The Philosophy of Mining: Historical Aspect and Future Prospect

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The influence of the humanitarian component (sacred, religious, social factors) on the origin and initial development of mining activity, metallurgy origin, the first natural and technical knowledge accumulation and application forms are considered. The hypothesis of the metallurgy occurrence in the stable communities of primitive miners is considered. The ideology component of important technological inventions, created in an environment where both these phenomena were extremely close, is shown. The organizational forms of mining activity in which sacred factors played an extremely important role from archaic mining communities to medieval religious orders (in particular, Cistercians) were analyzed. The role of traditions, beliefs and professional knowledge in the formation of the special mining communities' nature from ancient time to the Middle Ages, their heritable resistance and isolation have been revealed. The possible ways of future mining progress are described, for which the scientists' and entrepreneurs' substandard ideas and predictions are used.

Keywords: philosophy of mining; metallurgy; coal; ore; intelligent mine

Received: October 12, 2018; accepted: November 5, 2018

Philosophy and Cosmology, Volume 22, 2019: 76-90.
https://doi.org/10.29202/phil-cosm/22/6

Introduction

The mining philosophy is one of the most important components of the philosophy of technology, which searches for ways and areas of technical progress management in the mining industry on the moral responsibility principles, humanistic values and environmental safety. It explores a number of important issues of mining interaction with the natural environment, cultural and social spheres of society's life. Among the main areas of research we can identify: the definition of mining origin and the essence of the technology itself; the influence of mining and metallurgical activity on the science formation; consequences of natural environment changes caused by large-scale mining operations (in particular, environmental factors and the problem of mineral resources exhaustion); the relation of mining activity to other cultural phenomena (including the relation with politics, financial system, social transformations, etc.); formation of myths, beliefs, traditions of miners and their influence on mining activity motivation. The mining philosophy is closely connected with the mining history and shared history of science and technology [Haiko, 2013].

The famous eval trias (stone, copper, iron), which underlies the historical epochs periodization, is based on the ancient mining products, which shows the all-encompassing influence of mining activity on the foundations of civilizational humanity progress. Mining arose in the ancient time of the primitive society life and initiated technical activities development, the primary source of which was the search, processing and use of stone. More than 99% of the passed human trajectory (more than 2.5 million years) is associated with the Stone Age. A unique phenomenon of knowledge and mastering of ores and their metallurgical processing is one of the highest and most mysterious manifestation of the collective human genius. "Why did it happen at all? Why human beings now do not live like in the era of the Mesolithic?" — a well-known primitive man explorer Robert Braidwood posed the question [Haiko, 2015]. The answer to it, which is still formed by historical, mining, and metallurgical sciences, is the cornerstone of the mankind history.

The phenomenon of metals discovery had a decisive influence on the qualitative change in the human society life, differentiating its development into prehistoric and historic period. Extraction of ores provided humanity with fundamentally new materials, which had previously unknown properties (pliability, smoothness) and important advantages (ability to change shape, high thickness, service life). This allowed not only to improve the existing tools effectively, but also to create many new types, which opened up opportunities for technological progress. The occurrence of wars, the conquest of tribes and nations, the formation of a state system were largely possible due to the benefits of copper weapons. One of the results of the mining and smelting formation was settling down (most of the oldest mines were almost continuously exploited for centuries) and the development of underground space [Lynch, 2004; Pankratova et al., 2016]. An artery system of the ancient world arose, in particular the transportation of ores, metals and products. The search and development of new deposits contributed to the migration of the population, remote lands settlement and development, the dissemination of professional knowledge. The trade development was influenced substantially with metals, since they were the first universal equivalents of trade exchange means. Civilizational changes caused by mining and metallurgical activity were global in nature and combined both technological and social components of society's development. The well-known American ethnographer Henry Morgan argued: "When the barbarian step by step discovered native metals, began to smelt them in a crucible and found them; when he smelted the native copper with stannum and created bronze and, finally, when with greater thought strain he invented the pot fire and extracted iron from ore — nine tenth

struggles for civilization were won" [Hayko, 2015]. However, the factors and motives that ensured this civilization victory in the history of mankind are still unknown, and the scientific hypotheses put forward for their explanation contain a series of contradictions and blank pages.

In the second half of the twentieth century some researchers began to analyze, along with the utilitarian motivation and rational practices of the ancient metallurgists, to analyze the significant influences of sacred ("ideological") components on their production activity processes [Forbes, 1650; Hauptmann, 2000; Mikos, 2008; Babel, 2008]. The authors of several previous research papers who investigated the primitive mining phenomenon [Dorofeev et al., 2003; Haiko & Biletskyi, 2015] attempted to explain the close connection between the formation of resident mining communities, sacred religion, and mining and metallurgical technologies origin. The hypothesis of metallurgy emerging on their basis, as well as the study of the various cultural ("ideological") factors in the miners-metallurgists communities in later ages, is offered to the attention of the reader.

Metallurgy origin

The lack of archeological artifacts and the inability to use written sources (the birth of metallurgy significantly outstripped the emergence of writing) led to hypothetical explanations of the metal discovery processes and the emergence of metallurgy, which were based exclusively on the logic of utilitarian (technical) activity of the first metals exploration. At the same time, the basic thesis was the assumption that the first people became casual witnesses of unpredictable metal melting from ore in home hearth or forest fire and, using this clue of nature, began an independent metallurgical activity. At the beginning of the 20th century, such hypotheses were already set forth in fundamental papers and textbooks of history. An example of the "thinking inertia" according to the authors, is the hypothesis of a casual metal discovery, which has existed for more than a century, claimed the questionable (as it seems to us) notion that the birth of metallurgy is due to the observation of isolated occasional melting of copper from ore chunks , which unexpectedly fell into the bonfire of the first man. The pioneer of the metal, according to this version, could be ancient hunters or herders, who unexpectedly witnessed the self-melting of copper. Most of the modern historical reconstructions still reveal the version of "how a shepherd became a miner-metallurgist".

According to the authors, this version cannot answer of main question that is why, for hundred thousand years of Homo sapiens existence, "cases" of copper self-melting were "noticed" and used by people so late, only in the Neolithic? In search of the answer to the difficult question "Why?", we tried to consider the problem from another angle and put in the middle of the study the question "Who?", in other words, who could become a pioneer in metallurgy?

The significance of this issue is substantially increasing, taking into account the limited number of possible centers of metallurgy origin. Archaeological evidence of the last decades localized the proto-metal epoch emergence (IX — VIII centuries BC) by several centers in the eastern and central parts of Asia Minor). A little later (VI — V centuries BC) a powerful center of copper development in the Balkans was formed, and a millennium later in the South Caucasus. Such "historical geography" has divided researchers into mono- and polycentrists. The former believed that the development of copper took place in a single center, where ("diffusion") mining and metallurgical knowledge spread across the Black Sea, as well as the Middle East. The second defends the hypothesis of spontaneous generation of metallurgy in three or four separate centers, with the subsequent spreading it to adjoining and remote areas.

As we see, only residents of several regions could participate in the initial development of metals, and the presence in these regions of rich copper ores deposits located near the surface was necessary but insufficient condition for their discovery.

It is worth noting that the termination of the ancient copper deposits exploitation was almost always connected not with the exhaustion of their stocks, but with the resettlement (or extermination) of the population that owned mining and metallurgical knowledge. The most typical example is the history of the development of a powerful Kargalinsky deposit in the Southern Urals. During III – II millennium BC it was one of the richest copper crop centers in Eurasia (researchers found in the territory of 50 by 10 km about 30 thousand-mine shafts, most of which belong to ancient mining). At the end of the II millennium BC for unknown reasons, tribes that have been experienced in the ore field have left these numerous mines. After them, for three thousand years, the peoples who changed each other on these lands, were no longer able to master the development of local ores, and this despite the fact that thousands of depressions of mine shafts indicated certain places of rich deposits.

The complexity of this task is evidenced with the letters of the head of the Ural mining factories G.V. Gennin to Peter I, in which he pointed out that Saxon masters could not smelt copper from the Ural ores and advised to invite masters from Hanover, Zeissleben, and Mansfield , who "riffle" copper ores melt. In spite of the participation of well-known specialists and personal control of the first personae of the state, "the copper smelting industry in Russia was started incredibly long and vigorous: the case was new and very confusing".

The example given demonstrates quite convincingly how difficult it was to master ore deposits and to get metal even for specialists of the eighteenth century and how far away from the scientific truth the illusions that consider the discovery of copper as a matter of routine, readily accessible to first people living on copper-rich terrain.

In order to identify possible discoverers of metallurgy, the probability of casual copper melting and their role in metal development should be evaluated. Unfortunately, for the supporters of simple solutions, the likelihood of metal heating even from low-melting copper ore in a conventional hearth is very low (insufficient temperature). The researchers carried out hundreds of experiments that proved the impossibility of metallurgical treatment of copper ore without the purposeful blasting of air in the hearth. In exceptional cases, when the ore would be in the furnace for burning ceramics or in a forest fire of considerable strength, the required temperature (700-800 °C) could be achieved, but this is not a sufficient condition for metal heat. An important factor is the presence of a special regenerative environment, which required all-round contact with charcoal.

Suppose that an extraordinary case would still bring together all the necessary conditions. At the same time, in the fire center there would not be visible cast slabs or pieces of metal, but only small drops of copper, integral from the ore mass, even under the layer of ash. Even discovered ones, they had little to say to an ignorant person, and an attempt to replicate the melting in a conventional hearth would surely have ended in failure. These arguments give rise to motivated doubts in the casual nature of copper crop from ore, which serves as a stable version of the first metal development. Therefore, the successful searches of ores by unskilled people would be either improbable.

It should be remembered that in addition to ores, there were also native metals that could be found by anyone in the mountains and the river valleys. Most researchers attribute the primary use of metal with native copper. However, there could not be a lot of native copper found in the form of a separate stone. The earliest wares from it are small figgeries (amulets, beads, etc.). It is highly likely that the first person who accidentally found on the earth's

surface a copper nugget would never meet it again. Having such a limited amount of metal, they would hardly have thought about new production opportunities (if such considerations were generally inherent to psychotype "inhabitants" of those ages).

As we see, the role of "layman" in the process metals development could not be decisive. Moreover, the above arguments lead to the idea of a long-term purposeful activity of metallurgical processes development. And as Louis Pasteur pointed out, chance favors only the prepared mind.

In our opinion, there are many reasons to argue that metals discovery is connected with centuries-long experience of previous mining activity of mankind, with the distinction in the Neolithic (and possibly even earlier) of special communities of archaic miners ("stone hunters"), accumulation and development of the first knowledge of metals in these professional communities. Years of communities' experience that produced and processed flint, obsidian, pyrite, raw materials for mineral paints, etc., formed a special search outlook of archaic miners, who saw in the stone the presence of sacred, human-enclosed possibilities. At the certain stage of mining experience development (collecting samples of native metals and ores, identifying their features, knowledge of properties, the formation of appropriate sacred traditions), the creative idea of a new material "malleable", and later "fluid stone" (metal) appeared. It was comprehended and realized by mining groups, which passed the achievement of mining art from generation to generation in the system of special sacred cults.

The most ancient excavations of raw materials for the manufacture of mineral paints (hematite), cress (pyrite), etc. date from the period 35-40 millennia ago. The underground development of the flint was started much later (it was enough on the surface), but from the IX–VIII the oldest silos were mined, which already at the time of the Neolithic settled complex technical problems. Particular emphasis should be put on the magnitude and concentration of mining operations in the Neolithic era: almost every large deposit was discovered by several thousands of mine shafts (up to 20 m deep) with a ramified system of horizontal workings (usually in a flap scheme). The time for the continuous development of such deposits dates back several centuries (sometimes millennia), the number of discovered ancient mining centers is calculated by dozens (we can assume that only a small part of them is found by archaeologists), which gives grounds to assert the existence of a special stable community of miners who lived a sedentary way of life, were separated from other tribes by the specifics of their activities and their original sacred culture.

Indirect proofs of connection miners with predecessors who developed rock materials are observed in similar technologies of the Neolithic mines construction (for example, the use of a "fire method" for rocks destruction), the use of almost identical mining tools, even in the essential filling of mined-out space with a mining waste. The latter factor, which is typical for both flint and copper mines in the vast expanses of Eurasia, is particularly indicative, since the indicated labor-intensive technology is not a production necessity (especially in the case of filling shafts), but is rather a reflection of a certain cultural tradition. Presumably, there was a taboo on causing damage to the earth's surface, which required their "treatment" by returning to the original state (filling the cavities with the mining wastes). If extraction of ores was carried out by people who had nothing to do with existing flint development (for example, groups of casual hunters or breeders), this tradition would have been definitely interrupted.

In favor of the concept of developing copper as a single mining and metallurgical complex, numerous archeological excavations of ancient mines, which link the ores enrichment, metal melting, even the manufacture of metal tools with mining activities, show. Placement of the

oldest metallurgical structures near mining works, the nature of the common settlements of miners and metallurgists, the co-location of mining and metallurgical tools, enrichment and smelting sites give grounds to assert that miners and metallurgists have been the only community for a long time that originates in the activities of Neolithic miners [Mellaart & Catal, 1967].

An eloquent example of mining experience continuity can be one of the most ancient human settlements, Chatal-Khyuk (8th century BC, Southern Turkey). Located near two extinct volcanoes, it was the focus of obsidian development (volcanic glass) which was the best gunsmith material of its time. Archaeological excavations revealed obsidian deposits in many buildings of the city, as well as numerous workshops from it. It was in this settlement that small copper wares, copper slags, blisters were found, which confirms the possibility of conducting the first copper filings by miners, who developed rock material here from ancient times [Gayko et al., 2018].

Describing the first organizational and ideological factors in copper development, it should be noted that the metallurgical interference in the nature of materials was perceived by the first man as a mystical, wonderful phenomenon. It was filled with the symbolism of sacred forces. Archaic miners felt themselves in constant and direct contact with the invisible world that was no less evident to them than the real world. There are numerous indications of the extremely high role of the sacred-magical nature in ancient miners' activities, which indicate a significant influence of the servitors of ancient magical cults.

The objective basis for the emergence and spread of these cults was considerably greater (as compared to other production activities) factor of uncertainty in the results of miners-metallurgists work. It has never been known whether mining (the result of heavy, prolonged and dangerous work) come upon ore deposit; whether ore be of high quality; wheather miners face with break down the roof, flood or gas; wheather metal heat conditions provide its effective yield; wheather quantity and quality of metal prove to be desired. Stochastic nature of the phenomena faced by miners in their production activities, contributed to the use of supernatural forces, the affirmation of mystical concepts.

Among the characteristic examples of the sacred cults of the miners, we can mention the irrational tradition of essential filling of the mined-out space with mining wastes (as has already been mentioned); Solar symbols left in the Neolithic workings as an appeal to mystical patrons; a cult of mining tools that "helped" the successful underground mining, and so on. Indicative factors are numerous cult burial of small hoofed animals in mining excavations and sites (probably as a thank-you to other forces for the wealth of mineral resources). The tradition of ancient metallurgists burying with tools and rich copper ore is known, to have been a sort of "calling card" of the deceased when he moved to another world [Dorofeev et al., 2003]. Archaeologists have reconstructed some magical actions (for example, the construction of a sacred goffman labyrinth, the use of hostile bones, etc.), which archaic miners carried out in order to identify sites for the insertion of shafts.

The ethno-archaeologists who studied the lifestyle of modern human societies in conditions close to the original state (the tribes of Africa and Polynesia), indicate that many magic rituals are devoted to the metal heating: the choice of the smelting time "sanctioned by spirits"; blessing of the pot fire; adoration of the stithy; numerous taboos, which are constantly adhered to the metallurgist and blacksmith. Only a few men from the tribe possessed the secrets of metallurgical art (given them by spirits of fire force to convert stones to metal).

We suppose that there was a high degree of interaction between archaic miners and servitors of ancient magical cults. Probably this connection was more powerful among miners

than in other spheres of activity, which led to a more rapid formation of the ruling elite of the tribe (conditionally — caste of priests), since the presence of mineral raw materials largely determined the wealth and power of the tribe.

It is logical to assume that the first mining-metallurgical knowledge, which was perceived as magic, could be preserved and developed by the oldest castes of priests connected with mining communities, and passed from generation to generation. Their authority and ceremonial activity created effective incentives for the consolidation of the mining community to carry out particularly laborious and dangerous underground work, for numerous repetitions of difficult attempts to heat the metal (much of which did not produce the desired result). It is possible that the invention of air blast in the center of the hearth with the ore, which opened the possibility of metallurgical melting, was associated with the magical rituals of giving ore to fire of extreme force, that is, the high-temperature regime could initially be formed "ideologically" rather than "technologically" but in an environment where both groups of these factors were very close.

The factor of sacred cults and the activity of their servitors in mining communities should be considered as one of the necessary conditions for the birth of metallurgy. If we perceive as an obvious fact that the sacred practices of medieval alchemists have helped to reveal the properties of many ores, metals and their alloys, as well as obtain new metallurgical technologies [Haiko & Biletskyi, 2015], then why do not we expect primitive communities to be sacred ("ideological"), but purely rational ("technical") way of discovering metal riddles? Perhaps it was this methodological mistake for a long time that prevented the reliable historical reconstruction of the metallurgy beginnings?

From the written sources 3 millennium BC it is known that the metallurgists of Sumer belonged to the temple and were directly controlled by the priests. This practice took place in ancient Egypt, where there was a cult of the miners patroness — goddess Hathor. Probably the projection of such a relationship can be reasonably widespread in the earlier period of social development. The factors of the sacred outlook of the first man and the consolidating role of the ancient worship servitors should be considered as part of the necessary conditions for the start of metallurgical activity.

Traditions and beliefs of miners of the Middle Ages

The change in the slaveholding socio-economic foundations of the ancient world with the principles of Christian medieval society has fully influenced the state and organizational forms of production, which has a particular effect on mining and metallurgy. First, the era of global restructuring of the Western world caused a prolonged economic downturn. The volumes of ore mining and smelting during the "great relocation of people" declined sharply, many centers of ores development were abandoned and forgotten. For some time, the initiative of world trade development and the provision of currency metals (primarily silver) went to the countries of the East, in particular to the vast territories of the Arabian Caliphate (Arabic coins in the 7^{th} — 10^{th} centuries were distributed in most European countries). However, the confrontation between the West and the East, the level of trade and crafts development, the growth of cities demanded from Europe the revival of once powerful mining industries. One of the important impetus for the development of polymetallic deposits was the search for financial resources for the Crusades and the protection of the Holy Land, as well as the widespread use of silver for the manufacture of church utensils.

Unlike the mining of antiquity and the medieval East, where the work of slaves was widely used, in Christian Europe, the beginning of large-scale mining operations was associated with

special organizational forms similar to the ancient temple miners-metallurgists' ministering. A preferential phenomenon in the culture and technology history remains the special role of "white monks" (the Ordo Reformatorum Cisterciensium), which in the 12th — 13th centuries laid the foundations for industrial development of the main ore deposits in Central Europe, created a base of mining and metallurgical knowledge and cultural traditions of miners. The Cistercians created a fundamentally new type of Christian monks' organization — the Order (1118), which purpose was the internal economic colonization of Central and Eastern Europe. The mining activity substations were the administrative centers of hundreds of new monasteries, which moved further east — to Saxony, Bohemia, Moravia, Silesia, Hungary. The secular feudal government, threatened by the Cistercians Order, began to fully support the numerous mining artels who were first guarded by the Order, but eventually became a free workshop. In 1300 in the Czech Republic, the Royal Mining Code (Ius regale montanorum) was developed and approved, which secured a special status for miners and numerous privileges that quickly spread to other European countries. Proceeding from the fact that it was impossible to master mining art in the short term, and the replacement of miners by peasants serf always led to the decline of mining; the high and mighties were obliged to give miners special privileges, which freed them from many feudal duties, materially exaggerated among other people, formed a special caste spirit. Getting to professional mining associations was a complex task that required prior apprenticeship, numerous tests and formal initiation.

The development of European mining inside the religious orders, carried over the Order solemn initiation to mining shop one, which, by many signs, resembled its religious predecessor.

Simultaneously with special Christian rites, mining initiation included, among other things, the ancient ritual of "jumping through a leather apron" (an element of the working clothes of a medieval miner, which protected the body from scratches and moisture behind). This element of mining initiation has been preserved for many centuries and in a stylized form has been revived in the modern professional initiation of student-miners in the university. In general, miners' clothes, which at first was a white cassock of the Cistercian monarchy, became a sign of belonging to the privileged community of miners and could tell much about its owner (in particular, the hierarchy in the mining society). Special clothes was obligatory for mining celebrations and ceremonial events, and the strict tradition of its use was not interrupted until almost the twentieth century and recovered today in many mining regions, as a tribute to tradition.

The earliest sacred mining symbol was the horn. First, it was used as a signal instrument (beginning and end of work, danger, etc.), and later it was used as a reservoir for oil lamps. The most famous mining symbol is the miner lamps, and crossed mining hammers got the greatest recognition (hammer and chisel on the shaft) were the main tools for rocks destruction for many centuries. The oldest symbolic image of crossed hammers is known since 1111 (the monastery of Bergstegen, Germany), but today it is the most widespread symbol of mining.

As a rule, ancient mining was hereditary from father to son, and it was a matter of life of whole generations. From childhood, the respect for mining work and a respectful attitude to the wealth of the earth's interior were formed in the future miner, and the mining experience and professional knowledge were run in the family. Since the well-being of the mining artels completely depended on their mines, and the exhaustion of reserves on any site was a matter of time, miners constantly had to move further (in space) and deeper (in the depths of the earth), mastering all the more complex mining-geological conditions. This gave rise to the pioneering, exploratory nature of the mining activity, which in the conditions of increased

motivation of miner's labor (the freedoms granted by the Mining Code, high material success) enabled the emergence and introduction of new technical ideas.

Mining features were formed in exceptional conditions of underground labor, which distinguished miners from representatives of all other professions. Since the miner was underground from morning to evening, even the sun managed to see only a few hours in summer days, the rest of life (except for Sunday holidays) was held in the dim light of mine lamps. The work of the miners, filled with danger and extreme physical stress, required fellowship, mutual help, and togetherness. The courage needed to work underground was combined with the readiness to protect the treasures that were extracted, since small mining artels usually worked in a remote place and at times incurred robberies (it was no wonder that the main miners' attribute was the battle-axe and the sword, reliable instruments in confronting the thieves). This additionally stimulated miners to co-operate in the communities, contributed to the manifestations of solidarity between them.

The miner, even the most experienced and diligent, constantly depended on many occasions: he was on the watch for rocks fall, breakthroughs of underground water, the allocation of lethal gases, changes in the rock mass properties and the quality of ores. Understanding the limited possibilities of a person forced the miner to ask for protection and help in the higher forces of the universe, and the big risks and dangers formed a cheerful character. The rude "outer shell" of the miner, the revealing features of the vagrant and desperate man coexisted with deep religiousness, hope for God's mercy and intercession, and the development of personal spiritual rank. Typically, a medieval mine was consecrated by a Christian priest, before descending into the mine miners sang psalms and prayed in an underground chapel. The Christian foundations laid by the "white monks" in the times of the medieval European mining were further developed in independent artels and kept in different forms until the time of the industrial era (partly existing today).

It is hard to find any other craft where, in a professional environment, such a great number of Christian saints would be especially honored, among which St. Barbara, St. Anne, St. Anthony, St. Daniel and others received the greatest respect. Many underground churches and chapels devoted to the righteous, built by miners for many centuries, are astonished by their majestic beauty. Even more important were the churches in the miners' cities. The masterpieces of architecture and interior decoration were the mining cathedrals in Kutnya Gori, Freiberge, Annaberg, Schwaz, Claustal, and others. Special role was played by icons of miner's churches, which became relics for large mining regions. Examples can be the image of St. Anne Metercius, which for centuries was honored in the mines of Slovakia, Hungary and Romania, as well as the Mining Altar in Annaberg, widely known in German lands.

The true phenomenon of miner's attachment is connected with the cult of St. Barbara, patron saint of miners. A special attitude towards this saint has already spread among the miners of Europe in the 13th — 10th centuries, as evidenced by the construction of the miner's church of St. Barbarians in Kutna Gora (1388). The construction of the handsome cathedral was carried out on the contributions of Kutnerskie mines and the donation of numerous miners. An important factor in choosing the Most Holy Mother of God was the mission of St. Barbara as an intercessor of sudden death, which was especially important in the dangerous conditions of miners' labor. It is known that the remains of St. Barbara were transposed into Constantinople during the reign of Justinian the Great (VI cent.), and the first temple of her name was erected for the emperor Leo the Wise (at the beginning of the tenth century). Princess Barbara, daughter of the Byzantine emperor Alexei Komnina, who

married the prince of Kiev Svyatopolk (in Holy Baptism Michael), transported the remains of St. Barbara to Kyiv as "spiritual dying".

It had to strengthen Christianity in Rus'. For almost eight centuries, the relic was kept in the Michael's Golden-Domed Monastery. After the criminal destruction of the temple by the Bolshevik invaders (1936), the remains of St. Barbara were transferred to the Vladimir Cathedral in Kiev, where it is buried today. Miners from many countries of the world are trying at least once in their lives to visit this temple and honor their Most Holy Mother of God. Within the walls of modern universities where mining is being studied, there are usually picturesque and sculptural images of St. Barbara, which pass down the spiritual liaison among generations of miners. According to the ancient tradition, the memory of St. Barbara, which falls on December 4, is widely celebrated as the main miner's holiday ("Barburka"). In general, the old miners are perceived as an "idealistic guards", people of tradition, deep religious feelings and Christian outlook. It is not by coincidence that the founder of mining science Georgy Agricola, giving instructions to the miners, first of all sincerely said: "First of all, they have to hold sacred God" ("De Re Metallica", the Second Book, [Agricola, 2014]).

Along with the Christian traditions, some pagan superstitions persisted among the miners, in particular faith in the earth and mountain spirits, reflected in folk, fairy tales, and literary works. The tradition of identifying the spirits of the dungeon with the evil and destructive force that was still traced in ancient mythology, was inherent in the general population. The underground kingdom of Pluto for their imagination was filled with the dead souls. It is not by coincidence that among the mythical characters of Lesia Ukrainka's fairy-drama "Forest Song" the spirit of evil embodies the "one that sits in the rock". The landowner of a copper hill in P. Bazhov's Ural tales could be transformed into a lizard and indicate rich ore deposits, and sometimes she could settle some voracious underground treasures hunter's hash. It is interesting that the salamanders (lizards) image in the beliefs of the miners of Central Europe had the same characteristics as in the Urals. It is believed that the salamanders repeatedly pointed out to the miners the place where the mine should be laid (these mines allegedly turned out to be surprisingly rich). In some countries (in particular, in Slovakia, Hungary) medieval miners had even a holiday in honor of Salamandra — miners Helpers. In theatrical form, it is celebrated in some mining regions and now.

Among the mining community myths about underground dwarfs — gnomes are widely known. It was believed that in the bowels of the earth gnomes retain hidden treasures, such as metals and gems. They were recognized as skillful miners, metallurgists and blacksmiths, who, in their underground domains, forged miraculous rings, weapons and other magical items. Dwarfs hid deep underground, where they built cities and palaces. They did not love people for their lust for underground riches and sometimes scared them in underground workings. Among the names of the gnomes, the German miners singled out Nickel and Cobalt, from which the names of the later discovered metals were called. A systemic description of mystical inhabitants of mines gave Georgius Agricola in the book "On Underground Beings" (1548).

In the ancient heroic epic "Song of the Nibelunges" (for the first time recorded about 1200) underground guardians of the treasures were called "Nibelunges". Legendary knight Siegfried seized this treasure, and the dwarfs began to serve him. Subsequently, the epic carries the name "nibelunges" to all treasureowners, to various Germanic tribes, linking them with hill-man dwarfs. Gnomes appear in folk tales of most European countries, which stories often overlap with mining or blacksmithing activities. It is possible that the roots of these tales and myths are connected with the appearance of numerous miners from the South Caucasus

and the Middle East in Central Europe during the bronze age, who were significantly lower in height than locals, and had the magic art of converting ore into metal.

It is noteworthy that these beliefs have come to the new times and have not passed the miners of the Donetsk basin. The mountain spirit got here the name of Shubin and appeared as the gray old dwarf in the miners' minds. According to the inscription written by the writer Boris Gorbatov, Shubin wanders in mining scaring the miners: "Who will meet — that's why, soon Amba: Fill". There is also a more optimistic version of the story, according to which Shubin can be good, helping miners and protecting them from danger.

The underground world of mining excavations and fossils development were perceived mysteriously by uneducated people, and they were often biased in thinking of them as collisions with otherworldly forces of evil. D. Merezhkovsky, a writer, summarized these observations briefly: "All miners are the most obedient people, because the devil owns treasures of the underground, including ore". Such superstition of the common people existed throughout the Middle Ages and spread not only to the miners, but also to the metallurgists and smiths, and its echo has come to our times in folklore and the beliefs of many nations. These views were facilitated by the isolation of mining communities, the concealment of professional secrets by miners and metallurgists, beliefs and sacred representations of miners themselves. Georgius Agricola, responding to the witty critics of mining beliefs, said: "Laugh as much as you like, your prudent arguments will not destroy our mountain spirits, which we know from experience".

Only the industrial revolution and the powerful coal industry emergence, provided by the mass recruitment of seasonal peasants (people in the mining of casual, devoided of mining traditions, for whom underground work is a hated forced labor) could substantially change the rich cultural phenomenon that was created by "old mining". Today, the formation of a public consciousness in the spirit of preservation and creative use of the miners' cultural heritage of the past, whose work had an unusually rich history and significantly influenced the civilization of humanity.

Future Prospect

A rewind in the distant past has shown the influence of mining on the historical process, the role of "technological" and "ideological" components combination in mining activities and in the history of technology in general. This generates a logical question of the future role of mining and "subterranean conquerors" in the medium and long term [Haiko, 2005]. In this paper, we will not consider the directions of technological prediction related to the system analysis methods (such work for the extractive industries is still ahead). However, we take advantage of the system engineers' important findings — a variant of predicting the future based on what happened in the recent past and what we are facing today is almost always erroneous. Practice shows that breakthroughs in the technological development of the world are carried out, as a rule, without any connection with the people's standard beliefs about the future. Therefore, let us enumerate a few "non-standard" scientific approaches to mining technologies [Bondarenko et al., 2017; Falshtynskyi et al., 2018].

The scientific doctrine "The Mine of the 21st Century" [Haiko, 2005] breaks the "inertia vector" of the phase-by-stage improvement of traditional technical solutions and offers the concept of the current tunneling-extracting technology for the development of thin gas-bearing seams at large depths in an inert gas environment. It is based on a new Mining Intelligence Roadheader and aggregates of front roadway formations in rocks. Ventilation in mine is not expected, its workings are filled with methane (very limited in number personnel uses

individual means of supplying oxygen or seats in airproof cab of motortrucks, equipped with a life support system). Rope lifting of coal is replaced with hydro load lifting in boxes, as well as water interception. Schemes of a flat and a shaft surface are radically simplified. The predicted efficiency of thin coal seams development will increase by 5-7 times in comparison with traditional technologies [Astafiev et al., 2016; Snihur et al., 2016; Petlovanyi et al., 2018].

The concept of "intelligent mine", artificial intelligence in mining enterprises [Ge & Zhang, 2011; Tabachenko et al., 2016] become factors of the rapid change not only of the design and management system, but also of technology directly, becoming an integral part (in essence, the main technology). New properties of machines and computer systems to perform intellectual and even creative functions of a person, to find ways to solve problems independently, to be able to make complex decisions open fundamentally new opportunities for the minerals and underground space development.

In the near future, a sharp increase in the use of well geotechnologies is expected, which results in pumpable state of minerals in the place of occurrence and transporting them along wells to the earth's surface [Falshtynskyi et al., 2012; Lozynskyi et al., 2018]. Significant achievements of recent years in the underground coal gasification technology and underground gasifier thermal energy recycling open up new prospects for this coal geotechnology [Gayko & Kasyanov, 2007; Falshtynskyi et al., 2016]. This technology can be part of a single complex of coal methane mining, traditional and geotechnological development of coal seams.

The "shale revolution" in the United States opens the era of competitive methane and oil shale layers, and, having open, powerful deposits, becomes a leading geotechnology of the present and near future [Boersma et al., 2012; Hanushevych & Srivastava, 2017]. The start of large-scale development was launched in 2002 at the Barnett Field in Texas by Mitchell Energy & Development and its legal successer, Devon Energy. The pioneer of shale gas, George Mitchell, destroyed firstly a "hydraulic fracturing" of inertial thinking pattern, giving the world a fundamentally new operating technology. Directional drilling with extended heel and hydraulic fracturing of layers may become, in the short run, the basis of mining technologies for many minerals extraction, requiring special attention to the ecological aspects of productive deposits well-drilling.

Since the largest methane, reserves on the planet are concentrated in the gas-hydrate deposits of the ocean floor, and the reserves of the explored conventional deposits will be enough for about half a century, the development of gas-hydrates may in the near future be a salvage alternative to traditional gas supply. One of the most interesting approaches to solving the problem of gas-hydrates is the direction of shielded development, which involves the placement of loose gas-collecting screens over large areas of the seabed, the dissociation of methane and the allotment of its bottom gas pipelines [Haiko et al., 2018]. Physical methods of dissociation become here the basis of development technology.

"We are living in a wonderful time — in an era when radical technological changes are taking place in our eyes and what even yesterday seemed to be fantastic, today is a real project over which innovative companies work, and tomorrow it becomes a common event, without which we do not imagine our lives, — said Klaus Schwab (founder and president of the World Economic Forum in Davos) [Schwab, 2017].

Most of the aforementioned technologies have recently seemed fantastic. Moreover, these and similar ideas were widely used by science fiction writers in their writings, but they went further, posing new challenges in the development of the earth's interior. The scientific analysis of the fantastic hypotheses, developed in particular by Genrikh Altshuler

and Paul Amnuel (creating a register and a scale for estimating fantastic ideas), serves as one of the effective ways of predicting the future. The minerals development of the seafloor, rare space metals extraction and transportation, underground cities and intercontinental tunnels on the principle of Hyperloop, terroformation and "restructuring" of individual geological landscapes, "underground boats" and "thermal (energy) shafts" for rocks destruction and penetration through the earth's crust boundaries, the development of other planets interior and cosmic bodies, robots (artificial intelligence) instead of people and traditional mechanisms — that's a small section of fantastic ideas that gradually become a reality. The heroine of the novel Aleksey Tolstoy "The Hyperboloid of Engineer Garin" Madame Lamol calls over a deep mine, which reached the "olivinic layer" and gave great gold, on the Golden Island the eighth miracle of the world. Taking into account the ever-increasing depth developments and increasingly difficult conditions for conducting underground work, mining enterprises of the future will be real wonders of human and artificial intelligence. Moreover, as in ancient times, the very "ideological" (philosophical) component will give preference to a person over a competitor with artificial thinking and will provide new technological breakthroughs for the mankind benefit.

Conclusions

The preconditions of the metallurgy origin (according to the author's version) lay in the consistent development of mining technologies of the Stone Age and were connected with formation of the stable cultural "miners" communities in the Neolithic, which centuries devoted to the development of non-metallic raw materials and accumulated mining experience. In the depths of this community, a purposeful, long-lasting activity related to the development of metals was associated with the sacred cults of the miners.

Achievements of archaeometallurgy of the last decades add qualitatively new evidences in contemporary ideas about the development of the Neolithic revolution, make it possible to isolate a separate established community of miners-metallurgists and put it alongside farmers and pastoralists communities as an important component of the Neolithic revolution progress.

The factors of the sacred-magic character and the activity of the magic cults ministers in the archaic miners' environment should be considered as a necessary condition for the metallurgy origin, allowing not only rational but also sacred practices aimed at discovering the mysteries of metals (analogous to the mystical practices of alchemists of historical times). It is possible that the invention of the air blast, which provided the possibility of metal heating process, was associated with the magic rituals of ore testing with the fire of extreme force, that is, the high-temperature regime could initially be created by "ideological" rather than "technological" motivation.

In the medieval Christian Europe, the beginning of large-scale mining was associated with the special organizational forms of monastic orders similar to the temple ministry of miners-metallurgists of ancient civilizations. An exceptional phenomenon in the history of culture and technology remains a Cistercians Order ("white monks"), which in the $12^{th} – 13^{th}$ centuries laid the foundations for industrial development of the main ore deposits of Central Europe, created a base of miners' mining and metallurgical knowledge and cultural traditions.

The cultural phenomenon and historical heritage of ancient miners require scientific study and creative use for an objective understanding of the technology history, which should be considered as an organic combination of technological and humanitarian components.

Future prospects for the interior development are related to the introduction of artificial intelligence, the use of well geotechnologies, development of seabed deposits, and large-

scale construction development of underground space. Moreover, as in ancient times, it is the "ideological" (philosophical) component that will give preference to man over artificial intelligence and provide new technological breakthroughs for the mankind benefit.

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