made up a small proportion of the altered clay sample.

To verify the workability of Sample I we used a Pfefferkorn plasticity tester. The measured result (PI = 27.8% is a medium-range Pfefferkorn index value that indicates good workability and plasticity.

A chemical analysis was performed with an ED-XRF spectrometer Ametek Spectro iQ II. All the tested samples analyzed under the same laboratory conditions and suitable standard procedures. Loss on ignition calculated after a firing test in a laboratory muffle kiln with a three-hour cycle at 1050 °C and one hour at the maximum temperature. The results are listed in Table 1.

The mineralogical analysis was done with a Bruker AXS D5000 X-ray Diffractometer (Siemens). A qualitative evaluation was carried out using the PDF2 (Powder Diffraction File) database standards of the JCPDSICDD (Joint Committee on Powder Diffraction Standards-International Centre for Diffraction Data).

The XRD analysis showed that the samples mainly contained the following minerals: quartz, illite/muscovite, albite and gypsum. Sample I differed from sample II in showing a greater content of modified Na-plagioclase in illite and gypsum. Kaolinite, usually present in these kinds of rocks is not relevant.

Table 1

Results of the chemical analysis of Darbazi samples

Oxide	Sample I (altered part)	Sample II (hard part)
SiO_2	74.30	74.00
Al_2O_3	14.60	14.50
Fe_2O_3	0.60	0.64
TiO_2	0.43	0.48
CaO	0.45	0.25
MgO	0.74	0.57
Na_2O	0.61	3.09
K_2O	3.93	2.95
SO_3	0.57	0.30
LOI	3.53	2.82

The DTA diagrams show a weak endothermic peak at about 100°C that may be due to the presence of montmorillonite. The other weak endothermic peak at 180°C and the main one at about 540°C are typical of illite. A weak endothermic peak at 955°C and an exothermic event at 982°C is explained by transformation of the same mineral at higher temperature. The TG graph shows a first loss in weight at about 100°C and the main drop occurs at 550°C.

The micronized powder prepared from Samples I and II was used to prepare round and pressed (at 400 g/cm^2) samples. The bodies were fired in a laboratory muffle kiln with a cycle of 5 h at 1220°C/15 min.

The firing test showed good melting behavior for the two samples after firing. Each gained a very light coloring. Sample II already increased in size after reaching its minimum water absorption value.

The preliminary analyses of Samples I and II from the Darbazi deposit surely show applicability of this raw material in ceramic production. Positive elements found in the laboratory tests are:

- the material is easy to crush and grind in laboratory mills;
- good plasticity that was measured by the Pfefferkorn method (PI = 27.8);
- the samples have low F_2O_3 and TiO_2 content;
- the clay part shows presence of illite mineral and Na-feldspar;
- good melting behavior was observed at 1200°C (<0.5 mass-% water absorption);
- the material gains light coloring after firing.

Among negative elements are the following:

- the samples have low clay fraction and contain rock particles of different chemical and mineralogical compositions;
- the tests demonstrated presence of SO_3 (>0.5 mass-% in Sample I);
- very low proportions of kaolinite in the raw material.

PREVENTION OF NATURAL DISASTERS AND ELIMINATION OF CATASTROPHIC CONSEQUENCES USING MODERN TECHNOLOGIES

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Georgia is a mountainous country and landslides are widespread in it. In Adjara, Imereti, Racha, Guria, mountainous Samegrelo, etc. several tens of small and large landslides are observed during the year. This phenomenon is often the reason for the relocation of residents of these areas to other areas of Georgia. This, on the one hand, is associated with a large expenditure of the state budget of the country, and on the other – lead to a stressful state of the population displaced from the native places. Such an event is especially dangerous when landslide gatherings occur near or within large populated areas and cities.

In order to prevent landslides on a potentially dangerous slopes, the following types of work can be carried out as a preventive measure: terracing, anchoring with 12-25 meter long special metal anchors and cementing them, mixing cement into the ground, which will create a treated area, etc. All these operations require large financial costs. Due to the small budget of the country, it is actually impossible to carry out preliminary treatment of these dangerous zones, and therefore they are often strengthened either at the last stage of the development of a landslide, or at least after its detachment.

As one of the examples, here, we will touch on only one landslide that occurred in 2015 on the Tskneti-Betania highway.

After three days of heavy rains, in an instant, about 1,200,000 cubic meters of soil and rocks and 60,000 cubic meters of trees appeared in the gorge of the Vere River, temporarily blocking the channel and creating a natural dam. The length of the landslide was 1 km, and the width - 360 m. A few minutes later, breaking through this dam, all the accumulated mass of water, land and trees traveled along the gorge of the river Vere in the direction of Tbilisi city. A deadly stream knocked people down and carried cars with passengers. The result was - 22 dead people.

After the landslide process, it took a year for Georgian and foreign scientists and engineers to prepare and approve the highway reconstruction project. After geological, geophysical, geomorphologic and engineering surveys, it was finally decided to carry out work on a completely flat rock (with a slope of 45 degrees) of a landslide, erect high walls using the technologies unknown to us, but tested all over the world.

At the first stage, the slope was completely cleared of sediments. The mass of cleaned and displaced sediments (soil, stones and rocks) amounted to about 0.5 million cubic meters. At the same time, the location of the load-bearing walls on the slope was developed and their design parameters were determined. Slopes above and below the territory along the entire length of the rehabilitation road were reinforced with well-injection solutions. Using a system of steel anchors, the lower and upper parts of the 3-4 m high reinforced concrete retaining walls were strengthened. After the backfill of the wall was compacted (95% of the Proctormod.), 7-10 m high gravity bearing walls (MSE – Mechanically Stabilized Earth) were built on it with REINFORCED EARTH® technology (Fig. 1).

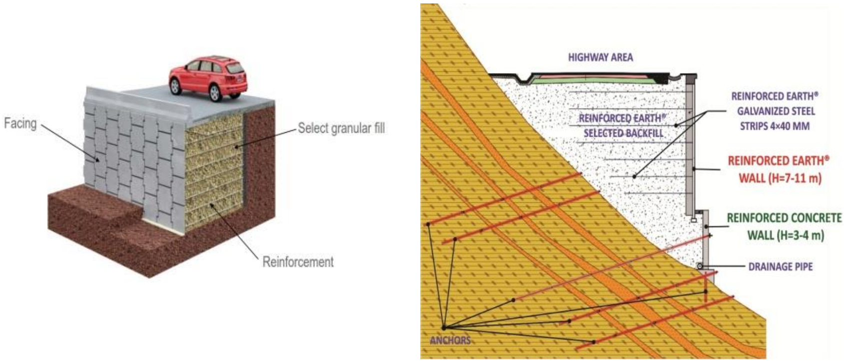

Fig.1. Typical MSE load-bearing wall cuts.

In order to extend the life of the rehabilitated section of the highway, the following works were carried out:

– Under the rehabilitated section of the road, a drainage system is installed on both sides of the artificial mound base;
– The road sides are equipped with cuvettes for drainage of water from the road. In addition, the culvert adjacent to the slope serves to collect water flowing down during rains and melting snow;
– Under the rehabilitated section of the road, there are three reinforced concrete culverts for draining water from culverts off the road;
– To prevent accidents with possible rock falls, the slope above the road is covered with a anti-rock fall grid;
– The automatic system of early warning of landslides is equipped;
– Recommendations were submitted to the Government of Georgia on the implementation of works on sites adjacent to a landslide, in order to prevent similar natural catastrophes in the future.

As a result of the work carried out, a guaranteed stable wall was obtained, on which a high-level highway was laid (Fig. 2).

Here it should be noted that such load-bearing and anti-landslide walls built according to this principle turned out to be so successful that 5 such walls were built only in the Tskneti area.

The construction of gravity-bearing supporting walls (MSE-Mechanically Stabilized Earth) with these new Reinforced Earth technologies allows creating a dense monolithic belt of 8-10 m wide sand-gravel behind the wall, which by itself gives the best results to prevent landslides.

Fig. 2. A newly built load-bearing wall and a highway located on it.

PENDULUM-TYPE CABLE CAR DRIVE SYSTEM WITH TWO DEGREES OF FREEDOM

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Cable cars are an economically and technically advanced type of freight and passenger transport that can be built in any terrain. Their work less depends on climatic conditions. They are successfully used in various areas of the national economy. Cable cars are a necessary transport, especially for the population living in the mountains, for whom it is difficult to descend to the lowland, and sometimes it is impossible, especially in winter. It is difficult and expensive to build railways and roads in such regions. Their cost is about 10 times and much more expensive compared to cable cars, which in such areas are prospective and profitable.

The existing pendulum-type cable cars are a system with one degree of freedom, in which constant or phase rotor motors are used as drives, which are necessary for soft start and precise stop of the car at the receiving platform during the braking period, regardless of the change in static load.

Pendulum ropeways with such a drive, this process is carried out due to complex electro automatic control systems that are structurally complex, require highly qualified service personnel, are uneconomical and difficult to maintain.

Our goal is to create a pendulum-type cable car system with two degrees of freedom, in which squirrel-cage induction motors are used as the main and auxiliary motors, And with a simple combination of on/off without interfering with the process of regulating the engine. Through sophisticated electro-automatic control systems, the car starts smoothly and stops precisely at the receiving platform, despite the change in static load.

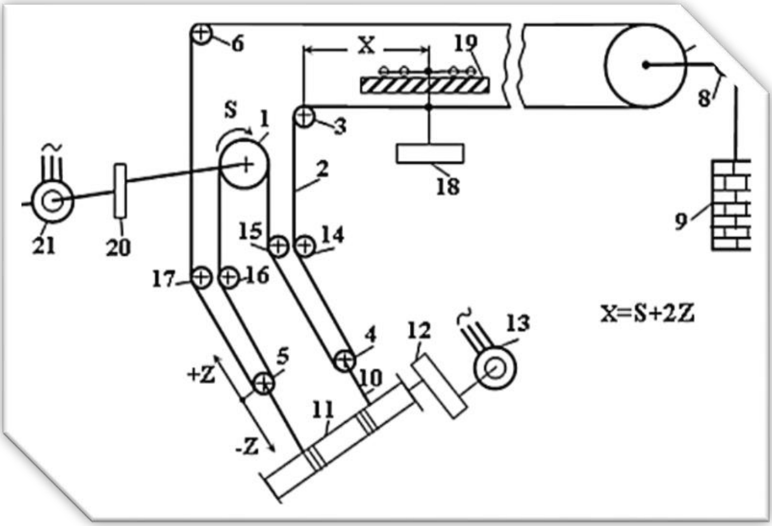

Fig. 1. A schematic diagram of a pendulum-type cable car with two degrees of freedom.where, 1 is the drive pulley; 2 - traction rope; 3, 4, 5, 6 - guide rollers; 7 - tensioner roller; 8 - pulley; 9 - tension weight; 10 - tail rope; 11 - drum; 12 - gearbox; 13 - asynchronous micromotor with a squirrel-cage rotor; 14, 15, 16, 17 - swivel blocks; 18 - wagon; 19 - traction rope; 20 - gearbox; 21 - main induction motor with squirrel-cage mouth rotor; X is the coordinate of the distance of the car; Z is the coordinate of movement of pulleys 4 and 5; S is the coordinate of the pulley movement. (X=S 2Z).

The theoretical study of the system presented in the Fig.1 is carried out using the Lagrange equations in generalized coordinates. 5 options for the operation of the system are considered:

1. The engine 21 and engine 13 are switched on at the same time and begin to rotate clockwise. 2. First, the engine 13 starts, after a while the engine 21.

3. The engine 13 starts for the first time, after a while the engine 21, and the engine 13 reverses.

4. The engine 21 starts for the first time, the engine 13 operates in dynamic braking mode.

5. When braking the car, it is brought to the receiving platform with a constant creeping speed using the engine 13. At this time, the engine 21 is braked.

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MINING-GEOLOGICAL AND METALS INDUSTRY BUSINESS RISKS, OPPORTUNITIES AND PROSPECTS

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Rational and effective exploitation of mineral resources is given special place in the socio-economic development of the state.

The rational analysis of risks and the process of their optimal management are important for the safe and sustainable operation and development of the mining-geological and metals industry related to the production of risky works.

The paper discusses the main risks of the mining-geological and metals industry, analyzes the problems of modern systems of their assessment and management of investment projects, methods and sequence of qualitative and quantitative assessment, recommenddations for improving the current situation are given, among them, International standards for managing business risks and opportunities.

For long-term economic growth, it is important to monitor, study and analyze dynamic geological processes and use the information obtained for this purpose to improve risk reduction, which greatly increases the safety and sustainability of the research industry development, taking into account innovative technologies, environmental processes and other relevant issues, where it is understood as Business as well as geological risks in the mining sector, as geological information supports all stages of exploration, exploitation, development, mine operation and closure, including mineral resource reserve estimates, project capital/operating costs and, therefore, the profitability of deposits and companies as a whole [1, 2].

Geopolitical tensions around the world, the global energy crisis, skills shortages, and an ever-increasing focus on Environmental, Social, and Governance (ESG) areas have somewhat altered the landscape of mining and metals companies in 2023, where these challenges create opportunities for those who are willing to effecttively overcome risks.

Notably, the Environmental, Social and Governance (ESG) direction in the research industry remains the number one challenge, but it is expanding in scope and complexity. At the same time, due to global conflict and resource nationalism, geopolitics has risen higher in the rankings, forcing company managers to understand more deeply the impact of geopolitics on strategy. Other risks and opportunities include climate change, net-zero roads, supply chains, global trade disruptions and new business models. (see Fig. 1) [3, 4, 5].

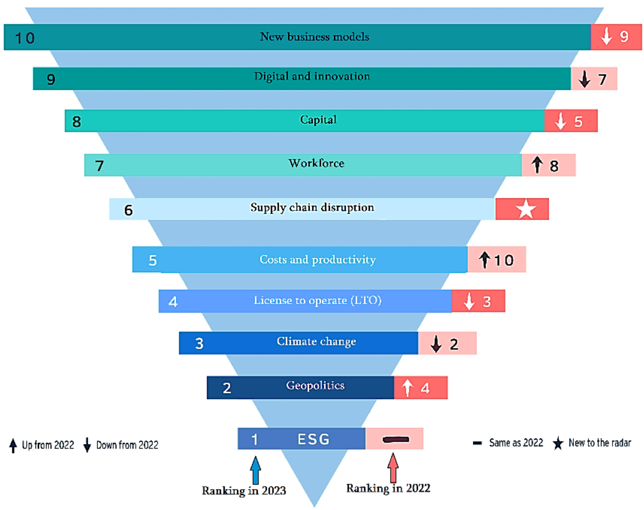

Fig. 1. Mining and Metals Industry Business Risks and Opportunities, 2022-2023 [3, 5]

In such conditions, companies should take into account market trends and commodity prices in order to anticipate potential risks and opportunities and, based on the requirements of continuous development, direct investments in new technologies and innovative approaches; that is, future plans must balance both, efficiency and environmental impact, unforeseen events or market disruptions, responses to companies' potential risks and challenges. It is important to establish and maintain good relationships with stakeholders, such as employees, communities and regulators, which is a good way to minimize risks and strengthen the company's reputation. Overall, by taking proactive steps to anticipate and effectively manage potential risks and opportunities, mining and metals companies have the opportunity to improve their situation and achieve higher results.

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LOGISTICS OPERATIONS MANAGEMENT IN THE OIL AND GAS INDUSTRY: TRENDS AND PROSPECTS

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The oil and gas industry is one of the most competitive segments in the world market; the revenues from its activity play an important role in the budget of countries and are used for the development of a number of economic sectors, infrastructure projects, and the formation of gold and foreign exchange reserves.

Oil and gas as unique and special mineral resources represent the main energy carriers, because their processing products are used in almost all industries, all types of transportation, military and civil construction, agriculture, energy, daily life, etc. Various chemical materials such as plastics, synthetic fibers, rubbers, varnishes, paints, detergents, mineral fertilizers and many others are produced from oil and gas in large quantities. Oil and gas determine not only the economy and technical potential, but often the politics of the state [1].

As a result of the development of information technologies and digitalization of business, the role of logistics has significantly increased in various industries, among them especially from the point of view of the oil and gas industry, where the efficiency and smoothness of the supply chain are becoming more and more important nowadays.

Today, logistics in various fields is going through an unprecedented period, due to the well-known events (global pandemic and Russia-Ukraine military conflict), however its future looks promising, where by using different technologies of innovation, the oil and gas industry is ready to overcome the challenges of the changing period of oil and gas prices, to achieve greater operational efficiency.

Under such circumstances, the oil and gas logistics industry is important to the various technologies that are introduced in the supply chain and lead to the effective use of the capabilities of even newer and different innovative and digital technologies and platforms, where the global oil and gas digital transformation market segmented with supporting technologies (big data/analytics and Cloud Computing, Internet of Things (IoT), Artificial Intelligence, Industrial Control Systems, Augmented Reality and Field Devices), together with - Oil and Gas Industry Activity (Upstream, Midstream, Downstream) and Geography [2, 3].

Notably, however, the Global Oil and Gas Logistics Market size is estimated to grow by USD 4,497 million between 2022 and 2027 accelerating at a CAGR/Compound Annual Growth Rate of 5.3%. The growth of the oil and gas logistics market share depends on several factors, including the shifting of freight from over-the-road to intermodal, the surge in offshore oil and gas exploration and production activities, and the demand for contract logistics services [4].

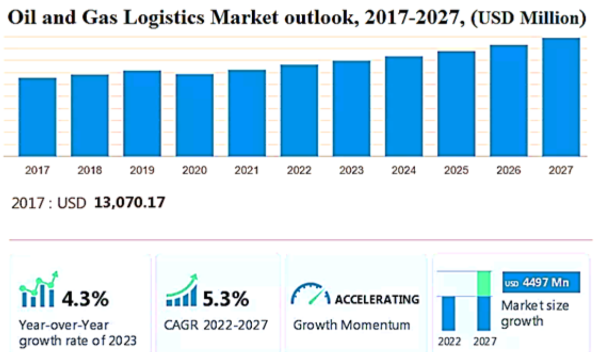

Fig. 1. Oil and gas logistics market, 2017-2027 (million USD) [4].

Based on the studied materials, the perspectives of the global supply chain in the research field include the effective solution of the following main directions:

- Rational analysis of the supply chain of oil companies so that they are aware of any supply disruptions and ensure security;
- Greater emphasis on transparency in the supply chain to minimize the risk of late deliveries of materials and equipment, which will help companies avoid unexpected disruptions in the supply chain and address the lack of information that many businesses face today;
- increasing supply chain digitization to create a more sustainable future;
- supply chain automation and analytics, including online supply chain management, transaction tracking and analytics;
- Development of contract logistics to control the entire supply chain - from producer to consumer.

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ZEOLITE-BASED CAPTURE AND TARGETED UTILIZATION OF CARBON DIOXIDE EMITTED DURING INDUSTRIAL PROCESSES

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Climate changes caused by emergence and distribution of greenhouse gases throughout the Earth is a global problem of a present day. It is known that carbon dioxide (CO_2) concentration on the Earth has surpassed the psychologically important 400 ppm mark, and there is an assumption that its concentration will be doubled till the end of the century. At that, the major part of carbon dioxides emitted from the enterprises to atmosphere falls on metallurgy and cement production (~26%). It is worth noting that by 2030 a demand for production of these two industries will increase by 50% [1, 2]. The mentioned current state made necessary and topical the development of such technological approaches and solution, which provide reduction of current CO_2 emission to atmosphere via implementation of main technologies of CCUS (Carbon, Capture, Utilisation and Storage) [3]. In this context, it is necessary to take CO_2 emission technologies into account and to create respective technological models.

Emission of "harmful" technological compounds, in particular CO_2 promoting "the greenhouse effect", is one of the ecological problems of cement production. It becomes "harmful" when emitted to atmosphere, however it is useful while being in cement-concrete modifying it and thereby accelerating the hardening [3, 4]. During 1 ton of cement grinding, 0,05-0,35 t of $CaCO_3$ and 0,04-0,06 t of $CaSO_4$ are added as mineral additives for carbonate and sulfate modifying that increases consumption of natural resources when using current technology. With this purpose, a study aimed at creation of device for capture and disposal of CO_2 as well as SO_x, NO_x from flue gases of cement production and validation of possibilities of CCUS technology implementation, has been conducted.

As the "purifying" adsorbent of industrial flue gases there has been selected a natural material – zeolite, in which cavities, channels and pores 0,2-1,5 nm in size occupy 50% of framework volume, that is why it can add "harmful" compounds CO_2, SO_x, NO_x available in flue gases of cement production using sorbents.

The idea of technological approach is as follows: zeolite tuff when dried in drying unit by flue gases, can attach "harmful" technological compounds (CO_2, SO_x, NO_x) from these gases by sorbents, while after sorptive saturation it can modify into "a container" for "harmful" compounds. Afterwards, by means of mixed grinding of zeolite and clinker, these "harmful" compounds will enter the cement mass. This way their "profitable" transformation into constructive component part of cement concrete occurs.

Carrying out of experimental works in large-sized drying drum of continuous action and establishment of numerous optimum parameters of sorption process is associated with great practical difficulties. For validation of hypothetic assumptions, a laboratory prototype of drying-sorptive, hybrid production unit of continuous operation (LPPDA) has been manufactured [5].

With the purpose of maximal approach of experiment to industrial conditions, a clinker was synthesized from loaded briquettes of special composition in the pilot furnace at 1450°C temperature. Initial concentration of CO_2 prior to entrance of flue gases going out of kiln to zeolite junction – cartridge and residual concentration of “harmful” compounds after their exit have been measured by gas analyzer.

With the purpose of modification and ensuing disposal of CO_2, SO_X, NO_X captured by means of sorbents in zeolite tuff, a zeolite tuff saturated with harmful gases in amounts of 20% will be mixed with mixture of 95% of “Heidelberg Cement Georgia” clinker and 5% of gypsum (80%).

The carried out study has confirmed the opportunity of “capture” by zeolite tuff of harmful gases from emitted carbon monoxide emerged during cement manufacture and processsability of wares intentionally obtained based on cement containing CO_2, SO_X, NO_X. Obtained results testify the prospects of development and validation of CCUS technology via elaborated technological approach.

The study has been conducted under financial support of the Shota Rustaveli National Science Foundation, Grant project AR-22-1730 “Cement production method for flue gases purification from (CO_2, SO_x, NO_x), via their putting through clinoptilolite sorber prior to atmospheric emission, establishment of feasibility through experimentation in lab environment, and concept confirmation”.

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SIMULTANEOUS PROCESSING OF GOLD BEARING RESIDUES OF THE MADNEULI ORE DEPOSIT BY BIOHYDROMETALLURGICAL METHOD

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At the present moment the maximum utilization of mineral raw materials is possible in two ways : I- to minimize the losses of useful components in the main processing of mineral raw materials, II-to develop and introduce advanced combined methods for the processing of waste (man-made raw materials) of mining and processing industry. Processing of man-made raw material has double effect: First, additional products required for industry are obtained, and secondly, non-renewable resources in nature are saved, the lifetime of the deposit is extended, the surrounding anthropogenic pressure is reduced, which has a positive impact on the environment and thus on the health of the future generation. On this basis in the researches the bacterial oxidation leaching method in heap version approved over the world nowadays, was used for processing of low grade raw material instead of oxidizing roasting and autoclave leaching for sulfide destruction [1]. The researches were carried out in the following direction: Simultaneous bacterial-chemical leaching of cyanidation residue of collective silphide floto concentrate and secondary quartzites of Madneuli using the heap method by dissolving the bacterial residue in cyanide and thiourea aqueous solutions. At the copper-barite-polymetallic ore deposit, almost half of gold remains in the residue of the heap cyanide leaching of gold-bearing quartzites, mainly concentrated in coarse fraction. The study of the material composition of residue showed that the average gold content reaches 0,85-0,9 g/t. Of this, the cyanidable form is 66,7 %, 11,1% is encapsulated in quartz and 22,2 % is covered with an acid-soluble layer. Grain-size analysis shows that the -10+1.0 mm grade is 69,8 % and contains 82,1 % of gold, while the fine -1.0+0 grade is poor in gold, indicating that during heap cyanidation the gold is mainly extracted from the material of same size. On bacterially treated quartzite residues it was laid out collective sulphide flotoconcetrate derived from waste and simultaneous processing of bacterial-chemical heap leaching was conducted.

The process involves two stages: I-the pyrite oxidation is carried out in acid medium by the bacteria A. th.ferroxidans, A.th. thiooxidans. Two active agents $Fe_2(SO_4)_3$ and H_2SO_4 ore formed in the solution. The copper passes into solution of the sulfate and is available for the solvent of gold particles, because of pyrite destruction. The I stage lasts 82 days (5 days active percolation, 2 days pause). At the end of the I stage, the copper content comprised 0,67 g/l and Fe^{3+} 12,8 g/l. Titer of bacteria comprised 10_7cell|me (first-10_4cell|me). At the second stage, a 1.0% aqueous solution of thiourea is added to the biocake, and after 14 days of percolation, 72.5% of gold and 69.2% of silver passed into the solution, while after cyanidation of the biocake 73.8% of gold and 51.2% silver passed into the solution (12 days). It should be noted that for solving Au and Ag in thiourea the similar conditions are required that are formed at the end of the first stage pH -2,5-3,0 concentration of $Fe_2(SO_4)_3$-0,35*0,40%. The addition of 1.0 % solution of thioureas is only necessary, in contrast to cyanidation process, where the formation of alkaline medium is required before cyanidation [2, 3].

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DETECTION OF LAYERS CONTAINING UNDERGROUND WATERS BY THE METHOD OF VERTICAL ELECTRICAL SENSING

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At previous conferences, we had the opportunity to provide information on the capabilities and importance of remote sensing geophysical research methods in solving the problem of detection of layers containing underground waters [1]. In the next period, we had the opportunity to conduct geophysical studies, the settlement of Marneuli Municipality in Jandara, in the floodplain of the Algeti River. The purpose of geophysical research was to study the geoelectric section to a depth of 20 meters by electrometry, differentiate rocks by their electrical resistivity, identify the water-bearing horizon and determine the sagging depths of its top and bottom, determine the thickness of Quaternary deposits.

The research was carried out by the method of vertical electrical sensing, using a symmetrical four-electrode AMNB Schlumberger device. According to the research data, a geoelectric column was constructed for each point of vertical electrical sensing. Coordinate system "WGS-84". Measuring equipment "ЭИН-209М".

To the west of the village of Jandara, in the floodplain of the Algeti River, a survey was conducted at 8 points by the method of vertical electrical sensing (Fig. 1).

Fig.1. Layout plan of vertical electrical sensing (VES) points.

The data obtained through the research was interpreted using the "IPI2win" computer program. According to the interpretation data, for each point of vertical electrical sensing a geoelectric column was constructed showing the thickness of the geoelectric layer, depth of layer bottom, the value of the true electrical resistivity of the layer, brief lithological descripttion of the geolectric layer and coordinate of the point of conducting vertical electrical sensing (Fig. 2).

According to the data of the research carried out by the method of vertical electrical sensing (ves) 1; 2; 3; 4; 5; 6; 7; 8.), two (I and II) geoelectrical layers were separated on the object. I - geoelectric layer, with an electrical resistivity of 2.0-110 Ohmm, represented by Quaternary deposits - boulder-pebble with sandy and loam filler, and II - geoelectric layer (Basic rocks) separated by electrical resistivity of 15-45 Ohmm, represented by Gypsum-bearing clays with sandstones layers.

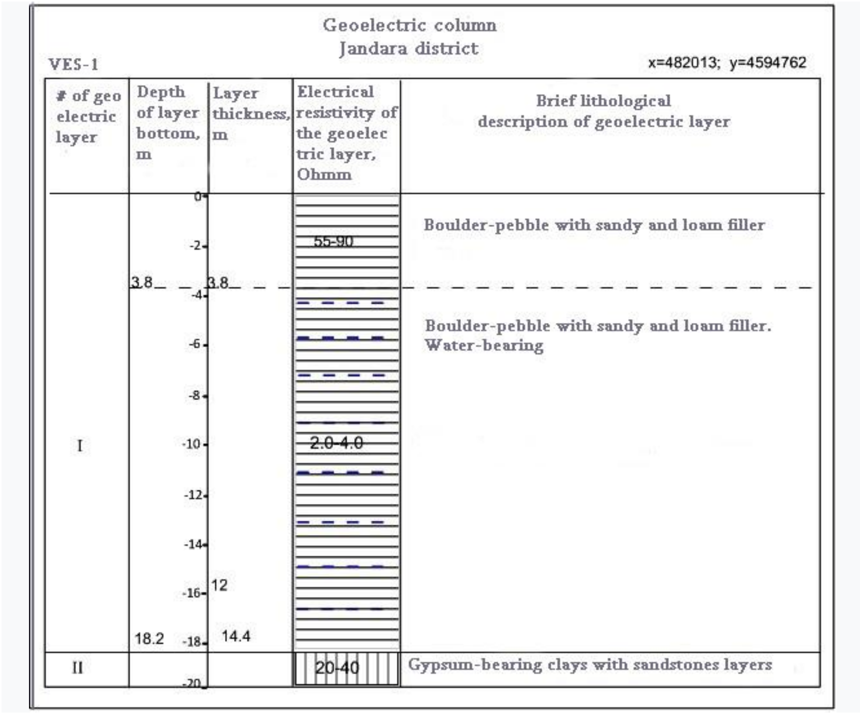

Fig. 2. An example of a geoelectric column, constructed by "VES-1" data.

The geological-geophysical interpretation of the data obtained by the method of electrometry in the floodplain of the Algeti River allows us to establish the following: The Quaternary deposits in the investigated area, whith thickness varying within 18-22 meters, are distinguished by the values of electrical resistivity of 2.0-110 Ohmm. The change in the electrical resistivity in a large range is mainly due to the difference in the composition of the Quaternary deposits and the degree of hydration (the higher the content of loam in the deposits and the degree of hydration and the lower the number of boulder-pebble inclusions, the lower the electrical resistivity and vice versa).

According to the values of electrical resistivity I – geoelectric layer (Quaternary deposits) can be divided into two, 3.8-4.0 meters of thickness and 40-110 Ohmm electrical resistivity layer separated in the upper part (slightly water-bearing boulder-pebble with sandy and loam filler) and 2.0-5.0 Ohmm of electrical resistivity under it (water-bearing with boulder-pebble sandy and loam filler). The total volume of Quaternary deposits varies within 18-21 meters.

II - geoelectric layer (Basic rocks) is a separate layer with an electrical resistivity of 15-45 ohmm, represented by slightly water-bearing gypsum clays with sandstones interlayers.

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SOME QUESTIONS ON THE TAXONOMIC OF PLANKTONIC FORAMINIFERS OF THE UPPER CRETACEOUS

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Planktonic foraminifera arguably have the best fossil record on the Earth because of their high rates of production, wide distribution in a variety of marine settings, high preservation potential, and relatively rapid speciation rates. As a result, they have been used extensively in biostratigraphic studies [1], they are considered the most important fossil group for interpreting Mesozoic and Cenozoic paleooceanography and stratophenetic studies of their morphology provide significant insights on macroevolutionary and microevolutionary patterns and processes.

The suprageneric classification of planktonic foraminifera at family and superfamily levels is based on significant characters such as the wall structure and surface or the mode of chamber addition (arrangement), although some also put emphasis upon the aperture position, the external apertural modifications or some significant test features, as the presence of tegilla, bullae, carinae or tubulospines [2, 3].

Genus Globigerinelloides

Most Cretaceous planispiral species have traditionally been included in the genus Globigerinelloides because of their coiling mode. However, a stratigraphic gap spanning ~4 Ma separates the extinction of Early Cretaceous species of *Globigerinelloides*, including the type species *Globigerinelloides algerianus* Cushman 1948, from Late Cretaceous planispiral species that have also traditionally been included in Globigerinelloides. Clearly they do not all belong to the same lineage. Differences in wall texture and wall-pore diameters among the planispiral taxa have been used by some authors to separate several Cretaceous planispiral lineages.

Family Heterohelicidae

Recent studies on Cretaceous biserial and multiserial taxa have emphasized the taxonomic importance of the initial coiling mode and wall-texture features within this morphologically diverse group, and this has led to significant revisions to their taxonomy and phylogeny [4].

Although nearly all species with a wholly biserial chamber arrangement had been included in *Heterohelix* Ehrenberg, 1843. This taxon is now considered as being correctly applicable to only a limited, monophyletic set of species and at least 15 additional genera have been created for Late Cretaceous biserial taxa during the past decade. Significant revisions to the taxonomy and phylogeny of Albian-Cenomanian biserial species [5], has more recently been followed by morphometric study of exceptionally well-preserved Turonian biserial assemblages [4], which resulted in further revision of the group. Additional studies are required to trace the biserial lineages through the Coniacian–Maastrichtian to determine their appropriate taxonomic classification. Until then, most Coniacian-Maastrichtian biserial species are temporarily classified under “Heterohelix”.

Family Globotruncanidae

Transitional overlap between marginotruncanid and globotruncanid species has been recognized since the study. Species in the genus *Marginotruncana* show some profoundly different morphologic characteristics that suggest the genus is polyphyletic. Characteristics of the peripheral margin are also very different for species included in this group. For example, M. coronata and M. pseudolinneiana have two keels separated by a wide imperforate peripheral band, whereas M. marianosi and M. sigali have one keel. Similarly, the relationship between single- and double-keeled species that were included in Globotruncana, needs further investigation.

Family Hedbergellidae

Development of a more stable taxonomy of the hedbergellids is needed to improve Cretaceous planktonic foraminiferal biostratigraphic and taxonomic framework. Revision of Early Cretaceous hedbergellids is ongoing, but problems encountered include their rare occurrence, poor preservation and low morphological diversity. Moreover, the validity of some morphologic features that have been used to discriminate some genera and species remain a matter of debate [6]. Detailed study of extraordinarily well-preserved assemblages spanning the Aptian/Albian boundary at several deep-sea areas enabled a major revision to the Aptian-Albian hedbergellid taxonomy. Observations of taxonomically and stratigraphically consistent differences in wall texture, wall pores, and apertural features led to the conclusion that species that should be included in Hedbergella became extinct at the end of the Aptian, whereas lineages that survived this extinction and then diversified during the Albian were assigned to Microhedbergella and Muricohedbergella. Additional *hedbergellid* genera have been named during the past decade: *Liuella, Pseudoclavihedbergella*, *Pessagnoina*; *Hillsella*. But understanding how these and other Late Cretaceous hedbergellids are related to the Middle Cretaceous lineages needs much additional study.

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MINERAL WATERS OF THE EASTERN PART OF THE GREATER CAUCASUS SOUTHERN SLOPE AND PROSPECTS FOR THEIR USE

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The eastern part of the Southern slope of the Greater Caucasus is almost completely occupied by the watershed area of the lower and upper reaches of the Aragvi River. This region, with the exception of the extreme northern part, is characterized by a medium-altitude mountainous-hilly relief, which is divided by valleys of numerous and high-water tributaries of the Aragvi River. Unlike other parts of the Southern slope of the Greater Caucasus, this region is characterized by a relatively mild climate: snowy winters and cool summers.

According to the scheme of tectonic divisions of the territory of Georgia [1], the Aragvi River basin is situated in the Mestia-Tianeti tectonic zone of the Southern slope fold system. In general, this zone is distinguished in very intense folds, the frequency of thrusts, transverse and lateral fractures. Global Caucasian large-scale faults are recorded in the considered region as well, but tectonic disturbances here are not as intense as in the western part of the zone - Svaneti and Mountainous Racha. It should be noted here that disjunctive disturbances play a decisive role in the mineral waters discharge.

Jurassic and Cretaceous formations participate in the geological structure of the region. They are represented by two lithologically distinct sequences: the Lower-Middle Jurassic mudstone sequence (dark-colored mudstone, with rare interlayers of quartz sandstones) and the Upper Jurassic-Lower Cretaceous carbonate flysch (limestones, clayey limestones, dolomites and marls, with sandstone interlayers). Lithologic composition of geological formations sheds light on the chemistry of mineral waters.

According of hydrogeological zoning scheme of regions of Georgia [2], the region under consideration is the eastern part of the hydrogeological intermassive of the Greater Caucasus Southern slope. For the Upper Jurassic-Lower Cretaceous aquifer complex developed here, porous-fissure filtration is characteristic. Carbonate rocks are characterized by porous aquifers, as a result of which they are rich in absorbed complexes, namely NaCl.

The region is included in the Carbonic Acid Mineral Water Province of the Southern slope of the Caucasus. However, in contrast to the western and central parts of this province, the content of carbon dioxide gas decreases significantly, and the content of free CO_2 dissolved in mineral waters rarely exceeds 500 mg/l.

Mineral waters of the region are also characterized by high chlorine content. Therefore, most mineral waters belong to the alkali-salt type: it is obvious that formation of chemical composition of these waters is largely due to the absorbed complex. Additionally, leaching of aquifer rocks also contributes to the afore-mentioned process, as a result of which Ca, Mg, Na are transferred to water.

According to chemistry, mineral waters distributed in the region can be divided into three main groups. These are: 1) weak (up to 2.0 g/l), 2) low (2.0 - 5.0 g/l) and 3) medium mineralization (5.0 - 15.0 g/l).

When assessing prospects of practical use of the mineral waters common in the Aragvi River basin, along with chemical composition, attention is paid to the easy availability of solutions and yield of water flow. As for the latter indicator, in most cases, the lack of flow does not constitute a basis for a negative conclusion, since as the practice of hydrogeological exploration shows, in the area of one or two sources with a small flow, deposits with quite large resources have been discovered through wells (Borjomi, Sairme, Utsera and others).

It is necessary to note that among mineral waters of the region, there are both potable healing waters (Essentuki № 4 and № 17) and table drinking water of Nazran type.

The mineral water resources of the Aragvi River basin, together with the beautiful natural conditions of the region, are very favorable for the balneological-climatic resorts construction in this region. Also, based on the carbonated waters low mineralization, it is possible to organize table drinking mineral water bottling. Additionally, based on carbonated waters weak and low mineralization, it is possible to organize bottling of table drinking mineral water.

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THE INFLUENCE OF EXPLOSIVE SUBSTANCE "OXYGEN BALANCE" ON THE ENVIRONMENT AND THE POSSIBILITY OF ITS REGULATION

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The composition, chemical structure, the elements ratio of explosive's molecules, have a great influence on blasting energy and environment.

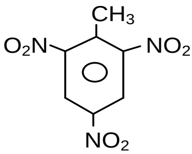
The criterion for evaluating the mentioned ratio is "Oxygen Balance" (OB) [1]. If the ratio is stoichiometric, then the explosion energy is maximized and the ecosystem is protected. During the explosion, "fuel" elements C and H are oxidized by endogenous oxygen.

When the ratio is stoichiometric, oxygen is precisely enough to produce higher oxides-CO_2 and H_2O. Nitrogen is released as N_2. In this case, OB=0. If the endogenous oxygen is more (positive OB) or less (negative OB) than the stoichiometric amount, then the explosion is accompanied by the release of nitrogen oxides, carbon monoxide, and other poisonous gases, which are undesirable from the point of view of environmental pollution.

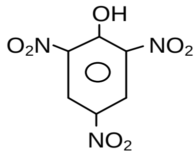
The OB of most synthetic explosives is strongly negative. Therefore, to bring them closer to zero, in general, mixture compositions are prepared...

Can the approach of OB to zero be purposefully regulated, not in mixed explosive compositions, the use of which has a number of disadvantages, but in individual explosive substances, in the process of their synthesis? Obviously, it can.

Let's compare the formulas of well-known explosives, TNT and picric acid:



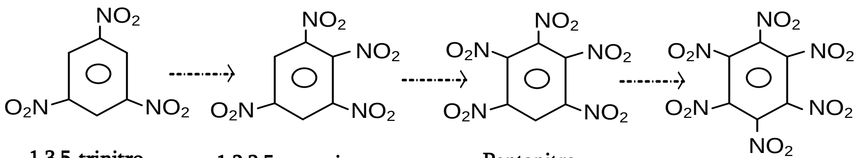
TNT



Picric acid

The rather high negative OB (-74.0) of the first of them decreases with the second (-45.4) by three tens at once. This is caused by a relatively insignificant difference in the "architecture" – chemical structure of their molecules...

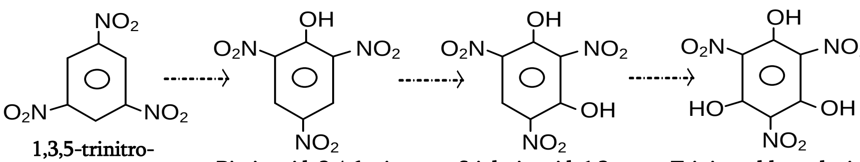
Below is a series of well-known explosives with OBs, showing the two-atomic gradational increase of oxygen:



1,3,5-trinitro-benzene (-56,3) — 1,2,3,5-tetranitro-benzene (-31,0) — Pentanitro-benzene (-15,7) — Hexanitrobenzene (0)

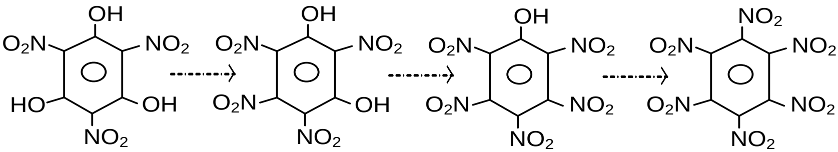
Similarly, the single-oxygen gradational increase maybe interpreted as follows:

1. The synthesis of picric acid, styphnic acid and trinitro phloroglucin from 1,3,5-trinitrobenzene by step substitution of OH-groups:



1,3,5-trinitro-benzene (-56,3) — Picric acid; 2,4,6-tri-nitrophenol (-45,4) — Stiphnic acid; 1,3-dioxy-2,4,6-trinitto-benzene (-36,0) — Trinitro phloro glucine; 1,3,5-trioxy trinitro benzene (-27,6)

2. The step replacement of each OH-group by NO_2, which, finally, also leads to hexanitrobenzene:



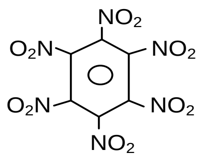
Trinitro phloroglu-Cine; 1,3,5-trioxy tri-nitro benzene (-27,6)

1,3-dioxy tetrani-tro benzene (-16,6)

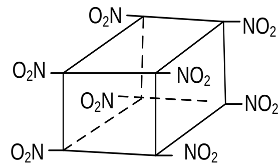
Monooxy pentane-tro benzene (-7,5)

Hexanitrobenzene (0)

Hexanitrobenzene is a strong and environmentally pure explosive with zero OB, as well as one of the most powerful explosives synthesized in the USA, at the end of the XX century– octanitrocubane [2]:

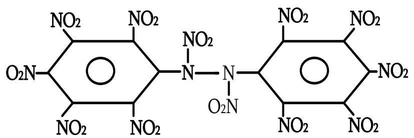


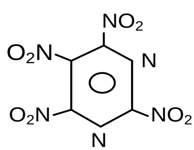
Hexanitrobenzene (0)



Octanitrocubane (0)

Thus, by the method of synthesis, we can regulate OB gradually, or approach it closer to zero at once. For this, in the formula of the "design" substance, we should take into account two oxygen atoms for each carbon atom, and one, - for each pair of hydrogen atoms. The rest, as it's said, is "a matter of technique", i.e., of a successful synthesis. Below are the formulas for two such hypothetical explosives, dodecanitrodiphenylhydrazine and tetranitropyrimidine:





If we synthesize such explosives, they will have OB=0, will be high-energy and environmentally pure substances.

It is relatively easy to regulate OB during the synthesis of CT compounds (Charge Transfer Compounds), from polynitroaromatics [3]. Both components of these bimolecular structures should be chosen so that the negative OB of one and the positive OB of the other will be as close as possible to each other. For example, picric acid (-45.4) and $NaNO_3$ (+47.0); 1,3,5-trinitrobenzene (-56,3) and $Mg(NO_3)_2$ (+54,1); 1,2,3,5-tetranitrobenzene (-31.0) and $Ba(NO_3)_2$ (+30.7), etc. The OBs of synthesized CT compounds may be obtained by the algebraic sum of the OBs of components.

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SYNTHESIS AND APPLICATION PROSPECTS OF NEW EXPLOSIVE CT COMPOUNDS

M. NADIRASHVILI, A. APRIASHVILI, G. TKHELIDZE, N. GUDUSHAURI

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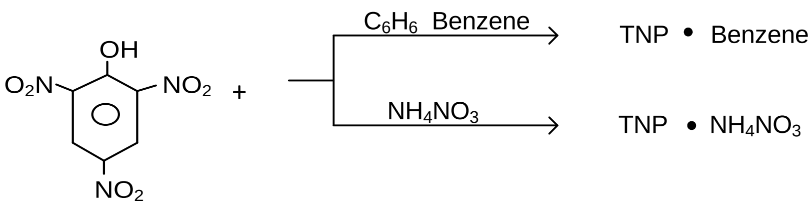
One of the main goals of our scientific research is the synthesis of CT compounds of various structures from poly nitro aromatic substances.

The mechanism of CT compounds formation is as follows: the presence of nitro groups in the molecule of the explosive aromatic substance impoverishes its π -electron system and gives the mentioned substances a strong electron acceptor property. Accordingly, their molecules develop the ability to pull the electrons of electron donor molecules towards themselves. Electrostatic attraction appears, as a result of which bimolecular aggregates are obtained - CT compounds, with a molar ratio of components 1:1 [1]. We use both organic - aromatic compounds and mineral salts as electron donor components [2]:



Picric acid, TNP

The synthesis of CT compounds is carried out under "soft" conditions, without energy intensive costs, in an "unusually" short time for organic synthesis, with the maximum yield of practically pure target products. These compounds have retained a fairly strong explosive ability.

Nowadays, we have synthesized about twenty CT compounds. Explosion testing shows that they not only retain strong explosive abilities, but in this regard, even surpass that explosives, from which they are synthesized. For example, the working capacity of the CT compound TNP • NH_4NO_3 synthesized from picric acid and ammonium nitrate exceeded the same characteristic of equal amount of picric acid, by 1/3 [2]. More interesting is that the content of picric acid in the CT compound is 30% less...

The above reasoning leads to other possibilities of using CT compounds. We mean the involvement of non-pure, as well as expired explosive substances - picric acid, TNT and others, in the mentioned reactions.

First, obviously, we rely on the result that was described above. In addition, we have developed a methodology that we use in experiments.

Non-pure and expired explosives, as a rule, in a certain dose, contain different substances, which interfere with the explosion process. Let's call them, conventionally, impurities.

Removal of these impurities creates certain problems, for example, technological, and especially - economic. Most importantly, their content significantly worsens the quality of explosives.

Let's briefly consider what will happen if we synthesize a CT compound from a poly nitro aromatic substance containing impurities, for example, TNP.

Suppose the amount of impurity is 10% of the molar mass of the substance. This means that 10% or 22.9 g of 1 mole (229g/mol) of TNP (Mr=229) is an impurity. The remaining mass or 90% of the mole (229g/mol-22,9g/mol) is unconverted TNP (206.1g).

As is known, under the conditions of synthesis of CT compounds, electron-acceptor and electron-donor molecules are actively attracted to each other, with a molar ratio of 1:1. If we use ammonium nitrate (Mr=80) in the role of the latter, obviously, only 90% of its mole, i.e. 72 g, will be spent in the reaction. Due to it, the mass of the obtained CT compound will be 278.1 g. (206.1g+72g). 22.9 g of impurities will be dispersed in it. By a simple calculation, it turns out that the synthesized CT compound already contains only 8.2% of impurities.

i.e. By synthesizing a CT compound we will obtain a greater amount, a stronger explosive, in which there will be almost 2 percent less impurities.

According to a similar calculation, if we use calcium nitrate - $Ca(NO_3)_2$ as an electron-donor component, the impurity content in the corresponding CT compound turns out to be 6.4%.

The use of barium nitrate - $Ba(NO_3)_2$ will reduce the amount of impurity in the CT compound to 5.2%, that is, as a percentage, it will decrease almost twice…

The conducted pilot-test syntheses gave hopeful results.

Respectively: 1. Synthesized CT compounds with the best explosive characteristics can be offered as industrial explosives. 2. After obtaining the desired experimental results, the process of synthesis of CT compounds can be used for the utilization of poly nitro aromatic non-pure and expired explosives.

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THE VARIATION OF OXIDATION-REDUCTION POTENTIAL IN SAIRME MINERAL WATER DEPENDING ON IRON CONCENTRATION

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Sairme mineral water is well-known for its properties, having positive impact on human health and curing specific deceases. Currently, the underground water deposit includes five self-flowing springs: №1, 3a, 3b, "Namarnevi" (the Spring of Beauty), and seven shallow boreholes: №4, 5, 27, 8, 56, 68, and 58. [1].

One of the important parameters of the mineral water quality is the redox potential (Eh), which is measured in volts (V) or millivolts (mV). The redox potential describes the conversion of chemical energy into electrical energy through redox processes in water [2]. A positive redox value in water shown the presence of oxidants, when the negative value of the latter indicates the presence of reduction substances. Redox processes play important role in definition or assessment of groundwater quality. The Eh of water is contingent on various factors, including the level of dissolved oxygen, water temperature, the concentration of hydrogen ions (pH), and the presence of heavy metals in the water [3].

The redox potential and dependance of it’s value on iron concentration was studied in the Sairme mineral water deposit sources as part of the present study program. The majority of the research was undertaken in the field due to the fact, that the parameters studied have ability to change significantly during transportation of samples. The redox potential was measured using a multi-parameter HI-98194, while the iron concentrations were measured using a portable spectrophotometer - HACH DR 1900. The measurement procedures rigorously adhered to the stipulated guidelines of the ISO/IEC 17025:2016/ 2017 standard. Before each measurement, the equipment was tested and calibrated in accordance of the standard operation protocols established and executed by the QA/QC system of DG Consulting laboratory. The diagram (Fig. 1) below illustrates the outcomes of field parameter assessments conducted on research samples from the wells of the Sairme mineral water deposit. It shows the negative correlation existing between the redox potential and iron concentration.

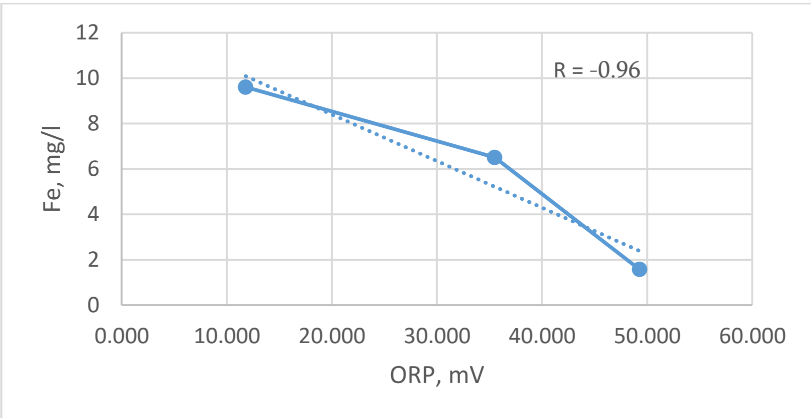

Fig. 1. Correlation between Oxidation-Reduction Potential and Iron Concentration

According to the available data, a high Oxidation-Reduction Potential (ORP) value corresponds to a low iron concentration. This correlation is substantiated by the calculated correlation coefficient, which numerically equals - 0.96.

In the groundwater, iron ions primarily exist in the form of iron (II) bicarbonate, which remains stable only under conditions of increased carbon dioxide levels and the absence of dissolved oxygen. Sairme's mineral water is of bicarbonate type; the analysis of dissolved gases have shown, that 98% of the dissolved gas is Carbon Dioxide and the dissolved oxygen is absent in the water. Given these findings, it can be inferred that iron in underground water of Sairme Deposit predominantly exists in the form of iron (II) bicarbonate. When mineral water is exposed to air, it loses dissolved carbon dioxide and dissolves some oxygen, as a result iron (II) is oxidized and transforms into iron (III) ion. In such circumstances, the redox potential (Eh) drops down to a value less than 0.2 V [4]. The above mentioned conclusion was proved by the results of our analytical studies undertaken in the field. Our investigations have proven an inverse relationship with a correlation coefficient of -0.96 between the redox potential and the iron content in Sairme mineral water.

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GROUND-PENETRATING RADAR IMAGES OF CYLINDRICAL BODIES BUILT WITH VARIOUS DIELECTRIC FILLERS AND PLACED IN THE ENVIRONMENT

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In the study of the karst environment, an important place is occupied by the possibility of detecting and registering spaces containing air and water, such as siphons, sufosis, by geographical, speleological and geophysical methods [1]. Despite the development of such methods as GPR, electrometry, seismometry, the possible identification, localization and interprettation of a partially aquifer is a significant difficulty. With the help of the method of physical modeling of georadar electromagnetic fields, it was possible to successfully solve a number of direct problems of electrodynamics [2].

The task is to isolate, fix and identify the radio image created by GPR electromagnetic waves for a cylindrical object partially containing water and located in a homogeneous medium.

The studies were carried out at the modeling facility of the GPR Laboratory of the Sector of Applied and Experimental Geophysics of the Institute of Geophysics [3].

Three models of a cylindrical body filled with water, air and half water with non-galvanic coupling [4] in a homogeneous medium are presented. Seven georadar profiles were drawn on the day surface of the model, of which only the central ones are presented.

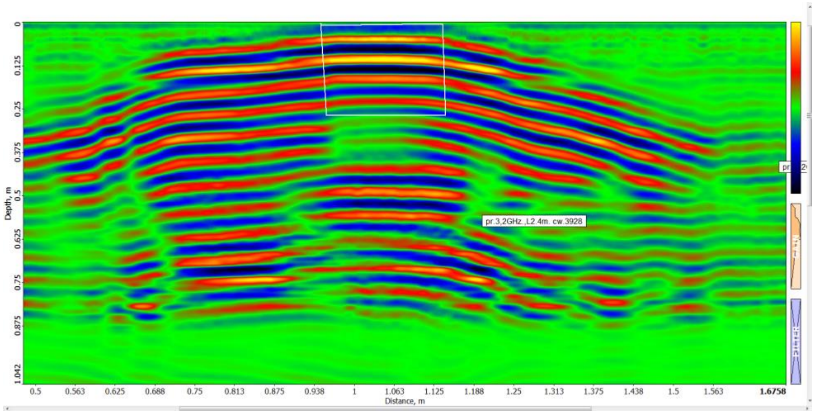

Fig. 1. The presented radarogram corresponds to a 2.4 m long central profile, for a 0.3 m long and 0.17 m in diameter cylinder completely filled with water, made by Zond 12-e with a 2 GHz antenna.

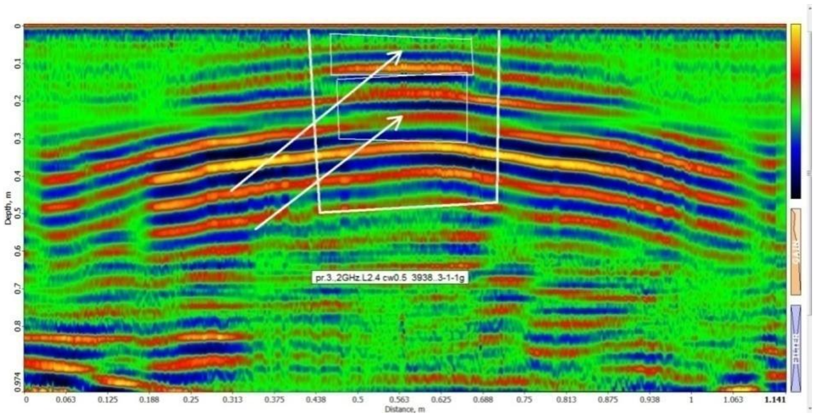

Fig. 2. Presented radarogram is a central profile of 2.4m long, for a 0.3m long cylinder half-filled with water, intersecting with a Zond12-e, 2 GHz antenna.

From the interpretation (Fig. 1, 2, 3) of radarograms by diffracted waves from the surface of the cylinder, it can be seen that the location in all three cases corresponds to the degree of the cylinder diameter and location coordinates.

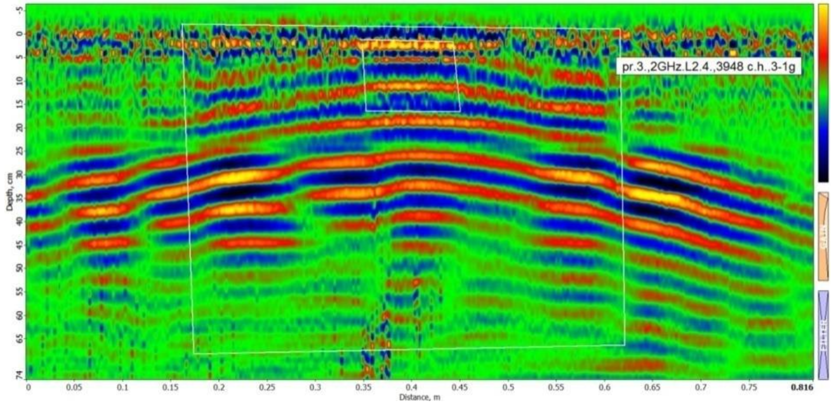

Fig. 3. The central profile radarogram for a 0.3 m long cylinder completely filled with air at the intersection with the Zond12-e, 2GHz antenna.

In addition, it turns out that the features of the radio image appear on the lower side of the location of the cylinder; in particular (Fig. 1) there is a significant ledge at distances of 1-1.18m and at depths of 0.3-0.5 m, which has an interference character. A sharp division of the radio image (Fig. 2) into two parts for depths of 0.1-0.25 m clearly characterizes the presence of an air-water interface. Along with this, the lower extensive part with a thickness of 0.3-0.5 m also has a phantom character. The radarogram (Fig. 3) of an air-containing cylinder contains a feature for depths of 0.15-0.25 m, which corresponds to the diameter of the cylinder in width, and at depths o+f 0.3-0.5m it also has an interference character. The strong interference image that characterizes all three cylindrical models should be the result of superposition of diffraction-reverberation phenomena occurring in the cylinder and requires additional research.

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ON THE POSSIBILITY OF DETERMINING THE DEPTH OF HIDDEN PARTS OF CYLINDRICAL BUILDING STRUCTURES BY GEORADAR METHOD

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In the area of the basement floor of the facility under construction, GPR survey was carried out to assess the location of radar images of bored reinforced piles and the degree of their penetration. The georadar profile was carried out and recorded using the georadar Zond 12-e, Prism-2.7 software, using standard 300MHz and 500MHz shielded georadar antennas. As an illustration, profiles from radarograms and the results of their interpretation are shown (Fig. 1, 2). The profile is recorded in the immediate vicinity of the support, built on bored reinforced piles, along the profile.

A cylindrical radio image is a vertically located set of more or less uniformly diffracted waves, consisting of two main parts. The first part is the pile body corresponding to the pile itself [1], that is, the body of the bored reinforced pile [2] and the second part is the shape of the in-phase axis after the base. It should be said that the considered radio image is a superposition of electromagnetic fields for incident, reflected/scattered and refracted waves [3] that exist in the body of the pile and separate it from the environment [4].

As a result of the interpretation of the conducted georadar work, it can be concluded that the deepening of the piles is in the range of about 13-15-17m, both cluster piles and individual geological drills were noted.

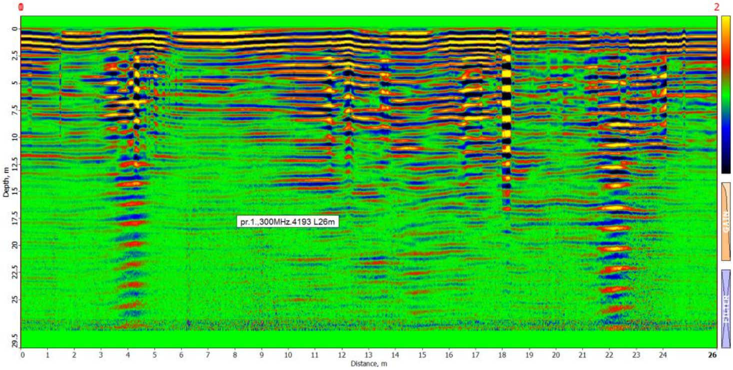

Fig. 1. Prof-1. The location of the radio image of the pile elements at distances of 4m, 22.5m. The bases of the cluster type are intersected by radar radiation. The depth of the pile is approximately 12.5-17.5m. Also, inclusions of parts of the piles are observed at distances of 12-14m at a depth of 12m.

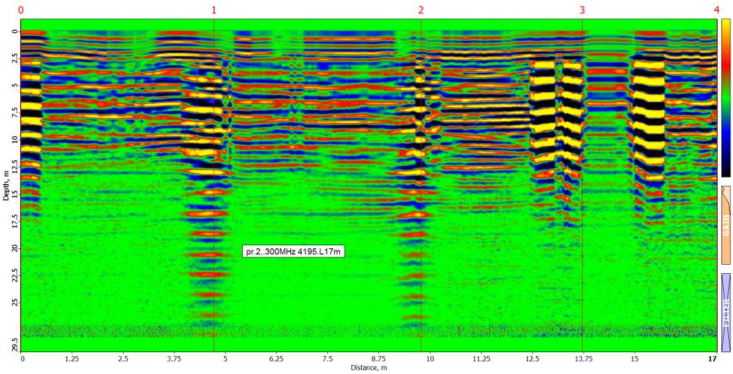

Fig. 2. Prof-2. Radio images of the pile are noted at distances: 0.5m, 4.5m, 6.5m, 10m, 13m, 16m. The average depth is 13-15-17m.

The location of the elements of the piles supporting the pillars is noted. The support elements have a circular bifurcated design, as a result of which they are a reflective, secondary source of radiation for the emitted electromagnetic wave of the radar. The last, oval or incomplete oval part of the radio image captures the location of the base of the bush pile/bored reinforced pile.

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GEOLOGY AND CONDITIONS FOR THE FORMATION OF THE MUTNOVSKOYE GOLD-SILVER DEPOSIT

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The Mutnovskoye gold-silver deposit is located in the South Kamchatka ore region of the Kamchatka Peninsula of the Russian Federation.

In geological terms, this is the southern segment of the Central Kamchatka volcanic belt of the Miocene-Pliocene age (1). The northern and northwestern boundaries of the region are large-amplitude faults separating the productive facies of volcanites from the sedimentary-volcanogenic rocks of the Upper Cretaceous and metamorphites of the Ganal ledge of the Kamchatka median massif.

The southwestern and northeastern flanks are covered by Pleistocene-Holocene volcanites of the East Kamchatka volcanic belt.

The Mutnovskoye deposit is confined to the Zhirovskaya paleovolcanic building. The foundation of the central part of the structure is volcanogenic-sedimentary formations from the Oligocene to the Miocene - the Mutnovskaya, Zhirovskaya and Asachinskaya strata. They are broken through by the extrusion of diorite porphyrites of the Veselovsky complex of the Eopleistocene-Early Neopleistocene.

More than 160 steeply falling quartz, quartz-carbonate veins, veining zones and mineralized crushing zones bearing gold-silver-polymetallic mineralization have been identified at the deposit.

The host rocks are propylitized and argillized to form quartz-hydromicaceous, adularia-hydromica-quartz and adularia-montmorillonite-hydromica-quartz varieties.

The main reserves of gold-silver and silver-polymetallic ores are concentrated in the vein zone "Determinative", traced at 2650 m along the strike and up to 500 m along the fall. Thickness of the zone is 3–19 m. Five ore bodies up to 300 m long, up to 3-3.5 m thick, traced to a depth of 250–300 m, with gold grades up to 10.6 g/t, silver 138.3 g/t (maximum - gold 194.1 g/t, silver 3605.2 g/t).

The length of other veins, bearing mainly silver-polymetallic mineralization, is 100–800 m, the thickness is 0.6–1.7 m, the gold content is up to 3.5 g/t, silver is up to 345 g/t. The average content of associated components is 290 g/t, indium - 20 g/t, selenium - 9 g/t, bismuth - 23 g/t.

The textures of the ores are banded, massive, colloform-banded, breccia. Ore minerals - pyrite, sphalerite, galena, chalcopyrite, tennantite, tetrahedrite, freibergite, bornite, native gold, argentite, arsenopyrite, pyrrhotite, marcasite, hessite, prustite.

The vertical span of gold-silver mineralization is 300 m, silver-polymetallic - 500 m. The level of erosion cut of the vein zone "Determinant" and most of the deposit is defined as upper ore, and on the flanks - above-ore.

The richest gold-silver ores are characterized by a ratio of gold to silver -1:15, ordinary -1:100. The fineness of gold is 650-837. The Mutnovskoye field is characterized by the presence of thermal waters on its area. Therefore, all calculated resources are located to a depth of 240 m.

According to fluid inclusion study, pyrite-polymetallic ores crystallized at temperatures of 370-310^{0}C, polymetals at

320-250^{0}C, and quartz-carbonate ores from the upper horizons of the deposit at 260-170^{0}C.

Analysis of the isotopic composition of sulfur in ores and enclosing metasomatites of the Mutnovskoye deposit showed a narrow range of δ34S value from -1.5 to +2.5‰, typical for hydrothermal polymetallic deposits of homogenized mantle, the source of this element.

Analysis of the isotopic composition of hydrogen and oxygen δD and δ18O show that the main source of water in the ore-depositing hydrothermal system of the Mutnovsky ore field was deep circulation meteoric waters.

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FACIES ANALYSIS AND ORE DISTRIBUTION OF THE UPPER CRETACEOUS SAKDRISI EPITHERMAL DEPOSIT, BOLNISI DISTRICT, GEORGIA

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The Bolnisi district is a part of the Lesser Caucasus and is located at its northern extremity. To the west, this ore district continues into the Eastern Pontides, Turkey. This favorable geotectonic location of the Late Cretaceous Bolnisi ore district (which is also part of the Arvin-Bolnisi Belt) between the Lesser Caucasus and the Eastern Pontides is reflected by its geological diversity, volcanism type and mineral deposit distribution. The Late Cretaceous (~87–71 Ma) bimodal volcanism in this region resulted in mafic and felsic rock types, the latter being a major host of the ore deposits and prospects, and being defined locally as the felsic Mashavera and Gasandami suites.

The Sakdrisi deposit consists of a 2-km long cluster of five major ore zones, which are aligned along the NE-oriented fault zone (Fig.1). Our interpretations and mapping program were undertaken on Sakdrisi 4 and 5. According to the previous investigations, the Sakdrisi Au-Cu deposit was considered as a southeastern part of the Darbazi-Abulmulk caldera structure [1], which is a part of the Bolnisi volcano-tectonic depression. During the mapping it was very difficult to find the evidences of the caldera structure in Sakdrisi deposit, as the system is Late Cretaceous and most of the deposits are eroded. The host rocks of Sakdrisi deposit is represented by Mashavera suite. Moritz et al. (2020) [2] published the U-Pb age of rhyolite samples (83.3±0.6Ma and 85.7±0.1Ma) from SW part of Sakdrisi deposit.

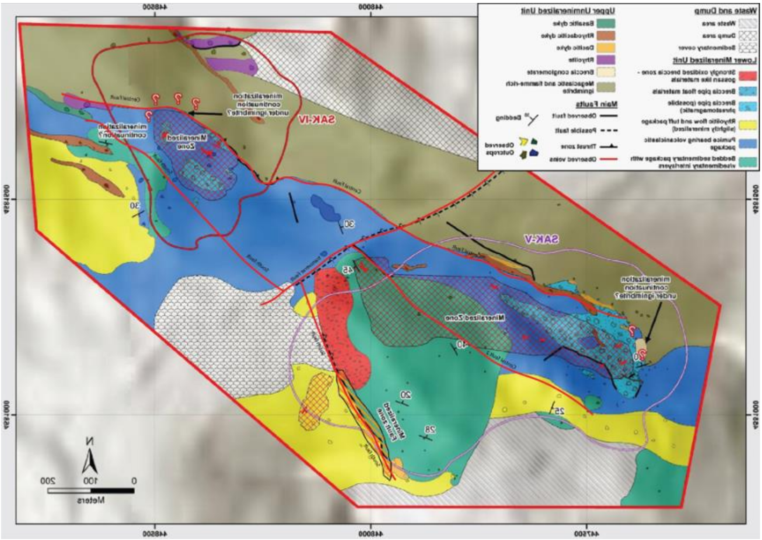

Fig.1. Geological map of Sakdrisi deposit (Popkhadze et al. 2021).

Two complexes have been recognized in this deposit, and they belong to the Mashavera suite. They include a lower mineralized volcano-sedimentary complex (LVSC) and an upper barren volcano-sedimentary (UVSC) (Fig. 3) complex, which are separated by a NE oriented thrust fault. The lower mineralized complex is composed of the following lithological units (Fig.1): bedded sedimentary mudstone with tuff interlayers, pumice-bearing volcaniclastic rocks, slightly mineralized rhyolite and rhyolite tuff, and crosscutting explosive breccia, which is well expressed in the Sakdrisi 5 open pit [3]. The upper non-mineralized complex consists of welded and non-welded ignimbrite, limestone lenses and crosscutting andesite-basaltic and rhyodacitic dykes.

The mineralized zones are present in the LVSC at certain horizons, and consist mainly in quartz-sulfide and quartz veins, as it was discovered as a bonanza zone located just beneath the thrust zone at the Sakdrisi 4 open pit. Explosive breccia in the system creates a fracture system sometimes together with the regional faults where gold/copper gold bearing quartz and quartz-sulphide veins and stockworks are developing. Recent data from 400–600 m deep drill cores indicate enriched mineralized zones, which is a new discovery for this deposit [4].

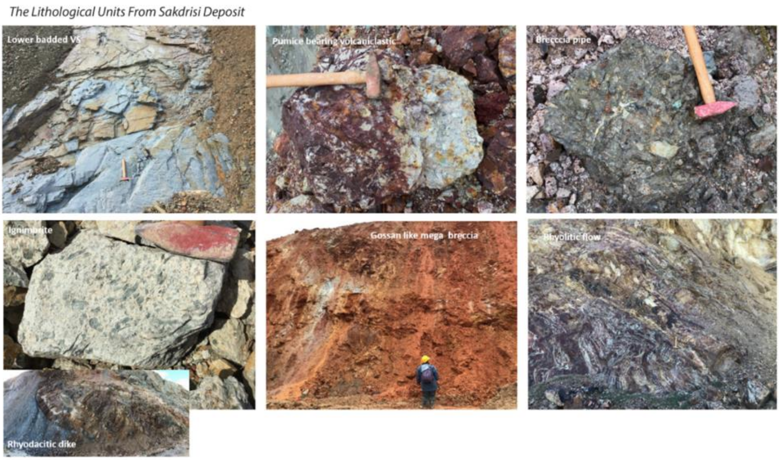

Fig. 2. Lithological units from Sakdrisi deposit: lower bedded volcano-sedimentary complex, pumice-bearing volcanoclastic, explosive breccia, welded ignimbrite, gossan like mega breccia, rhyolite flow.

On the Fig 1 is interpreted the Sakdrisi deposit with principal lithological units and main fault zones on Sakdrisi 4 and 5 deposits. The main fault is the central fault, which is a thrust fault and also this zone separates the upper non-mineralized units from lower mineralized units. South fault is well outcropping in the Sakdrisi 5 and separates the greenish bedded volcano-sedimentary gypsum bearing horizon from strongly oxideзed volcanoclastic pumice-bearing and fine-grained tuff horizons. The transverse faults are interpreted between Sakdrisi 5 and 4 and Sakdrisi 4 and 3 ore clusters.

In conclusion, on Sakdrisi deposit there is both a structural and a lithological control on mineralization: the fault system created the fractures, along which mineralized quartz, quartz-barite and quartz-sulfide and sulfide veins have been emplaced. The explosive breccia is mostly mineralized, even non-mineralized explosive breccia pipe in the close system created very fractured/permeable zones for fluid migration. Clastic/pumice-bearing rocks from Sakdrisi deposit is a good permeable rock, which here is strongly oxidized and mostly gold-bearing.

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STUDY OF CONSTRUCTION AND FACING STONES OF THE JVARI MONASTERY

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In Georgia, local stones have traditionally been used for the construction and facing of religious structures, churches, and monasteries. Buildings constructed and adorned with these stones have withstood the test of time, despite enduring the effects of various natural and historical processes, as well as suffering different types of damage over the centuries. The preservation of cultural heritage is the responsibility of the state and each individual, and it remains a subject of constant attention and interest.

One of the most important monuments of Georgia's material culture is the Jvari Monastery in Mtskheta, which has been included in UNESCO's list of World Cultural Heritage sites. The study of the monument's condition and the issues related to its restoration and conservation has been relevant from the 20th century until the present day.

The Mtskheta Jvari Monastery (small and large churches) is an architectural structure built in the late 6th century. The monastery is situated right on the edge of a cliff, at the confluence of the Mtkvari and Aragvi rivers (on the left bank). The large church has mainly remained in its original state, but throughout history, it has suffered many damages, particularly during the Arab invasion when the church was set on fire (one of the main reasons for interior stone damage) [1]. The small church has survived to this day in a heavily damaged condition, with numerous losses and reconstructions.

There are many literary materials about cultural-historical studies of the Mtskheta Jvari Monastery and geological research in its vicinity. The initiative to study and create relevant documentation belongs to the founder of the Georgian Art History School, Giorgi Chubinashvili.

The visual dictionary of stone damages in the large and small temples is created based on the illustrated dictionary of stone damages published by the International Council on Monuments and Sites (ICOMOS), an international organization for cultural heritage [2]. The study of the stone in the appropriate direction (after determining its nature) begins with an accurate characterization of its damages [3].

Protecting monuments that are directly exposed in open spaces, in the macroclimate, such as the external facades and reliefs of temples is particularly challenging. Even with a thorough study of the material, its condition, and the causes of damage, it is practically impossible to fully neutralize these causes of damage. This is because one of the main factors contributing to the damage is the macroclimate of the location where the monument is situated.

The aim of our research was to determine the nature of the building stones of the Mtskheta Jvari Monastery (small and large churches) and assess their current condition. We conducted fieldwork on the research site and analyzed the damaging factors, made possible by studying the physical, mechanical, mineralogical and chemical characteristics of the samples collected in the field conditions.

In addition to the fieldwork and laboratory research conducted by us, the results of previous scientific research, materials stored in archives, and data from laboratory studies conducted in previous years were also utilized. Based on the conducted work, it can be stated that the building stones of the large church mainly consist of quartz-feldspathic (arkosic) sandstones with a limited amount of crystal clastic tuffs (tuffites), while the building stones of the small church consist of crystal clastic tuffs (tuffites) and tuff sandstones.

Summarizing the types of damages in the large and small churches, it can be said that the structural decay and mechanical damages of the stone in the large temple are evenly distributed across all facades and are relatively less pronounced compared to the facade stones of the small church. The damages on the interior side of the church are fragmented. It is worth noting the low cement content in the natural stones, which contributes to the intensification of weathering and leaching processes. Each facade has its characteristic damages.

The condition of the facing stones in the small church is worse than that of the large church. Here, structural and mechanical degradation occur in equal amounts and at a higher frequency.

The condition of the building stones in the large and small churches is not alarming but challenging and requires urgent restoration. During this process, it is necessary to determine the "compatibility" of the materials used with the original material and their physical-mechanical parameters.

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GEOLOGICAL SETTING OF THE CENTRAL PART OF THE TRANSCAUCASUS, 1:200 000 SCALE GEOLOGICAL MAP AND EXPLANATORY NOTE

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The Transcaucasian Massif is one of the main tectonic unit of Georgia and the Southern Caucasus; it runs between the Southern Slope Zone of Cavcasioni in the north and the Miner Cavcasioni Tethyan ophiolite suture zone in the south.

The paleoceanic complex of the Transcaucasian Massif is considered to be a Neoproterozoic – Paleozoic terrane, while the pre-Hercynian basement of the massif is considered to be a Neoproterozoic–Early Paleozoic peri-Gondwanan terrane.

Within the Georgian Block the basement are termed as the Dzirula massif that includes two salients. One of them crops out within the basin of the r. Dzirula and its tributaries, while the other is exposed within the gorge of the r. Chkherimela. They are made up mainly of granitoids, gneisses, migmatites, crystalline schists; basic and ultrabasic magmatic rocks are met in fewer quantities. The extreme east of the massif, termed here the Chorchana-Utslevi strip, bears some less metamorphosed rocks – phyllites and associated ultrabasic rocks, mylonites, blastomylonites, marble lenses and others.

The region is characterized by pre, syn- and postcollisional events. At the pre-collisional stage within the region, there were systems of island arc, intra-arc and back-arc basins.

Precollisional Tectonostratigraphic unites of the region represents by:

- The Cambrian–Devonian Back-Arc–Forearc Complexes;
- Uppe Paleozoic granites, diorites and other magmatic rocks;
- Upper Triassic- Early Cenozoic sedimentary and volcanic-sedimentary cover. The Transcaucasian Massif during the Upper Triassic-Eocene developed as a relatively uplifted structural-morphological islandarc-type unit. Within the Georgian Block, accumulation of mainly shallow-marine, lagoonal-lacustrine, coal-bearing, and salt-bearing deposits of variable thickness was accompanied by island-arc type and withinplate volcanic eruptions.

The Oligocene epoch is considered as the beginning of syn-collisional stage of development of Georgia. The Oligocene –Lower Miocene deposits resulting from accumulation in hemi-closed basins of the Paratethys are represented by sandy-argillaceous gypsiferous facies.

The marine basins of the Tethys in Late Cenozoic were replaced by Transcaucasian basins of euxinic type (the Paratethys) and, later, by continental basins with subaerial condition of sedimentation. The Dzirula high subdivides the Transcaucasian intermontane depression into two foreland basins: the Rioni (Black Sea) in western Georgia and Kura (Caspian Sea) in Eastern Georgia.

The process of compilation of State Geological Maps of the medium scale has considerably long- term history in Georgia. The existing state geological maps and digital geological map of Georgia and explanatory note, published in 2020, were used in the preparation of the Central Transcaucasus geological map [1].

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RESISTANCE OF GEOPOLYMER BINDERS TO AGGRESSIVE ENVIRONMENTS

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A geopolymer is a material obtained by alkaline activetion of aluminosilicates at ambient temperature or slightly elevated temperature, having an amorphous or semi-crystalline polymer structure with Si^{4+} and Al^{3+} cations, tetrahedrally coordinated and linked oxygen bridges [1, 2]. During hydration, geopolymers give a product that is predominantly calcium silicate hydrate.

Sulfate and chloride corrosion of building materials is one of the most significant types of corrosion. It manifests itself when building structures are exposed to saline sea and ground waters, atmospheric air with an increased content of sulfur compounds, as well as acid rain.

For the study, a geopolymer materials was used, made on the basis of clay rocks of Georgia (argillite and low-melting clay) modified at 700 °C and granulated blast-furnace slag of the Rustavi Metallurgical Plant.

Alkaline activator NaOH, Na_2CO_3, and Na_2SiO_3 was used as a mixing liquid.

The assessment of the corrosion resistance of geopolymer materials was carried out according to the change in the mass and strength of the samples after 180 days their immersion in aggressive solutions: in 2% and 5% solutions of H_2SO_4 and HCl, as well as in 5% solution of Na_2SO_4.

As shown by the test results, geopolymer materials have a higher acid and sulfate resistance compared to OPC, which is in good agreement with the data of other studies. According to the authors of [3], the high corrosion resistance of geopolymer materials is explained by the absence of $Ca(OH)_2$ in their composition, a compound that is the main cause of the destruction of Portland cement concrete.

For X-ray phase analysis sample No.27 was chosen (Fig.1), which was synthesized from 80% slag and 20% argillite and activated with a solution of $NaOH + Na_2SiO_3$.

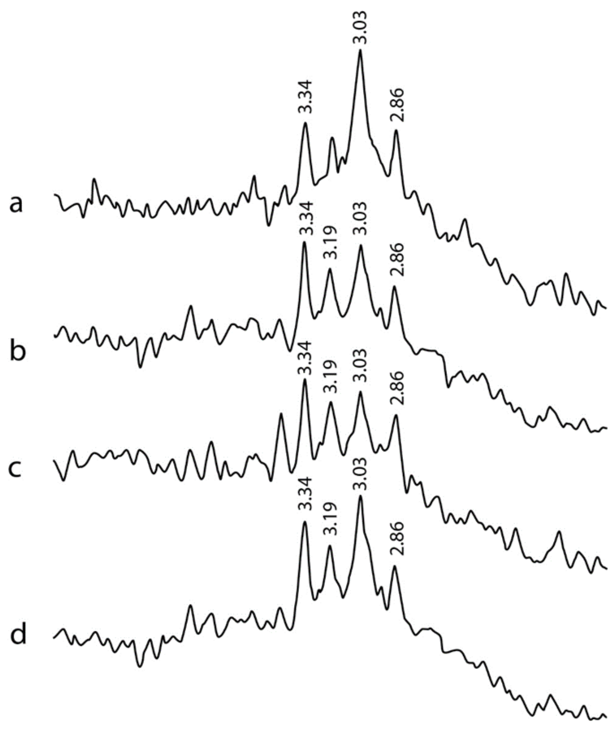

Fig. 1. X-ray patterns of sample No.27: a - before immersion in an aggressive solution; b - after 180 days of immersion in 5% H_2SO_4 solution; c - after 180 days of immersion in 5% HCl solution; d- after 180 days of immersion in 5% Na_2SO_4 solution.

As the authors of [4] believe, the main reason for the loss of concrete strength in an acid solution is the degradation of the geopolymer matrix, which is reflected in a decrease in the intensity of the X-ray amorphous phase in X-ray patterns (Fig. 1b and Fig. 1c).

Another process is observed when the material is immersed in a 5% Na_2SO_4 solution (Fig. 1d). Here, the phase composition and phase ratios remain almost on par with the initial material.

So, as our studies have shown, geopolymers obtained from local raw materials have a high resistance to aggressive soluteons, which is in good agreement with the data of other researchers and our previous works [5].

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THE STUDY ON ENRICHMENT OF GLAUCONITE SANDS FROM THE GHVERKI DEPOSIT/ORE OCCURRENCE

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The research was aimed at studying the enrichment of glauconite-containing raw materials from the Ghverki deposit. The Ghverki ore occurrence is located 8 km northwest of the Kharagauli railway station. It is represented by greenish glauconite sandstones of Albian age, the thickness of which reach 3 m, and extend for 200 m.

Macroscopically, the rock is a greenish gray sandstone with fine (<0.5 mm) glauconite grains, moderately cemented and moderately carbonated.

According to the mineralogical analysis, the following minerals are found in the rock: glauconite, quartz, hematite, magnetite and carbonate clay, which occupies the main of the mass and plays the role of cement. Glauconite occurs in two forms, the first form (80%) - isometric dark green grains with small white (presumably carbonate) veinlets, and the second form - light green, shapeless fragments (20%).

A technological scheme for the enrichment of glauconite-containing raw materials from the Gverki deposit has been developed, combining the following operations: crushing of raw materials to 0.63 mm, disintegration and desludging, drying of the sandy fraction and magnetic separation, fourfold cleaning of rougher concentrate /magnetic fraction/ in a closed circuit, resulting in production of 227 kg of concentrate with an iron oxide content of 15.3% from 1 ton of ore.

NEW DATA ON THE PRECAMBRIAN SERPENTINITES OF THE KHRAMI CRYSTALLINE MASSIF

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The Khrami crystalline massif is a relatively large outcrop of a deeply eroded part of the horst-like uplift of the Artvin-Bolnisi zone.

In the Chochiani river-gorge, 1 km from its confluence with the Khrami River, M. Kekelia et al. discovered a small lenticular allochthonous body of serpentinites (coor. 0429319/ 4598621) among the Precambrian autochthonous gneiss-migmatite complex of the Khrami massif [1]. The age of these rocks in terms of their geological position and their analogy with the similar rocks of the Dzirula massif is Precambrian [2]. Contacts of serpentinites with gneiss-migmatites are tectonic. In the contact zone, strongly crushed small, rounded fragments of serpentinites and gneisses, cemented by quartz and quartz-feldspar material, are observed. Serpentinite is composed of serpentine, tremolite and talc. Serpentine is represented by chrysotile and sarpophyte. Tremolite is presented as long transparent fibrous aggregates, often grouped and forming sheaf -like accumulations. Talc creates usually brownish, sometimes, colorless fine-scaly and radiated aggregates. Relics of structures or minerals of initial rocks were not found in thin sections.

M. Kekelia et al. and I. Gamkrelidze and D. Shengelia consider that the serpentinites of the Khrami crystalline massif, by petrological and geochemical features, as well as in comparison with similar rocks from other regions of the Alpine-Himalayan mobile belt are fragments of the oceanic crust [1, 3].

According to I. Gamkrelidze et al., the serpentinites of the Dzirula massif are considered as a remnant of the upper mantle of the Paleo-Tethys [2].

We have carried out a chemical analysis of petrogenic elements and RE of Precambrian serpentinites of the Khrami crystalline massif (Table 1). It should be noted that the composition of RE was not previously determined.

According to the compositional analysis the serpentinites are characterized by high magnesian content and low content or almost complete absence of alkalies.

Table 1

Chemical composition of Precambrian serpentinites of the Khrami crystalline massif

№	15	16	S-1-a	S-1-b	S-1-c	159	163	152	164
SiO_2	43.51	43.26	38.48	43.09	36.77	55.42	56.49	42.00	49.26
TiO_2	0.09	0.03	0.05	0.05	0.05	-	-	-	-
Al_2O_3	2.64	0.79	1.50	1.60	1.75	2.43	2.61	1.74	0.17
FeO	6.52	6.56	7.40	6.93	7.54	3.43	2.27	6.73	7.28
Fe_2O	-	-	-	-	-	1.98	2.88	1.62	0.54
MgO	29.63	24.52	27.82	29.52	29.76	28.40	29.72	33.21	28.29
MnO	0.10	0.08	0.08	0.10	0.07	-	-	-	0.04
CaO	5.23	4.88	4.06	2.92	3.82	4.96	3.18	3.27	2.48
Na_2O	0.14	0.14	0.14	0.14	0.14	0.05	0.11	0.05	-
K_2O	0.07	0.05	0.09	0.08	0.06	-	-	-	-
P_2O_5	0.001	0.001	0.001	0.001	0.001	-	-	-	-
SO_3	0.02	0.02	0.04	0.01	0.05	-	-	-	-
Cr	2066	2108	2437	2425	2471	2100	1900	1400	-
Ni	1502	1586	1850	1793	1858	2000	2300	3000	-
Cl	734.2	849.6	951.1	851.9	1013	-	-	-	-
La	105.3	63.44	44.01	37.25	19.5	-	-	-	-
Co	86.18	84.5	100.9	89.19	97.31	75	94	120	
Ba	80.59	47.53	114	40.24	60.5	-	-	-	-
Nd	42.76	41.64	52.42	47.88	52.36	-	-	-	-
Cs	41.59	28.31	19.96	16.91	9.68	-	-	-	-
Zn	40.14	41.43	41.56	37.21	38.29	130	110	90	-
V	34.42	30.11	48.82	40.17	42.71	38	36	34	-
Sr	10.77	11.66	14.85	5.85	11.68	-	-	-	-

Ce	10.71	92.4	10.77	34.94	10.62	-	-	-	-
Rb	6.87	2.88	4.60	4.35	3.08	-	-	-	-
Zr	5.53	0.32	0.32	0.31	0.32	-	-	-	-
Sn	5.18	3.91	1.52	1.50	1.51	4	5	6	
Y	4.34	2.58	2.17	2.36	1.60	-	-	-	-
As	3.77	7.61	39.90	8.64	5.01	-	-	-	-
Cu	3.52	5.15	3.14	2.90	2.16	-	-	-	-
Br	2.46	0.28	0.30	0.24	0.32	-	-	-	-
Ta	2.41	2.41	2.46	2.62	4.01	-	-	-	-
Hf	2.07	1.84	4.97	3.02	3.49	-	-	-	-
Hg	1.89	1.81	1.81	1.78	1.88	-	-	-	-
Bi	1.66	0.70	0.70	1.00	0.71	-	-	-	-
Sb	1.59	1.57	1.54	1.49	1.47	-	-	-	-
W	1.36	1.36	1.39	1.35	1.40	-	-	-	-
Pb	1.31	3.55	0.70	0.67	0.68	10	21	7	-
Ga	1.13	1.12	1.09	1.09	1.10	-	-	-	-
Nb	1.10	0.39	0.50	0.38	0.38	-	-	-	-
Ge	0.67	0.69	0.68	0.68	0.67	-	-	-	-
Tl	0.64	0.64	0.64	0.64	0.64	-	-	-	-
U	0.56	0.53	0.54	0.52	0.52	-	-	-	-
Mo	0.55	0.55	0.56	0.55	0.56	-	-	-	-
Th	0.45	0.62	0.71	0.44	0.41	-	-	-	-
Se	0.44	0.44	0.43	0.42	0.43	-	-	-	-

Samples №152, 164 (M. Kekelia et al., 1977)

The data obtained show great similarity with those of the rocks of the oceanic crust. According to the CaO-Al2O3-MgO diagram (Fig. 1), the initial rocks of the serpentinite of the Khrami massif are of harzburgite-dunite composition, correspo-nding to the theoretical composition of pyrolites. According to these features, as well as the composition of petrogenic ele-ments and RE, they are identical with the serpentinites of the Dzirula massif [2].

Thus, our data fully confirms the idea of M. Kekelia et al. and I. Gamkrelidze and D. Shengelia that the Precambrian serp-entinites of the Khrami massif, by petrological and geochemical features, and also by their comparison with similar rocks of the

Dzirula massif, are fragments of the oceanic crust [1, 3].

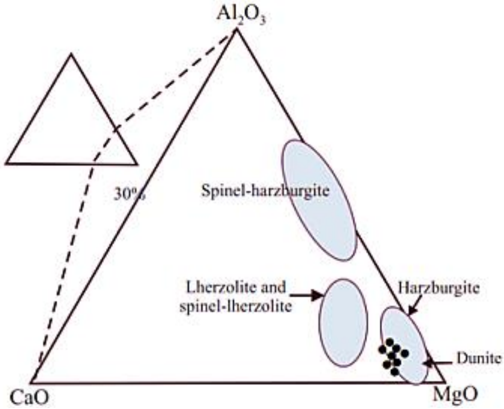

Fig. 1. Relationship between serpentinites and their protoliths in a MgO-Al_2O_3-CaO (wt.%) ternary diagram [4].

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INVESTIGATION OF POSSIBILITY OF ADDITIONAL BENEFICIATION OF FLOTATION TAILINGS AT RMG COPPER PROCESSING PLANT

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JSC RMG Copper Madneuli beneficiation plant processes copper ores from Madneuli and Sakdrisi deposits (open pits). ROM (Run of Mine) grades vary between 0.25-0.5% for copper and 0.3-1.0 g/t for gold. After modernization of Madneuli plant and commissioning new equipment, the process of beneficiation consists of three-stage crushing reducing the rock size from 1200 mm to 25-30 mm, three-stage grinding with target particle size P80=0,074mm, froth flotation and dewatering. Through rougher-scavenger flotation and two-stage cleaner operations, copper-gold concentrate with a copper content >10% is produced. Copper and gold losses in the final tailings range between 25-30% for both metals.

The purpose and subject of the study is to investigate possibility of additional recovery of both metals from flotation tailings, by employing gravity concentration, regrinding and again flotation.

Gold in copper ores is present by syngenetic and epigenetic minerals. Syngenetic gold is mostly (93-95%) present as electrum in a form of fine-grain inclusions within other minerals (pyrite and chalcopyrite).

Epigenetic gold is high-grade free gold embedded in the microcracks of mineral crystals and is commonly found in association with quartz. Its share in the ROM does not exceed 5-7%.

Since gold is mainly recovered together with associated minerals (chalcopyrite, pyrite), certain amount during flotation still reports to tailings, therefore causing some losses of valuable metals. Tailings also contain difficult-to-float useful minerals in a form of fine aggregates, as well as some secondary copper sulphides. These sulphides are formed in the secondary enrichment zones, which are obtained by the impact of copper sulphate on sulphides (pyrite) and are not completely replaced (chalcosine pyrite mantle).

Compared to other minerals (quartz, mica, sericite), the above mentioned minerals in the tailings are characterized by higher density and they can be extracted by gravity separation using high efficiency centrifugal field concentrator.

Based on conducted tests, the possibility of recovering them from tailings has been determined. Since the content of copper and gold in the tailings is variable, the tests have been conducted under conditions of different characteristic contents of the useful component in the tailings. The test results are given in Table 1.

Table 1

Summary of Beneficiation Test Results of Current Flotation Tailings

Name of product	**Test №1**	**Test №2**	**Test №3**	**Test №4**	**Test №5**
Au in flotation tailings (g/t)	0,30	0,27	0,34	0,32	0,16
Cu in flotation tailings (%)	0,08	0,06	0,14	0,08	0,07
Mass output of gravity concentrate (%)	13,86	5,78	9,12	8,91	8,11
Grade of gravity concentrate - Au (g/t)	**1,75**	**3,78**	**2,76**	**2,5**	**1,2**
Grade of gravity concentrate - Cu (%)	**0,17**	**0,16**	**0,61**	**0,30**	**0,18**
Stage Recovery of Au in gravity concentrate (%)	80,9	80,9	74,0	69,6	60,8
Stage Recovery of Cu in gravity concentrate (%)	29,5	15,4	52,8	33,4	20,9

As shown in above table, the degree of concentration of gold in the gravity concentrate depends on the mass output of the concentrate, which is one of the key parameters during this process, while the recovery can be deemed as constant for specific type of tailings, ranging between 75-85%.

Further processing of the obtained gravity concentrate can be accomplished with 2 different methods:

1. Grinding of gravity concentrate with subsequent flotation;
2. Leaching (cyanidation) of gravity concentrate.

For further tests the first method was selected. The gravity concentrate was ground down to 40 μm and floated again. Results of flotation of gravity concentrate are given in Table 2.

Table 2

Gravity concentrate flotation results

Name of product	**Test №1**	**Test №2**	**Test №3**	**Tes t №4**	**Test №5**
Mass output of concentrate after regrind/flotation (%)	5,44%	1,30%	2,53%	2,10%	1,31%
Grade of final concentrate - Au (rg/t)	**21,0**	**200,7**	**79,0**	**86,3**	**58,1**
Grade of final concentrate - Cu (%)	**1,9%**	**6,2%**	**12,4%**	**8,5%**	**5,4%**
Stage recovery of Au in flotation concentrate (%)	68,4%	78,1%	76,8%	71,0%	70,5%
Stage recovery of Cu in flotation concentrate (%)	58,8%	49,1%	54,6%	65,8%	39,4%
Total concentrate production (t/year)	16573	1654	5081	4107	2341

Initial studies were conducted using a collective scheme of flotation (test 1). Despite the high yield, due to the low content of copper and gold in the product obtained by collective flotation, the tests were continued with a selective scheme (tests 2-3-4-5). As the table shows, due to selective flotation a copper concentrate with average copper content of 5-7% is obtained. The gold content in the concentrates is high and varies from 200 to 60 g/t, on average it is 65-75 g/t.

Thus, tailings beneficiation with above method and obtained final concentrates will positively affect the overall process of beneficiation within Madnueli plant, with expected increase of overall recoveries by 2-3% for copper and 5-7% for gold.

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GEOLOGICAL AND TECHNOLOGICAL CHARACTERISTICS OF THE DEPOSIT - MANIFESTATION OF CLAY OF MOUNTAINOUS ADJARA AND PROSPECTS FOR THEIR USE

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1. Despite the centuries-old history of the traditional use of clay raw materials, the demand for it periodically changes. There are new directions, innovative technologies that pose modern challenges to the old, already studied deposits-manifestations.

2. Within the framework of this topic, we will discuss the composition of clays (mineral, chemical) of different locations in mountainous Adjara region, genetic features, distribution conditions, as well as the possibilities of using different types of raw materials, taking into account technological characteristics, ecological and mining-geological conditions.

3. In the study area, modern relief forms are formed by a network of the rivers (Adjaristskali and its tributaries), With narrow ridges developed between them, with watersheds and abruptly sloping slopes, as well as weathering crust, in the formation of which a great role is given to lithological composition of rocks, gravitational and exogenous factors.

4. Modern sediments in the region have a significant distribution and are represented by deluvial-proluvial, deluvial and eluvial facies formations.

5. The stratigraphic range of the region under consideration is not very wide; it is composed mainly of rocks of the volcanogenic-sedimentary complex of the Middle Eocene. Volcanoge-

nic and partially terrigenous deposits of the Upper Eocene alternate in the eastern part.

6. Volcanogens are represented by effusive, extrusive and intrusive facies. Petrographically, lavas and pyroclastics are subalkaline basalt or basalt-andesite in the lower and upper parts of the formation and subalkaline-alkaline, limestone-alkaline basalt-andesite and dacite in the middle part

7. Clay deposits are mainly found in the upper reaches of rivers, on relatively straightened morphological units of the aforementioned narrow ridges, on the slopes of watersheds, almost everywhere, except for rocky river escarps. Alluvial deposits are spread over a small area. The clays in this region are mostly eluvial. The vertical zonality is clearly visible on the section;

8. Based on the analysis, it is easy to see that the distribution (origin) of clays here is not related only to any particular stratigraphic horizon (unit). It also does not represent a product of only a certain structural-textural or mineral-petrographic composition of the rock.

9. Based on the petrographic composition of spread volcanogenic deposits, clay's (Kvashta, Brili, Buturauli, Pirveli Maisi, etc.) mineral composition of the main deposits of the region is more or less different, but not to such an extent that they can be divided according to this sign.

10. Clays are mostly of polymineral composition, with most of some clay minerals. Buturauli has a montmorillonite- halloysite composition, Brili - kaolinite-halloysite-montmorillonite. Montmorillonite is not found in the clays of Kvashta and Ortsva. All, except the mentioned clay, contain quartz, most of Ca - Na feldspar and iron oxide, some of them chlorite and hydromica.

11. There is also uniformity in terms of chemical composition. The main components of clays according to the deposit are

as follows: SiO_2 within 50%; Al_2O_3 content between 19 - 23%; humidity 1.5 - 3.5%; crystallization water 6 -9 %. All deposits clays contain 8-12% iron oxide.

12. The main technological characteristics of these clays (depending on the deposits) were studied, such as: plasticity, clay composition, firing temperature, total shrinkage, water content, average density, porosity, etc. The presented clays are of medium and high plasticity. Part of the tiles formed from the above-mentioned clays was fissured, while the other part does not meet the requirements of the standard for water content. Plates were formed from crushed test materials up to 0.2 mm thick by pressing, which were fired at various temperatures. The water absortion of annealed tiles ranges from 1.5% to 4%.

13. This raw material, in terms of water absorption, meets the requirements set by the standard for exterior and interior facade and floor slabs. These clays without enrichment cannot be used for the manufacture of porcelain stoneware.

14. Clay deposits in the region are characterized by small reserves and distribution by area. The processing of some of them is problematic from the point of view of the activation of landslide processes (Buturauli, Gocha-Kana, Magla-Kana, etc.). Along with environmental problems, road infrastructure is important (Brili is located 15-20 km from the Central Road).

15. The deposit of the village of Pirveli Maisi is distinguished by its relatively good location. However, its reserves might be within 100,000 m^3, and there is no prospect of an increase. The possibility of joint processing looks interesting - the use of clay from the villages of Pirveli Maisi and Kvashta.

IMPORTANCE AND ROLE OF SAND IN THE HARDENING PROCESS OF LIME MORTAR

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The monuments of Georgian architecture, with their originality and uniqueness, are an inseparable part of world civilization and culture.

Rehabilitation and restoration of monuments in Georgia is carried out intensively, but the causes of damage to monuments and the ways of their subsequent elimination and restoration are practically not studied [1].

In the construction process, mainly the so-called lime mortar is used, which is a mixture of sand, lime and water [2].

The lime mortar hardening process is carried out in several directions. First the chemically unbound water evaporates, then the calcium hydrate interacts with carbon dioxide in air, during which the calcium hydrate gradually loses chemically bound water to form calcium carbonate – a solid salt. The absorption of carbon dioxide process takes decades. In addition to the carbonation process, lime-free particles interact with clay substances, actively decompose them and form gel-like hydrosilicates and act as binders for various particles.Therefore, in addition to the quality of the lime, the sand is of great importance in the hardening process of the lime mortar. It must contain different cation-containing aluminosilicates so that different hydrosilicates can participate in the hardening process.

To determine the optimal composition of the mortar was used a standard sand from France (Standard Sand, Conforme ISO 679, 2009), as well as two samples from Georgia: gray sand from the Aragvi Valley and "Sachkhere sand" of light yellow color.

The chemical composition of all three research sands is given in Table 1. The chemical composition of the lime used is also given here.

Table 1

Data from chemical analysis of sands and lime

Constituent elements in the form of oxides	SiO_2	Al_2O_3	CaO	K_2O	Na_2O	Fe_2O_3	MgO	MnO	TiO_2
Standard	82.8	2.13	0.51	0.99	0.14	0.52	–	0.18	0.08
Light yellow from Sachkhere	62.66	10.26	1.23	3.09	0.28	1.93	0.68	0.03	0.34
Gray from the Aragvi Valley	39.74	7.50	15.31	1.24	0.13	4.22	1.95	0.12	0.48
Lime	0.32	0.09	56.60	–	0.14	0.09	0.14	0.01	0.01

As can be seen from the data in the table, the sands are different in chemical composition, and lime mainly contains calcium.

The results of X-ray diffractometric analysis of the sands coincide with the results of chemical analysis (Fig. 1). On the X-ray pattern of the yellow sand, unlike the other two sands, we have several peaks, at 2.70, at 2.80 Å, which represents salts with different crystalline structure in this sand, mainly potassium salts, makes us think that they are gel-like silicates and are to some extent soluble in water.

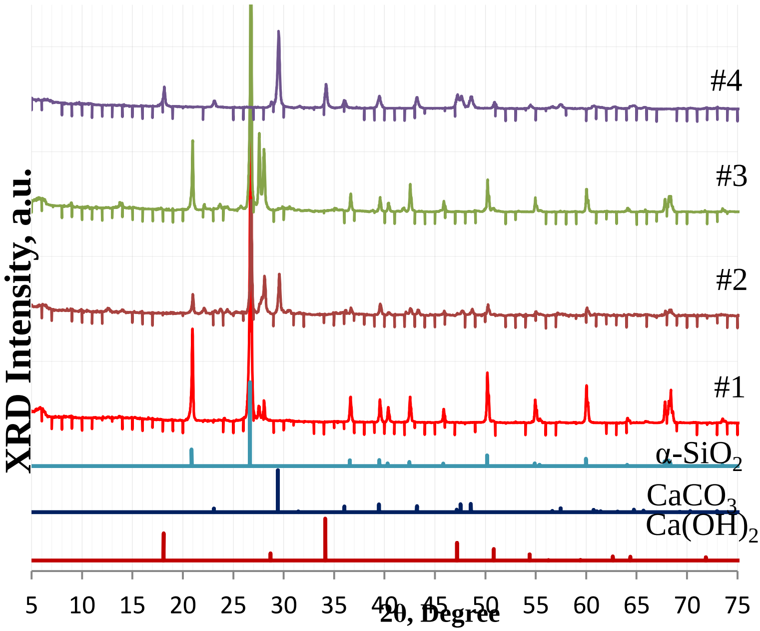

Fig.1. X-ray diffractogram of research samples: #1 – sand standard; #2 – sand gray; #3 – sand yellow; #4 – Georgian lime

Testing of mortars of different compositions showed that the greatest hardness has a mortar prepared on yellow Sachkhere sand in the proportion of 1:1 and 1:2 (lime:sand). Table 2 shows the hardness testing results of different composition lime mortar.

Table 2.

Hardness testing results of lime mortar

Composition of mortar, %				Hardness after 28 days and nights, MPa
Lime	g	Sand	g	
Pierced lime at 1000^{0}C	150	Standard	150	1.5
	100	Standard	200	1.0
	75	Standard	225	0.75
	150	Gray	150	1.5
	100	Gray	200	1.0
	75	Gray	225	1.0
	150	Yellow	150	2.2
	100	Yellow	200	2.0
	75	Yellow	225	1.5

Thus, the results obtained showed that the chemical composition of the sand is of particular importance for lime mortar. The greater the amount of different cation-containing salts in the sand composition, the more intensive and diverse is the carbonization process in the mortar, and as a result its hardness is high.

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MACROECONOMIC ASSESSMENT OF THE GEORGIAN MINERAL RESOURCE BASE: THE BASIC DRIVER FOR ECONOMIC DEVELOPMENT

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Methods of macroeconomic appraisal of mineral resources were elaborated by Schurr, Netschert, Mc Kelvey, Hubbert, Lieberman, and finally by de Verte Harris [1] and afterward developed by us [2-5]. Here we are proposing an updated and renewed methodology.

The Net Present Value (NPV) of any mineral resource, as we have proven [2, 5], may be computed as:

$$NPV = \int_{n=1}^{t} \alpha_n \frac{\partial I_p^n}{\partial t}, \quad (1)$$

Where: NPV = net present value, α_n = discounting factor, I_p^n = price index of n^{th} year, t= discounting term.

Simultaneously, increment of reserves of any resource is a function of the exploration drilling footage:

$$Q_t = K \int_0^h e^{-Bh}\, \partial h, \quad (2)$$

Where: Q_t = reserves of a resource in year t, h = drilling footage, K, B = coefficients.

Now, expressing reserves of a resource in terms of its NPV, and drilling footage in terms of necessary investments, and then generalizing the computed results for the Georgian resource fund, we may generate a model of ultimately recoverable investments, shown on Fig. 1.

Table 1 below shows the assessment of the actual mineral resource base and its possible development in conditions if needed investments are made.

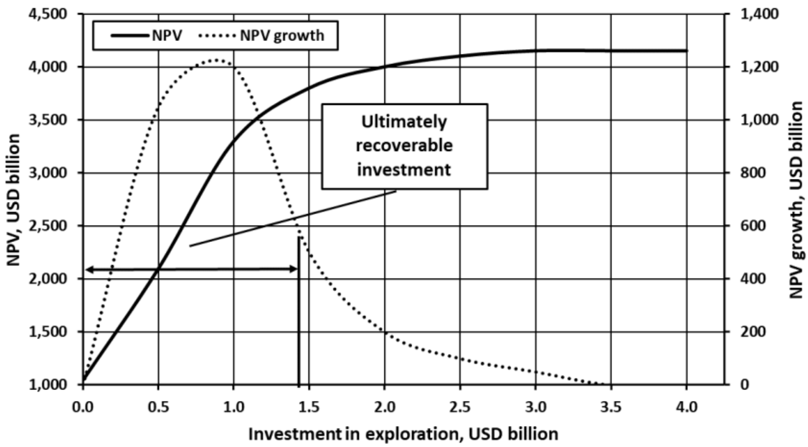

Fig. 1. Development model of the Georgian mineral resource fund.

The provided information will help investors, first of all, to assess the volume of ultimately recoverable investments mitigating this way venture risks, and secondly, to choose resource, commodity and a deposit, in which investments should be made.

Hence, the most important issue of such approach is the possibility to imply mineral resource base of Georgia in the economic turnover of the country. It is benchmark information for capitalization of mineral resources and for launching a real, modern capital market, which today is in a rudimentary state. But for doing this dramatic update of the existing economic legislation would be necessary, including elaboration of: (i) the modern Mining Code; (ii) the modern legislation on stock and commodity exchanges; (iii) the modern legislation on ETF funds. Some amendments should be introduced to the Tax Code and the legislation on commercial banks.

Table 1

NPV of the Georgian mineral resource fund and the possible model of its development

Type of mineral resource	NPV of the resource fund, USD billion	Model NPV of the resource fund, USD billion
Energy resources	213,428	1,805,000
Metals and rare elements	120,063	513,000
Chemical resources	101,282	186,200
Ceramic resources & gems	26,405	41,800
Facing resources	63,710	152,000
Metallurgic, inert &building resources	29,912	34,200
Mineral waters	494,846	1,067,800
Total	1,049,646	3,800,000

Such changes will allow launching the modern economic and financial engines totally absent in Georgia, and among them:

1. The Caucasus commodity exchange
2. The Caucasus Gold Exchange
3. The Caucasus Gold ETF Fund and other ETF founds
4. Etc.

Most of the Georgian population tends towards the European Union and the western democracies.

Merging with the modern Europe is unfeasible without initiation of the approach described.

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OBTAINING AND TESTING OF METAL-POLYMER LAMINATES UNDER DYNAMIC LOADS

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Obtaining modern lightweight armor materials with desired strength and high ability to suppress kinetic energy remains an actual problem [1]. Recently, composites (laminates) containing thin aluminum plates and textiles based on aramid/ Kevlar, glass, carbon fibers (ARALL, GLARE and CARALL) have been effective in several industries, including aircraft construction. These materials are characterized by low ability to form and develop cracks, high plastic deformations. As it turns out recently, they are quite effective in terms of suppressing shock waves during explosion [2, 3]. Along with this, it should be said that the studies of metal-polymer composites (laminates) in this direction are in at the initial stage and require a deeper study. In this regard, our attention was focused on the studies previously carried out at the Mining Institute, which provide for the evaluation of the blast resistance of steel under the conditions of a certain distance of the charge from the surface of the sheet. In our opinion, such an approach to the study of the explosion resistance of new materials, including metal-polymer laminates, will provide us with objective data on the behavior of the material under explosion conditions.

The obtained results can be used in the fields where the structure/product is required to suppress dynamic loads completely or partially. It can be said that ARALL and GLARE type materials were created mainly for the purpose of protecting structures working on dynamic loads (increasing crack resistance, reducing fatigue). The aim of the research is to manufacture and test GLARE and ARALL type metal-polymer laminates on their resistance to explosion and impact.

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NUMERICAL CALCULATION OF PROBLEMS OF EXPLOSION WELDING AND REINFORCEMENT BY COMPUTATIONAL EXPERIMENTAL METHODS, MATHEMATICAL AND COMPUTER MODELING OF PROCESSES

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From the point of view of technical and economic efficiency, it is very important to carry out scientific research with modern methods, through mathematical and computer modeling of processes. It is known that industrial-technological progress determines scientific-technical progress and it periodically requires the development, improvement and introduction of new technologies and appropriate methodology. From this point of view, a new method is added to the traditional theoretical and experimental methods of scientific research - in the form of a computational experiment, which includes numerical calculation methods together with analytical solution methods and provides for the integration of the research system, process and mathematical model of the event in computer mathematics systems. At the same time, it provides the possibility of their visualization and optimization based on process imitation or simulation.

Mathematical modeling of high-speed processes is one of the important aspects of solving theoretical and practical problems. Mathematical modeling of explosion welding and reinforcement as technological processes is one of the effective methods for reducing the number of experiments and costs, as well as increasing the quality of welding and the competitiveness of products.

In order to model the process of explosion welding of reinforced bimetallic composites, a number of test and technological tasks were solved within the project:

- development of mathematical models of the welding process, determination of empirical dependences and numerical calculation of the quantities involved in it;
- calculation of the shock-wave load parameters in the explosion welding process and determination of welding quality criteria.

An impact occurs when one body falls on (collides with) another and the force of contact between the bodies changes in a very short period of time. The rapid change of dynamic load leads to accelerations of the elements and the emergence of inertial forces as a result, which generates additional stresses and deformations. Stresses and deformations induced in the impacting body reach maximum values.

The deformation has a wave nature. After the gradual suppression of oscillations, a state of static equilibrium is established, which is accompanied by a reduction of stresses and strains to static values.

Using the LS-DYNA software package, the following will be implemented within the project:

1. Computer modeling of the process of metal plate shooting due to the impact of instantaneous expansion of flat charge detonation products;
2. Modeling of the collision process of the shot plate with the matrix;
3. Modeling of collision processes of reinforcing elements and metal plates.

In addition, the parameters of explosion welding and reinforcement will be determined, the microstructure of reinforced bimetallic samples will be investigated.

Mutual comparison of the results obtained through mathematical and computer modeling, in the conditions of their full correlation, gives reliable results, which will allow us to obtain reinforced composite materials with optimal parameters.

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THE MTKVARI (KURA) RIVER FLOOD BASALTS (SOUTH CAUCASUS CONTINENTAL FLOOD BASALT (CFB) PROVINCE, GEORGIA): STATE OF RESEARCH AND FUTURE PROSPECTS

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The internal architecture of large CFB provinces like the Deccan Traps and Columbia River flood basalts, has gained importance as these provide vital clues to constraint the chrono-stratigraphic framework, evaluate the magmatic processes vis-à-vis the emplacement dynamics of flows and impact of voluminous volcanism on climate. However, such studies in the smaller provinces are either lacking or poorly documented.

The Javakheti Volcanic Province (JVP) extending over the area of synonymous highland is situated in central part of the Lesser Caucasus Mountain system and is an important center of voluminous post-collisional volcanism. The area boundaries correspond to the Childyr Lake, Shirak and Bazum ridges on the south, the Mtkvari (Kura) River upper reaches on the west, the Trialeti Ridge composed of the Paleogene volcanogenic-sedimentary rocks on the north. The eastern distribution limit of young volcanics corresponds approximately to the Tsalka–Gomareti–Dmanisi-Stepanavan line, though three large basaltic lava rivers tens kilometers long extend along the Mtkvari (Kura), Mashavera, Khrami and Debed valleys outside the delineated area. Most of the Neogene to Quaternary volcanics sequences erupted during the Pliocene epoch. They form a part of continental flood basalts that are spread across southern Georgia, central and northern Armenia and NE Turkey. Sheth et al. (2015) [5] made an attempt to document some features of the lava flows in the Armenian counterpart and named the province as South Caucasus CFB Province as the smallest and youngest continental flood basalt province in the world. Despite the active research by Georgian and foreign workers conducted in the Georgian counterpart of the South Caucasus CFB Province and in the JVP in particular, documentation of the physical volcanology of these widespread basalt lavas seems to be missing in the local and international literature.

Joint fundamental research of the Mtkvari (Kura) River flood basalts and interflow horizons, which constitute a small part of the South Caucasus CFB province has started since 2016 by Georgian-Indian team. The research team project has been recently granted by the SRNSF of Georgia. It is intended to study the lava flows and associated interflow horizons in order to classify lava morphology in relation to volcanic facies architecture and comment on their emplacement dynamics and on the environment of deposition of the interflow horizons. Flow mapping of critical sections with the special emphasis on accurate documentation of common flow morpho-types in lava sequences and internal structures will enable to identify and record their physical volcanology and classify them into typical morpho-types.

Preliminary work in the Kura, Khertvisi, Saro, Eshmakis-Khevi and Toloshi sections has revealed some important physical volcanological features suggesting that pahoehoe lavas dominate but rubbly pahoehoe and aa are common. These features will be used to identify volcanic and sedimentary facies that can shed light of emplacement dynamics of the eruptions and palaeoenvironment [2]. Recent studies have also revealed that in all previous studies numerous lobes forming compound pahoehoe lava flows were erroneously considered as separate lava flows [1]. The team has already improved this mistake at several sections and will continue working in this direction. Several previously unknown sedimentary interflow sedimentary horizons have been found and some of them have been studied as well [3, 4].

There is abundant amount of scope for the future research relating to the study of physical volcanology of these lava flows, apart from building robust volcanic facies architecture in this part of the province, which is the first of its kind as well as the comprehensive study of the interflow sediments including red boles/bole beds.

Our work along with already introduced model of the Debed River flood basalts (Armenia) will serve as a helpful guide for the future volcanological studies of the entire province. It can become a ground for initiation of regional and international collaboration in this field of research through tracing and mapping the flood basalts within neighbouring regions and correlations with such well-known CFB provinces as Deccan Traps in India. Sustained and coordinated research efforts over the next decade can surely make the South Caucasus CFB province internationally famous for its spectacular exposures and the role it has to play in our conceptual understanding of CFB volcanism.

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ABOUT THE FOLDED STRUCTURES, CONDITIONS OF ITS FORMATION AND STRATIGRAPHY OF THE GAGRA-JAVA ZONE OF THE GREATER CAUCASUS

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The relevance of the seismic activity of the Southern slope of the Greater Caucasus has always aroused the interest of scientists, but the relationship between seismic and tectonic zones has not been studied in sufficient detail. After the Racha earthquake, which caused great destruction in this mountainous area, the Gagra-Java zone is of the particular interest. The Racha earthquake took place on April 29, 1991, with a magnitude of 6.9 and an intensity of 9, with a hypocenter of 17 km. Therefore, we decided to associate this phenomenon with hypothetical active zones and reveal their internal structure and amplitude.

The Gagra-Java zone is the southernmost tectonic unit of the Greater Caucasus located along the boundary with the Black Sea-Transcaucasian microcontinent (microplate). In geological building of the discussed area of the Gagra-Java zone participate Lower, Middle and Upper Jurassic sandy-clayey deposits, Middle Jurassic volcanic rocks and Cretaceous and Paleogene carbonate formations, with more than 6 km of total thickness.

In the limits of geological-structural profiles there were distinguished folded areas bounded by steep faults and variously deformed and sometimes difficult to identify as the same structure. The reason of such collage of different dislocations is the vertical disharmony of folding and multiple overprint of tangentional compression of different orientation

Folding of the Gagra-Java tectonic zone was formed at the Early-, Middle Alpine stage of the evolution of the Greater Caucasus during the manifestation of Bathonian (Adigean) and active at the boundary of Eocene-Oligocene (Pyrenean) phases of tectogenese. The folding took place in conditions of the north-eastern tangential compression of the region, stipulated by motion and pining of the Black Sea-Transcaucasian micro-continent to the Gagra-Java zone. Late Alpine newest stage (Late Miocene-Anthropogene) took place in conditions of sub-meridional horizontal pressure on the active marginal Gagra-Java zone. These movements took place during the newest and Quaternary orogenies in conditions of collision of the Black Sea-Transcaucasian microcontinent and the Greater Caucasus. Multiple tangential compressions of different directions promote processes of formation of non-uniform folded structure of different age in Gagra-Java zone, which is continued today.

For the first time on the right tributaries of the river Aragvi (Ananuri village) we carried out detailed structural-lithological and paleontological research by nannoplankton, within the framework of detailed geological study of the Southern slope of the Greater Caucasus and Gagra-Java zone. The obtained results have shown, that in the sediments of the Gagra-Java zone confined to the Upper Eocene according to lithofacies and the rather poor list of planktonic foraminifers (their majority are not defined to species), according to nannoplankton 5 complexes of different levels of Miocene – Lower Pliocene age were established. And within the limits of flyschoid sediment of the Southern slope 1 subzone of the Upper Miocene-Lower Pliocene age is distinguished. In this part of the section also 4 Paleocene nannoplankton zones and 3 Upper Cretaceous zones are established.

Detailed lithological-stratigraphic and micropaleontological studies give grounds to establish that this boundary zone between large geotectonic units has a specific tectonic structure, large amplitude and is still active.

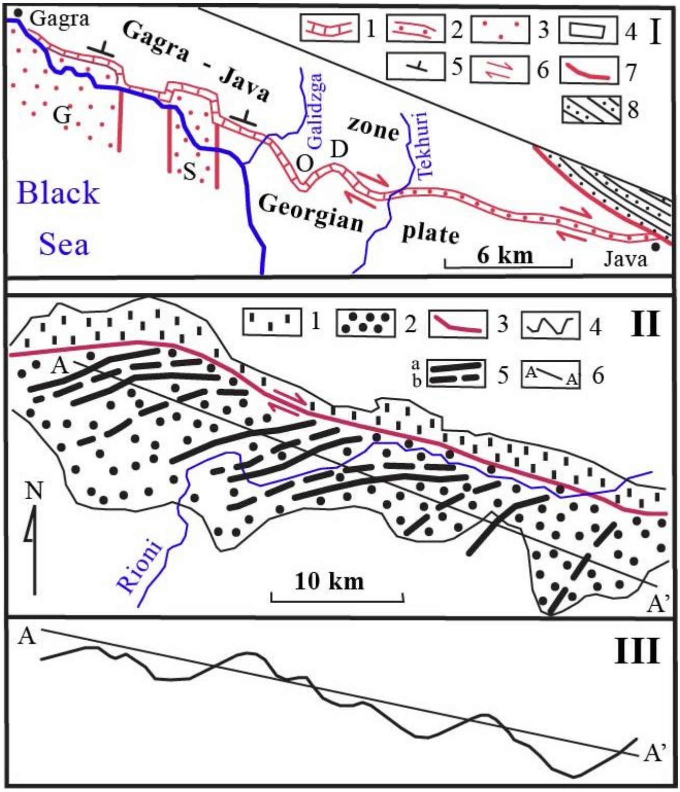

Fig. 1. Scheme of the structure of the Gagra-Java (G-D) fault zone (compiled using available geological materials).

I - morphology and kinematics of the G-D fault: 1 - western segment represented by a steep flexure; 2 - eastern segment is formed by graben-synclines; 3 - sholies: G - Gudauta, S - Sokhumi; 4 - Racha-Lechkhumi syncline. The nature of the movement along the fault: 5 - reverse fault; 6 - shear; 7 - Orkhevi fault; 8 - Mestia-Tianeti flysch zone. II - Structural diagram of the Racha-Lechkhumi (R-L) syncline.

1 - Northern steep limb of the syncline, developed in the G-D tectonic zone; 2 - southern gently sloping limb of the syncline, located within the Georgian block; 3 - G-D fault; 4 - syncline boundary along the base of the Upper Cretaceous. Folds complicating the southern limb of the syncline: 5 - a - anticlines, b - synclines; 6 - structural profile line. Hemifolds: O - Okumi, D - Jvari. III - Structural profile a the base of the Upper Cretaceous along the southern slope of the R-L syncline along the A-A' line.