

## REVIEW

**“KURUMS: A PHENOMENON OF THE CRYOSPHERE”  
(review of the monograph by V.R. Alekseev)**

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An analytical review of the recently published monograph by Vladimir Romanovich Alekseev is presented. This monograph is devoted to kurums, a specific type of the covering coarse clastic formations that are widespread in the mountainous permafrost of northern Asia.

**Keywords:** kurums, coarse clastic formations, mountainous permafrost, frost weathering, desorption, frost creep, heave, solifluction, rock glaciers, congelation ice, cryogenic processes, cryomorphogenesis

A popular science monograph by V.R. Alekseev “Kurums: A Phenomenon of the Cryosphere” (Fig. 1) is devoted to kurums, which are one of the least studied phenomena in the cold regions of the world. This is a voluminous (348 pages) book with a long (more than 600 titles) list of references. The monograph is well illustrated with photographs, figures, and tables.

The extremely widespread occurrence of kurums in the mountains of the cold regions in the world, and, in particular, in Russia—from Karelia to Chukotka and from Taimyr to Altai Mountains—allows us to consider kurums as the key type of the covering deposits in the mountain permafrost. Kurums are very complex and dynamic systems. Some of their facies

are affected by very rapid vertical and horizontal displacements, others are intensively watered. Therefore, disturbance of the natural regime of these formations by technical measures is often accompanied by unpredictable consequences (suffosion, creep, appearance of slope icings, etc.).

However, despite the extremely widespread occurrence of kurums, very few modern researchers specialize in this field. Much less monographic summaries with a holistic view on kurums have been published.

One of the reasons for the poor study is technical difficulties of mining in kurums composed of large blocks cemented by ice and soil. Hence, the drilling in

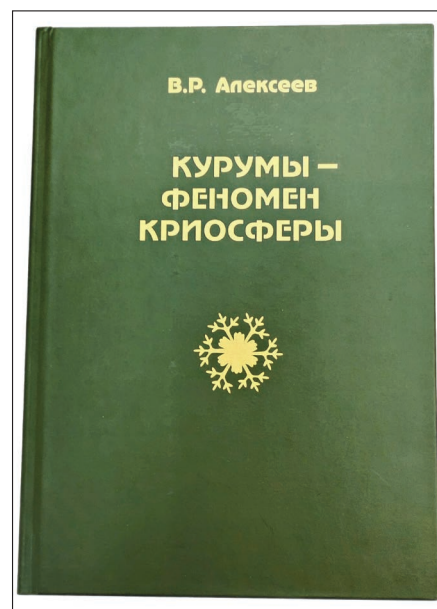


Fig. 1. Vladimir Romanovich Alekseev (a) and his monograph “Kurums: A Phenomenon of the Cryosphere” (b).

kurums is associated with large financial expenses and requires of powerful equipment. As a rule, such works cannot be afforded within the framework of small modern scientific projects.

In the 1970s and 1980s, large infrastructure facilities were extensively built in the Soviet Union. The study of kurums and evaluation of their impact on technical structures became the most urgent during the lying of the Baikal-Amur Mainline in permafrost areas of the Patom and Stanovoy highlands. Many experts in geocryology, geomorphology, and engineering geology from the leading scientific institutions (Moscow State University; Institute of Geography, Russian Academy of Sciences; Melnikov Permafrost Institute, Siberian Branch of the Russian Academy of Sciences; etc.) were involved in solving this project. Dozens of articles considering various issues of this versatile problem were published.

It turned out that the difficulty of the study of kurums is caused by not only technical but also methodological problems. Even estimation of the grain size composition of these formations appears to be a challenge because of a large size and weight of debris. Perhaps, that is why most of data on kurums obtained during that period fit into a few small monographs. The most important of them are the works [Tjurin *et al.*, 1982; Govorushko, 1986; Romanovsky *et al.*, 1989].

Unfortunately, even in our time, journal papers and annual collections of scientific conferences demonstrate that interest in the study of kurums and mountain permafrost as a whole has almost waned in the national science.

In this context, the monograph by V.R. Alekseev [2021] is very relevant, useful, and timely. According to the reviewer, it solves two important problems. Firstly, the monograph is a kind of summary–quintessence, generalizing a lot of scattered publications for the last 30 years, directly or indirectly relating to the key aspects of the kurum formation. At the same time, it states the fundamental issues associated with kurums and related phenomena in a popular form, making the results of their study accessible to a wide range of readers.

**In the first chapter**, the author acquaints a reader with the main features of the morphology of kurums, analyzes the origin of the term “kurum”, and gives various definitions of this phenomenon proposed by different authors and different scientific schools. It turns out that, in spite of the physical apparentness of this phenomenon, there is no unambiguous definition of it.

Further, the author considers different types and feeding mechanisms of kurums, focusing on the fact that a necessary condition for their occurrence is the presence of cold climate and permafrost. Whereas, in warm regions, the coarse clastic slope formations are essentially different and are not kurums. Therefore, kurums are a distinctive feature of the permafrost and

are formed as a result of the complex combination of frost weathering, freezing, solifluction, desorption, etc. Kurums arise and develop in close paragenesis with rock slides, avalanches, snowfields, and glaciers.

In the following paragraphs of the first chapter, V.R. Alekseev attempts to typify and classify kurums according to some features. For example, the author distinguishes valley, slope, and watershed kurums on the basis of the underlying relief, which seems appropriate. However, like all previous researchers, the author faces classification problems of kurums, both due to insufficient data on their internal structure and origin, and due to the continual nature of this formation and the lack of clear boundaries with other types of the coarse clastic formations of the mountain permafrost.

The author concludes that, at present, it is impossible to create the detailed genetic classification of kurums, which is probably conditioned by their poly-genetic origin. Therefore, it seems very rational to use the algorithm proposed by the author for their typification according to 14 morphological features. This algorithm can be very useful in the field description of kurums and their large-scale mapping.

In the following paragraphs of Chapter 1, the author considers some natural and technogenic formations morphologically similar to kurums, such as stone glaciers, stone mounds (*obo*), and ancient megalithic structures within the cold regions. In terms of the cryogenic origin, discussion of the megaliths seems very timely and relevant. Some modern “alternative-scientists” continuously broadcast about numerous traces of ancient civilizations in Siberia and Arctic in their numerous monographs, TV programs, and Internet-resources. They describe the “strangely” stacked giant megaliths or oddly shaped rocks with obvious signs of the artificial origin.

All these statements are a direct result of the modernization of the Russian educational system according to the “western principle”, which began more than 30 years ago and continues to this day. As a result, specialization of individual researchers has narrowed in so much that the obvious and well-studied 30 years ago natural phenomena are now considered as mysterious incomprehensible ones and even become cargo cults! Therefore, the paragraphs of the monograph by V.R. Alekseev devoted to the debunking of such cargo cults are extremely topical.

At the same time, indeed, many structures, created by man in the ancient times in the cold regions, are often composed of material from kurums and have their properties. Such formations are some stone mounds, slab graves in the highlands, and others. The author tries to deal with these phenomena in more detail in Chapter 2.

In the last paragraph of Chapter 1, the author analyzes the geographical distribution of kurums and their role among other rock formations, analyzes the

altitudinal zoning, latitudinal and longitudinal zoning, association with slope aspect, climate, etc., and gives the examples of different scale maps and diagrams.

**The second chapter** of the monograph is devoted to the discussion of the very border issues and completely unresolved questions of the origin of some natural phenomena, as well as the artificial objects related to crushing, freezing, and dynamics of the coarse clastic rock material in the cold regions.

The author discusses the formation of stone pillars of an aerodynamic shape, which are widespread in Eastern Siberia, in the Polar Urals, and in Subarctic. In spite of the obvious manifestation of the kurum-forming processes here, a mushroom-like shape of residual rock columns – tors of the Northern Verkhoyniye cannot yet be explained solely in terms of the kurum-forming. Although, according to the reviewer, the distinct mushroom-like aerodynamic shape of many objects and the absence of weathering products at their base clearly indicate their aeolian origin as a result of wind corrasion and do not cause questions for geomorphologists familiar with the classical German [Penck, 1961; Davis, 1962] and Russian [Chichagov, 2010; etc.] works on arid geomorphology.

In other paragraphs of Chapter 2, the author considers such phenomena as spherical nodules on the islands of the Franz Josef Land, the Vottovaara quarry in Karelia, rocky steppe mounds, etc. In the next paragraph of Chapter 2, the author discusses the hypothesis of the specific water bearing capacity of kurums in the cold regions related to intensive condensation of the atmospheric moisture in their bodies.

The author finds parallels with some, now lost, ancient technologies of the water obtaining in arid regions directly from atmospheric vapor, discusses interesting details of various experiments, including scientific ones, which were set up by different researchers in different years in order to obtain water by condensation. Some of the experiments have been successful, others not so much. In general, in this section, full of detail and quite specific data, there are more questions than answers on physics of the condensation processes in kurums and similar artificial stone structures. The author's thoughts about a possible role of ancient megalithic structures with numerous water channels serving as water reservoirs also seem to be interesting.

In the last paragraph of Chapter 2, the author returns to natural kurums in terms of their recreational and aesthetic value as the objects for testing various types of cross-country vehicles, as well as physical training and endurance. Indeed, kurums are the natural heavy-going landscape for any type of modern machinery. On the other hand, this makes kurums a good testing site for new models. Every year, kurums attract more and more attention of extreme hiking and auto-tourism.

**The third chapter** of V.R. Alekseev's monograph is devoted to the discussion of cryogenesis in kurums, the role of snow cover and ground ice, which give kurums their phenomenal specificity. Many of the issues considered in this chapter are devoted to physics of the ice formation and heat exchange in kurums related to their specific radiation balance, to the processes of seasonal phase transitions of water, etc. The chapter contains rare photographs of congelation, basal, and other types of ice in kurums.

One of the paragraphs of this chapter is devoted to the analysis of the thermal regime. The conclusions are supported by the interesting schematic geological models, results of observations in geothermal wells, and temperature graphs indicating that the daily temperature variations in the summer period do not spread deeper than 2–3 m. However, in winter, the higher thermal conductivity of kurums leads to greater cooling of underlying rocks. In general, the author concludes that it is the frozen state that gives kurums their specific properties. Moreover, in regions with discontinuous permafrost, kurums contribute to its more active formation.

The next paragraph is devoted to the analysis of dynamics of kurums and to mechanisms of their movement. Like many of his predecessors, the author comes to the conclusion about the polygenetic character of the kurum movement results from heave, desorption, solifluction, suffusion, etc. The author comments on different ways, which were used by different authors in qualitative and quantitative estimations of the rates of kurum movement.

A logical continuation of the discussion is the consideration (in the next paragraph) of the interaction of kurums with different types of sediments and their transformation during the natural evolution. Here, the author operates with the data on the grain size composition and roundness of fragments under weathering. The author assures a reader that, during this evolution, well-rounded boulders and pebbles, morphologically very similar to the formations of a fluvial series, may arise in some facies of kurums.

In the next paragraph, the author analyzes the few data on the relative and absolute age of kurums, rightfully associating their extensive formation with the cold epochs of the Quaternary period and with the main stages of the formation of permafrost as a whole.

In the next very important section, the author characterizes a facies structure of kurums following the most developed and thorough scheme of A.I. Tyurin et al. [1982]. This scheme divides kurums into more than 30 facial varieties, being very logical within the framework of theoretical considerations. At the same time, this scheme is extremely difficult to use in practice, because the boundaries between most facies are conditional and unclear. Moreover, there are no strict boundaries in nature. The boundaries exist only

in the classifications invented by man. They do not reflect the depth of knowledge of a particular phenomenon; rather, they illustrate the deterministic way of thinking and the methodology of a researcher.

Probably, for this reason, this and other schemes of the facies analysis of kurums remained not too much in demand and stopped their development after 1980. They were no longer used in the monograph by N.N. Romanovsky et al. [1989]. Nevertheless, it is the scheme of the facial separation of kurums by A.I. Tyurin et al. [1982] that most thoroughly describes their morphogenetic diversity. This allows us to proceed to the ideas of the continual series of the coarse clastic formations in the cold regions, including stone glaciers, kurums, talus, desorption, and other groups of slope processes and sediments in the permafrost.

The last paragraph of the chapter is devoted to the analysis of the engineering hazard of kurums at the bases of engineering structures, as well as hazardous secondary processes, which are common within the kurum fields and the formations related to them. Here, the author considers to a greater extent the results of technogenic activity, which have led to the formation of technogenic stone glaciers and associated ice-rock slides. The Rasvumchor Plateau in Khibiny Mountains, technogenic glaciers of the Rudnaya Mountain on the Putorana Plateau are well known areas of such phenomena.

**In the fourth chapter**, the author discusses the unique and extremely diverse flora and fauna of kurums. The description of this world is accompanied by specific folkloric passages, the metaphorical language of which emphasizes and reinforces the phenomenal appearance of kurums and even consolidates the diverse material given in the previous chapters. It should be noted that most of the taxa given by the author characterize the entire ecosystem, in which kurums are perhaps not a major element. However, some rare species, which the author describes in more detail, are definitely associated with kurums. One of them is the black-capped marmot. The point is that, for many small animals, kurums provide an opportunity to locate their dwelling as deep as possible, several meters below the surface, where annual and mean winter temperatures are close to zero.

The description of the vegetation world of kurums should be noted separately. The author considers the colorful and the richest world of epilithic lichens. Indeed, while most other plants only try to survive in the harsh conditions of kurums, for lichens kurums are the main biotope and, in some areas, the only type of substrate suitable for habitation.

Another large section, which completes Chapter 4, is devoted to not the happiest pages of the history of the human interaction with kurums. Here, the author provides interesting historical information about the extremely harsh conditions of the develop-

ment of some deposits in the high-altitude areas of the cold regions. The history of the development of the northeast of Russia during the years of the existence of the Central Administration of Prison Camps deserves special attention. This period involves the development of tin-uranium concentrate at the Budguchag deposit in Magadan oblast, the Vostochny uranium deposit in Chukotka, etc. It is interesting that most of the residential structures in the areas beyond the forest boundary were built from the coarse clastic material of kurums. Many structures have survived to the present day.

**The fifth chapter** is devoted to a discussion of technogenic kurums. The author refers them to refuse large-block dumps of mining deposits, which are frozen and saturated with ground ice. In general, of course, there are common features between the technogenic and natural kurums, especially in terms of the thermal physics, grain size composition, and climatic conditions in the course of their formation. However, the origin of these formations is principally different. Mining enterprises annually store millions of tons of coarse clastic rocks in the form of dumps. The author considers unique and single results of the observations over the temperature dynamics of some dumps, within which the specific thermal structures have been formed for several years, gives the results of assessment and forecast of the dynamics of some dumps in the near future.

In the following sections of Chapter 5, the author considers the advantage of coarse fractions of clastic material for construction purposes, gives the properties of rock fill for road construction in permafrost areas, and many other practically useful data, directly or indirectly derived from the "theory of kurum-forming". The kurum material can be used to protect certain structures from excessive thawing as a natural accumulator of cold and thermal regulator, as filtering material in the construction of hydraulic structures, and many others.

**In the final, sixth chapter**, the author decided to present the results of the analysis of the published literature in the field of the study of kurums and related phenomena. The results of this analysis are disappointing. The publication activity in Russia declined over the past 30 years. Over the past 10 years, only 27 works have been published including only 11 articles and 0 monographs. While from 1970 to 1980, 100 works were published, including 24 articles and 7 monographs.

In this chapter, the author also analyzes the most important publications from his point of view, peculiarities of the authors' methodology, and even provides some of their biographical data and photographs. In general, this section seems useful, especially for the most inquisitive young researchers, who need to know "by sight" their predecessors and, perhaps, their opponents or theoretical contradictors.

In conclusion of Chapter 6, V.R. Alekseev discusses the reasons to distinguish the separate relevant direction – kurum science. The reviewer fully agrees with the author, because, being engaged for many years in stone glaciers, simultaneously had to study a wide range of phenomena of cryogenic-gravitational series. The point of the latter is fully covered by the term kurums in the understanding of the author of the monograph. Moreover, following the continual concept subsequent to a number of domestic and foreign specialists, the reviewer believes that the objective cognition of kurums is impossible separately from the gravitational-slope and glacial processes of morpholithogenesis and cryolithogenesis.

In conclusion of the monograph, the author again returns to the definition of kurums, but with the consideration of the performed data analysis. Analyzing the morphogenetic diversity of kurums and their facies, the author convinces of the necessity to combine them under the general term "kurumium". It seems original and logical in the descending lithodynamic series (eluvium, colluvium, deluvium, proluvium, alluvium, limnium, etc.). However, in the opinion of the reviewer, this requires special discussion. In addition, the reviewer completely agrees with the author that improvement (completion) of the kurum classification is long overdue, because the classifications, which have been published earlier, as time shows, appear not quite functional and remain almost unused in the modern literature.

Thus, the content of the monograph and the style of presentation used by V.R. Alekseev allow us to consider this work as the well-illustrated popular summary, which gives a broad idea of the modern study of kurums and paragenetic phenomena. The language of the presentation is amazingly balanced and easy to understand without losing the essence. The author often touches on very deep and almost philosophical issues of synergy and self-organization of matter in the cold regions. He does it in the implicit form, without formulas and strict definitions, but through thinking, posing questions, lyrical digressions and even metaphors, thus encouraging a reader to find his own solution.

It is difficult for the reviewer to formulate any serious comments on this monograph, even though he cannot fully agree with some of the author's conclu-

sions. However, the monograph is of the highest rating for the popular science genre. It involves almost the entire volume of key fundamental knowledge about kurums and related phenomena at the current time, except for some narrow issues. In addition, the monograph contains a very extensive list of citations, including the most modern ones. The list of references is the comprehensive compilation of domestic and foreign literature on kurums and related phenomena.

It is necessary to note once again the brightness of the language used by the author, which makes this book a unique and colorful edition. Undoubtedly, this monograph will be useful to a wide range of readers from schoolchildren to professionals in the field of the Quaternary geology, permafrost science, geomorphology, and geography. The monograph can be recommended as additional educational literature for students of natural sciences of higher and special educational institutions. It will be extremely useful for biologists, soil scientists, and archaeologists working in cold regions and permafrost environments. Some sections will undoubtedly be of interest to many travelers, romantics and other adventurers.

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