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ACADEMICIAN KANYSH SATPAEV AND THE MINERAL RESOURCE BASE OF KAZAKHSTAN

Abstract. The current state of the mineral resource base of Kazakhstan, which has strategic importance for the country's economy, is at the high level. It is largely thanks to the inherited powerful mineral resource base, created by efforts of many generations of Kazakhstan's geologists under the leadership of Kanysh Imantayevich Satpaev. However, since the end of XX century, rapidly developing technologies in the mining industry have drastically reduced the time of mining and increased its scale, thus determining the lag behind resource replenishment in many types of minerals. In this connection, accelerated expansion of prospecting and exploration work (P&E) is required, which should follow scientifically substantiated recommendations, with continuous scientific support.

Incomparable volumes of mining works over exploration surveys in favour of mining field development have led to sharp excess of production over replenishment, which in the coming decades may result in a deficit of a number of minerals, traditional and strategically important for the country: Cu, Pb, Zn, Au, W and other, due to lack of an acquisition target fund to sustain the targets under exploitation. The authors see the solution in accelerated revival and reversal of exploration works. In fact, geology has entered the era of searching for hidden deposits, because easily discovered targets are almost completely exhausted in Kazakhstan and throughout the world. Exploration work should be carried out using scientifically sound recommendations developed on the basis of new theoretical concepts, new computer technologies and analytical research.

Key words: mineral resource base, minerals, mining, replenishment, prospecting and exploration (P&E), new scientific research directions.

In the "golden period" of Kazakhstan's geology, which started with Kanysh Satpaev, efforts of several generations of geologists created a powerful mineral resource base, providing a high impulse to the country's economy. The mineral resource complex is of strategic importance to Kazakhstan, accounting for up to 70% of GDP and most of foreign exchange earnings. Therefore, the main source of economic growth of Kazakhstan, rich in various mineral deposits, is a powerful mineral resource base (MRB) providing the economy at present and in the near and far future. Pioneering Satpaev and his associate geologists meant under this term, apart from already discovered commercial deposits with calculated balance and off-balance reserves, also a fund of promising areas and ore occurrences, which being studied further could lead to new discoveries and replenish the existing, ready for development, commercial reserves (figure 1).

The current state of the republic's mineral resource base should be assessed as quite good one [1]. Kazakhstan is among the top ten leading countries in the world on main types of available minerals. Its mineral resource base consists of fuel and energy complex fields (hydrocarbons, coal, and uranium), ferrous, non-ferrous, noble and rare metals. Kazakhstan's share in the world reserves includes 18% of uranium, 10% of chromium, 9% of lead, 8% of zinc, 4% of gold, 5% of silver, 5% of copper, 5% of manganese, 9% of rare and rare earth elements, and 2% of petroleum (figure 2). Kazakhstan is a large exporter of energy raw materials, ferrous and non-ferrous metals. In particular, Kazakhstan accounts for 41% of total uranium and 16% of all chromium mined in the world.

Thus, the most significant reserves of hydrocarbons, uranium, coal, ferrous metals, which, if used rationally, can be the base of the country's economic and industrial development for a long period of time: from 50-80 in case of chromium and iron, and to 100 and more years in case of uranium, coal and manganese.

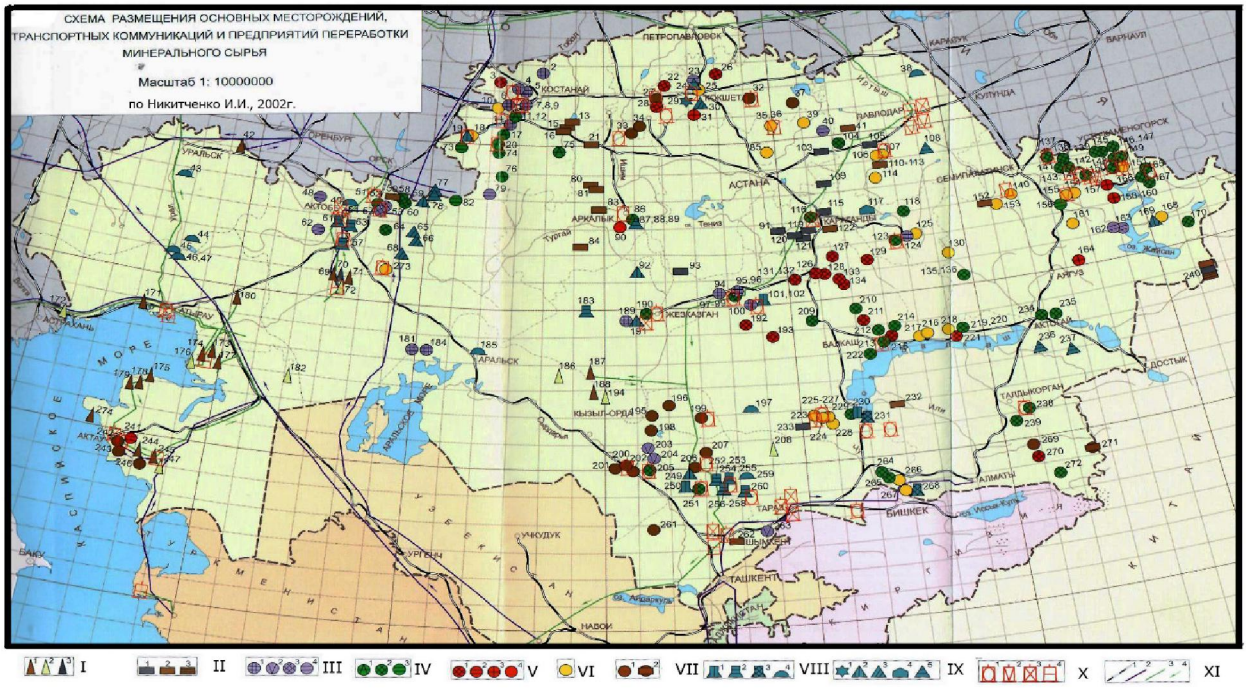

Figure 1 – Layout of main deposit fields, transport communications and processing facilities

Deposit fields: I: 1 - oil, oil-and-gas, 2 - gas, gas condensate, 3 - bitumen;
II: 1 - carbonic, 2 - lignite, 3 – oil shale;
III: 1 - iron ore, manganese iron-ore, ferromanganese, 2 - vanadium, 3 - chromite, 4 – titanium-bearing placers;
IV: 1 - bauxite, 2 - copper, lead, zinc, 3 – nickel-bearing weathering crust;
V: 1 - tin, tungsten, molybdenum, bismuth and beryllium, 2 - strontium, 3 – tantalum and niobium, 4 – rare earth;
VI: gold ore;
VII: 1 - uranium, 2 – lignite and uranium;
VIII: 1 – barite, 2 - phosphorite, 3 - feldspar, 4 – mineral salts;
IX: 1 – technical diamonds, 2 - asbestos, talc stone, 3 - muscovite, vermiculite, 4 - corundum, 5 - kaolin, refractory clay

Processing facilities: X: 1 – concentrators in various industry sectors, 2 - metallurgical, 3 - chemical, 4 – petrochemical

Transport communications: XI: 1 - railroads, 2 – gas pipelines, 3 – oil pipelines, 4 – transportation directions.

These data are based on the deposit field fund, which was established in the Soviet period. Part of these fields is already in use at an earlier or later stage of development. Given the advance nature of mining technologies and huge capacity equipment, most of solid fossil minerals will be exhausted in the next 10-20 years. In this regards, prospects of the country's mineral resource base for solid minerals, except for the above mentioned ferrous metals, uranium and hydrocarbons, are very uncertain: since the end of XX centuries, the high-tech mining industry sharply increased the production scale, causing unacceptable lagging of **mineral resource replenishment behind their extraction** for many types of minerals.

Given the general picture of distortions in subsoil use in Kazakhstan, the need in accelerated actions to cover the gap between mining and their replenishment became a clear-cut problem. This can be achieved only by a sharp increase in prospecting and exploration activities (P&E), which, due to focus on investors, fell to zero.

Thus, the data [1] show extremely uneven distribution of means for mining works and exploration surveys by investors. Following are sums taken from the total amount assigned to P&E but invested on mining of: gold (6.8%), copper (1.99%), lead and zinc (1.53%), iron and manganese (0.9%), chromium (0.74%) (figure 3).

These figures are alarming: such a sharp mismatch between the financing of mining, on one side, and prospecting and exploration activities, on the other, **can only grow the gap between them**. Such tendency in modern subsoil use is dangerous since it causes total depletion of the deposit fund prepared for development of fields.

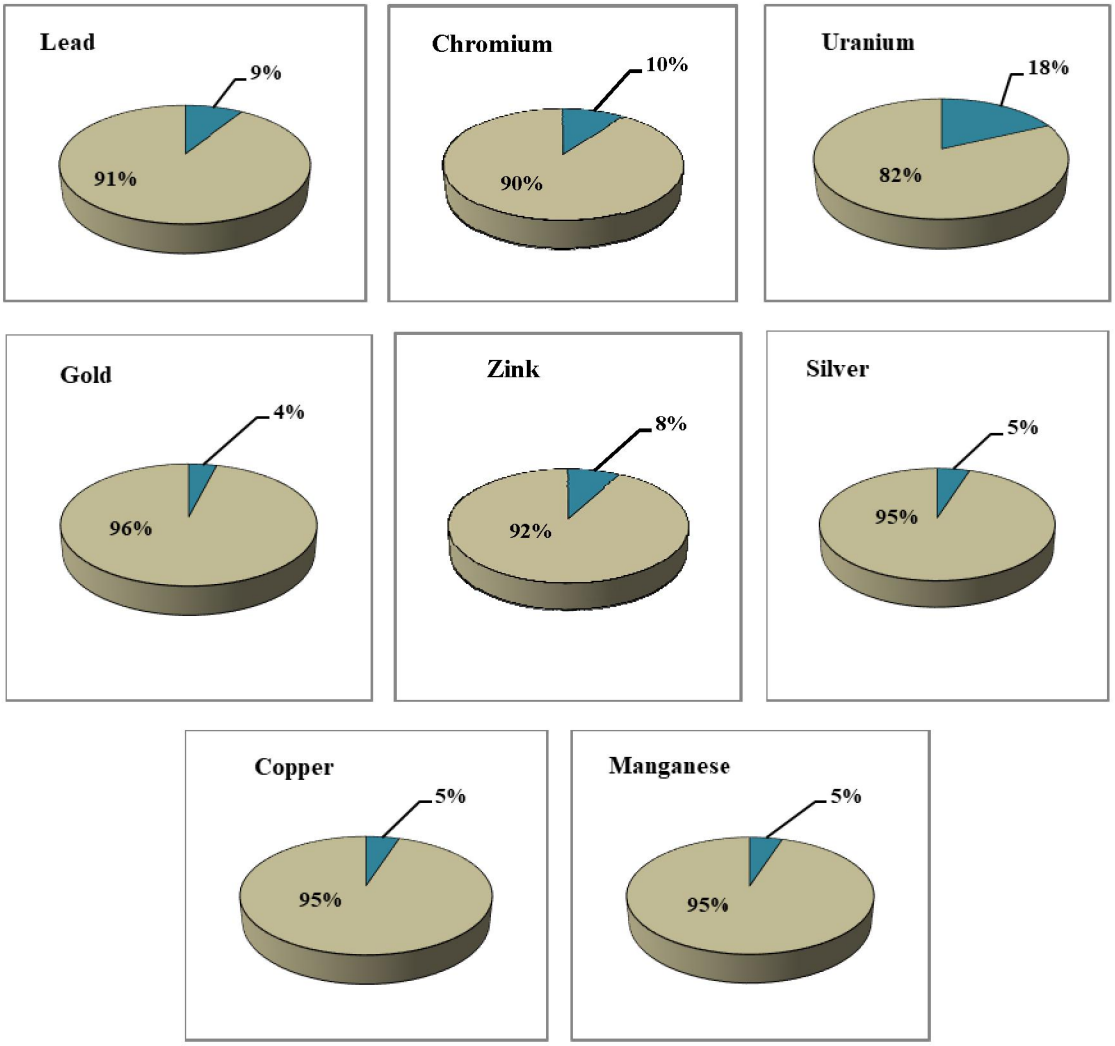

Figure 2 – The Kazakhstan's share (turquois colour) in the world's main mineral reserves (olive colour)

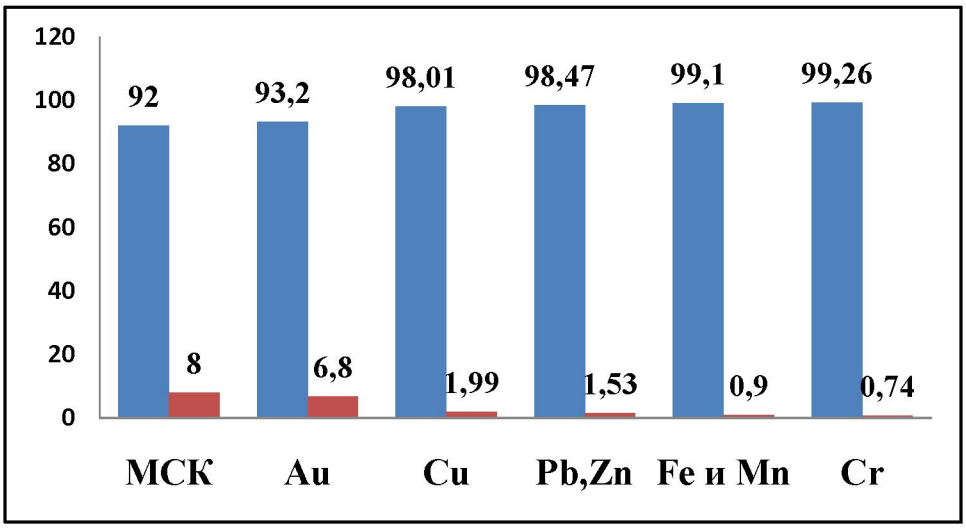

Figure 3 – Investments in mining (blue) vs. P&E (red)

Besides, the mineral reserve base of Kazakhstan in recent decades experiences additional impacts, caused by fall of competitive capacity in a large group of fields of minerals, important and traditional to our country: **copper, molybdenum, zinc, gold** and other, and we face revaluation of the reserves. The balance sheet should be thoroughly revised to see clearly the true "face" of the present-day raw mineral complex. It is quite obvious what should be done: expansion of the country's prospecting, evaluation and exploration activities on the base of analysis of numerous ore occurrences and promising areas, enlisted in various catalogues, compiled upon earlier conducted geological prospecting, surveying and thematic works. Taking into account the risks and financially intensive costs, it is useless to expect that investors will carry out the P&E works themselves. It was demonstrated over a quarter of a century of our Independence: investors have not done any discoveries both within and outside the limits of their licensed areas.

In most cases, investors finance only P&E works with purpose of specifying the reserves of a licensed object in question and its outlines.

The conclusion to draw from the above is, with support of the state, to accelerate the expansion of prospecting and exploration activities with subsequent extraction. The fund of easily retrieved deposits is nearly exhausted both in Kazakhstan and in the whole world, the search for hidden and deep deposits should be carried out, applying scientific recommendations, in close contact with science. This principle was earlier in practice in the Kazakhstan's geology. The idea has been put forward by Kanysh Imantayevich Satpaev for years ahead as "Geology and metallogeny of the most important ore mining districts of Kazakhstan". In 1960s-1990s, it allowed employees of the Institute of Geological Sciences - the main brainchild of Kanysh Satpaev - jointly with miners of all geological departments (West Kazakhstan, North Kazakhstan, Central Kazakhstan, South Kazakhstan, and East Kazakhstan) to implement a series of scientific-production works on the following subjects: Geology and Metallogeny of the Uspensky zone, North Kazakhstan, North-West Balkhash, Mugodzhars, the Ulytau-Dzhezkazgan region, North Balkhash, Karatau, the Big Altai, the Chingiz-Tarbagatai mega-anticlinorium, the Chu-Ili belt, the Balkhash segment of the Earth crust and many other thematic studies [2]. It is noteworthy that the works above were not limited by reporting, but followed by publication of numerous monographs, which can be regarded truly as **"the Golden Fund"** of information about the geological structure of the Earth crust of Kazakhstan and its metallogenic potentials. These works of 1970s-1990s laid grounds to majority of contemporary search projects. These fundamental publications bear their actuality today; they will be in demand in distant future [2 and other].

Continuity of scientific and production activities facilitated the high efficiency of P&E works. Those years enjoyed discovery of gold ore fields, namely: Vasilkovsky, Varvarinsky, Yenbekshi, Pustynny, Karierny, Bakyrchik, Bolshevik, Suzdalsky, Akbakai, Dalabai, Arkharly, Yubileiny, and others. The copper ore fields include the Aktogai field group, Koksai, Benkala, Zhaisan, Koktaszhal, Maksut, Koktas, Borly, Zhilandy, Avangard, Kundyzdy, 50-yrs of October, Nurkazgan, Kosmuryn, Tesiktas and many others. The discovery list of the golden period of Kazakhstan's geology can be extended by many more pages. This review on efficiency of P&E works of the second half of the XX century has been made to emphasize once again the high productivity of the alliance of science with production.

Success of the prospecting works of this period was determined in many respects by preliminary high-level metallogenic research, directly leading to P&E activities.

All geologists of the former Soviet Union associate the birth of the Metallogenic School in Kazakhstan with the name of Kanysh Satpaev. During the period of intense development of metallogenic ideas in 1950s, he was one of the first, who was actively engaged in creation of the theory of metallogeny and principles of metallogenic mapping. In opinion of V.I.Smirnov, E.A.Radkevic and other metallogenists of the Union, this was largely favoured by diversity of ore deposits in Central Kazakhstan, which provided large comparative material and allowed for certain generalizations. In addition, the fruitful development of metallogeny in Kazakhstan was conditioned by practical needs and necessity in scientific justification of search methods in the richest ore deposit region. Wide range of interests of Kanysh Satpaev, his high all-geological culture facilitated his successful approach to significant problems, and made him run the regional Metallogenic Analysis, one of new directions of metallogenic research.

In the course of metallogenic studies in Kazakhstan (1950s-1990s), various theoretical concepts have been developed: metallogenic analysis from the geosynclines positions, deep faults, tectonic-magmatic

activization, lineament analysis, stereometallogeny, metallogeny of ore districts, astroblems, new global tectonics and other.

These studies were centred in the Satpaev Institute of GeoSciences and its Altai Department, the Kazakh Institute of Mineral Resources (KazIMS), and a number of thematic parties, organized in some geological departments.

Achievements of these years were highly appreciated by numerous state awards and prizes (the Lenin prize, the USSR State prize, and the KazSSR prize and others).

Revival of P&E, needed to replenish the exhausted reserve fields, requires mobilization of geological research forces. To this end, the search works should only be implemented on the basis of scientifically grounded recommendations and with backup of science. In order to increase its validity, it is recommended to generalise, systematise and analyze the huge arsenal of the predecessors' materials, followed by set-up of the digital data base.

It is expected that the studies will result in development of volumetric models of metallogenic zones, ore fields and deposits with use of modern 3D computer technologies, and improvement of ore formational and mineralogical-geochemical search criteria.

The geological-genetic modelling of ore objects is especially important for predicting of *hidden mineralisation* in industrial ore-mining areas, studied in detail from the surface (Rudny Altai, Central Kazakhstan and other). Accordingly, it is necessary to develop fundamentally new technologies and methods of prediction and search for hidden deposits at depths of 500-1000 m in order to cover with metallogenic forecasts the deeper strata.

It is necessary to carry out more detailed prognostic and prospecting works at the scale of 1:50,000-1:10,000 in promising ore districts, basing on a new theoretical and methodological principles in order to develop further and strengthen the mineral resources base.

For this purpose, it is necessary to provide access to the sites owned by subsoil users to scientific institution employees for comprehensive field studies, to ensure obtaining of the most effective forecasts for allocation of areas and preparation of prospecting works. It is necessary to oblige subsoil users to allocate financial means for scientific research in those areas and fields in their possession.

It is necessary to carry out geochemical mapping of the entire area of exposure to daylight surface of the Kazakhstan's Paleozoic, using modern analytical methods. The effectiveness of this technique is proved by the geochemical survey carried out in the 2000s in the Chu-Ili region at a scale of 1:5,000,000, which facilitated identification of new, previously unknown ore nodes of copper, rare and rare-earth elements.

It is advisable to continue studies of geological conditions of formation and placement of *large and superlarge* fields of copper, polymetals, gold, rare metals and other minerals, which form the basis of the country's mineral and raw material complex. Such giant deposits contain majority of raw material reserves in a number of countries (Russia, Uzbekistan, USA, Canada, China, etc.).

It is also recommended to intensify scientific research and practical assessment of non-traditional field types, which may represent an additional source of mineral resources. These are deposits in weathering crust (Cu, Ni, Co, Au, Ti, Zr, Sn, etc.), gold ore deposits in ancient and young conglomerates, apocarbonate deposits (Jasperoids) and stockwork deposits in granite plutons (the Fort Knox type), stratiform polymetallic and rare-metal sites, jewellery diamonds, platinum group metals and other. Unconventional field types should be studied within the framework of national programmes in the process of systemic study of the Kazakhstan's subsoil.

Another promising area for metallogeny is the study of *reserve territories*, covered by the loose Meso-Cenozoic sediments. These areas have capacity of buried deposits and residual weathering crusts of various minerals (Cu, Ni, Co, Au, Ti, Zr, Sn and others). Their evaluation requires mapping of subsurface geology (ГГК-200), including a complex of drilling, geophysical, geochemical works, and remote sensing materials.

Kazakhstan's hydrocarbon reserves were secured for a long term after discovery of three giant fields: Kashagan, Tengiz and Karashiganak. However, the problem of replenishing reserves in old on-land oil-producing regions with developed infrastructure is still acute. In addition, it is necessary to strengthen oil exploration in the southern, eastern and northern regions of Kazakhstan with promising oil and gas sedimentary basins.

Digitalization of P&E activities and the unified geological databases of research institutions and subsoil users could create conditions for prompt update of cartographic and other geological information, improved P&E prediction quality, more effective monitoring of the mineral resource base and P&E projects, which in turn would increase the investment attractiveness and efficiency of subsoil use in Kazakhstan.

Specialists occupied in mineralogy and petrography should be regularly trained to secure knowledge of material composition of mineral raw materials which affects the quality of the technological production chain.

Modern technologies and ideas open up a lot of new benchmarks for geological exploration, and geologists have no doubt that their implementation in the above mentioned directions will lead to new discoveries. However, this is only possible if prospecting and exploration work is adequately funded, in accordance with the objectives set before scientists and producers.

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АКАДЕМИК К. И. САТБАЕВ ЖӘНЕ ҚАЗАҚСТАННЫҢ МИНЕРАЛДЫ-ШИКІЗАТ БАЗАСЫ

Аннотация. Қазақстан Республикасының экономикасында стратегиялық маңызға ие минералды-шикізат базасының қазіргі жағдайы өте жоғары деңгейде. Минералды-шикізат базасының осындай жоғары деңгейі, негізінен, Қаныш Имантайұлы Сәтбаев жетекшілік еткен көптеген қазақстандық ғалымдардың күшімен құрылған. Алайда тау-кен өнеркәсібінде XX ғасырдың аяғынан бері қарқынды дамып келе жатқан кен өндіру технологияларының минералды шикізатты өндіруге қажетті уақытты күрт қысқарттуы және оның көлемін ұлғайттуы, пайдалы қазбалардың көптеген түрлерінде минералды-шикізат қорларының азайыуына себеп болды. Осыған байланысты ғылыми негізделген ұсынымдар мен ғылыми бағыт-бағдар негізінде геологиялық іздеу-барлау жұмыстары жүзеге асырылуы тиіс.

Мақалада көрсетілгендей, пайдалы қазба кенорындарын өндіру мақсатында дайындалған кен өндіру және геологиялық барлау жұмыстарының арасындағы көлемдік айырмашылығы кен өндірісінің күрт төмендеуіне әкеп соқты. Осыған орай перспективті өнеркәсіптік нысандардың болмауына байланысты алдағы 10 жылдықта мемлекет үшін дәстүрлі және стратегиялық маңызы бар пайдалы қазбалар – Cu, Pb, Zn, Au, W және т.б. жетіспеуі мүмкун. Тек Қазақстанда емес, сонымен қатар бүкіл әлемде оңай ашылатын кенорындар қорының таусылуы салдарынан, геология саласының жасырын пайдалы қазба кенорындарын ідеу дәуіріне өтіп кетуін ескере отырып, авторлар геологиялық барлау жұмыстарын жылдам қалпына келтіруге және қалпына келтірудегі айқын жағдайға ерекше назар аударады. Геологиялық барлау жұмыстары жаңа теориялық тұжырымдамалар, жаңа компьютерлік технологиялар және аналитикалық зерттеулер негізінде әзірленген ғылыми негізделген ұсыныстардың көмегімен жүзеге асырылуы тиіс.

Түйін сөздер: минералды-шикізат базасы, пайдалы қазбалар, кен өндіру, толықтыру, геологиялық барлау жұмыстары, жаңа ғылыми зерттеу бағыттары.

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АКАДЕМИК К. И. САТПАЕВ И МИНЕРАЛЬНО-СЫРЬЕВАЯ БАЗА КАЗАХСТАНА

Аннотация. Показан достаточно высокий уровень современного состояния минерально-сырьевой базы (МСБ) Казахстана, имеющей стратегическое значение для экономики страны. Данный высокий уровень обусловлен в значительной степени унаследованием мощной МСБ, созданной усилиями многих поколений геологов Казахстана под руководством Каныша Имантаевича Сатпаева. Однако, стремительно развивающиеся в горной промышленности с конца XX века технологии добычи резко сократили сроки отработки

месторождений полезных ископаемых, увеличили ее масштабы, определив тем самым отставание восполнения минеральных ресурсов по многим видам полезных ископаемых. В связи с чем, требуется ускоренное расширение поисковых и разведочных работ, которые должны проводиться на базе научно-обоснованных рекомендаций и с научным сопровождением.

Показанные в статье несопоставимые соотношения объемов добычных и геологоразведочных работ (ГРР) в пользу разработки подготовленных для этого месторождений полезных ископаемых привели к резкому превышению добычи над восполнением, что может в ближайшие десятилетия привести к дефициту в стране ряда традиционных и стратегически важных для нее полезных ископаемых – Cu, Pb, Zn, Au, W др., в связи с отсутствием фонда перспективных объектов в подставку к отрабатываемым. Исключение отмеченной ситуации авторы видят в ускоренном возрождении и развороте геологоразведочных работ. Учитывая, что геология вошла в эпоху поисков скрытых месторождений полезных ископаемых, так как легкооткрываемые объекты не только в Казахстане, но и во всем Мире почти полностью исчерпаны. ГРР непременно должны проводиться с использованием научно-обоснованных рекомендаций, разрабатываемых на базе новых теоретических концепций, новых компьютерных технологий и аналитических исследований.

Ключевые слова: минерально-сырьевая база, полезные ископаемые, добыча, восполнение, геологоразведочные работы, новые научные направления исследований.

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