MINERALOGICAL SOCIETY OF GEORGIA
G. TSULUKIDZE MINING INSTITUTE
GEORGIAN TECHNICAL UNIVERSITY

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

BOOK OF ABSTRACTS

6th International Scientific-Practical Conference on
Up-to-date Problems of Mining and Geology

24-25 September

Tbilisi
2020

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GEOLOGICAL SETTINGS OF GENESIS OF ENDOGENOUS ORE DEPOSITS OF THE CAUCASUS

D. AREVADZE

I. Javakhishvili Tbilisi State University, A. Tvalchrelidze Caucasian Institute of Mineral Resources, Tbilisi, Georgia.

1. A study of the chemistry, concentration and pressure of ore-forming fluids in the endogenous deposits of the Caucasus shows that porphyry copper, skarn, copper pyrite, pyrite-polymetallic and copper-barite-polymetallic deposits are derivatives of fundamentally identical abyssal chloride-sodium brines and heavy metal concentrations sulfur in tens of grams per liter.

With gradual cooling of primary fluids, high-temperature deposits are formed with low contents, but with large reserves of the useful component — porphyry copper molybdenum.

During boiling, sharp dilution, and interaction with the host sedimentary or volcanic sedimentary rocks, concentrated bodies of amorphous ore sediments are formed. When they are recrystallized by residual or reconstituted diluted solutions from another source, medium-low-temperature deposits of copper, lead, zinc and barium are formed. It is this stage of transformation of primary amorphous ores that is fixed during fluid inclusion and isotope-geochemical studies.

Common to the deposits of these formations are: vertical or lateral mineralogical zoning, near-critical crystallization temperatures of early mineral associations, sodium chloride profile of solutions, synbate changes in temperature, salinity and oxidetive potential, occurring against a background of a decrease in the fraction of the deep component of water fluids, and near meteorite integral sulfur isotopic composition.

2. A number of specific features are characterized by vein and metasomatic deposits of lead, zinc and barium within the Gagra-Java zone and the Okriba uplift of the Southern slope of the Greater Caucasus: spatial separation of barium from lead and zinc, low copper contents, the absence of anhydrite in the presence of Ca^{++} fluids and $HS0^{-}_{4}$, the presence of hydrocarbons in ores and fluid inclusions, a wide scatter in the sulfur isotopic composition, the absence of a clearly defined mineralogical zoning, and the evolution of ore-forming solutions from bicarbonate-calciums to sodium chloride. All these signs are expressed in deposits of the Mississippi type.

These deposits are controlled bydeep faults and it is impossible to exclude the participation of endogenous fluids in their formation, which is indicated, in particular, by isotopic studies.

3. Deposits of antimony-arsenic with gold and gold-sulfide formations, in contrast to the above, are characterized by a high concentration of carbon dioxide in the fluid, which has mainly a crustal source and enters the system together with metamorphogenic waters. The presence of a abyssal component in the system, in addition to geological factors, is confirmed by the sodium chloride component of the fluid and the sulfur isotopic composition.

4. In all the systems studied, a deep component is detected. Introduced core material by metamorphic and oil waters significantly changes their specialization, leading to the formation of deposits of certain ore formations: the initial deep chloride-sodium fluids form deposits of Mo, Fe, (Wo, Sn), Cu, Zn, Pb and Ba; hydrocarbon-rich fluids - Pb, Zn, Ba, (Sz), and carbon-dioxide-rich fluids - Sb, As, Hg, W, Au, (U). The role of carbon dioxide is to stabilize thiocomplex compounds of heavy metals, and the role of hydrocarbons is to stabilize sulfur complexes with an intermediate oxidation state (S°, S^{+4}).

5. The phase composition of fluid inclusions is a reliable criterion for assessing the potential ore content of hydrothermal systems: authigenic ore daughter minerals unambiguously indicate the potential ore content of fluids and determine the mineralization profile (magnetite and hematite - skarn-iron ore, chalcopyrite-porphyry copper and needle-like arsenopyrite - gold-arsenic); liquid CO_2 is an indicator of gold-sulfide and antimony-arsenic mineralization.

P-T-X conditions and sources of sulfur, carbon and water of endogenous deposits of the Caucasus

Ore Deposits	Mineral Association	T°C	P bar	Salt composition of fluids	Salinity in weight % equival. NaCl	Sources of		
						Sulfur	Carbon	Water
THE LESSER CAUCASUS								
Porphyry copper-molybdenum	$CaCO_3$ $CaCO_3$-ZnS-PbS FeS_2-$CuFeS_2$-MoS_2 FeS_2-MoS_2 SiO_2-FeS_2	<150 280-160 360-320 400-320 450-370	⩽1000—>100	$\frac{Na^+K^+Ca^{++}}{Cl^-(HCO_3^-)}$ $\frac{Na^+K^+(Fe\ Cu)}{Cl^-(HSO_4^-)}$	40 → 3	Abyssal	Abyssal + From host rocks	Meteoric+Abyssal ↑ Abyssal
Skarn iron ore (Dashkesan)	$CaCO_3$-ZnS-PbS FeS_2-$CuFeS_2$-SiO_2 SiO_2-Fe_3O_4 Скарны	200-160 320-200 420-350 >500	⩽700—>100	$\frac{Na^+K^+\ Ca^{++}}{Cl^-(HSO_4^-)}$ $\frac{Na^+K^+Ca^{++}Fe^{++}Mg^{++}}{Cl^-}$	85 → ~3	Abyssal	Abyssal	Meteoric+Abyssal ↑ Abyssal
Pyrite-coper-barite-polymetallic	$BaSO_4$ $BaSO_4$-PbS-ZnS ZnS-$CuFeS_2$-FeS_2± ($CuFeS_2$-Cu_3AsS_4) $CuFeS_2$- FeS_2 FeS_2-$CaSO_4$±MoS_2	<180 280-160 320-250 350-280 410-340	⩽300—>100	$\frac{Na^+K^+}{HSO_4^-Cl^-}$ $\frac{Na^+K^+}{Cl^-(HSO_4^-)}$	~40 → 1.2	Abyssal	Abyssal	Meteoric+Abyssal ↑ Abyssal
Gold Sulphide	SiO_2-Ca_2CO_3±(Sb_2S_3-AsS) SiO_2-$CaCO_3$-Me_xTe_y SiO2-CaCO3- Me_xS_y-Au SiO_2-$CaCO_3$-FeS_2-FeAsS SiO_2- FeS_2	240-160 320-230 380-340	⩽400	$CO_2H_2S\frac{Ca^{++}}{HCO_3^-}$ $CO_2\frac{Na^+K^+}{Cl^-HCO_3^-}$	~ 8 → 2	Abyssal	From host rocks + Abyssal	Metamorpho-genic

SOUTHERN SLOPE OF GREATER CAUCASUS								
Pyrite and Pyrite-polymetallic	SiO_2-CaCO3 ZnS-PbS-SiO2 $CuFeS_2$-Fe_{1-x}-S FeS_2-Fe_{1-x}-S FeS_2-SiO_2	<120 300-180 325-260 425-375 450-425	800 → 150	$CO_2 \frac{Ca^{++}K^+}{HCO_3^-Cl^-}$ $\frac{Na^+Ca^{++}}{Cl^-HCO_3^-}$	50 →2	Abyssal	From host rocks	Abyssal + Meteoric
Lead -Zinc Barite deposits	$CaCO_3$-FeS_2 $BaSO_4$ ZnS-PbS+($BaSO_4$)	200-160 320-200 420-350 >500	340 → 60	$\frac{Na^+}{Cl^-}$ $\frac{Na^+}{HCO_3^-Cl^-}$ $\frac{Ca^{++}}{HCO_3^-HSO_4^-}$	1	Abyssal(?)	From host rocks+ Abyssal	Meteoric → Abyssal
Antimony Arsenic with gold	As_2S_2-AsS±HgS Sb_2S_3-($CaWO_3$-AsS) FeAsS-FeS_2 SiO_2(Метаморфогенный этап)	210-150 300-220 390-320 250-100	>1000	$CO_2 \frac{Na^+Ca^{++}}{HCO_3^-Cl^-}$ $CO_3N_2 \frac{Ca^{++}Na^+}{HCO_3^-}$	8 → 2	Abyssal	From host rocks + Abyssal	Metamorpho-genic

RESEARCH AND IMPROVEMENT OF IMPACT RESISTANCE METHOD

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Impact resistance is resistivity solid body influence Impact energy without loss of bearing capacity. In another way, the impact resistance is the amount of relative impact energy, at which the specimen does not destruct. Unit of measurement Joule/m^2.

At present, the following methods determining Impact resistance [1, 2] are applied: Blasting, Impact bomb, Drop-Weight, Charpy and Izod impact test. The method of blasting and Impact bomb requires a complicated device. Charpy and Izod methods are limited and mainly used in metal testing. The drop-weight method is relatively simple and is used to determine the impact resistance of rocks, concrete, ceramics and other materials.

The main tool of the Drop-weight (Hereinafter - hammer impact) method is the impact hammer [3, 4]. The method involves repeated impacting from increasing step and from unchanging height until complete failure of the specimen.

Despite the simplicity of the hammer impact method, the following issues need to be improved [1-5]: impact hammer configuration, weight, impact velocity, pattern of contact with the specimen, swallowing, repeated impact; sample deformation, cracking, dynamics, specimens decomposition; determination of rupture area; hammer impact height, step size and so on.

Therefore, research into the method of determining impact resistance – improvement is one of the modern, scientific and technical issues. The paper presents the issue of the height and the step size of the hammer impact.

A basalt specimen impact test was performed using a hammer impact method. The impact is carried out at varying heights with constant step size and unchanged height [5] (Tab. 1).

Table 1

Mean value of test results

Variant of testing	Specimen #	Impact step/unchanging height, m n/h	Failure Height of specimen, H	Impact energy,J/m E_i	Area of failure,m^2 A_i	Relative destruction energyJ/m^2 E_r	Impact resistance J/m^2 I_r
I	1;2;3;4	0,01/	0,157	26,3	0,00123	21382	17106
II	5;6;7;8	0,03/	0,063	14,4	0,00119	12101	9681
III	9;10;11;12	0,05/	0,048	14,0	0,00114	12281	9825
IV	14;15;16;17	0,08/	0,033	11,2	0,00111	10090	872
V	18;19;20;21	0,12/	0,025	10,8	0,00118	9153	7322
VI	13	/0,24	0,24	4,80	0,00116	3000	2400
VII	22	/0,28	Not failure		0,00113		
VIII	23;24;25;26;27	/0,30	0,30	6,00	0,00110	5455	4364

In the first variant, the impact step is 1 cm and the specimen is failure into seventeen strokes. In VI variant, the specimen was destructed by a hammer impact from a height of 24 cm.

The failure mechanism of the samples can be formulated as follows. A cone is formed below the surface of the sample. In Variant I, the cone size and density gradually increased with the impacts. It can be said that the sample under the action of impacts tempered, hardens, compacted, resists the impact and is late breaking.

Variant VI does not have a gradual impact on the specimen, the process is much faster, the cone size and density are smaller than Variant I, the specimen does not harden or compact, and is broken by a single blow. Therefore, the relative energy of decomposition in option I is 21382, and in option VI is 3000 joules / m^2.

The relative Impact energy and impact resistance are, respectively, calculated by formulas (1) and (2):

$E_r = E_i / A_i$ (1)

$I_r = E_r / K$ (2)

Where: Er Ei Ai definition is presented in the table; K reliability coefficient = 1.25.

In Figure 1 is presented a relationship graph between relative impact energy and impact step.

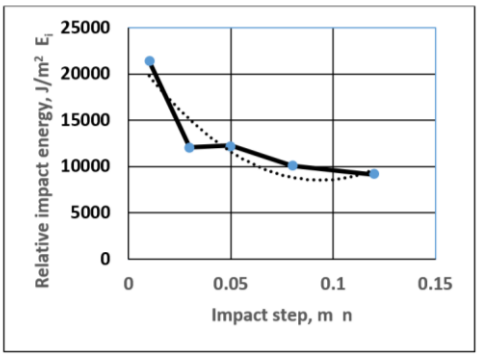
Formula (3) Relationship between Relative destruction energy and impact step Fig. (a); (4) Fig. (b) and the correlation coefficient are as follows:

$E_r=2E_i+0,6n^2-301767n+22681$; $R^2= 0,8574$ (3)

$E_r=1777,6n^2-37468n+12518$; $R^2= 0,9019$ (4)

Including variants II to V an average of 6.5 cm step is used. The difference between the values of the impact resistance thus obtained is small.

a)



b)

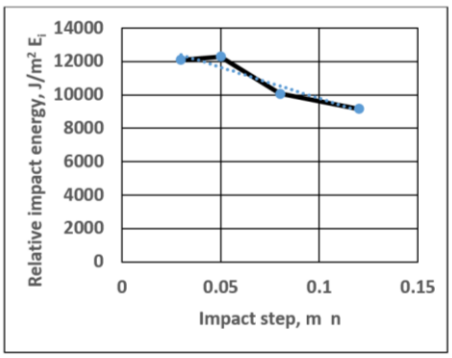


Fig. 1. Relationship graph between relative impact energy and Impact step (a) I-V variant; b) II-V variant).

Depending on the task, the appropriate test variant is used. For example, when the impact is calculated on the impact of a bomb, it is advisable to use the VI-VIII, sea, lake wave, river impact, wind, avalanche variant II - V.

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HORIZONTAL EXTRUSION AND ASSOCIATED FOLDING DEFORMATIONS

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In the folded zones structural associations are widespread. Their formation is often caused by multiple changes of the deformation background, in particular, intersecting folds and faults that subsequently folded and so on.

It is known that the formation of folds is associated with the orientation of the main compressive forces. Based on the analysis of the structural forms of folded deformations, three types are mainly distinguished: 1- Vertical folds - with a vertical axial plane and a gentle fold flexure, which are formed by bending the layer in the vertical plane. 2- Horizontal folds - with a vertical hinge. The above is formed by bending of the layers in a horizontal plane. 3 - Lying folds - the hinge and the axial plane are gently dipping or horizontal. Similar folds form when the layer is bending in the horizontal plane or tilting of the vertical fold takes place.

Thus, the formation of vertical, horizontal and lying folds is a process of folding, where each form is characterized by different dynamics and kinematics, as well as by specific structural associations. Change of deformation style of a particular tectonic object may be caused by a change in the tension field, at the same time it may be caused by local tectonic deformations. One of the most common forms of folded structures is secondary, parasitic folds, which are often located in the limbs of larger folded structures. Often their spatial orientation coincides with the spatial arrangement of large folds. Usually, according to the location of these structures, directions and a sign of local deformation in the rocks can be determined. In our case, the direction of the secondary parasitic folds does not coincide with the direction of large plicative structures, but they make an angle of up to 90˚ with the main direction, which should be associated with lateral extrusion of rocks during horizontal compression.

The purpose of this work is to identify such specific structures. The objects interesting in this respect are the eastern end of the Adjara-Trialeti folded zone and some sections of the frontal strip of the Greater Caucasus southern slope. As a result of our field work (2017-2019), secondary parasitic folds were first established here - the orientation of their axial planes does not coincide with the directions of large folds that are background for the region. Thus, in the limbs of south vergence - linear, latitudinal, plicative structures spread in the frontal part of the southern slope, small parasitic structures with axial planes dipping westward and eastward are established, i.e. along the strike. These structures are especially well-observed in the Didi Jakha river gorge (the right tributary of the Aragvi river, near the village of Ananuri) and on the left bank of the Aragvi river, on the road to Avenisi village in Upper Cretaceous carbonate limestones. Similar structures are also observed on the northern periphery of the Adjara-Trialeti folded zone, where the main folded structures are characterized by north vergence, and folds of west vergence are identified on their limbs and in monoclinal arrangements (Saskhori

village). Similar structural associations are observed in the Bagebi settlement of Tbilisi, in the southern limb of the Saburtalo syncline of latitudinal direction, where in the Oligocene-Lower Miocene thin-layered sandstones a cascade of folds of western virgation is identified. In the r. Tedzami gorge (on the way to the village of Salome), adjacent to the meridional section of the regional Saskhori-Ideleti fault a folded system vertically disposed to the fault plane is established.

Thus, the factual material provided by the author indicates the presence of secondary parasitic folds with different spatial orientations within the regional folded structures. This actually confirms the idea of the presence of folded deformations characteristic of shear and horizontal extrusion under conditions of meridional horizontal compression.

ANALYSIS OF THE HETEROGENEOUS EQUILIBRIUM "GAS – SOLUTION – MINERAL"

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To analyze the heterogeneous equilibrium "gas – solution – mineral", special attention is paid to the question of the mutual influence of the chemical nature of the gas and the solid phase on the equilibrium state parameters [1].

It is noted, that a saturated solution corresponds to the equilibrium state of the analyzed system. A saturated solution is a solution that is in equilibrium with a solute. The phase equilibrium between the solution and the solute is dynamic. A saturated solution is an independent phase, has a constant composition at a constant temperature, and its concentration is determined by the solubility of the substance [2, 3].

Thus, the studied system includes three phases:

1. Solution;
2. Solid phase in solution;
3. Gas phase.

In this article, when analyzing heterogeneous equilibrium in the system "carbon dioxide – solution – calcite mineral", it is shown that the dissolution of a $CaCO_3$ mineral from the class of natural carbonates depends on the pressure of carbon dioxide above the solution. On the other hand, the influence of gas on the solubility of silicate minerals is not expected.

Two images are seen on *Fig. 1*. As you can see, *t*he calcite belongs to the *trigonal crystal system and light rays are refracted in two different ways, passing through a crystal [4]*.

And so here we are again coming back to the equilibrium in a system $"CO_2$ – solution – $CaCO_3"$, that is determined of considerable interest for the geology.

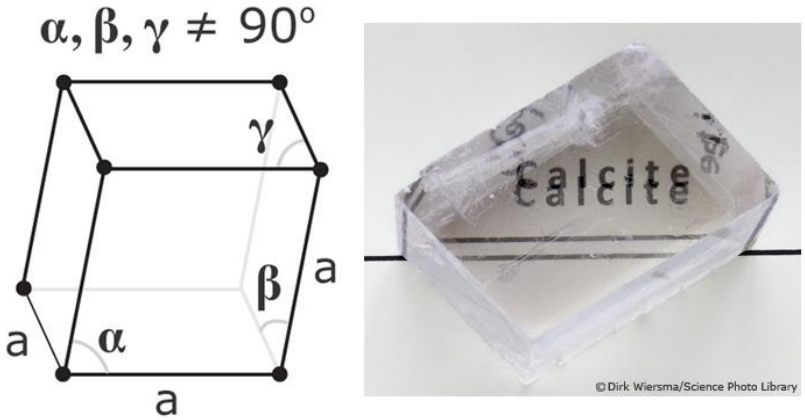

Fig. 1. The calcite crystal lattice; calcite is a birefringent material *[4]*

Schemes of all possible interactions in a three-component system are considered and compiled. The calculations of the component compositions of saturated mixtures were performed using a computer program.

According to the experimental results, the dissolution of carbonate rocks is greatly influenced of fixed P_{CO_2} above the solution. In the presence of CO_2 gas phase, the solubility of the $CaCO_3$ mineral in solution is $\approx 4{,}61 \cdot 10^{-4} mol/dm^3$, but in a system that was initially closed to CO_2 solubility of mineral is reduced several times.

It should be emphasized that practically the considered equilibrium to a large extent controls the hydrogen index of rivers, lakes and other natural waters.

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STUDY OF THE EXPLOSIVE PROPERTIES OF A HYBRID MIXTURE OF METHANE AND COAL DUST

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Notwithstanding the significant improvements in scientific and technical capabilities aimed to preventing the explsions of methane and coal dust in coal mines, the accidents in mines caused by explosions remain the main challenge of mining community. Several hundred miners die or acquire serious injuries from explosions every year. During the past decade, more than 50 serious accidents occurred in various countries, caused by explosion of methane and coal dust. These explosions represent a serious issue for the active mines operating in Tkibuli – Shaori (Georgia) coal field. As a result of two explosions 10 people died and 9 were seriously injured in 2018 in Tkibuli.

The literature analysis reveal that the explosions caused by methane and coal dust are treated as independent quantities and therefore the interaction effects as a result of combined mixture of methane and coal dust is neglected. Furthermore, there are no studies found about the coal dust quantity composition affects explosion intensity and flammability of the entire mixture. Finally, there are no studies found to account for different site conditions, such as physical, chemical and material composition of coal, affects the mixture and its ability to explode and/or deflagrate.

This paper presents the studies conducted at G. Tsulukidze Mining Institute to determine the coal dust fraction influence on the explosion severity one the mixture with methane and establish dangerous concentrations threshold for Tkibuli coal mine.The experimental studies are currently conducted at the Mining Institute with the aim to determine the detonation, deflagration and ignition / flammability of the coal dust and methane mixture. For this purpose, a new shock tube was constructed in the explosion chamber at the Mining Institute.The explosive ability of the mixture of coal dust and methane in the shock tube will be defined according to EU standard: EN 14034, ASTM standard E1226 and Chinese standard GB/T 16425. The shock tube consists of explosion chamber, sectional pipes, the system of metered supply of water, methane, solid particles, fuel, high pressure and flame sensors to study the explosive properties, computer module managing the processes and devices recording the oscillogram measurements. The mixture`s deflagration is studied with high-speed video cameras (models: MotionBLITZ EoSens Cube7 and MotionBLITZ EoSens mini2).

This research was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) – Project: YS-19-421.

EXPLOSIVE WELDING OF STEEL SHEETS OF DIFFERENT HARDNESS

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The explosive welding method allows to weld two different metal plates on the entire contact surface, regardless of the size and configuration of the plate. There is no other alternative to welding of different metals and alloys. We have obtained multi-layered samples of both flat and cylindrical shapes. The composite materials obtained by this method are characterized by high strength of the welding zone. Physico-mechanical properties of the transition layer are noticeably improved. Scientific studies have suggested that during the explosive welding, a moving stream of particles is generated at the point of collision of the metal plates, by means of which the surface self-cleaning of the metal plates takes place before the welding process [1,2]. This is due to the fact that the physical and mechanical properties of the welded plates do not differ much from each other. In our studies, the chemical composition and other physico-mechanical properties of the two welded metal plates are fundamentally different.

Ammonite 6ЖВ and its mixtures with ammonium nitrate were used as explosives during explosive welding [3]. The density of the welded materials does not differ much from each other and varies from 7.8 to 7.9 g/cm3, and their hardness is radically different. Hardness values range from 20 to 54 HRC. Experimental works were carried out on the samples casted and rolled by Ferdinand Tavadze Metallurgy and Materials Science Institute. 20 pairs of plates were tested for welding hard and soft metal ones. Each plate differed in its chemical composition and mechanical properties. During welding hard and soft metal plates, the kinematic and technological parameters of explosive welding have been experimentally studied.

The structure of the alloy steel before and after the explosion was studied (see Fig. 1 and 2). The figures clearly show the defect structure of the alloy steel after the explosion.

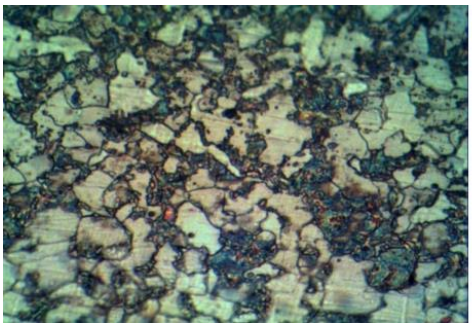

Fig. 1. The structure of alloy steel before explosion

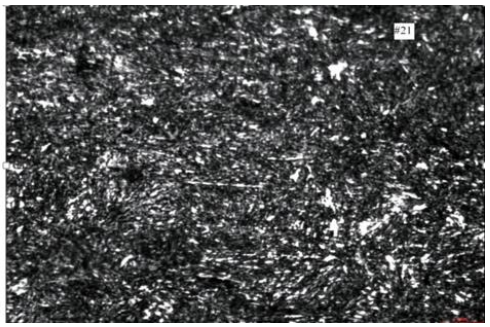

Fig. 2. The structure of alloy steel after explosion

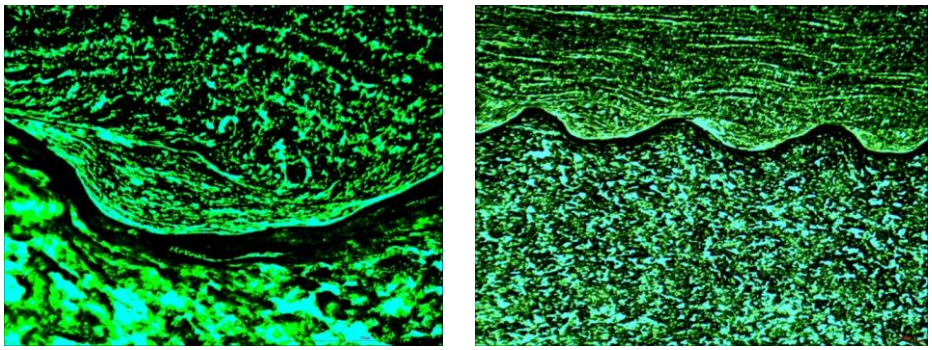

Fig. 3. Structure in welding zone

Fig. 4. Explosive-welded steel plates of different hardness

The different plates of high hardness have been welded with the substantially softer materials. Kinematic and technological parameters of explosive welding have been studied experimentally (Experiments continue on other materials as well).

The results of the research conducted show that it is possible to obtain heterogeneous plates.

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IMPROVEMENT OF RESEARCH METHODS OF THE BASIC CHARACTERISTICS OF PHYSICAL PROCESSES AND THERMODYNAMIC SYSTEMS

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Explosives containing military-engineering products, as well as other products of the national economy, have safe storage and shelf life, after which they are subject to utilization by burning or exploding in accordance with international norms, which are associated with some economic and environmental difficulties. Therefore, its solution requires an in-depth study of the issue. The Grigol Tsulukidze Mining Institute was involved in the ongoing scientific research in this regard, and based on the analysis of the research carried out, the following was established [1]:

1. Utilized colloidal gunpowder is not inferior to standard explosives in terms of detonation and energy characteristics, and industrial explosives may be manufactured on their basis.
2. Determination of the main characteristic values of a new class of industrial explosives developed on the basis of utilized colloidal gunpowder requires the elaboration of a new research methodology and the creation of an appropriate material and technical base.

Accordingly, optimal prescriptions of new class of industrial explosives were developed on the basis of utilized colloiddal gunpowder and, in order to determine their detonation and energy characteristics, a detonation speed recording device [1] was developed and a new detector was designed [2].

In the modern sense, a comprehensive prediction of being investigated physical processes is possible only through their computer modeling, which allows virtual realization of the experiment, and in the course of processing the results using computer graphics, in terms of visuals and perception of the process creates invaluable conditions for research. Designing a new type of calorimeter requires calculating the strength of the metal-clad. This was performed by computational experiments: 1. An analytical solution of the load on the wall of the bomb as a result of the explosion, and 2. Computer modeling of the explosion process in a bomb of specific geometry. This allowed to optimize the explosion chamber cladding, mass and geometrical dimensions through a simple analytical dependence. Based on the data obtained by the analytical solution, the simulation model of the calorimeter was developed and the computer modeling of the explosion was performed using the ANSIS LS DUNAS computer program. The combination of analytical calculation and computer modeling results led to the reliability of the results of the calculations performed using the mathematical model [2].

Based on the research, new methods for determining the performance ability of utilized colloidal gunpowder have been developed, which can be used as an additional technique to evaluate explosives. And it has become possible to determine all the basic characteristics of modern industrial explosives with inc-

reased crisis diameters by a new type of calorimeter designned by us, the manufacturing of which is currently underway.

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STRUCTURAL MODEL OF FRONTAL PART OF THE EASTERN ACHARA-TRIALETI FOLD-AND-THRUST BELT USING SEISMIC PROFILE INTERPRETATION

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We present the results of an integrated structural interprettation of the frontal part of the eastern Achara-Trialeti fold-and-thrust belt(ATFTB). The ATFTB is located in the northern part of the active collisional Lesser Caucasus orogen associated with Arabia-Eurasia convergence and represents a good example of mountain building processes [1]. The collision between the Arabian and Eurasian plates caused inversion of the Achara-Trialeti extensional basin during the Miocene time [1, 2, 3]. Our interpretation has integrated seismic profiles, several oil wells, and the surface geology data to reveal structural characteristics of eastern ATFTB. The rocks involved in the deformation range from Paleozoic basement rocks to Mesozoic-Tertiary rocks. The seismic profile reveals the presence of upper and lower structural complexes [2, 3]. The seismic profile shows that the structures mainly are represented by north- and south-vergent thrusts, north-vergent duplex, and structural wedge. The upper structural complex is represented by a shallow triangle zone and the traingle tip is located in Middle Miocene deposits. The lower structural complex is represented by a structural wedge and the wedge tip is located in the Upper Cretaceous strata [2, 3]. Structural cross-section shows that building of thick-skinned structures of eastern ATFTB was formed by basement wedges propagated along detachment horizons within the cover generating thin-skinned structures. The seismic profile reveals that perspective structures mainly are represented by a duplex or structural wedge.

Acknowledgement: This work was supported by Shota Rustaveli National Science Foundation (SRNSF) [grant № PHDF-18-1967. 2-3 D Structural Models of Frontal Part of Eastern Achara-Trialeti: implication for oil-gas exploration]

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INCREASING THE DRESSABILITY OF GOLD-CONTAINING POLYMETALLIC ORES BY PRE-ENRICHMENT

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Gold-containing polymetallic ores are characterized by complex textural-structural features. The ore associated mining waste is represented by different structural quartz-feldspar and quartz-feldspar-sericitic rocks. Studies have shown that in the fragments of various size small particles of both ore minerals and gold are mutually impregnated with varying intensity. To increase the dressability of the ore of such complexity, prelimnary enrichment was carried out, which included fragmentation and classification and from the classes obtained, in particular, enrichment of the fraction of 8-3 mm by the gravitational method on a diaphragm jig of improved construction. The introduction of additional control values, together with the control parameters of the process, increases the efficiency of loosening of the layered material, which leads to the effective separation of minerals of different densities. As a result, large amounts of tailings with a lower content of ore minerals, in particular gold, can be isolated, which is the basis for increasing the degree of enrichment of the material released from the tails and its effective enrichment in next operations (flotation). For this purpose, a mathematical model of the process was developed, which provides for the influence of process disturbing values (content in the initial material, thickness, and other factors) on the enrichment indices. Both paired and multiple relationships between the enrichment indices and the disturbing values involved in the process were plotted. Based on the optimization technological criterion and the mathematical model of the process, the law of optimal control was obtained, and an appropriate control method was developed that regulates the main and additional control actions of the sedimentation process according to the change in disturbing influences.

BIOSTRATIGRAPHY OF THE CRETACEOUS/PALEOGENE BOUNDARY SEDIMENTS ACCORDING TO MICROFOSSILS OF THE NICHBISI SECTION

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For the detailed stratigraphic division and specification of the volume and age of the successions (lithostratigraphic units), in the facies of the eastern part of the Achara-Trialeti folded zone of the Lesser Caucasus fold system the sections of the Dzama, Tana, Tedzami, Kavtura, Nichbura, Khekordzula and Algety river basins have been studied. This paper cites data obtained as a result of the Nichbura section survey across the Cretaceous/Tertiary boundary (Campanian, Maastrichtian, Danian).

In the study area the Campanian is represented by **the Tsitelkalaki suite**. Its main part is built of white lithographic limestones, in which sometime interlayers of light green, fine-grained sandstones and marls occur. In the lower part of the suite the Middle Campanian nannoplankton zones *Ceratolithoides aculeus* (CC20) and *Uniplanarius sissinghi* (CC21) are identified. In the sediments, corresponding to the CC20 zone and according to planktonic foraminiferas the *Globotruncana ventricosa* zone is established. The layers of CC21 zone are conformably continued by the Upper Campanian *Uniplanarius trifidus* zone, which corresponds to the lower part of the same name CC22 zone of the Sissinghs (1977) [3] scheme. Here is established the planktonic foraminiferal *Rugoglobigerina rugosa* zone. Thus, the age of Tsitelkalaki suite is Middle and Upper Campanian.

The Saskhori suite conformably continues the layers of the Tsitelkalaki suite. Its lower part is represented by the alternation of reddish-brown, thick-layered limestones, light gray sandstones and white limestones. Vertically upwards it is gradually replaced by the alternation of medium-layered, chalky limestones, light gray marls and sandstones. Rarely, the interlayers of micro-conglomerates also occur.

According to Nannoplankton, the following biostratigraphic units are established in the suite: 1) Zone *Quadrum trifidum* (upper part), which corresponds to the *Tranolithus phacelosus* (CC23) zone of the Sissinghs (1977) [3] scheme; 2) Zone *Arckhangelskiella cymbiformis.* This zone is correlatable to the Zone *Reinhardtites levis* (CC24) and subzone *Arckhangelskiella cymbiformis* (CC25a) of the Sissinghs scheme (1977); 3) Zone *Lithraphidites quadratus*. This zone is correlated with Sissingh's (1977) subzone *Arckhangelskiella cymbiformis* (CC25b); 4) Zone *Micula murus*. This zone is comparable with the Sissingh's (1977) [3] subzones *Arckhangelskiella cymbiformi*-(CC25c) and *Neprolithes frequens* (CC26a); According to small foraminifera in sediments of the Saskhori suite (upper part) a rather poor association of *Globotruncana contusa* zone is revealed.

Stratigraphically higher, the Gavazury formation continues the Saskhori sui-

te. Contact between them is not observed in any sections studied by us. Therefore, we do not rule out the existence of top Maastrichtian nannoplankton zone *Micula prinsii*, which corresponds to the Sissingh's (1977) [3] subzone CC26b. Presumably it should be covered by a geographical gap. The reason for this assumption is the Tetritskaro sections, where direct contact was found between the Maastrichtian and Danian. Here the Maastrichtian CC26b and Danian NP1 zones are interconnected by a 5cm thick interlayers of the so called "iridium clays" [1, 2].

The Gavazury formation is built up of the alternation of reddish, greenish, pinkish and grayish marls, sandy marls, gravels and clays. There are established 4 Danian Nannoplankton zones: *Biantholithus sparsus* (NP1); *Cruciplacolithus tenuis* (NP2); *Chiasmolithus danicus* (NP3) and*Ellipsolithus macellus* (NP4), which are identical in composition to similar biostratigraphic units of the standard scheme of Martini (1971) [4]. As in other parts of Georgia, here too after the mass extinction of Cretaceous species as a result of a cosmic catastrophe at the end of Maastrichtian, no taxon extinctions have been reported throughout the Danian stage. Only species-forming events took place.

The micro-paleontological study of the Nichbisi section once again confirmed a sharp difference between the Danian assemblages and Maastrichtian associations. Only 5 of the 27 Maastrichtian Nannoplankton species crossed the Maastricht-Danian boundary. The planktonic foraminifera has also become almost extinct. The sediments of *Globorotalia pseudobulloides* zone of the Gavazury suite are characterized by completely new species of fine *Globigerins* and *Globorotalia* [5].

Thus, based on the detailed analysis of micro- and nannofossils, in the eastern part of the Achara-Trialeti zone of the Lesser Caucasus fold system in the sediments on the Cretaceous-Paleogene boundary the Late Cretaceous "CC" and Paleogene "NP" zones of International Standard schemes were established. This enables both local and remote correlation of the studied sediments. Besides, the age range and volume of lithostratigraphic units studied in the research region were determined.

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ENGINEERING GEOLOGICAL SURVEY OF LOESS-LIKE SOILS FROM THE MID-STREAM OF THE KURA RIVER

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Primary and secondary loess (loess-like) sediments are intermittently distributed in arid and semi-arid regions in the mid-latitudes of northern and southern hemispheres, including inland, temperate deserts, semi desert edges, periphery of Quarternary glacial ice sheets and some costal zones. The total loess area covers about 11% of the Earth`s land surface [1]. From geotechnical and engineering geological points of view loess and loess-like sediments are classified as problematic soils due to their collapsible behavior. One of the most intriguing problems relating with collapsible soils is instability and considerable settlement due to minor changes in the water content which can cause remarkable damages to overlying structures [2].

There are no primary loess deposits on the territory of Republic of Georgia, though secondary loess, also known as loess-like sediments, are widespread. Their distribution and thickness vary and are related with geomorphological features. The main distribution zones are the latitudinal belt in the southern and eastern part of the county: the upper (Aspindza-Akhaltsikhe municipalities), middle (Shida Kartli Valley) and lower (Kvemo Kartli Depression) streams of the Kura River. Moreover, loess-like sediments are presented in the territories of the Iori River and the r. Alazani gorges [3]. The study area is located in the eastern part of Georgia, covering three municipalities, including the surrounding territories of the capital (Tbilisi).

The site was investigated and classified in field conditions. Moreover, sampling of rocks for laboratory testing and analysis was accomplished. The engineering geological properties of the study area were determined, including in situ field density, specific gravity, liquid limit, plastic limit, plasticity index, shrinkage limit and consolidation characteristics such as coefficient of subsidence (collapse). Three different types of loess-like silts were identified, including yellowish-brown and yellowish-gray silts and sands. The results of microscopic studies of the sediments were connected with physical and mechanical properties. The studied soils are of a collapsing type and their subsidence is greatly increased by excessive wetting under constant pressure. Various types of criteria were tested for evaluating collapsibility of loess-like sediments, the most acceptable and pertinent one was chosen and clarified as a role criterion. After site investigation and performing laboratory tests the soil collapsibility potential was confirmed through comparison of the selected criteria.

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INTERFERENCE FOLDED STRUCTURES OF THE GREATER CAUCASUS

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The development of interference folded structures within the extreme north-western part of the Greater Caucasus (GC) was noted earlier [1]. However, the extent of manifestation of interference folding within the GC, its morphological features and the causes of formation were determined by the authors [2, 3, 4]. The study of the interference folding of the GC is important for reconstructing the kinematic and geodynamic conditions of the formation of its structure.

As a result of many years of regional detailed geological and structural studies, as well as analysis of the existing geological maps of different scale, the authors found a wide developpment of interference folding within the GC. It is a kind of plicative structures, significantly differing from the main linear folded structures of the region by its age, morphology, orientation and genesis.

As is known, interference folding arises as a result of superposition of tangential compression deformations of differrent planes and ages, causing reorientation and transformation of primary folded structures [5].

Detailed studies of the fold structure of the GC showed that interference folding is developed in the southern edge of the fold system of the North-West, Central and South-East Caucasus and compose sections longer than 85 km and having a width of up to 25 km. The bands of development of interference folding generally have sub-latitudinal strike, which is why they are clearly distinguished against the background of the north-western orientation of the main linear folding of the GC.

In addition to the sub-latitudinal anti-Caucasian orientation, areas of the interference structures have southwestern, southeastern, and submeridional orientations. The morphology of intersecting folded structures is also different, and it is represented mainly by dome-shaped, brachymorphic and more complex plicative formations.

The interference folded structures are located in different tectonic zones of the southern slope of the GC. They are composed of Mesozoic-Cenozoic strata of various ages and composition, the total thickness varies between 1.5-10.5 km.

A study of the intersecting folding of the GC showed that it was formed due to oblique interference with the previous linear deformations of the northwestern strike of later deformations in the form of submeridional tangential compression. As a result of diverse dislocation, young nonlinear interference structures appear in the region. The mechanism of the formation of interference folding is confirmed experimentally by physical modeling [2].

The interference folding was formed at the late orogenic collisional stage of development of GC as a result of the change of the direction of tangential compression from north-east to sub-meridional in the Anatolian-Caucasian-Iranian seg-

ment of the Mediterranean mobile belt. It took place due to the global process of changing of geodynamic conditions in the region. Initially drift of the African-Arabian continent in the northeastern direction and after the separation of Arabia from Africa by the submeridional movement of the latter during the newest stage of deformation.

Thus, the determination of interference folding on the GC clearly indicates a earlier unknown regional process of changes in the geodynamic situation in the region during the Alpine structure formation. In addition, the development of over-lapping folding contradicts the currently most widely accepted notion of the formation of the GC structure as a result of a uni-plane, one-act and one-way underthrusting mechanism of the deformation of the region

The conclusions drawn are important for elucidating the conditions of the GC Alpine folded structure formation. They testify to the manifestation in the region of deformations more diverse in genesis, in the form of repeated discordantly oriented southern tangential compression. They interrupted the inheritance and orientation of the structural development of the GC, which points to the activity of nonlinear processes of tectogenesis in the newest era in the region.

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ESTIMATION OF RESOURCE POTENTIAL OF THE TECHNOGENIC DEPOSIT OF PYROMETALLURGICAL ORIGIN

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Recycling technogenic accumulations of the mining and metallurgical industry is associated with significant difficulties due to the complexity of the composition and heterogeneous physicochemical properties of the dumps [1], especially those that accumulate in the production of large-tonnage ferroalloys [2]. The practice of using these materials now, mainly in the building materials industry, is irrational; they can be more effectively used as metallurgical raw materials [3].

The main determining factor in assessing the appropriateness of the targeted development of a technogenic deposit (recycling for the purpose of extracting metals) is the technical and economic assessment of its resource potential. The existing assessment methodology, mainly provides the analysis of the feasibility of extracting metals by determining the expected environmental and economic effect R [4]:

$$R = E_p + E_s + E_e \rightarrow max \quad (1)$$

where - E_p and E_s, respectively, the economic effects of the use of secondary metals and related non-metallic products, $/t; E_e - the effect of reducing environmental damage, $/t.

From the point of view of maximizing the scale and efficiency of processing, a more rational approach is the method of technical and economic analysis (diagnostics of efficiency) [5], which provides for the analytical determination of the lower threshold (permissible) concentrations of the extracted metal(s) I_{min}, at which the profitability of the extraction will not decrease below the zero threshold. To determine the concentration threshold of condition of the studied resource, we use the mathematical expression:

$$I_{\min} \geq ((C_m - C_{e1} + C_{e2}) / P_m K_{vpm} K_r) \times 100\% \quad (2)$$

where - I_{min} the permissible lower limit of the content of the target metal in the technogenic resource,%; C_m - extraction costs, $/t; C_{e1} and C_{e2} - specific environmental costs before and after extraction, $/t; Pm - market base cost of recoverable metal, $/t%; K_{vpm} - coefficient of variation of the market price; K_r is the recovery coefficient.

The ratio of the actual content of the target metal I_{ac} to its calculated threshold content I_{min} is called the condition coefficient of the resource - K_k:

$$K_k = I_{ac} / I_{\min} \quad (3)$$

A technogenic resource can be considered as a conditional secondary raw material if $K_k \geq 1$. In turn, to determine the resource potential for replacing the primary ore concentrate, we introduce the index of the ore substitution - I_{os}, which can be calculated from the following equation:

$$I_{os} \leq 1 \Rightarrow K_{r2} I_{ac} / K_{r1} I_{oc} \quad (4)$$

where I_{ac} is the content of the target metal in the secondary resource,%; I_{oc} is the content of the target component in the replaced ore concentrate,%; K_{r1} is the coefficient of extraction of the target metal from ore concentrate; K_{r2} is the coefficient of extraction of the same metal from secondary raw materials (established experimentally).

In this case, the consumption rate of the secondary technogenic raw materials of the threshold condition in the production of a product with a given content of the target component I_{met} is equal to:

$$N(\mathrm{I}_{\min}) = I_{met} / I_{\min} K_{r2} \quad (5)$$

And the consumption rate of this secondary resource, which differs in content from the calculated concentration threshold of condition, will be equal to:

$$N(I_{ac}) = N(I_{\min}) / K_k = I_{met} k_k / I_{\min} K_{r2} \quad (6)$$

In turn, for a more accurate assessment of the resource (conditional reserves) of the target metals contained in the technogenic formation, we use the formula:

$$Q_j = Sh \sum_{j=1}^{n} I_{acj} \gamma_{mj} I_{osj} / K_{kj} \times 100\% \quad (7)$$

where - S is the area of technogenic formation, km^2; h - the thickness (average height) of this cluster, m; I_{acj} - the content of the j-th target metal(s),%; γ_{mj} - the specific gravity of the metal, t/m^3; I_{osj} - the ore substitution index and K_{kj} - the condition coefficient.

When using secondary industrial raw materials, the expected savings of E_P funds for the purchase of the main ore concentrate can be calculated by the formula:

$$E_p = P_i Q_i (N_{qi} - \frac{N_{qi} N_{qj}}{W_1 N_{qi} + W_2 N_{qj}}) \quad (8)$$

where - P_i is the purchase price of ore concentrate, \$/t; Q_i - purchase volume, t; N_{qi} is the concentrate consumption rate, t; N_{qj} is the rate of consumption of the secondary resource approved by the technological regulations, t; W_1 - the norm of waste generation during the processing of basic raw materials, kg/t; W_2 - waste generation norm during the processing of technogenic raw materials, kg/t.

Environmental component of the processing of technogenic accumulation is equal to:

$$E_e = M_v \cdot S_a \cdot K_e \cdot K_{eh} + \sum_{j=1}^{n} P_{ej} \cdot M_j \quad (9)$$

where - E_e is indicator of cost savings on the environment, \$/t; M_v - market value of land adjacent to the enterprise, \$/km^2; S_a - the land area saved from pollution, km^2; Ke - coefficient of ecological and social significance of this territory; K_{eh} - the environmental hazard coefficient of the metal pollutant; P_{ej} - state duty for the accumulation and landfill of metal pollutant, \$/t; M_j - the mass of metal recovered during recycling, t.

Calculations show that under the production conditions of the Zestafoni Ferroalloy Plant, the condition threshold of manganese-containing secondary raw materials, under the conditions of having its own source of electricity generation -

(Vartsikhe HPS - 0.03-0.04 $/kWh), when melting a special conversion low-phosphorus slag (LPS Mn 38-40%), constitutes 24% Mn. The consumption rate of such manganese technogenic raw materials is 2.6-2.8 tons. With an excess content of manganese in secondary raw materials in the limit of 26%, the consumption rate in the production of LPS decreases to 2.2-2.4 t. In turn, for the production of conversion ferrosilicomanganese (Mn 57-60%), the threshold for condition is the manganese content 27-28%. In this case, the consumption of technogenic raw materials is 2.9-3.1 tons.

With a satisfactory modulus of phosphorus - M_p (P/Mn ≤ 0.006) and silica - M_{Si} (SiO_2/Mn ≤ 0.6), secondary raw materials containing manganese in an amount of 30% (e.g. sludge for the production of electrolytic manganese dioxide or slag FeMn 88), are effective can be used in the production of commodity ferrosilico-manganese (Mn 65-70%), with a consumption of 2.8-3.2 t.

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FOR TKIBULI-SHAORI DEPOSIT UNDERGROUND COAL GASIFICATION METHOD USAGE

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Coal remains the main source of global energy production in the 21st century. Despite stricter environmental legislation, advanced technologiesand increased use of renewable resources, coal-fired thermal power stations currently generate more than 38% of the world's energy. Since 2000 coal production has increased by 68% from 4638,4 million in 2018 to 7813,3 million [1, 2]. Despite the growth of the world coal mining industry, it is an unsolvable problem to develop rational and irreduntant technologies for coal mining.Losses during extraction works make up 20-25%. At the same time, it is difficult to ensure occupational safety. In the last 10 years, more than 50 serious accidents have occurred in the coal mining countries [3]. In many countries around the world, research is underway to improve the technology of coal mining, which is relevant for the rational and safe development of Georgia's main fuel and energy resource, Tkibuli-Shaori coal field.

Since Georgia's declaration of independence until now, Tkibuli-Shaori coal mine has not been able to be involved in ensuring the country's energy independence. However, at present occupational safety is one of the challenges for mines operating in Tkibuli, where, in 2018 alone,as a result of two industrial accidents, 9 miners died and 6 were seriously injured. Due to this situation, the work of the mines was suspended for more than a year.

Tkibuli-Shaori deposit is characterized by difficult mining-geological and mining-technical conditions: prone torock burst and rock bumps;during the extraction process, explosive concentrations of dust and gas are formed; coal seams have self-igniting properties and endogenous fires are common. Despite numerous scientific and engineering efforts since the development of the mine, improvement of processing systems and technologies did not work [4, 5, 6]. The current processing method is an improved version of the original room and pillar system. This method was developed by G. Tsulukidze in 1917-1920 for temporary use. In 70s of the past century its use was banned, and in 1985 it was still temporarily allowed to be used until new technologies were introduced. Coal losses on extraction process works make up 45-60%. Long work (frequent during underground mining) make it impossible to maintain prepared areas due to endogenous fires caused by the self-igniting properties of coal seams.

The article discusses the results of world mining of coal underground gasification, the experience of modern scientific research and existing enterprises that can be used to develop a method for the rational and safe development of the Tkibuli-Shaori coal deposit.

The idea of underground coal gasification is related to four great scientists: Williams Siemens, Dmitri Mendeleev, Anson Baths and William Ramsay. Since the idea was born technology has evolved [7, 8, 9]. The idea of underground coal

gasification involves the syngas synthesis through the slow combustion of coal seams, which is carried out through wells. Part of the wells serve to supply water-oxygen injection solution to start the combustion of the coal seams, and part of the wells to bring the syngas to the surface during the combustion process (Fig.1).

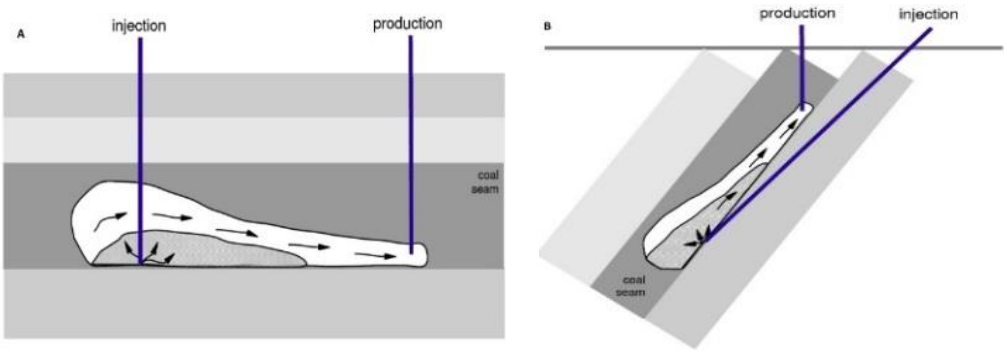

Fig. 1 Scheme of Underground Coal Gasification
A- horizontal coal seams, B – steeply dipping coal seams

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ABOUT THE ROLE OF RHEOLOGICAL PARAMETERS OF THE ROCKS IN GEOTECHNICAL PROBLEMS

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The history of the study of the landslides already numbers 250 years, more than 5 000 publications are well-known. The major, part of them is based on the method of limited equilibrium and implies: the separation of expected landslide body on vertical segments and determination of the forces acting on each element by means of equilibrium equations, determination of starting shearing tensions (T_{st}) of landslide body by their means and their comparison with the intensity of retaining shearing tensions (T_{ret}).

In recent years the so-called shear strength reduction method is used, which implies knowledge of reduced computation values in comparison with the initial rock adhesiveness and the angle of internal friction, for example, as a result of wetting of the massif.

For the landslides of slipping-plastic type, which are widely presented in Georgia and in Tbilisi, the analytical and numerical methods must be used, which will more completely estimate the tension - deformed state of the massif taking into account its hypsometry, stratigraphy, underground waters, time and other factors.

In this case, the knowledge of the adhesiveness and the angle of friction for the rocks determined by the "method of rapid loading" is inadequate and especially for characterization of the stability of the massifs containing clay elements, the knowledge of their geological parameters has gained more and more importance. This fact is also topical for mining geomechanical problems on the whole. From this view-point, despite the achieved successes, the state of rheological part of the mining geomechanics is difficult to estimate as good. The criteria for estimation of the essence of rheological parameters for definite problems of the geomechanics are not yet elaborated. There are no clear indications in the literature as which problem should be solved in "rheological" statements, which in the "static" and which in the "dynamic" and how to evaluate objectively such an approach [1].

By "rheological" setting of geomechanical problems the main objective reason of non-popularity of the development of solving methods and their purposeful use is the difficulty and labor intensiveness of determination of rheological parameters themselves by laboratory [2] or natural-analytical rules [3]. In spite of this fact, in the conditions of modern measuring means, equipping of geotechservice laboratories by the means of determination of rheological parameters of rock samples by express-methods is highly desirable. In parallel, presyometric, borehole inclinometric survey and other deformametric systems and the methods of their use must be developed in natural conditions. All above-mentioned will contribute to a better knowledge of the hardness and deformation characteristics of engineering-geological elements and, respectively, for more reliable design of geotechnical objects.

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HYDROCHEMICAL PECULIARITIES OF FRESH UNDERGROUND WATERS OF MUKHRANI ARTESIAN BASIN

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Mukhrani artesian basin represents an ecologically well-protected groundwater reservoir with unique structure, which contributes to the high degree of renewal of water resources therein.

Relatively old formations extend to the peripheries of the basin under consideration, while its central part is filled up with modern Quaternary sediments. The main hydrographic network of the Mukhrani lowland is represented by the Ksani and Aragvi rivers. These water bodies bound the area from the west and the east, and play an important role in the formation of the groundwater in the artesian basin.

Within the Quaternary sediments of the basin the following water bearing aquifers can be distinguished:

1) water bearing aquifer of contemporaneous alluvial sediments of riverbed and floodplain (aQ4), which stretches along the Aragvi and Ksani riverbeds and floodplains. Water mineralization does not exceed 0.4g/l. By chemical composition the water is bicarbonate calcium-sodium-magnesium type.

2) water bearing complex of undifferentiated Quaternary alluvial-proluvial sediments (apQ1-3), that spreads over entire lowland. Thickness of the sediments amounts 200-225 m [1].

Ground waters of the Mukhrani artesian basin show hydrochemical zonality. This is the case for both the ground- and the pressure waters. For groundwaters two zones can be distinguished. The first zone includes riverbed and floodplain sediment areas and contains water with mineralization up to 0.5g/l. The second zone is represented by Upper Quaternary sediments of the central part of the basin and contains waters with mineralization ranging from 0.5 to 1.0 g/l [2]. For artesian (pressurized) waters, hydrodynamic flows of ground water with respective hydrochemical zones can be distinguished. Mineralization of waters in the first zone is 0.5-0.6 g/l, whereas in the second and the third zones it is up to 0.3 g/l and 0.3-0.5 g/l respectively [3,4].

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DEVELOPMENT OF NEW CONSTRUCTION OF NONDESTRUCTIVE MAGNETC CONTROL SYSTEMS BY USING 3D MODERN HALLS SENSORS

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The report discusses modern systems of nondestructive control by using the magnetic induction of steel ropes. The basic principles and technical characteristics of this systems are given [1,2].

A new direction is proposed for the development of the magnetic method of nondestructive control, which makes it possible to achieve the necessary accuracy of magnetic control and increase technical parameters, taking into account the structural features of the steel rope [3].

Based on the innovative magnetic head developed by Rope Systems Lab, a new design of a multi-channel synchronous magnetic head with 3D Halls sensors is proposed; it will allow us to detect internal wire breaks in steel ropes and establish their location.

This approach can be used to refine and improve methods for continuous monitoring of longitudinal ferromagnetic products [4, 5, 6].

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THE CURRENT STATE OF RESEARCH ON RESOURCE BASE OF NATURAL PIGMENTS OF GEORGIA

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Almost all types of natural pigments are found in Georgia. Important among them are iron oxide pigments, to 260 deposits and occurrences of which are well known. But their supplies were so insignificant in the total resources of pigment raw material of the Soviet Union that they were not paid due regard to. The absolute majority is known as ore occurrence, none of them have been thoroughly explored and technology tests on enrichability have not been conducted. Reserves are approved only for a few deposits (about ten deposits in Imereti and Guria), and even for the low categories (C_2, P_1, P_2, except Matkhoji-Udzlouri, where reserves have been estimated for categories $B+C_1$).

Today, as the Georgian construction industry is absolutely dependent on the import of pigments and paint-and-lacquer materials, the local ecologically safe pigment raw materials are noteworthy.

In order to test above mentioned raw material on enrichability and investigate dyeing properties of obtained from them manufactured product (finished product), based on the familiarization with materials of Geological Funds, the most promising deposits were selected: Shrosha-Ubisa, Matkhogji-Udzlouri and Poladauri, the latter being known in archive materials as iron ore.

Laboratory-technological samples of mumiyo-type raw material of Shrosha-Ubisa and Matkhoji-Udzlouri deposits were studied for enrichment, taken by the channel method. Their material composition and technological properties were determined. The electrolytic deposition method was chosen for the enrichment of pigment raw material. Pigments from Matkhogji-Udzlouri field with 43.8% content and 92.9% recovery of Fe_2O_3, and from Shorosha-Ubisa field with 51.2% content and 88.44% recovery of Fe_2O_3, were obtained.

On the basis of Shrosha-Ubisa field raw material, from one tonne of crude ore can be obtained 274.2 kg/t of finished product with 43.8% content of Fe_2O_3, and Matkhoji-Udzlouri field raw material - 303,2 kg/t of finished product with 51,2 % content of Fe_2O_3. The products obtained meet the requirements of paint-and-lacquer manufacturing.

The laboratory-technological sample of iron ore of Poladauri deposits group, taken by channel method, has been studied for enrichment. The mineral and chemical composition, structural and textural features have been studied as well. Magnetic separation has been selected from several methods used to isolate pigment component from it. The recommended ore enrichment technology scheme and regime have been developed to allow to product anti-corrosion red iron oxide type pigment (from crushed up to 1.25 mm ore), which meets the requirements of the standard on red iron oxide of grade “A”: the mass content of Fe_2O_3 in it exceeds 72%, has high colouring ability and is resistant to atmospheric agents.

Products obtained from base ore by the recommended enrichment technology scheme are as follows:

- Anticorrosive pigment - red iron oxide, with 43.69% yield; 72.7% content; 60.05% recovery.
- Mumiyo-type pigment – with 32.99% yield; 51.75% content; 32.1% recovery.
- Waste - with 23.32% yield; 15.97% content; 7.85% recovery.

Products obtained: mumiyo-type pigment and red iron oxide fully meet international requirements for pigments (coating ability, dyeing intensity, oil absorption, etc.).

VOLCANOGENIC DEPOSITS OF NON-FERROUS METALS OF THE CENTRAL SEGMENT OF THE ALPINE-HIMALAYAN MOUNTAIN-BELT AND PROBLEMS OF ORE GENESIS

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Within the Alpine-Himalayan mountain-fold belt there are known fragments of paleoisland arcs and contiguous structures – back-arc and intra-arc basins. One of such paleoisland arcs is the Pontian-South Caucasian magmatic arc. Volcanostructures situated within this arc host the largest deposits of non-ferrous metals. During the Alpine epoch, maximum volcanic activity in the eastern part of this belt (Armenia and western Azerbaijan) occurred in the Bajocian-Late Jurassic, whereas in the western part (Georgia and the Pontides in Turkey) – in the Cretaceous time.

On the territory of Turkey, the industrial sulfide deposits are Ashikoy, Lahanos, Kutlular, Chayeli, Murgul, Cherra-tepe. It should be emphasized that the Eastern Pontides is the only region of the Pontic-South Caucasian island paleoarc where hydrothermal-sedimentary deposits of non-ferrous metals have been identified, such as the deposits of Ashikoy and Chayeli (Madenkoy).

Another type of hydrothermal-sedimentary mineralization is represented in allochthone that was transported onto the paleoisland arc structure from the marginal sea basin of the Paleotethys. Mineralization pattern and geological settings here are similar to those observed on the island of Cyprus [1].

Examples of stokwork-veinlet ores in the Pontides are Murgul, Kutlular, Cherra-tape and Lahanos. On Lahanos stokwork of sphalerite-pyrite-chalcopyrite composition is manifested in dacite stok. Stokwork-veinlet mineralization is concentrated in the area of development of quartz-sericite-chlorite metasomatites. The geological position similar to the Lakhanos has the Murgul deposit.

Copper-lead-zinc veinlet-disseminated mineralization is a distinctive feature of the Georgian and Armenian deposits. Unique in the ore-geological sense is the Georgian Madneuli deposit, within which the multilevel gold, barite-sulphide and copper ores are spatially brought together.

Madneuli volcanic dome is located on the slope of Dalidag paleovolcano, which is constructed of ignimbrites and rhyodacitic flows as well as pyroclasts of andesite-dacites. Two ore levels are distinctly distinguished at the deposit: the upper – barite-polymetallic with gold in quartzites, and the lower – mainly composed of copper veinlet-disseminated ores (with pyrite).

It should be emphasized that baritic, barite-polymetallic and copper ores are separated in space and, probably, are of different ages. Gold mineralization in "secondary quartzites" is the earliest. It seems that intensive transformation of rocks with the formation of a metasomatic column inside the domed Madneuli structure preceded the main ore process.

In Armenia, some epigenetic copper and barite-polymetallic deposits hosted by Middle Jurassic volcanites have been exploited for a long time. These are:

Alaverdi, Shamlug, Akhtala and Kafan deposits. At the Alaverdi district, the geological section of Middle Jurassic productive series is represented by (from bottom to top): andesite and dacite lavas, tephroidalturbidites, and piles of submarine colluviums, hyaloclastites and a thin unit of chemogenic-sedimentary. This orebearing sequence is overlapped by a Late Jurassic volcanogenic complex [2].

Isotopic-geochemical data indicate the participation of considerable amount of sea waters in the hydro systems of volcanogenic deposits [3]. Experimental studies [4] on the extraction of elements from rocks under PT-conditions corresponding to fluid functioning, assume it possible to regard both magmatic and sedimentary rocks as a source of metals from volcanogenic deposits.

In the Lesser Caucasus, a large amount of isotopic-geochemical and thermosbarogeochemical studies has been carried out, on the basis of which, as well as literature data for other regions, we can state that the following features distinguish volcanic (sulfide) deposits: 1. Ore composition strongly depends on petrochemical features of rocks. For example, copper-zinc mineralization is usually associated with andesite-basalts and sodic rhyolites; 2. Within the limits of ore-knots, ways of hydrotherm migration are marked by alterations in mineral composition of rocks; 3. Barite-sulfidic ores in secondary quartzites show gently displayed vertical zonality; 4. By their salinity hydrothermal solutions are close to sea water, but in comparison with the latter, they are enriched in Fe, Ag, Pb, Cu and Zn; 5. The most favorable conditions for the stable accumulation of hydrothermal-sedimentary ores existed on the seafloor, at depths of 2-3km; 6. Data on isotopic composition of hydrogen and oxygen in fluidal inclusions in quartz, barite and calcite from volcanogenic barite-polymetallic ores are interpreted in favor of the participation of both sea and meteoric waters in the ore-forming process, with the predominance of the former.

The evolution and functioning of hydrosystems in volcanic complexes can be conceived as follows: firstly, accumulation, in local depressions of back-arc and intra-arc basins of volcanogenic-sedimentary, predominantly calc-alkaline sequences; then, after the decrease in volcanic activity, emplacement of intrusive took place whose crystallization occurred at a depth of about 2 km from the surface or 1 km – from the seafloor. Hydrothermal sedimentary ores by their composition and structure have similarity with modern extinct “black smokers”. Mineral zonality of which can be explained by the redistribution of ore-forming components as a result of destruction of “ore hills” and their subsequent diffusion from deeper to shallower levels [5].

A few words on the formation of gold-bearing quartz veins and veinlets at Madneuli. We assume that they were formed simultaneously with the formation of explosive breccias. Precipitation of gold, quartz and minor sulfides in secondary quartzite occurred during the destabilization of magmatogenic fluids. Heinrich (2005) studying Cu-Au porphyry deposits pointed out that the low-salinity of magmatic water is capable of gold transporting under high temperature regime. One of the main requirements of this, according to Heinrich, is the presence of a sufficient quantity H_2S. Magmatic fluids under high pressure pass into liquid form, without heterogenous phase transition, and their influence on the surroundings is expressed by significant potassium and propylitic alterations.

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ESTIMATION OF VENTILATION STREAM DYNAMICS AND TUNNEL GEOMETRY AFFECT OVER THE EVACUATION PERIOD ADJUSTED TO THE MODEL OF MOTORCAR TUNNEL IN CASE OF MODELLED FIRES

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The quality of the motorcar tunnels operation is determined according to its safety for which, every single danger should be identified and the volume of risk - consequently evaluated. The volume of risk arisen from existing danger depends on heavy results from dangerous action and the probability of possible dangerous action.

Due to certain reasons, one of the dangers in motorcar tunnel is considered initiation and spreading the fire. The fire initiated and increasing in such space features few damaging factors: great volume of heat formed during the burning process of inflammable material influencing basic infrastructure and toxic products, released from incomplete burn influencing human vitality.

Upon the possible arrival of such circumstances, the supreme priority is to save human lives; at that moment, the only right move is to perform timely and organized self-evacuation from the risk zone. While the self – evacuation can be completed since the moment of fire initiation till the collapse of ventilation system. Overall, the time of evacuation significantly depends on the opportunity of spreading the burnt products throughout the tunnel.

As commonly known, the burnt products, formed from the absence of multiple ventilation flowsin the horizontal tunnel, shall be spread in both directions of the tunnel, while in case of longitudinal ventilation flow, most part of the burnt shall spread towards the stream direction, however, the less part of it shall be spread in the opposite direction of the tunnel, as long as the speed of spreading burnt products exceeds the critical speed of the ventilation flow. Moreover, spreading the burnt products has also the great influence over the length of reversal ventilation flow.

With bending tunnel, burnt gases spreading is asymmetric, due to the high temperature of burning material, less firmness and the “floating”, thus caused. Apart from the given factors, the burnt products spreading is also affected by gradient factors. Determination of correlation among each factor with the spreading of burnt material under such circumstances is quite important.

The report focuses on one of the motorcar tunnel models created in terms of the grant provided by the Shota Rustaveli National Scientific Foundation. It specifically refers to the model of operating motorcar tunnel in which the fire, initiated and developed can be modelled at the decreased scale.

Amendment can be possible in ventilation air flows, pressure, bending of the tunnel angle as well as in other specifications therefore, determining regularity of burning products distribution according to critical speed of ventilation flow, rever-

sal length, gradient factor and other characteristic specifications shall also be permitted considering the influence of transformable systems and elements as well as without consideration of those factors.

Moreover, taking into account specific characteristics of tunnels geometry and aerodynamics of ventilation flows numerical modelling of fires is planned for further appropriate modelling of motorcar tunnels, and, corresponding conclusions shall be drawn based on the **comparison** of the obtained results.

ACKNOWLEDGEMENTS

This work was supported by Shota Rustaveli National Science Foundation (SRNSF) [Grant number AR-19-1936, Project title "*Development and testing of transformable system to save life in road tunnel in case of fire*"].

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MODELS OF HORIZONTAL AND INCLINED ROAD TUNNELS

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We have scheduled to study important technological parameters of ventilation under fire conditions on physical models of different scales of road tunnels. Modeling will be performed on the tunnel models of G. Tsulukidze Mining Institute and of Georgian Technical University. These models complement each other and help us to determine the regularity of the variations in a critical velocity, a back layering length, and a gradient-factor. Physical modeling results will be compared with numerical modeling results obtained using full-scale modern engineering software packages Pyrosim and Fluent to allow new results to be used for specific tunnel geometry, location and topology.

The critical velocity is defined as the minimum longitudinal ventilation velocity to prevent reverse flow of smoke in case of fire. The backlayering length is the distance, at which toxic products of combustion spread upstream of the fire when the ventilation velocity is lower than the critical velocity. Gradient-factor is defined as a grade correction factor, to be applied for estimated fires in sloping tunnels.

The report presents projects of experimental tunnels, as well as methods for conducting experiments and analyzing the results obtained [1, 2]. The control values for the experimental tunnels are given in Tables 1-3.

Depending on the modeling scale (1:40; 1:60) the calculations of firepower in the nature and on the model, as well as the amount of heat released and the gas consumption are given in Table 1.

Table 1

Firepower in the nature and on the model

Firepower in according modeling scales 1:40 and (1:60)		Natural gas consumption, m^3/h [l/h]	Heat released on the model, MJ/h
In the nature, MW	On the model, kW		
5 (5)	0.494 (0.179)	0.05313 [53.13] (0.01928 [19.3])	1.778 (0.646)

In the nature air velocity fluctuation range is between 0.2-6.0 m/s. 0.2 m/s is the minimum speed to ensure turbulence in the tunnel, and 6.0 m/s - the maximum permissible speed in accordance with construction regulations and rules. The variation of velocities for the models is given in the Table 2.

Table 2

Firepower in the nature 5 MW

Modeling scales 1:40 and (1:60)				
Air speed in the nature, m/s	Air speed on the model, m/s	Tunnels cross-section, model [nature], m^2	Air consumption on the model, m^3/h	Increment of air temperature on the model, ^0C
6.0 (6.0)	0.949 (0.780)	0.04 [64] (0.027 [95.7])	136.6 (74.2)	96.4 (8.9)
3.0 (3.0)	0.474 (0.390)	0.04 [64] (0.027 [95.7])	68.3 (37.1)	192.8 (17.8)
1.0 (1.0)	0.158 (0.130)	0.04 [64] (0.027 [95.7])	22.8 (12.4)	578.6 (53.4)
0.5 (0.5)	0.079 (0.065)	0.04 [64] (0.027 [95.7])	11.4 (6.2)	1157.2 (106.8)

Table 3

Firepower in the nature 30 MW

Air speed, scale 1:60		Tunnels cross-section, model [nature], m^2	Air consumption on the model, m^3/h	Increment of air temperature on the model, ^0C
Nature, m/s	Model, m/s			
6.0	0.780	0.027 [95.7]	74.2	53.4
3.0	0.390	0.027 [95.7]	37.1	106.8
1.0	0.130	0.027 [95.7]	12.4	320.4
0.5	0.065	0.027 [95.7]	6.2	640.8

Fire power and air velocity on the model and in nature are calculated according to the formulas

$$\frac{Q_m}{Q_n} = \left(\frac{l_m}{l_n}\right)^{2.5}, \quad (1)$$

$$\frac{U_m}{U_n} = \left(\frac{l_m}{l_n}\right)^{0.5}, \quad (2)$$

In the formulas the index m corresponds to the model; n - nature; Q - heat dissipation rate, MW, kW; l - length, m; U-air speed, m/s; l_m = 12 m; l_n = 480 m for scale 1:40; l_m = 12 m and l_n = 720 m for scale 1:60. The remaining values are shown in Tables 1-3.

ACKNOWLEDGEMENTS: This work was supported by Shota Rustaveli National Science Foundation (SRNSF) [Grant number AR-19-1936, Project title "*Development and testing of transformable system to save life in road tunnel in case of fire*"].

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TRANSFORMABLE SYSTEMS FOR INCREASING EVACUATION PERIOD AND MINIMIZATION OF DAMAGING FACTORS OF FIRES IN ROAD TUNNELS

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Fires in road tunnels to this day remain a high-risk factor and are still the subject of intensive engineering research. For existing and under construction automobile tunnels in Georgia, the total number of which in the near future will be more than fifty, the only risk factor is a fire. Despite the use of modern methods of designing underground tunnels, which aims to maximize the consideration of fire risk factors, the problem remains unresolved for the existing network of road tunnels, to which great attention and financial resources are directed [1, 2]. After the powerful fires that have occurred in developed western countries, the European Union pays special attention to the Trans-European Network, which is a top priority for the safety of existing and under construction tunnels.

The presented paper describes the manufacturing technology of light transformable partitions, with variable aerodynamic resistance, which can be installed without special effort in road tunnels with various ventilation systems.

The proposed idea is to improve ventilation technology to save the lives of people in a fire. It was developed in accordance with our previous studies [3–5], which was also based on the experience that large fires are almost impossible to completely localize in tunnels. The idea of the study is to artificially increase the aerodynamic drag of the tunnel at the right time using transformable systems, which will slow down the diffusion processes of the combustion products along the way people are evacuated.

As a result, the ventilation system will become more flexible to save lives as the evacuation period increases. The proposed technology allows the use of aerodynamic correction to significantly control the flow of heat and toxic gases during fires in order to maximize the time for safe evacuation of people in extreme conditions.

The present study is based on the results of numerical simulations, where tunnel ventilation is modelled using dynamic pressure between portals. The study examines the distribution dynamics of hazardous combustion products for fires with a capacity of up to 30 MW.

A comparative analysis of numerical studies for tunnels with a longitudinal ventilation system, where ventilation processes are examined in a tunnel with and without flexible partitions in fires of various capacities. The calculations analysis shows that the proposed low-cost technology of flexible transformable partitions will be especially competitive in existing road tunnels, since it does not reduce the expensive underground space intended for traffic. In addition, the time and money

to install transformable equipment will be minimal, and therefore ventilation systems with transformable elements will also be economical and efficient.

ACKNOWLEDGEMENTS
This work was supported by Shota Rustaveli National Science Foundation (SRNSF) [Grant number AR-19-1936, Project title "*Development and testing of transformable system to save life in road tunnel in case of fire*"].

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GREEN ECONOMY AND CURRENT ASPECTS OF MASTERING MINERAL RESOURCES IN GLOBALIZATION

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1. Green Economy as economic activity implies less impacts on the environment and ecology. The activities are based on sustainable development and ecological economics. The United Nations Environment Program (UNEP) Green Economy report explains that the green economy implies equality of resources of other countries and also moving towards the less carbon.

The development of a green economy promotes the wise use of natural resources and reduces negative environmental impacts. Considering the sustainable development of the country's economy, it accelerates clean consumption and production practices, attracts green investment, creates new green jobs, prevents environmental degradation and depletes natural resources, thereby improving the socio-economic status of the state and its population [1].

The main sectors of the green economy based on various literary sources are presented in Figure 1.

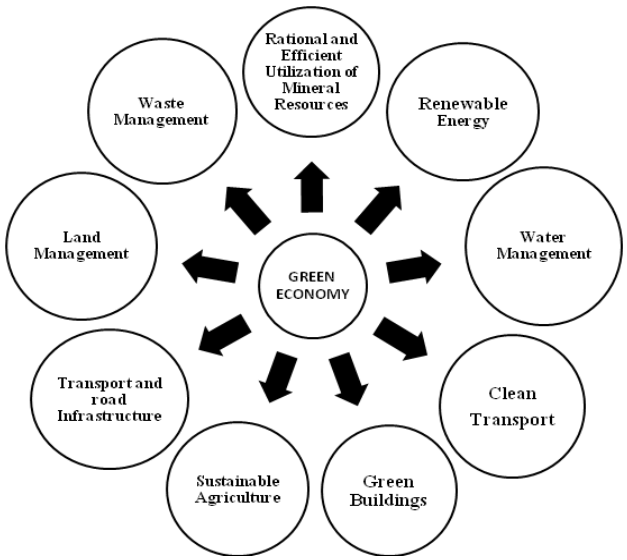

Fig. 1. Main sectors of Green Economy

2. Recently, the environment has become mankind's survival of solving the major factor in the country's economic development and welfare of the people closely related to the achievement of important countries in the green business promotion, investment, modern, green technologies and sharing best practices and experiences and enhancing international cooperation.

In terms of supporting sustainable economic development for the country, it

is important to preserve natural capital and expand and enhance green growth opportunities by realizing potential and implementing effective economic development mechanisms.

In the face of rapid economic growth, it is necessary to implement an economic model focused on environment and green growth resources and energy efficiency, waste management, clean transport, sustainable agriculture and others through. Promoting new sectors and business models should be an important stimulus to diversify the economy, increase competitiveness and access new markets [1,2].

1. Although the evolutionary process of world industrial production is complicated by the influence of various factors from time to time, its overall direction is still characterized by an increase in demand for mineral products. Its consumption growth is due to a number of reasons, including: fossil-fuel, metals and raw materials consumption in developing countries compared to industrialized countries, the emergence of new areas and non-traditional methods of use, as well as population growth. At the same time, the growth rate of mineral raw materials consumption in the world has been declining, due to the saturation of demand, lower consumption of energy in the advanced countries and reduction of the material availability of the goods. In addition, there is a gradual depletion of mineral resources around the world, leading to increased production costs, resulting in an increase in mineral and raw materials production and a slowdown in their use.

Changes in mineral resource mastering rates and the volume of mineral resource supplies are subject to the complex influence of mining, geological, socio-economic and technological factors.

It has been known that the world's annual consumption of natural resources since 1970 has exceeded the Earth's regeneration capacity by 1.5 times, meaning that the Earth needs 1 year and 6 months to recover its resources. However, by 2030, taking into account these trends, consumption will double production. As the United Nations says, if such a trend in per capita consumption continues, consumption by 2050 will increase by 70 %.

Total annual output of the World Mining Complex Expert estimates in recent years have ranged from US $ 0.8-1.1 trillion, 70 % of which comes to liquid and gaseous energy-consumers. Over the next 25 years, with the increase in planet population, industrial and agricultural production, and scientific and technical progress, it will be necessary to extract more energy and other minerals from the minerals. The scale and effectiveness of the use of mineral raw materials significantly determine the state of the economy, the standard of living of the population and the progress of modern society [3,4,5].

The state of mineral resources supply is one of the global problems for both world economies and individual countries. Significant Macroeconomic Indicator – there is a close correlation between GDP and GDP per capita. Developed countries reduce energy expenditure on GDP, which means increasing energy efficiency. This is in line with the overall trends in the decline in mineral resource utilization rates and is one of the proofs of the shift to sustainable economic development.

4. The Green Economy As an important part of the economy and ecosystem,

it calls for active public engagement alongside effective Public-Private Partnerships (PPPs), which are vital to the country's inclusive economic growth and sustainable economic development, as engagement, participation and cooperation helps to develop more effective laws.

In order to increase the state's national wealth and budget revenues, it is necessary not only to make more intensive use of the existing mineral resource base, but also to develop and expand geological exploration and exploration activities with the involvement of innovative infrastructures (clusters, business incubators, etc.). Thus, raising the efficiency of the study and use of minerals is an important national task.

The Green Economy as one of the contributing factors to achieving the principles of sustainable development of the economy, it will significantly contribute to the gradual elimination of poverty in the population, replacing traditional jobs and replacing them with green jobs. Its development enables the introduction of new technologies, disaster risk avoidance, environmental safety, sustainability and social efficiency, while also ensuring optimal and rational mastering of limited mineral resources in the interests of present and future generations.

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EXPLOSION PROTECTION SYSTEM DEVELOPMENT

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Over the last decade the G. Tsulukidze Mining Institute has been carrying out studies aiming at developing protective systems against accidental and terrorist explosions. At different times, these studies have been supported by the NATO Science for Peace and Security (SPS) Programme, U.S. Civilian Research and Development *Foundation* (CRDF), the International Science and Technology Centre (ISTC) and the Shota Rustaveli National Science Foundation.

Despite the presence of an array of tools of prevention and strict security standards, accidental and terrorist explosions are associated with large human and material losses each year. Methane explosion in coal mines, and dust and fuel cloud explosion at different industrial sites have led to disastrous consequences.

At present, development of protective systems is one of the top research priorities. Preliminary studies are needed to create quick-acting, reliable and effective protection systems.

Blast mitigation systems make use of an energy suppression barrier, which is activated between the place of explosion and the area to be protected, to ensure the reduction of excess pressure generated by a shock wave and the attenuation of fire caused by explosion. Design parameters for a protective system of a new generation were selected, based on the findings of the preliminary research carried out at the Mining Institute. The studies served to determine the properties of dispersed water barrier with high attenuating capacity, as well as of the design of a new protective device. Shock wave mitigation processes with the use of different agents have been studied in underground conditions. A wireless detector, which is to identify blasts and generate a system activation signal, has been designed and tested.

The proposed protective design contains the following elements: i) a wireless blast detector, which instantaneously activates the protective device; ii) an absorber, which ensures the discharge of dispersed water in a tunnel before the entry of a shock wave [1, 2].

The proposed system prototype has been tested in the underground experimental facility of the Mining Institute [3, 4, 5, 6]. Test results were used for determining the quick-action response capacity, reliability and effectiveness of the design. The system activates in 22 msec from the moment of blast and ensures the reduction of excess pressure generated by a shock wave by 2.5-3 times. The comparison of the properties of the proposed system and available designs has shown that the proposed system is highly competitive and can be used in transport corridors, coal mines and other facilities exposed to the threat of explosion. Presently, efforts are being made to ensure the commercialization of the system.

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MAIN PIPELINE HYDRO-TRANSPORT SYSTEM FOR TRANSPORTATION OF SOLID LOOSE FOSSILS AT LONG DISTANCES

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Pipeline hydro-transport systems became widely used for transportation of solid loose fossils from the second half of the last century due to many positive properties compared to tradetional means of transportation, due to particularly high technical-economic indicators and ecological purity.

The longer the distance of transportation of solid loose materials, the higher these indicators. One of the big advantages is that it is possible to be carried out under any geographic conditions. Centrifugal soil pumps are mostly used for transportation of materials, which develop comparatively low pressure, due to the structural performance considering the specific nature of the designation. Thus, it is necessary to connect such pumps sequentially to the main pipeline for transporttation of the above materials at long distances. The higher the number of centrifugal soil pumps sequentially connected to the main pipelines based on the transporttation distance, the more difficult the regulation of their operation, especially during the transitional regimes, the more frequent the probability of creation of hydraulic shocks. All of the above make provision of sustainable regimes of the reviewed systems very complicated, which often becomes the reason for development of emergency regimes with negative outcomes [1, 2].

Due to the above, largest technical-economic significance is attached to processing of the technological scheme of the main pipeline hydro-transport system, will be able to eliminate the above negative factors and safe operation with high technical-economic indicators will be possible.

The paper reviews the technological scheme of the multi-step pipeline hydrotransport system processed by us for transportation of the hydraulic fluid of solid loose fossils with the carrier liquid at long distances by pipelines, where high pressure centrifugal water pumps are used instead of centrifugal soil pumps [3, 4]. To perform its function, it has a mechanism for obtaining a hydraulic fluid, which is installed within a drum and consists of an auger and quill shafts, which are attached to the axle between the inlet pipe wings. A nozzle is placed within a chamber receiving a solid loose component, which is performed within it by an auger. At the same time, each station is equipped with volumes located under the perforated drum for obtaining a mixture of liquid and solid components, which are respectively connected to the pump inlet pipe and the suction chamber of the solid component.

Such technological scheme of the pipeline hydro-transport system allows the mixture (hydraulic liquid) to be transported in the carrier liquid of solid loose fossils (as a rule, water) at any distance with an optimal concentration.

In addition, use of high-pressure water pumps on the head pump and line pump stations as a source of energy allows for minimizing the number of steps sequentially connected to the main pipeline, i.e. significantly increase technical-eco-

nomic indicators of the system and ensure sustainable operation.

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POSIBILITI OF APLICATION OF RESIDUAL SOLUTIONS OF COPPER CEMENTATION

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The study was funded by the Shota Rustaveli National Science Foundation [FR-18-6322]

Intensification of the ore mining and processing industry calls attention to the feasibility of exploiting copper-bearing intractable and mineralized rocks.

In this regard, the application of biohydrometallurgical methods demonstrates its advantages. Among microorganisms used in biohydrometallurgy, Acidithiobacillus ferrooxidans are distinguished as having an active oxidizing property. Its involvement intensifies the process of oxidation of divalent iron to trivalent iron by 10^5 times, which results in the release of energy.

At the same time, during this microbiological oxidation, an oxidizing bioreagent is formed, which is a composition of trivalent iron and bacteria-synthesized exopolysaccharides, the oxidation potential of which in sulfuric acid solutions is 80-120 mV higher compared to the pure ferric oxide sulfate under the same conditions [1, 2].

We consider it appropriate to apply this feature in practice. We believe that residual solutions formed during the cementation of quarry water in ore deposits can be used for the biohydrometallurgical process of low-grade copper ore heap leaching.

The composition of waters derived from the quarry water cementation process was studied.

The analysis of the water coming out of the reactor is given in the table below.

As shown in the table, the iron content in the outflow waters is high. Here the iron is mainly represented in a divalent form. At low pH conditions, by using native iron-oxidizing bacteria, the bivalent iron can be oxidized to trivalent, and the obtained strong oxidizing ferric oxide sulphate can be used to extract copper by application of the heap processing method in low-grade intractable sulfide ores and embankments.

Table 1

Specified element	Unit	Value
pH		3,3
Cu^{2+}	Mg/L	40,0
Fe_{total}	Mg/L	1800

In laboratory conditions, the scheme was tested on an example of an ore field.

The content of the copper in the test subject was 0.5%, in the form of secondary sulfides and in oxidized form. 70% of the total content of copper was seco-

ndary sulfides, 28.8% - oxidezed, and 1.2% - primary sulfide (chalcopyrite).

Both methods were applied in the process of copper leaching – using bacterially treated cementation residual water and with the application of pure chemical method. The process was carried out under equal conditions for 60 days. The results of the analysis showed that the amount of copper transferred to the solution using the acid leaching process was 55.0%, and in the case of application of the bioreagent method - 82.2%.

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INVESTIGATION OF THE AZAMBURI MIRABILITE MINE AND LAKE WATER TO OBTAIN ANHYDROUS SODIUM SULFATE

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The mining industry makes a significant contribution to the development of the local economy. An important challenge for the mining industry is the mitigation of environmental impacts, after the completion of mining operations recultivation the territory and at the same time maintain the positive economic benefits [1]. Extraction of minerals is advisable only if economic, ecological and social interests are proportionately taken into account, which is achieved by improving mining technologies.

It is known that Georgia is rich in natural resources, which include ore and non-metallic minerals. From the non-metallic minerals lakes of Azamburi group are important.They are situated in Sagarejo Municipality, the Mirabilite deposit. Lakes of Azamburi Group are presented by 3 lakes: Sakhre-Lake, Garejela and Kachaal-Lake. Only the first two are important in terms of Mirabilite stock. The total reserves of Mirabilite in the Azamburi field exceed 1 million tons.

The issue of obtaining anhydrous sodium sulfate from a brackish lake in the form of salt-water at the Mirabilite deposit and its surface has not been resolved yet.

At the mine, the area of the lake's mirror surface changes seasonally. In the autumn-winter period it declines sharply and the deposit is covered by a layer of mirabilite crystals.

According to the seasonal change in the climatic conditions of the region, in order to determine the composition of seasonally crystallized mirabilite at the Mirabilite Mine and from it, we, in December-March 2019-2020, at one-month intervals, examined complete chemical composition of crystallized mirabilite and salt-water.

In December 2019, the water level of the Sakhare-Tba is significantly reduced. The surface of the lake, free of water, is covered with a layer of mirabilite crystallized from salt-water. In January and February 2020, there is practically no salt-water on the surface of the lake, and its traces are recorded only in the form of small individual puddles. In addition, the mirabilite layer crystallized in December, in January-February, passed into Tenardite. The chemical composition of the salt-water itself has also changed. Sodium and sulfate ions dissolved in salt-water decreased by about 0.6 times in January-February compared to December. Molar appropriateness of compounds in crystallized mirabilite and in salt-water do not differ significantly from each other.

It is planned to continue monitoring the dynamics of salt-water composition and total salt content during the year to determine, under the influence of environmental climatic conditions, how will change the concentration of sodium sulfate in lake water and also the conditions of natural mirabilete crystallization, in order to obtain anhydrous sodium sulfate.

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ESTIMATION OF NOISE POLLUTION OF TORNIKE ERISTAVI STREET OF TBILISI BY MOTOR TRANSPORT

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The social, economic and urban problems of large cities are further deepened due to the constantly worsening environmental ecology, the study of which is associated with the study of not only natural, but also physical factors. Physical factors are increasingly defined as risk factors for the urban population and belong to the group of anthropogenic factors. Noise is one of the unfavorable physical factors that worsen the environment in cities. Its unfavorable impact on the human body is universally recognized and manifests itself in a wide range: from mild irritation to pathological changes in the auditory, central nervous and cardiovascular systems.

The main input to transport noise (up to 90%) generation in modern cities is the auto transport. Normative parameters for unstable noise are equivalent to sound levels L_{Aeqv} (dBA), which depends on a traffic intensity, part of trucks and public transport into the transport flow, average velocity of traffic flow, geometric characteristics of the road, parameters of the dividing line and etc. [1].

Present research refers to the estimation of state of noise pollution in road areas adjacent to Tornike Eristavi str., which is one of the main highways of Tbilisi. Studies were accomplished on weekdays. The main part of transport flow on researched sections was passenger cars. The number of passed motor transport in the investigated regions changed depending on time of the day and night. Fig.1 shows changes in the traffic intensity (number of passing transport in one hour interval of time) in both directions in the studied sections of the street during the day and night (Fig. 1).

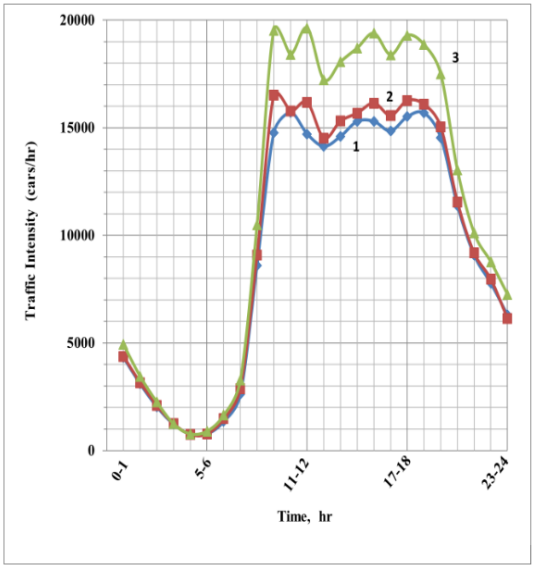

Fig.1 - change in traffic intensity during the day and night between the cross-roads of Tornike Eristavi street.
1 - between the intersection with Giorgi Chkhondideli street and the intersection with David Guramishvili Avenue;
2 – between the intersections with Mechanization street and Giorgi Chkhondideli street;
3 - between the intersections with Akaki Tsereteli avenue and Mechanization street.

As shown in the fig.1 the traffic intensity increases sharply from 8 a.m. to 10 a.m. in the morning. From 10 a.m. to 20 p.m. it is maximal and after 20 p.m. it decreases sharply and by 24 p.m. its value is equal to 6000-7000 cars/hours.

On fig. 2 are shown results of calculations of equivalent to noise level L_{Aeqv} for researched sections of Tornike Eristavi street, during day and night with one-hour time intervals.

As the figure shows, the values of L_{Aeqv} from 10 a.m.to 20 p.m. are about 81 dBA between the intersections with Akaki Tsereteli avenue and Mechanization street, for other sections – 80 dBA.

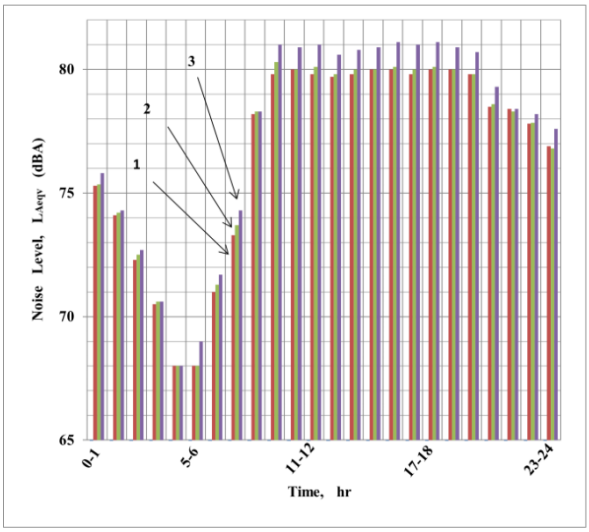

Fig.2 - changes in equivalent to noise level L_{Aeqv} with one-hour time intervals during day and night between the cross-roads of Tornike Eristavi street.
1 - between the intersection with Giorgi Chkhondideli street and the intersection with David Guramishvili Avenue;
2 – between the intersections with Mechanization street and Giorgi Chkhondideli street;
3 - between the intersections with Akaki Tsereteli avenue and Mechanization street.

It is known that the territory where the noise level is more than 80 dBA belongs to the group of uncomfortable territories and the territory with noise level of 60-80 dBA –to relatively uncomfortable group. Consequently, the territory adjacent to the Tornike Eristavi street between the intersections with Akaki Tsereteli avenue and Mechanization street is uncomfortable. The territory between intersections with Mechanization and Giorgi Chkhondideli streets can be considered relatively uncomfortable.

According to the results of the study, it can be concluded that road transport significantly affects the ecosystem of Tornike Eristavi street. It is necessary to optimize noise pollution sources by restricting transport flow velocity, decreasing of part of trucks in the transport flow at a defined time of day and night, glazing of buildings with noise protection glass, arranging of noise protection shields and green spaces along the road and etc.

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STAGE OF THE DEVELOPMENT OF THE UPPER CRETACEOUS PLANKTONIC FORAMINIFERS

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During the Cretaceous period, the development of planctonic foraminifers (PF) followed the path of biological progress, increasing population density and resettlement from shallow to deeper water areas. The Late Cretaceous era was a polytaxon stage, which was interrupted by short-term oligotaxon episodes. In the evolution of PF during the Late Cretaceous several stages can be identified. At the same time, each stage has a certain set of morphotypes, a certain type of life strategy, its own type of evolutionary development and the level of taxonomic diversity.

The Late Albian-Senomanian polytaxon stage. By the beginning of the Late Albian, the globotruncanide had already formed the main features: the type of structure of the shell, the structure of the wall, the character of the peripheral edge, the morphology of the mouth, the umbilical area, the sculpture, the shape and the number of chambers. The development of late-year morphotypes was consistent with *Ticinella*, which appeared in the Late Aptian presumably from *Hedbergella* [1]. At the beginning of the Late Albian is characterized by the predominance of species with r-strategy, which had a gradual change of the main morphological features. The emerging representtatives of the *Praethalmanninella - Thallmanninella-Rotalipora* belonged to the K/r group of strategists. Morphological changes also affected planalinids, which led to a wide but short-term resettlement of representatives of the genus *Planomalina*. The latter came from representatives of the genus Globigerinelloides and its morphological feature is also the appearance of the keel, first at the initial and then on the last turn. Planalinide is also characterized by the presence of relic estuaries in the umbilical area. The morphological diversity of spiral-coil *Heterogenicides* is abruptly increasing [2].

Oligotaxon interval on the Cenomanian-Turonian boundary is associated with the manifestation of an ocean-free oxygen event (OAE-2). Events have taken place within the PF complexes, leading to a sharp reduction in taxonomic diversity. In cases where the oxygen minimum zone did not reach the top of the water column, the border line crossed the taxa of r-strategists, as well as *Praeglobotruncana* and fine *Dicarinella* with r/K strategy. In the case when the oxygen minimum zone covered the eufotic zone, only small *Heterohelix, Hedbrgella* [1], as well as representatives of PF with highly elongated chambers belonging to the *Schackoina* genus were preserved. The shacoins had radial-extended cameras of the last turn, which facilitated the process of floating in the upper layers of water thickness. That is why similar morphotypes – *Leopoldina, Blowiella, Schackoina* are typical for episodes of OAU, starting with Early Cretaceous. Thus, the

Cenomanian-Turonian boundary interval was a typical oligotaxon stage in the development of PF and the dominance of primitive taxa with r-strategy [3, 4]. Episodes of the most intense manifestation of OAU are associated with the "flowering" of conservative *Heterohelicidae.*

The Turonian-Santonian polytaxon stage. After the Cenomanian-Turonian event, a new stage of diversification of the PF began, which is associated with the appearance and wide spatial distribution of two-keeled *Marginotruncana* and *Dicarinella* with a very diverse form of the shell. The morphology of their shells is so diverse that several new taxa – *Sigalitruncana, Carpathoglobotruncana, Falsotruncana* - are highlightted in the Turonian-Coniacian interval and the widespread development of transitional forms has been noted [3, 4, 5]. Among the keelless taxa dominated *Whiteinella* and *Archaeoglobigerina* with an umbilical estuary and a distinct peripheral belt close to the present keel that appeared in the Turonin. It is with this interval associated with the first appearance of real K-strategists, and the general taxonomic and morphological diversity of *Globotruncanidae* in the Turonian-Santonian interval allows to attribute it to the category of polyaxon. The evolution of the Turonian-Santonian PF developed according to the punctualistic scenario of K-and K/r strategists and on the gradialist - r-strategists. During this period, *Heterohelicidae* reached a high taxonomic diversity and among them sculpted forms of the genus *Sigalia* appear. At the same time, the planalinides have a subordinate meaning.

The Late Santonian-Campanian boundary oligotaxon interval. This segment was dominated by r-strategy species. The end of the Santonian is marked by a sharp reduction in taxonomic diversity due to the disappearance of most specialized *Marginotruncana* and *Dicarinella*, i.e. K-strategists. In the terminal Santonian, the *Concavatotruncana* genus disappears completely. The taxonomic diversity of r-strategists has decreased due to the extinction of most species among *Hedbergella* and *Whiteinella*. The process of taxonomic diversity reduction, which began at the turn of Coniacian and Santonian, continued throughout the Santonian century. At the end of the stage, *Archaeoglobigerina* prevailed among the *Globotroruncanide*, among the Planalinides dominated the representatives of *Globigerinelloides*, and among the Heterohelicidae – *Heterohelix*, *Hendersonia* (r- and r/K strategists) dominated. Here, the first representatives of the genus *Globotruncana* appeared; their rapid evolution and wide territorial resettlement is typical of the next interval.

The Campanian-Maastrichtian politaxon stage. The Campanian-Maastrichtian Globotruncanidae is characterized by a combination of all the characteristics of highly specialized taxa in different variants. Some of them were new, such as the replacement of porticos on tegilla in the estuary of *Globotruncana*, the hypertrophied bulge of the dorsal side at *Contusotruncana*, the appearance of forms with spikes and growths at the ends of the chambers at *Radotruncana*. The Late Maastrichtian is characterized by the presence of the genus *Abathomphalus*, which had a narrow umbilicus estuary with a tegilla, ribbed sculpture and two widely spaced keels. The morphology of the shell of this genus combined both the signs of *Globotruncana* and *Rugoglobigerina.*

The Campanian-Maastrichtian interval is also characterrized by the active development of keelless taxa. Thus, from the genus *Archaeoglobigerina* came the genus *Rugoglobigerina* with a sculpture in the form of pronounced ribs. This genus reached the maximum taxonomic diversity in the Maastrichtian century, when several branches - *Bucherina, Rugotruncana, Trinitella* and *Plummerita* originated from it. In the middle of the Campanian century, the diversity of *Globotruncanella* with flattened cameras and a portico estuary quickly increased. Appearing in the Turonian, these forms had a subordinate value up to the specified interval. There should be noted the large size of all these forms; especially it concerns such species as *Globotruncanita stuarti, Contusotruncana sontusa, Abathomphalus intermedius, A. mayaroensis* and the majority of *Rugoglobigerina*. Relatively slow evolution and large variability have led to the emergence of a large number of transitional forms and the genus affiliation of some of them is difficult to identify .

The Campanian-Maastrichtian interval was characterized by a gradualistic type of evolution and was a polytaxon stage in the development of Globotruncanidae, when their diversity was the greatest. The apparent predominance in the complexes, had highly specialized species with K/r and K strategy. The punctualistic type of evolution is typical of the Late Maastrichtian, when short-lived taxa of *Bucherina, Rugotruncana, Trinitella* and *Plummerita* appear, some of which were monotypical. High taxonomic diversity characterrizes the Campanian-Maastrichtian interval in the group of spiral-coil *Heterogicidae* with a multi-row type of structure. High taxonomic diversity is also typical of spiral flat *Planomalinidae*, which vary in size, sculpture and number of cameras, also forms with a bifurcated last chamber appear.

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RESEARCH OF THE TERRITORY OF ADJARA-GURIA BY REMOTE SENSING METHOD

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The folded structure of Adjara-Trialeti is one of the elements of the latitudinal direction lineament of the Caucasus, linear-rift structure, which sharply changes direction to the south-western in the western part, which is the result of the global Ponto-Caspian lineament [1].

Within the studied area the quality of the folding is weak, folds are mostly related to the faults; they represent block folds with 10-30º angle of dip extending over a short distance. Large and steep folds (60-80º) occur in immediate vicinity of the faults.

Fault structures create a grid of orthogonal-diagonal system, they are well deciphered in aerial space images and they determine the block structure of the studied area. One of the transverse blocks of complex structure is located in the northern part of the area and is a zone bordering the intermountain area of Georgia. Stratigraphic analysis of intermountain area of Georgia and the block indicates that the movement between the adjacent blocks was of key-like character and dislocation between them exceeded 5000-6000 meters. Northern block intensively subsided in Quaternary and Pliocene and southern block is sunk in Eocene. This kind of movement is possible only in the system of steep faults, which is also confirmed by the boring data – gently sloping structures on the surface change the inclination angle in depth to the vertical. Thickness of the tectonic zone of this rank is usually 1.2-1.5 km and the movement takes place along several tectonic planes. In modern conditions, this zone is covered with gently sloping structures that cover the deep-seated structure.

To the south, five more latitudinal tectonic zones are revealed (distance between them amounts 5 km). They include faults of the same orientation and form rectilinear folds.Thus, the western part of the transverse lineament of Adjara-Trialeti consists of six elements, which may be characteristic of the entire Adjara-Trialeti zone.

A 40 km wide tectonic zone of northeastern orientation, which crosses the study area diagonally, is part of the Ponto-Caspian lineament and consists of several elements. The marginal element of the zone borders the Guria depression in the northwestern part of the region. The amplitude is 700-800 meters with a submerged northwestern block. The mentioned fault zone causes lowering of the seabed by 800 meters in Turkish waters as well. In the central part of the district is being deciphered a tectonic zone of this system with a thickness of 10 km, which crosses the entire area diagonally and forms folded structures of this direction in the south-western part of the area.

Faults with north-western orientation are encrypted in all territory of the district and it is a part of a transgressive lineament, which extends in a territory of Turkey and Iran over a distance of 1000 km. In the study area, individual faults of

this system border tectonic blocks and no folded structures are observed along them.

Meridional faults include the entire area, but two 12-12 km thick significant zones of this system of can be seen by decipherring. One of them is revealed in the western coastline of studied area and includes numerous echelon-likely disposed faults which are well deciphered till the Guria depression. The zone forms the eastern shore line of the Black Sea basin and defines its configuration, which is also confirmed by isolines of aquatory.

The second zone is deciphered to the east from the village of Shuakhevi and is one of the stages of westward sinking Adjara-Trialeti folded system and a crystalline basement as well. It consists of a large number of parallel faults with the connected dyke bodies characterized by positive linear morphological forms. The meridional tectonic zone is a segment of the trans-regional lineament, so-called Shatski uplift, which appeared before the Cambrian and still functions indicated by a drop in the absolute marks of the relief in the western block, by about 400-500 meters.

The faults determine the block structure of the district. There are distinguished eight tectonic blocks within the studied area, which are bounded by tectonic zones and characterized by different stratigraphy. As a result of the accomplished investigations, we can make a conclusion:

1. Structure of the western part of the Adjara-Trialeti has a block nature. The blocks are bounded by tectonic zones of different orientation regulating the accumulation of sediments in the blocks;
2. The faults are rectilinear structures and they form a network of orthogonal-diagonal orientation;
3. The faults are part of larger structures, and their development took place over a long period of geological time, probably from the Cambrian to modern times;
4. The crystalline basement, which is exposed in the Dzirula zone, in about 100 km to the west, sunk over about twelve kilometers. This process, in our view, is largely determined by meridional faults, and the sinking must be of a stewise nature.

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SYNTHESIS AND RESEARCH OF "MOLECULAR COMPOUNDS" FROM SOME EXPLOSIVES

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Picric acid, methyl picrate, trotyl and other polynitroaromatic substances can form, "**Molecular Compounds**" **("Charge Transfer Compounds")** [1]. The molecules of mentioned well-known explosives contain three electro acceptor nitro groups, because of their aromatic fragments impoverished from π – electrons. So, they can react with electro donor compounds, according to the molar ratio 1:1. In this case, between reacting substances doesn't happen distribution of chemical bonds, but only takes place either transfer of one π – electron from donor molecule (for example, naphthalene) to electro acceptor molecule of trinitrate, or transition to joint ownership:

Picric acid Naphthalene Naphthalene picrate

According to existing views, in the above-mentioned and similar cases, aromatic fragments of the molecules are placed parallel to each other, in **parallel planes**. It should be noticed, that the name, "naphthalene picrate'' is somehow conditional.

The purpose of our research is to synthesize several molecular compounds from picric acid and trotyl, using some π – electro donor aromatic substances, such as benzene, toluene, phenol, diphenylamine, etc. It's remarkable, that corresponding reactions are going on in rather"soft'' conditions, with high yield of products. Their explosion properties have been studied.

For comparison, from the same components, in the same ratio (1:1), we prepared the **mixture compositions**, for testing as explosives.

Thus, the above can be expressed in such a conditional scheme:

Molecular Compound ⟵ Explosive ⟶ Mixture Composition

Despite the explosive strength of two outer members, such transformations of explosives can be interesting from the **standpoint of economics**.

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THE RESEARCH OF CHEMICAL STRUCTURE OF EXPLOSIVE – METHYLPICRATE BY COUNTER SYNTHESIS

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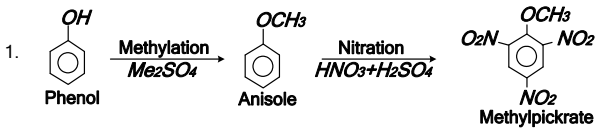
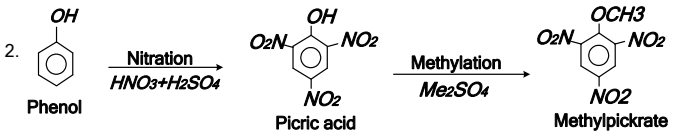
Establishment of chemical structure of a substance, is the first step of its identity and further practical application. Nowadays, there are many physical and chemical methods to solve this problem, such as spectral and element analysis, definition of molecular weights, chemical conversions, etc.

Counter synthesis is one of the effective chemical methods, for establishment of molecules structure. It means the synthesis of the **same** (one) **substance** by two or several different reaction schemes.

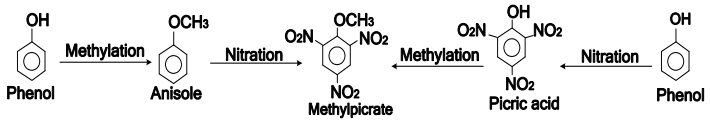
In the earlier period, we have used counter reactions as one of the methods for synthesis and identification of several phenyl acetylene phenols [1,2].

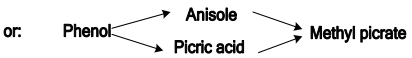
Now, we used this method for synthesis of methylpicrate. This well-known explosive we synthesized by two different methods: 1. Methylation of phenol and further nitration of obtained anisole; 2. Nitration of phenol and methylation of received picric acid:





Thus, the united scheme maybe depicted so:





Identity of methylpicrate received by two different schemes, has been established by IR-spectra, thin layer chromatography and definition of melting points.

It should be noticed that identity of methylpicrate automatically proves identities of two intermediate products - anisole and picric acid. So, there isn't necessity of additional research of their structures. In spite of this, we established their identities too.

In general, counter reactions, with the same purpose maybe used for many other explosives, as well as for polyfunctional substances and so on.

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PROSPECTS FOR THE DEVELOPMENT OF MODERN CABLE CARS IN GEORGIA AND EUROPEAN SAFETY REQUIREMENTS

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In the publication the development trends of cable cars of the leading industrial countries of Europe are discussed. Features of the development of cable transport in Georgia during the Soviet and independent times are given. On the example of Austria, the current state of the cable car park is analyzed.

The focus is on the main technological challenges in the field, which affect and will continue to affect the implementtation of modern cable transport systems in Georgia in the future.

The directions for improving the EU regulatory framework for cable transport to ensure the safety of both passengers and staff are shown.

On an example of the operational practice of the EU, cable transport illustrates the results of implementing modern safety regulatory requirements.

Based on the available data, it is concluded that it is necessary to implement measures that will facilitate the implementation and safe operation of modern types of cable transport systems in Georgia.

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IN MINING, THE LOCATION OF ADITS OR PARTS THEREOF, BY RADIO IMAGE AND BY FIXING THEIR INCLINATION FROM THE DAY SURFACE BY GEORADAR

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The GPR method allows to determine the location of the adit or its parts from the day surface or other horizontal planes in non-visual and non-mechanical, non-invasive contact conditions. To solve these types of direct problems by the method of physical modeling [1], parallel GPR profiles were obtained from the horizontal surface of the modeling unit [2], radio images of inclined pipes [3] of adit models were investigated. Depending on the depth of the radio image and their horizontal displacement the inclination angle of the adit model can be determined. The models of adits complicated by different designs were considered. The GPR image of the physical model of the adit recorded from the day surface was processed using the "Zond 12-e" GPR software the "Prizm 2.5". The simulation results are applicable to the natural environment on the basis of the similarity theory of GPR physical modeling, which was developed and implemented at the Institute of Geophysics, in the sector of Applied and Experimental Geophysics, in the laboratory of Physical Modeling of GPR and Electrometry. To illustrate this, we present two GPR profiles for the adit model shown in Fig. 1 and Fig. 2.

Between prof-1 and prof-7 of the adit model, a shift of radio images was recorded at a distance of 35 cm. In accordance with the principles of physical modeling of the similarity of GPR fields [4], the same result extends to the nature and location of a real pit.

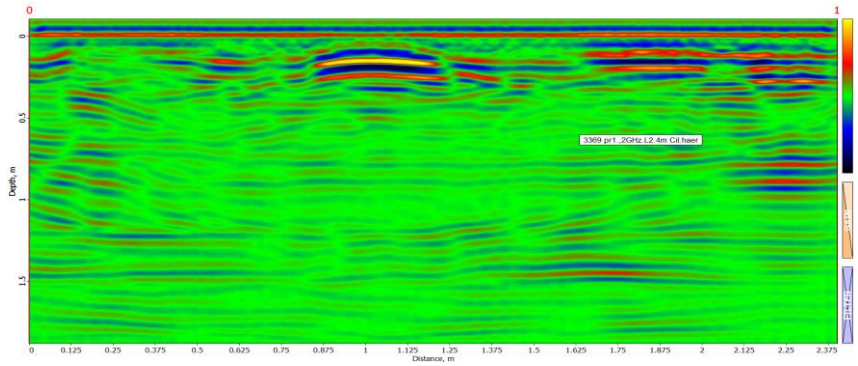

Fig 1. The radarogram is made by GPR" Zond 12-e" with its standard antenna at a frequency of 2 GHz for a distance of 2.4 m, prof-1.

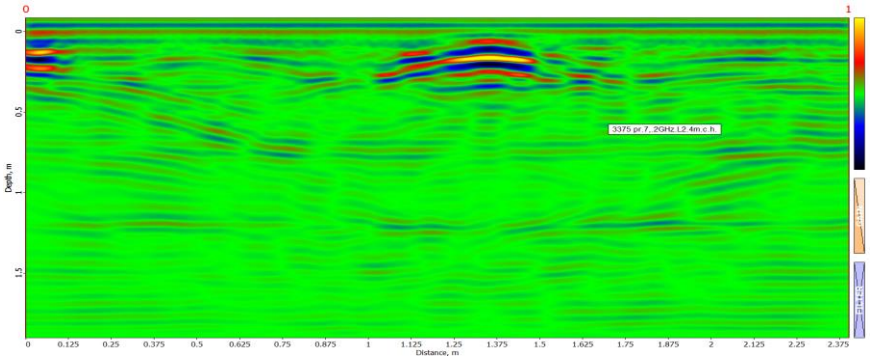

Fig. 2 The radarogram was done using the GPR ,"Zond 12-e" and its antenna at the center frequency of 2 GHz. The distance is 2.4 m, prof-7.

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PRELIMINARY GPR RECOMMENDATIONS FOR RESCUE PLANNING IN MINING

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The method of GPR location allows determining the location of the pit from the side wall [1] in non-visual and non-mechanical, non-invasive contact conditions. Having determined the algorithm of the GPR data processing options, the location of the pit can be determined from the radio image [2]. The GPR radio image of the pit model observed from the side wall [2] was processed using the "Zond 12-e" GPR software, "Prizm 2.5" software, an algorithm developed by the Institute of Geophysics, the sector of applied and experimental geophysics in the GPR location and electrometry laboratory.

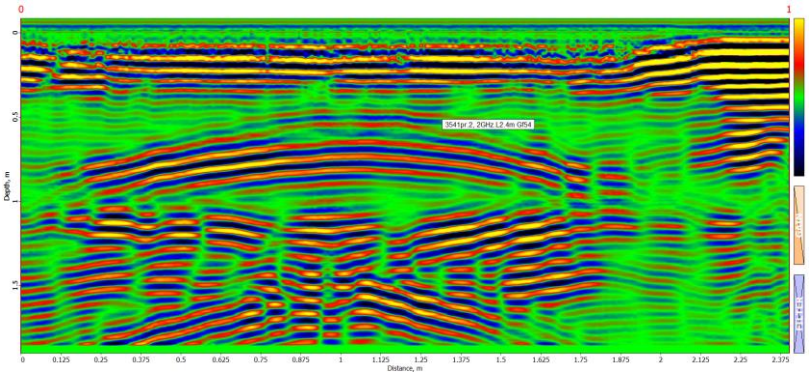

Fig.1. Radarogram made on the installation of modeling bulk solids from the side surface [3], when the model is located in the center of the simulated area. The presented GPR profile passes along the vertical wall of the model installation and crosses the pit model.

After applying the options algorithm for the same profile, we obtained the following GPR picture given in Fig. 2.

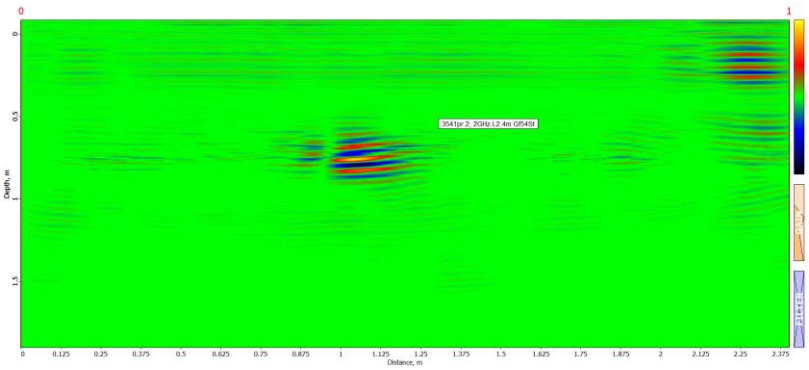

Fig. 2. The georadarogram shows a radio-processed image of the GPR model of a pit (an air-filled plastic tube) processed by the algorithm with a real location and overall parameters (solution of a direct problem).

In accordance with the principles of physical modeling of the similarity of GPR fields [4] the same result are applied to the radio image and location of a real pit.

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THE BRIL CLAY DEPOSIT

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The work presents the results of study of the Bril clays located in the Adjara highlands. The detailed research of the samples by polarizing microscope (AMSCOP 600T – petrographic analysis) made it possible unambiguously identify the essence of rock-forming and accessory minerals, their granulometric sizes, forms of grains and crystals, the process of replacement, products and degree of conversion, degree of cementation between mechanical minerals and basic (cementing) mass and to ascertain the essence of relict rock fragments. X-ray diffraction analyzer (DRON-3) was applied to determine the quantity and essence of certain mineral phases composing the samples and X-ray fluorescent (XRF 3600B) analyzer – to identify the general chemical composition. The physical-mechanical properties of the aforementioned clays were studied in order to determine the field of their application.

The Bril clay deposit comprises six districts: Naziarevi (up to 10 m thick), Gagma Kisrebi (up to 17 m thick), Ikita Gagma Kisrebi (up to 17 m thick), Tsitskhvnari Hill (up to 17 m thick), Nakhiznevi (up to 18 m thick) and Chanchkhistavi (up to 3 m thick).

According to the classification the Bril clays belong to the group of clay deposits originated as a result of weathering of primary medium-acid volcanogenic rocks. They are common in quite a large area and their thickness varies within 0.5 – 60 meters.

Lithologically, the clay rocks of Gagma Kisrebi and Ikita Gagma Kisrebi are similar. According to the data obtained by polarizing microscope the mineral composition of rocks, sampled at various places, are similar.

Macroscopically the rock sampled in the Gagma Kisrebi district at 4 m depth from the surface is light brown, porous; it easily disintegrates and does not react with hydrochloric acid.

Microscopically the rock is entirely represented by a very turbid homogeneous clay-montmorillonite mass containing a lot of psammitic terrigenous material; the latter is unevenly distributed in the rock and is generally represented by quartz and feldspar grains of small size; chlorites are so dispersive that their peculiarities are not clearly observed; in some places there is observed increased quantity of ferric hydroxide; small size ore mineral grains are scattered against the whole background of the rock. The chemical composition of the rock is the following: SiO_2 - 52.73%, TiO_2 – 0.25%, Al_2O_3 – 18.57%, FeO (Fe_2O_3+FeO) – 7.52%, MgO – 2.03%, MnO – 0.17%, Na_2O – 0.87%, K_2O – 1.77%.

The X-ray pattern of the X-ray diffraction analysis distinctly show quartz and plagioclase phases, chlorites are fixed in comparatively small quantity while the X-ray amorphous phase, represented by dispersive X-ray amorphous clay minerals is in a large quantity.

Macroscopically the rock sampled in the Gagma Kisrebi district at a depth of

7 m from the surface is light brown, porous; it easily disintegrates and does not react with hydrochloric acid.

Microscopically the rock is entirely represented by a very turbid homogeneous clay-montmorillonite mass containing a lot of psammitic terrigenous material; the latter is unevenly distributed in the rock and is generally represented by quartz and feldspar grains of small size; in some places the increased quantity of ferric hydroxide is observed; ore mineral grains of small size are scattered against the whole background of the rock.

The X-ray pattern of the X-ray diffraction analysis distinctly shows quartz and chlorite phases; plagioclase phases occur in small quantities, while the X-ray amorphous phase, representted by dispersive clay minerals (montmorillonite), is in large quantity.

Clays from the Ikita Gagma Kisrebi district are similar to those from the Gagma Kisrebi district. Macroscopically they are reddish-brown; they easily disintegrate in the desiccated state; they do not react with hydrochloric acid.

The clay rocks of the Tsitskhvnari Hill district are similar to Plastic clay rocks from the Naziarevi and Nakhiznevi district.

The integrated studies showed that raw material of the Bril deposit clays is good for making bricks and quality items though after the required mineral composition and grain size dimensions of the raw material are selected, it is necessary to process this material previously (if needed) and strictly observe technological processes of drying and firing.

MICROFAUNA (FORAMINIFERS, OSTRACODES) COMPLEXES OF TARKHANIAN-CHOKRAKIAN SEDIMENTS OF WESTERN GEORGIA

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Biostratigraphy of Tarkhanian-Chokrakian sediments has been studied by mollusk fauna [1] and foraminifera [2] widespread in Georgia. At the modern stage of research some stratigraphic questions require specification and amendment with new data. From this viewpoint complex study of microfauna – for aminifers and ostracodes is important and is accomplshed for the first time.

Foramonifers and ostracodes of Tarkhanian-Chokrakian sediments are discovered in the stratigraphic section of the Samegrelo depression (villages Urta, Khorshi, Betlemi, Tamakoni, the rivers Intsra, Chanistskali) and the Racha-Lechkhumi sub-zone (villages Chkumi, Bardnala, Gvirishi, the river Namkashuri). As a result of the microfauna sstudy, we identified the lower and upper stages in the Tarkhanian and the lower, middle and upper stages in the Chokrakian.

In the Lower Tarkhanian sediments following microfauna is distinguished: Foraminifers – *Textularia tarchanensis* Bogd., *Quinqueloculina boueana* d'Orb., *Q. boueana levis* O. Djan., *Q. selene* (Karrer), *Sigmoilina mediterranensis* Bogd., *S. tenuis* (Czjzek), *Discorbis* ex gr. *tarchanensis* O.Djan., *Nonion granosus* d'Orb., *Globigerina tarchanensis* Sub. et Chutz. Ostracodes – *Loxoconcha carinata* Lnkls., *L. carinata alata* Schn., *Aurila* aff. *dentata* Mull., *Cytheridea mulleri* (Munst.), *A. caucasica* Schn.

In the Upper Tarkhanian sediments following microfauna was defined: Foraminifers – *Quinqueloculina boueana* d'Orb., *Q.* aff. *boueana* d'Orb., *Q. selene* (Karrer), *Q. ungeriana* d'Orb., *Q. circularis* Born. *Sigmoilina tenuis* (Czjzek), *S. tenuis tarchanensis* O.Djan., *S. mediterranensis* Bogd., *Caudina linter* O.Djan., *Florilus bouanus* d'Orb., *Flintina sp. Nonionella pulchella* O.Djan., *Globigerina* sp., *G. tarchanensis* Sub.et Chutz., *Ammonia beccarii* (Linne), *Discorbis* ex gr. *Tarchanensis* O.Djan. Ostracodes – *Aurila caucasica* Schn., *A.* aff. *dentata* Mull, *Cytheridea mulleri* (Munst), *Loxoconcha carinata* Lnkls., *L. carinata alata* Schn. *Leptocythere stabilis* Schn. In the Tarckhanian sediments unitary specimen of some microfauna species are found. Some species of fauna pass into the Chokrakian sediments almost without any changes: Foraminifers – *Quinqueloculina ungeriana* d'Orb, *Q. selene* (Karrer), *Sigmoilina mediterranensis* Bogd. და *Ammonia beccarii* (Linne); ostracodes – *Cytheridea mulleri* (Munst), *Loxoconcha carinata* lnkls., *L. carinata alata* Schn.

Microfauna in yellowish thin-layered sandstones and grey clays is of Lower Chokrakian age: foraminifers – *Quinqueloculina akneriana* d'Orb., *Q. akneriana longa* Gerke., *Q. akneriana rotunda* Gerke., *Q. selene* (Karrer), *Q.* aff. *laevigata* d'Orb., *Q. ungeriana* d'Orb., *Q. elongata-carinata* Bogd., *Q.* aff. *longuiscula* Bogd., *Q.* ex gr. *circularis* (Born.), *Tschokrakensis caucasica* (Bogd.), *Triloculina subfoliacea* Bogd., *T. austriaca* d'Orb., *Sigmoilina*

tschokrakhensis Bogd., *S. haidingerii* (d'Orb.), *S. haidingerii tschokrakensis* Bogd. *S. mediterranensis* Bogd., *Spiroloculina irma* Bogd., *Articulina tschokrakensis* Bogd., *Caudina linter* O.Djan., *Florilus boueanus* (d'Orb.), *Ammonia beccarii* (Linne) and ostracodes – *Pontocypris suzini* Schn., *Bairdia* ex gr. *exlicata* Schn., *Leptocythere* aff. *ukrainica* Schn., *L. stabilis* Schn., *L. rugosa* Schn., *L. bardnalensis* Popkh., *Tranchylebenis elengatissima* (Lnkls.), *Cytherura magna* Schn., *C. filicata* Schn., *loxoconcha carinata* Lnkls., *L. carinata alata* Schn., *L.* aff. *bairdi* Mull., *Aurila* aff. *denudata* (Reuss), *A. dromas* Schn., *Cytheridea mulleri* (Munst.), *Xestoleberis fuscumaculata* Mull., *X.* aff. *lutrae* Schn.

In the Middle Chokrakian sandy clays and dark grey clays abundance and diversity of foraminifers is observed; they are almost identical to the species found in the Lower Chokrakian sediments and in addition, there occur foraminifers – *Quinqueloculina dimitrievae* (Bogd.), *Q. purula* Karrer, *Flintina* sp. *Triloculina tricarinata georgiana* O.Djan., *Pseudopolymorphina tschokrakensis* O.Djan., ostracodes – *Pseudocythere caudata* Sars., *Pontocypris* sp., *Paracytheridea* aff. *reussi* Schn., *Cytheretta* sp., *C. korobkovi* Schn., *Aurila spinulosa* (Reuss), *Cyprideis littoralis* (Brady). In the Upper Chokrakian sediments species in common for the Tarkhanian-Chokrakian are not observed. Among the foraminifers *Quinqueloculina akneriana* d'Orb. *Articulina* aff *tshokrakensis* Bogd., *Sigmoilina tschokrakensis* Gerke., *Nonion bogdanoviczi* Vol., *Ammonia beccarii* (Linne) are remarkable, and from ostracodes – *Cytheridea mulleri* (Munst.), *Aurila spinulosa* (Reuss), *Candona* ex gr. *candida* Mull., *Cyprideis littoralis* (Brady). At that stage of the Chokrakian Age microfauna is represented by unitary specimen.

In the stratigraphic section of Tarkhanian-Chokrakian sediments of Western Georgia 42 species of foraminifers 16 genera and 32 species of ostracodes 10 genera are established. The fauna contain the Mediterranean species along with other ones that are widespread only in the Crimean-Caucasian synchronous sediments [3]. There are also endemic forms found only in the Tarkhanian-Chokrakian sediments of Georgia.

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THE TECHNOLOGY FOR PRODUCING A HIGHLY ACTIVE POZZOLANIC ADDITIVE BASED ON THERMALLY MODIFIED CLAY ROCKS FOR CEMENT/CONCRETE

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Cement/concrete is one of the most energy- and material intensive sectors of the construction industry. The most expensive concrete component is cement. The use of a pozzolanic additive in cement/concrete is an effective method of reducing the cost of the clinker part of cement.

In recent time throughout the world, the metakaolin is very popular as a highly active pozzolanic additive for cement/ concrete [1]. Adding metakaolin makes it possible to increase the density, water tightness and mechanical strength of cement/ concrete and thus helps to reduce the consumption of cement in concrete. Metakaolin is obtained by heat treatment of kaolin clays, the world's reserves of which are quite limited. Therefore, intensive work is underway to obtain metakaolin from conventional polymineral clays, which would make available and inexpensive to obtain this material (metakaolin) [2].

Thermal modification of conventional clays to expand the local resource base is a common and proven practice, and this method has been used in the world for a long time [3].

Georgia does not have reserves of kaolin clays; therefore, it is extremely important to develop a technology for producing a highly active pozzolanic additive from widespread local polymineral clays, which this work is devoted to.

For this purpose, we have studied clay rocks of Georgia: clay shales (Kvareli), argillites (Teleti) and fusible clays (Gardabani).

Clay rocks were investigated by chemical, mineral-petrographic, x-ray, differential thermal, and other methods of analysis. The optimal mode and temperature of thermal modification were revealed for each rock.

The quality of the pozzolanic additive is determined by its ability to absorb calcium oxide hydrate, which is released during the hydration of cement minerals and turns into sparingly soluble hydrosilicates and calcium hydrogranates, thereby increasing the strength of the cement and, consequently, the quality of the latter.

The pozzolanic activity of the heat-treated additives was determined by the method of absorption of lime from a lime solution in accordance with GOST R 56592-2015 (Mineral admixtures for concretes and mortars. General specifications). According to the results of tests, it was found that all the studied additives have different pozzolanic activity depending on the heat treatment temperature. According to the requirements of the standard, the additive has high pozzolanic features if the amount of CaO absorbed from the saturated solution is more than 70 mg/g, medium - from 30 to 70 mg/g and low - up to 30 mg/g.

According to the data obtained, thermally modified clay rocks are characterized by high pozzolanic activity [4].

Modified additives were tested in a composition with cement. The results of physical and mechanical testing of cements are graphically shown (Fig. 1).

It has been determined that thermally modified clay rocks under a certain heat treatment regime can be used as a highly active pozzolanic additive in Portland cement. The use of these additives up to 35% will make it possible to reduce the share of clinker in Portland cement without reducing mechanical strength, and adding about 6% of modified clay rocks, a significant increase in cement mechanical strength is observed.

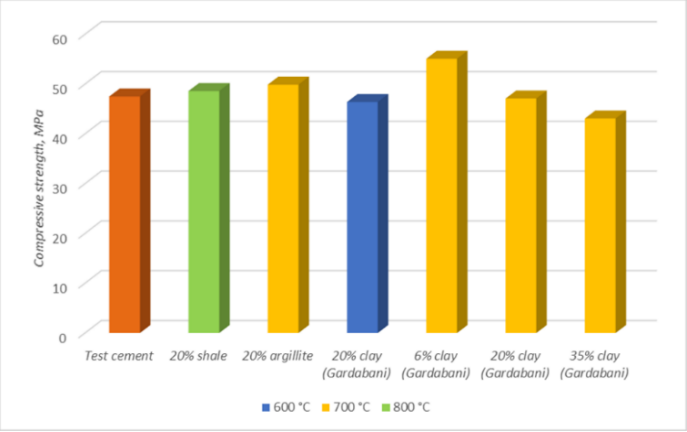

Fig. 1. Hydraulic activity of cement samples after 28 days. Hardening, containing different amounts of additives, with different temperature modification

This work was supported by the Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [grant №AR-18-343].

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COMPARATIVE CHARACTERISTICS OF PRE-ALPINE METAMORPHITES OF THE LOKI, AKHUM AND ASRIKCHAY MASSIFS AND OF THE OPHIOLITE OLISOSTROME OF THE AMASIA-SEVAN-AKERA BELT (SOMKHIT-KARABAKH TECTONIC ZONE)

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Within the Somkhit-Karabakh tectonic zone (the Lesser Caucasus), pre-Alpine metamorphites are represented in the Loki, Akhum and Asrikchay massifs, and also occur as blocks in the ophiolite olistostrome of the Amasia-Sevan-Akera belt. Metamorphites of the massifs are similar in composition and P-T conditions of formation (Fig.1).

There the following mineral associations are occurred (the mineral symbols are given according to D. Whitney and B. Evans [1]):
In metapelites – Cld+Chl+Pg+Qz+Ab, Ms+Cld+Qz±Ab, Bt+Ms+Chl+Pl+Qz, Ms+Chl+And+Bt+Pl+Qz, Grt+Ms+Chl+Qz+Ab and Ms+Chl+Cb+Qz
In metabasites – Act+Act_{Hbl}+Chl+Ab+Cal+Ep, Cb+Spn+Tr+Chl+Tlc+Srp, Act+Chl+Ep+Ab+Cal, Cb+Chl+Spn+Ep and Srp+Chl+Cb+Tr [2-4].

Metamorphic rocks of the Loki, Akhum and Asrikchay massifs are represented by chloritoid-chlorite-sericite, chlorite-sericite-quartz-graphite, andalusite-mica, cordierite-mica, plagioclase-amphibole, actinolite-chlorite-albite, chlorite-actinolite -carbonate schists and graphite-bearing quartzites related to andalusite baric series. By analogy with the Loki massif allochthone-imbricate structure of Akhum and Asrikchay metamorphic complexes and Early Variscan (Bretonian) age of regional metamorphism is assumed. Analogs of almost all the above varieties of meta-schists are also found in allochthonous blocks of the Amasia-Sevan-Akera belt [2-4].

In the tectonic blocks of the Amasia-Sevan-Akera belt the metamorphic formations of moderate or high baric types – garnet amphibolites, garnet-quartz-plagioclase-amphibole schists and plagiogneisses and kyanite and glaucophane schists are observed. It should be noted that in the metamorphic complexes of the Loki and Akhum-Asrikchay massifs they are not found. A probable analogue of the ophiolite formations of the Loki and Akhum-Asrikchay massifs, purely conditionally, can be considered albite-epidote-chlorite-actinolite porphyroids of the Dzoraget block.

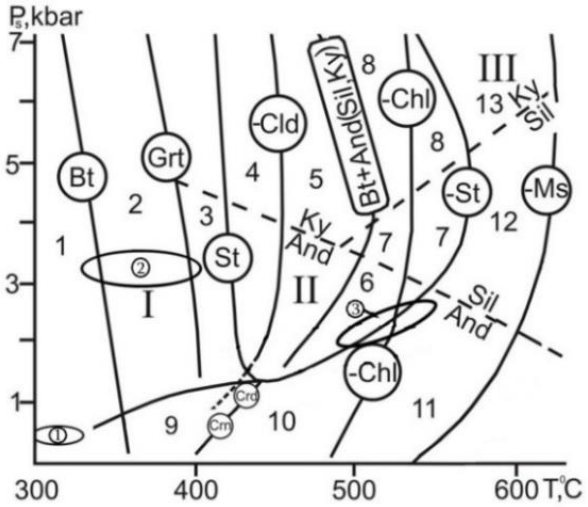

Fig. 1. The position of the pre-Alpine metamorphites of the Loki, Akhum and Asrikchay massifs on the P_s-T diagram of low- and medium-temperature facies and subfacies of metamorphism (according to S. P. Korikovsky [5] with the authors' additions).
Fields of metamorphism facies: I - greenschist, II - staurolite (epidote-amphibolite), III - biotite-muscovite-gneiss; subfacies: 1 - chlorite-sericite, 2 - biotite, 3 - garnet, 4 - staurolite-chloritoid, 5 - staurolite-chlorite, 6 - staurolite-biotite-andalusite, 7 - staurolite-biotite-sillimanite, 8 - staurolite-biotite kyanite, 9 - albite-epidote-hornfels, 10 - andalusite-biotite-muscovite-chlorite-hornfels, 11 – andalusite-biotite-muscovite-horny, 12 - sillimanite-biotite-muscovite-hornfels, 13 – kyanite-biotite-muscovite hornfels. In circles, arabic numerals denote the position of metamorphic rocks of the Somkhit-Karabakh tectonic zone: ①- Precambrian (?) metaophyolites of the Loki, Akhum and Asrikchay massifs, ②- Paleozoic metamorphites of the Safarlo-Lok-Jandari tectonic sheet of the Loki massif and Akhum and Asrikchay massifs, ③Paleozoic metamorphites of the Moshevani tectonic sheet of the Loki massif. Symbols of minerals indicate the reactions of the appearance or disappearance (-) of critical minerals or associations.

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RISKS OF URBANIZATION AND WAYS TO MINIMIZE THEM

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One of the major challenges of modernity is urbanization. It is a result of the rapid increase in population density in the central areas of the country, especially in the capital. Concentration of population in local areas causes many problems related to household, health, education, trade, rest and other vital issues.

All of this requires increasing amounts of potable and technical water. Drinking water is used not only for water supply but for the supply of facilities that require a large amount of technical water for drinking, such as: food industry, pharmaceuticals, medical facilities. This requisite may be satisfied by groundwater. The increase in demand leads to the intensive exploitation of aquifers, which may lead to the depletion of these horizons.

The most vulnerable is the first aquatic horizon from the day surface - the groundwater horizon, since it is close to the customer and does not require deep wells. There are 2 ways to protect groundwater from complete or partial drainig: the first is to limit its exploitation, which is virtually impossible in the face of growing demand, and the second is artificial refilling of groundwater at the expense of excess surface runoff.

VOLCANIC GLASSES ON THE TERRITORY OF GEORGIA AND PROSPECTS FOR THEIR USE

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Along with obsidian and pechstein (pitchstone), perlites are acid volcanic glasses. They are formed on the edge of molten magmatic lava as a result of rapid cooling, when in contact with the ground and differ from each other mainly by the water content in the texture.

Perlite mainly consists of Si, Al, Fe, Ti, Mg, Mn, Ca, Na, K elements oxides. It also contains water and gases: CO_2, N_2, H_2, SO_3, Ne, Ar. The location of gases and water in volcanic glass is unequal. There are two types of water in perlites – structural and mobile. It may also contain hydroxyls (OH). Structural water is linked to the tetrahedrons of aluminosilycium oxygen through a hydrogen binding. Its content is 1-3%. Depending on the texture, there are massive, layered, breccias land pumice-like perlites. A specific peculiarity of perlites is their ability to swell and increase the initial volume, when heated.

Swollen perlite is a loose, lightweight, stable material that can be used at temperature from -200°C to +900°C. It has thermal- and noise-insulation properties and can absorb liquid in an amount of more than 400% of its weight and it is biologically stable. Perlite is chemically inert and environmentally friendly. It can be used in both unprocessed and swollen conditions. Mainly, swollen perlites are used as insulating materials and as adsorbents; they are used for the purification of water, as filters – in the food industry and medicine, etc. Swollen perlites are also widely used in agriculture.

The objects of research were perlite and obsidian from two different regions of Georgia: perlite and obsidian of so-called “Korghan” deposits of “Ninotsminda” region and perlite from the village Toloshi in Aspindza region.

Petrographic analysis of the samples showed that the perlite of the Toloshi location is a rock with a dacite composition and structure, which is built of volcanic glass, where perlite spheroidal cracks, obtained as a result of depletion, and pure crystals of plagioclase ranging in size from 0.03 to 0.5 mm, are rarely observed in the glass. Minerals, probably pyrite are also rare. Perlite of the Paravani deposit is built of a strongly altered volcanic glass, in which perlite spherical cracks are common. The glass is devoid of any admixtures. The only mineral found is chlorite, which is a product of volcanic glass replacement. There are also iron-enriched areas that are likely to be a product of the destruction of some iron-containing mineral.

The obsidian sample consists entirely of volcanic glass. Rarely, at large magnifications (100x diameter), the smallest grains of plagioclase are observed, as

well as cracks, which can be characterized as perlite.

Infrared spectrographic analysis was performed on the Agilent Cary 630 FTIR Spectrometer. The study of all three samples by IR spectroscopy showed that the spectra of the samples are similar to the IR spectra of silicates. These are two high-intensity bands of valence vibrations (γ_1) of Si—O—Si bonds at a frequency of 1073.5 cm^{-1}– obsidian; 1057.6 cm^{-1}– perlite (Toloshi); 1040.9 cm^{-1}– perlite (from Paravani deposit). An increase in the vibration frequencies of the bands is completely consistent with the results of chemical analysis of the samples, since the frequencies of these bands depend on the value of the SiO_2/Al_2O_3 ratio. The band of deformation vibrations (γ_1) of the same bond is 466.8, 468.7 and 470.6 cm^{-1}, respectively. In addition, the perlite from Paravani deposit, unlike these two samples, has a band of 550.7 cm^{-1}, 692.2 cm^{-1} and 912.3 cm^{-1}. The first two bands can be attributed to Al—O vibrations, and the third at 912.3 cm^{-1}– to Al—OH vibrations.

It is interesting, that in these samples water and hydroxyl groups are represented in different kinds and in all three samples the band of deformation vibrations of water is equally fixed (at≈401640 cm^{-1}). In the valence vibrations zone of water obsidian has one band – 3445 cm^{-1}, in the perlite of Toloshi deposit two bands – 3438.5 cm^{-1} and 3640 cm^{-1} are observed and in the perlite of Paravani deposit there are three types of hydroxyl groups – at 3440, 3619.2 and 3695.7 cm^{-1}. These three species correspond to data known from literature.

It has been established that the chemical composition of minerals differs from each other mainly by the content of Al_2O_3. It has been shown that SiO_2-containing volcanic glass is mainly in an amorphous state. Perlites differ from each other both visually (perlite of the Toloshi deposit is dark gray and the other–of the Paravani deposit– is white), as well as in terms of composition. In the perlite spectrum of the Toloshi deposit, in the internal vibration bands, as well as in the vibration bands between the Si — O — Si (Al) tetrahedra, we can see that the replacement of silicon with aluminum is less common than in the perlite spectrum of the Paravani deposit. The prospects for the use of volcanic glass are also shown.

SEDIMENTOLOGICAL-ICHNOLOGICAL ANALISIS OF THE ARDAGANI-1 SECTION (PALAEOCENE-LOWER EOCENE BORJOMI SUITE, GEORGIA)

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The studied outcrop Ardagani1 is located on the steep, southern flank of the Borjomi Anticline, in the environs of Ardagani settlement, along the Borjomi-Bakuriani road. The section, measured bed by bed, is 45.3 m thick. It is composed of dark grey and grey calcareous siltstones and mudstones intercalated with very fine and fine-grained calcareous sandstones. They belong to the uppermost part of the Lower Tusrebi lithostratigraphic unit dated on the basis of micro foraminifers to the upper Paleocene (Thanetian)[1].

The whole section shows rhythmic alternation of mudstone, siltstone and sandstone layers, which constitute sandstone-siltstone-mudstone or siltstone-mudstone depositionnal rhythms/beds. The rhythms/beds of similar character and thicknesses form packages. Particular lithologies and their thicknesses vary from package to package and throughout the section in general. The lower part of the section is dominated by siltstone - mudstone beds of centimetric thicknesses. Some beds start from very fine-grained sandstone, which is usually 3–8 cm, exceptionally 15 cm thick. These deposits are arranged in packages, which are from several tens of centimetres up to 2 m thick. The sandstones usually show parallel to oblique, in places hummock-like lamination. In the mudstones (often marly), a transition from dark grey/grey to greenish grey portions up the rhythm is well observed. The mudstone is usually 3–5 cm, rarely up to 30 cm, and exceptionally up to 50 cm thick. Thin (up to 5 cm) siltstone beds form transitional portions of beds between the sandstone and the mudstone. In the middle part of the section, mudstones are thicker and fairly prevail within the beds. In some packages, they form two to more than ten depositional rhythms. Rarely, some rhythms start from fine- to very fine-grained calcareous sandstone, which is usually parallel laminated at the base and at the top. Some thicker sandstone beds show flute casts on their base and mud intraclasts in the upper part. Flute casts point to the general direction of transportation from the south. In the upper part of the section, the role of sandstone

beds increases as well as their thicknesses (10–150 cm). The siltstone-mudstone intervals become thinner. The uppermost part of the section becomes more and more sand-rich with abundant plant detritus.

Trace fossils in the Ardagani 1 section are unevenly distributed. Some intervals of the lower part of the section seem to be barren of trace fossils. In other intervals of this part, only *Trichichnus* is present.

The middle part of the section is the most rich in trace fossils. They were observed on larger, parting/bedding surfaces. *Polykamptongeorgianum, Scolicia*isp., *Trichichnus*i sp. and *Chondrites intricatus* (Brongniart, 1823) are the most common traces. They are less common in the upper part of the section. *Scolicia* occurs mostly as variable preserved endichnial, hypichnial and epichnial full reliefs. *Polykamptongeorgianum*occurs in 55 horizons of the section. It frequently co-occurs in the same bed with *Trichichnus*i sp., *Scolicia*isp., *Chondrites intricatus*, and *Planolites*isp.. Single co-occurrences with *Phycosiphonincertum* Fischer-Ooster, 1858, *Nereites*isp., *Chondrites stellaris*Uchman 1999, *Halimedides*isp., *Ophiomorphaannulata* (Książkiewicz, 1977), *Spirophycusbicornis* (Heer, 1877), *Thalassinoides*isp., and *Zoophycos*isp. are noticed. *Ophiomorpharudis* (Książkiewicz, 1977), unnamed tubular burrow and tubercles are present in the sectionas well (Uchman et al., 2020, submitted manuscript).

The trace fossil assemblage is atypical but it resembles the Nereitesichno subfacies of the Nereitesichno facies, which is common of mudstone-dominated deposits in the distal parts of the deep-sea turbiditic depositional systems[2].

ACKNOWELEDGMENTS

This works was supported by the Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [Grant number FR-18-3765 - Ichnology and Sedimentology of the Paleocene-Lower Eocene Sediments in the Achara-Trialeti Fold-Thrust Belt, Georgia].

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BEHAVIOR OF PLASTCONCRETE UNDER ELEVATED AND HIGH TEMPERATURES AND OPEN FIRE CONDITIONS

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Plastconcrete distinguished by a number of advantages, in some cases by unique properties, compared to other traditional materials. First of all, it is a high mechanical characteristic of stretching and chemical resistance to aggressive environments, which makes their use promising in construction [1-2]. On the other hand, as polymeric materials, they have a negative property such as relatively low resistance to elevated and high temperatures. The need to study this feature has long been emphasized, but it has not been extensively studied to date. However, recently there have appeared publications on the behavior of plastconcrete in elevated and high temperatures. As for the durability of plastconcrete for open fire, it is almost unexplored by today's Standard [3-4].

It should be said that as a result of the study of the impact of light oil on the material its fire-technical characteristics are formed: Flammability, combustion, flame propagation, heat generation, smoke generation, toxicity of gaseous substances and so on. The present paper deals only with the study of characteristics of plastconcrete such as combustion and incineration. Modern fire-detection characteristics are based on Western standards such as ISO 458 94, ASTM D 28 63, CSA C 22-2N0.6, UL 94. We used the latter document to evaluate the flammability of the concrete. It identifies seven categories of substance (material).

The object of the study was the following composition of concrete: Wrestling Component - BRE 452 mark (Turkish production) polyester resin - 12%, filler - andesite powder (grain size <1 mm) - 85%. Andesite powder is obtained by the processing of high energy mill in the form of rock FRITSCH and RETSCH. The polyester resin is incorporated with TEOS (tetraethyl orthosilicate $(C_2H_5O)_4Si$) for reduction of Flammability. Its content was 2% of polyester resin.

Elevated temperatures (80–160℃) adversely affect neither polymers made of unmodified nor modified based on polyester resin. On the contrary, if we look at the mechanical properties, there is an increase in rigidity and strength. At high temperature (350℃) the TEOS efficiency is shown. At this temperature, unlike unmodified, modified plastconcrete does not crack and shows a strength increase by 14%. Intensive thermal decomposition of plastconcrete starts at 400 and at 500℃ temperature it results in ignition and complete loss of strength.

The open fire test of the material showed:

Category HB: The combustion rate of a sample of about 3 mm in thickness was 15 mm/min. With this setting, plastconcrete can fall into this category.

Categories V-0, V-1, V-2: The burning of the vertically fastened specimen does not stop either after 10 seconds or after 30 seconds. Drops do not appear in combustion According to this behavior, plastconcrete cannot be classified as such.

Category 5V: At the first stage, a vertically attached specimen was tested.

The five-to-five-second impact of the open fire revealed that the material was not being ignited, and that there was neither ignition nor fusion. In the second stage, a wide slab of the same thickness was tested. As a result of this experiment, we found that the passage of the samples through the scaffolding does not result in a five-to-five-second fire impact on them.

Thus, plastconcrete was tested under all the conditions required by UL94 and the combustion parameters of the material were therefore adopted. According to the test results of UL 94 standard, the presented concrete belongs to HB and 5V categories.

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EVALUATION OF THE IMPACT OF CURRENT ANTHROPOGENIC GEOLOGICAL FORMATIONS ON THE ENVIRONMENT: IMPLICATIONS FOR THE IMPROVEMENT OF ECOLOGICAL CONDITIONS OF GEORGIA

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Recent worldwide scientific progress has given a powerful incentive to the advancement of technological potential followed by the development and construction of industrial, transportation, mining - processing, energy enterprises, leaving a negative technogenic trace on the Earth's surface, nature and our living environment. It has already been recognized that the generation and accumulation of a great amount of industrial and domestic vs. solid waste still remains one of the acute problems. In some areas of high industrial development this process reaches the extent that causes the creation of contemporary geological formations around us leading to obvious change of original natural landscape. As these formations are recorded in the form of unconsolidated solid waste clusters, they easily undergo modern geodynamic and hydro geological processes and their spread and impact on the environment is immense. Very often they have negative effects not only on the living environment, but also on the whole ecosystem - many harmful substances, heavy metals, cyanides, nitrates, pesticides, fuel products, DDT etc. disseminate from similar arrays in the soil of surrounding areas, causing contamination of drinking water, agricultural land and other vitally important facilities.

Georgia is not an exception in this respect. At present, similar problems also exist here and there is no management or regulation tool whatsoever for recording and research of these formations. The situation in some quite important areas calls for immediate resolution of the issue. For example, Madneuli mining and enrichment plant, its tailing storages and landfills, Chiuatura mine output piles, mines of raw materials, international energy and transport corridors etc. Systemic scientific research of the above-mentioned anthropogenic arrays has never been conducetd in our country. Except for studies carried out as a part of other certain projects covering absolutely different issues such as the open-cut mine licensing, construction of roads and other linear structures, construction site preparation, etc. The novelty envisaged by the proposed project lies in the fact that it will lay the basis for management of industrial waste on the territory of Georgia, deal with its potential generation and become a part of a comprehensive mechanism of its environmental impact assessment that contributes to the estimation of formations spreading and variation of their boundaries, as well as to fundamental research of ongoing processes. All this requires scientific study of the issues and elaboration of unified management system based on the findings in order to develop a common vision and take timely preventive measures. All of these actions will be important steps forward and serve the improvement of our living environment and the whole ecosystem.

Correction – Elene Akhmeteli