Journal of Geological Research
https://ojs.bilpublishing.com/index.php/jgr-a

ARTICLE

Properties of Natural Catastrophes

Ospanova N.K.*

Laboratory of paleontology and stratigraphy, Institute of Geology, Earthquake Engineering and Seismology of the National Academy of Sciences of Tajikistan, Tajikistan

ARTICLE INFO

Article history
Received: 16 June 2020
Accepted: 26 June 2020
Published Online: 30 June 2020

Keywords:
Earthquake
Biotic crises
Catastrophism
Evolution
Spontaneity
Changes

ABSTRACT

A variety of phenomena of a catastrophic order and fear of their consequences served as the reason that until now the properties of disasters remained incomprehensible. We found out the properties of natural catastrophes. It is shown that knowledge of these properties is of great importance, because it contributes to the formation of an objective judgment on natural processes and phenomena.

1. Introduction

The interest of geology and paleontology in the study of disasters is not accidental; it is due to the fact that numerous phenomena of a catastrophic nature fall into the sphere of study of these sciences. These include earthquakes, mudflows, landslides, collapses, volcanic eruptions, biotic crises and more. The mere statement of these phenomena is not the key to their knowledge, and each event requires a thorough description and study, because any catastrophe has "its own face". A variety of events of catastrophic order is the reason that in the study of catastrophes there are many unclear points regarding both their prediction and their consequences. Therefore, the question arises: are there any common features inherent in such a diverse range of phenomena?

We have clarified the properties of a catastrophe as a natural phenomenon [1,2]. But due to the vastness of the topic, we only mentioned in passing that one of the consequences of the disaster is the emergence of a new quality. Here this point is covered in more detail. This work is a continuation of earlier research.

2. Methodological Premises of the Study

When clarifying the properties of natural disasters, the author used the experience obtained as a result of many years of study of the evolution of Paleozoic corals. Despite the specifics of the development of different groups of the organic world, as well as the specifics of the evolu-

**Corresponding Author:*
Ospanova N.K.,
Laboratory of paleontology and stratigraphy, Institute of Geology, Earthquake Engineering and Seismology of the National Academy of Sciences of Tajikistan, Tajikistan;
Email: ospanova2005@mail.ru

 DOI: https://doi.org/10.30564/jgr.v2i1.2004

tion of the living and nonliving, there are general fundamental principles that equally act at different levels of the existence of matter and have power both for the functioning of biological systems and for the functioning of ordinary physical systems. Therefore, we consider the clarification of the evolutionary properties of individual groups of animals and heliolitids as one of the bricks that can be used in constructing of the General Theory of Evolution. The author took into account the mathematical approach to explaining phenomena of a catastrophic order, as well as the traditional approach to understanding catastrophes as large-scale events that entail negative consequences. The synthesis of numerous data, as well as the interest in the evolution of the organic world and evolution in general, allowed the author to establish the properties of the catastrophe as a natural phenomenon.

3. Catastrophe Properties

A wide audience, most likely, is not very familiar with our studies due to their novelty and the limited number of publications; therefore we consider it necessary to briefly recall the properties of the catastrophe that we established as a natural phenomenon. The catastrophe is understood as *a sudden change in the behavior of the system, as well as the general type of systems in which such changes occur* [3], and from these positions a huge number of phenomena fall under the definition of the catastrophe: evaporation of water, sudden tipping over or falling of an object, change of mood, differentiation of cells, the appearance of a rainbow in the sky, etc. The multidimensional nature of the disasters makes it clear that they include not only natural disasters, faults of regional significance, giant folded systems, multi-kilometer thrusts and landslides, but also micro-fractures, local displacements of rocks, small folding, even if these folds are only a few millimeters.

A catastrophe has the following properties: sudden manifestation (which follows already from its definition), relative short duration, irreversibility of consequences, unpredictability, spontaneity [1,2], and long-range action [2].

The relative short duration is due to a sharp disruption of the balance that existed before a catastrophe; because of this the energy release associated with the catastrophe is pulsed. In order for the catastrophe to occur, it is necessary to achieve a certain critical level of energy required to starting the catastrophe and overcome its resistance to the external environment, the balance of which it violates. Pulse discharge, which determines the high speed of the catastrophe, explains the short duration of its action.

Irreversibility of the consequences stems not only from the fact that the catastrophe does not fit into the surrounding course of development and violates its order, but also from the relative short duration of the catastrophe, as well as the composition of its elements. Stewart [3] identified the components of the catastrophe: *the space of control parameters, the space of variable states,* and *the response surface*. The presence of a region of variable states between the control space and the response surface causes a qualitative difference between the beginning and end of the disaster.

Unpredictability follows from the suddenness of the manifestation and can relate both to the time of the beginning or end of the catastrophe, the place of manifestation, so to its intensity, the magnitude of the impact and the evaluation of the consequences. No one can know in advance the energy potential of the catastrophe, as well as the resistance of the environment, which it overcomes and which is different in each case. Therefore, it is difficult to predict both the time of its beginning and the whole range of consequences caused by it. From this it follows that *in the matter of predicting disasters there will always be a greater or lesser area of uncertainty*.

Spontaneity is associated with the inability to prevent a catastrophe. There is a gap between the space of control parameters and the response surface in the form of the space of variable states, and intervention in the course of the catastrophe is possible only in the space of variable states. Due to the transience of the process, it is difficult to do as much as trying to stop an explosion that has already begun. Spontaneity can also manifest itself in the fact that one catastrophe is capable of provoking a cascade of catastrophes. *The cascade of catastrophes is a series of catastrophic events that follow each other*. The duration of the intervals between them depends on the specific conditions in which the disaster occurred, and can range from the first seconds and minutes to several days and months. For example, the events of 1911 in the Pamir can be reflected in the following scheme of cascade: *an earthquake - a collapse of rocks blocking the river bed - filling a reservoir with water* (the emergence of Lake Sarez). A simplified diagram of the tsunami-related cascade is as follows: *earthquake - tsunami - destruction of buildings (coastline, dams, etc.) - flood.*

In addition to these properties, long-range action is inherent in catastrophes: the remote consequences of the catastrophe are more durable than the catastrophe itself. That is, the consequences of the disaster last much longer than the time of the disaster. Such a paradox occurs due to the difference in the speed of implementation of different processes. The speed of the catastrophe itself is huge, so the inverse proportion to it - time - is small. The consequences caused by the catastrophe are less energetically saturated (if there is no replenishment with additional por-

  DOI: https://doi.org/10.30564/jgr.v2i1.2004

tions of energy) and proceed at a slower rate; respectively, the time for their implementation increases. For example, impact events are short-lived, the fires, destruction and “cosmic winters” caused by them last much longer, and it may take hundreds or thousands of years to restore destroyed biocenoses. An atomic explosion lasts seconds or fractions of the second, the radioactive cloud generated by it exists for a longer period, the increased radiation field lasts for many years, and genetic abnormalities due to radiation exposure affect hundreds or thousands of generations, and so on.

Since disasters cover a huge range of phenomena, examples can be very diverse and numerous [2]. Here we would like to give only a few illustrative examples regarding the unpredictability property and related to geology.

The seismic shocks that make up the earthquake are divided into foreshocks (shocks preceding the main one), the main shock (maximum in strength) and aftershocks (shocks following the main one). Practice shows that it is very difficult to predict in advance the number of shocks that accompany the main earthquake, their strength and the possibility of occurrence. There is large number of such earthquakes, which were not accompanied by additional shocks. But there are other examples. During the Karatag earthquake (October 21, 1907), three shocks of the same strength occurred (9 points each), followed by an interval of 21 and 6 minutes. In total, 12 000 people were killed. A Garm earthquake of magnitude 8–9 occurred on April 20, 1941, and then up to April 1, 1942, about 200 seismic shocks of different strengths were noted [4]. After the main shock of the Vahdat earthquake with the magnitude of 6-7 points (November 10, 2013), from November 10 to 30, 370 aftershocks were recorded [5]. Scientists believe that the number of aftershocks can reach several thousand.

It should be noted that at present about 200 earthquake precursors are known, but not one of them can “predict” the exact time of the start of the earthquake. The same can be stated in relation to other catastrophic phenomena, for example, tsunamis. At one time, Soviet scientists set the threshold for the magnitude of Pacific underwater tremors giving rise to tsunamis. For 20 years they have not missed the single tsunami. The paradox is that three quarters of the alarms turned out to be false [6].

4. Irreversible changes

Scientists consider the unidirectionality of processes as a property of internal asymmetry inherent in nature [7]. This statement in itself is only an ascertaining of what is observed in practice, but by no means an explanation of the essence of asymmetry. From the standpoint of the properties of the catastrophe as a natural phenomenon, the asymmetry that manifests itself quite often finds its natural explanation: the high quality of the beginning and end of the catastrophe and the practical impossibility of intervening in its course due to the impulsive nature of the realization are the reasons that the previous state is replaced by the new, different from the previous one, expressed in the emergence of the new quality. Breaking the old, cardinal changes impede the restoration of the system in its previous form, both due to the fact that its elements undergo the change, as well as due to the death of some of the elements. In addition, the imbalance, as a rule, is associated with a series of events, which we call the "cascade" [1,2], when one equilibrium shift provokes the series of shifts. Therefore, as a rule, not one prohibition, but the series of prohibitions impedes the course of reverse changes. The space of variable states between the beginning and the end of what scientists understand as the catastrophe plays the role of not only the guiding channel, but also the role of the negating link - when the previous state of equilibrium is already broken, and the canalizing changes, which have begun, cannot return the system to its original state.

One of the consequences of the disaster, therefore, is the emergence of a new quality.

As a new quality, one can consider, for example, the accumulation of huge reserves of fresh water in Lake Sarez, formed as a result of the Usoi collapse, provoked by an earthquake and blocking the river [8].

A striking catastrophic event is the fall of an asteroid. Traces of the fall are recorded on space and aerial photographs in the form of ring structures, the dimensions of which allow us to judge the scale of the event. Space aliens not only left craters, but also violated the normal stratification of rocks, created high temperatures and pressures, as a result of which mineral deposits that were gigantic in their reserves could arise (the emergence of a new quality). An example is the Popigai crater in Russia (100 km, 36 million years), which is associated with the field of industrial diamonds. Scientists have calculated that they can provide all of humanity for 3 000 years in advance (oral report by Academician B.S. Zeylik). The Wredefort crater in South Africa (200km, age 2 billion years) gravitates to half of the world's gold reserves. Chicxulub in Mexico (180km, 65 Ma) is 2/3 of Mexican oil production. Finally, Sudbury in Canada (200km, 1.9 billion years old) contains 1/3 of the world's nickel reserves [9], etc.

We can also recall that after mass extinctions that have repeatedly occurred in the history of the Earth’s organic development, biota never returned to its previous state: the taxonomic composition changed, ecological dominants completely changed, the nature of biotic and abiotic connections became different. Evolution began to go in a completely different way. Therefore, one geological era is not similar to another, and the division of geological time is carried out precisely on the basis of the staged development of the organic world. The qualitative difference between the different stages of the geological development of biological life can be explained from the standpoint of the properties of the catastrophe itself (impossibility of returning to the initial state). As Gould points out [10], the intensity of episodes of drastic changes establishes a hierarchy of geochronological intervals: the largest episodes serve as the boundaries of the eras (Cambrian biotic explosion, Permian and Cretaceous extinctions), and the smaller ones as the boundaries of periods.

Since the catastrophe leads to the emergence of a new quality and completely changes the direction of development, and the state of equilibrium before the catastrophe's begin differs from the state of equilibrium after catastrophe, it follows that the catastrophe leaves its mark forever. Violating the initial state of equilibrium, the disaster thereby violates the symmetry that existed before it in nature between abiotic factors or systems, between biotic ones or between those and others [2]. Regarding living things, it should be noted that the catastrophe itself does not induce organisms to change, but it changes the environment, and the changed environment, in turn, can stimulate the change of organisms.

5. Discussion

Cuvier is considered as the founder of catastrophism in geology, who proposed in 1812 the hypothesis of overturns (from the Greek *katastrophe* - overturn) expressed in interruption of long periods of stability by individual extinctions and structural disagreements. Cuvier postulated a relatively small number of disasters and spread them only on land (flooding of the islands), he did not describe any marine disasters and cataclysms. Unlike Cuvier, British researchers believed that each interval of geological time was accompanied by a catastrophe and that their total number was close to one hundred [11].Cuvier spoke of one act of creation, while the British believed that every calm interval of time ended in the cataclysm destroying all life, and then the Creator re-created the world, where other forms played a role. A sharp change in organic residues made it possible to build maps of the occurrence of layers, which over time acquired practical significance in the constructing work. Thus, although Cuvier is considered to be the founder of catastrophism, different researchers (or different scientific schools) put different meanings in the concept of catastrophe and catastrophism.

Over time, the views on catastrophes and catastrophism underwent changes - from the recognition of the global nature of catastrophes (for example, the theory of Eli de Beaumont about the collapse of the earth's crust to shrink as a result of cooling of the bowels or G. Shtille's point of view about the simultaneity of mountain formation on the whole Earth) to their denial. Gould [10], who postulated principle of intermittent change, considers the term "catastrophic" unsuccessful in relation to many important processes of the physical and biological development of the Earth; periods of sharp changes he calls "leap". Gretener believes that the term "catastrophism" is burdened with a hint of annihilation, and it cannot be used to refer to geological events, which are simply quick changes, destructive for some and beneficial for others. He considers the terms "spasm", "episode", "event", "leap", "point change" as more neutral [12]. On the contrary, Benson sees the sharp transition between old and new species as paleontological confirmation of the presence of microcatastropism, which is a common way of evolution of species [11]. Emergy writes that in a certain sense both magmatic and metamorphic minerals can be considered catastrophic in origin, since the processes that form the primary deposits are discontinuous in time and space [13]. At the same time, he makes a reservation that these natural processes are likely to occur always in one place or another on the Earth, therefore, both primary and secondary mineral deposits can serve as examples of uniformism (uniformity theory).

It is clear from the statements of the authors that in their constructions they do not take into account mathematical achievements in relation to understanding of catastrophes.

We may not know the name of the founder of the mathematical theory of catastrophes Rene Thom; we are not required to study the theory of peculiarities of Hassler Whitney. But one cannot ignore the fact that many unrelated phenomena obey the same laws. For example, a Dovetail type catastrophe (a dovetail curve) is considered as a universal model because of the constant occurrence in the theory of peculiarities of smooth mappings. So many disasters can be portrayed with this model [14]. The catastrophe in the understanding of mathematicians is *a sudden change in the characteristics of a system with small, smooth changes in its external or internal parameters*. It is emphasized that *the crisis of the system occurs instantly*. Using this part of the mathematical analysis, a wide variety of phenomena can be described, including riots in prisons. That is, this area of theoretical research has the most immediate practical significance. Therefore, it is hardly possible to recognize as correct the ignoring of the term "catastrophe" in relation to geological phenome-

  DOI: https://doi.org/10.30564/jgr.v2i1.2004

na. The terms for which Gretener [12] advocates as neutral (“spasm”, “episode”, “event”, “leap”, “point change”), due to their neutrality and semantic ambiguity, do not possess the informativeness that the word “catastrophe” has. For example, the arrow of a device can make the leap and return to its former position, which cannot be said about disasters: disrupting the existing equilibrium, they completely change the balance of forces.

At the same time, mathematical curves that describe the behavior of an object at the moment of changing its state do not reveal the essence of a catastrophe as a natural phenomenon. First, the same curve covers a wide range of unrelated phenomena. Secondly, the curves on the plane cannot give an idea of the visible damage that cause disasters in the area, as well as the consequences of these damages. Therefore, we believe that establishing the properties of the catastrophe as the natural phenomenon is important for understanding the essence of real events.

6. Conclusions

Studying the properties of a disaster helps to understand many phenomena, which simply cannot be displayed in one small article. Only the geological aspect of disasters is affected here. In particular, the reason for the difference in different stages of the geological development of the Earth is shown. Is it possible, based on the fact that catastrophes lead to the emergence of a new quality, to draw a conclusion about the creative role of catastrophes? No, the catastrophe is always destruction, it plays the role of closed doors, putting a ban on certain areas of development and thereby channeling the choice of another development way. As stated above, the catastrophe does not induce organisms to change, but it changes the environment, and the changed environment, in turn, can stimulate a change in the living.

An analysis of the nature of the catastrophic changes shows that in the matter of catastrophe prediction there always remains a greater or lesser area of uncertainty. Nevertheless, one often hears undeserved accusations against scientists about the fact that they still “have not learned” to predict the exact time of the start of an earthquake. Moreover, the scientists themselves are also lamenting about this. Such a philistine point of view is based on absolute ignorance of the properties of natural catastrophes. In the case of disasters, we are dealing with statistical, averaged data, and not with accurate. For example, some leading scientists consider the frequency of seismic activity as a very dubious forecast criterion [15]. Any events in this world have the probabilistic nature of implementation, and the probability can change over time.

We borrowed a mathematical definition of a catastrophe and its elements. But it is clear that the study of the properties of disasters cannot be limited by mathematical curves because they do not cover the whole spectrum of concomitant changes caused by disasters, and do not provide a visual representation of real events.

Elucidation of the properties of a catastrophe aims to form an objective view of natural processes and phenomena. The study shows that false hopes of the exact time prediction of the beginning of disasters must be discarded. This does not mean that it makes no sense to identify the precursors of earthquakes, volcanic eruptions or tsunamis; we must study the world in which we live. But sometimes illusions can be just as harmful as ignoring the obvious facts.

References

[1] Ospanova, N.K. Catastrophes as an integral property of the geodynamic development of the Earth[M]. Geodynamics, mineralization and geoecological problems of the Tien Shan: Materials of the International Conference on the 70th anniversary of the Institute of Geology of the National Academy of Sciences of the Kyrgyz Republic (September, 2013). Bishkek: Ilim. 2013: 167-172.

[2] Ospanova, N.K. Anthropogenic factors in the light of the doctrine of natural catastrophes[J]. The scientific heritage. Budapest, 2020, 2(45): 24-30.

[3] Stewart, J. Secrets of the catastrophe[M]. Moskow: Mir. 1987: 76.

[4] Niyazov, Dj.B. Garm earthquake of 1941 and the beginning of the establishment of the seismic service of Tajikistan[M]. Geology and issues of seismicity of the territory of Tajikistan (Materials of a scientific conference dedicated to the 80th anniversary of Academician of the Academy of Sciences of the Republic of Tatarstan, Doctor of Geological and Mineralogical Sciences Djalilov Manzur Rakhimovich). Dushanbe: Balogat. 2014: 218-219.

[5] Djuraev, R.U. Geological aspects of the Wahdat earthquake on November 10, 2013[M]. Problems of geology, seismology and earthquake engineering of Tajikistan (Materials of the Republican conference dedicated to the 30th anniversary of the Kairakkum earthquake on October 13, 1985. Dushanbe: Sadoi Kalb. 2016: 190-195.

[6] Aristarchov, N. Understand and predict[J]. Knowledge is power. 1985(8): 9-10.

[7] Atkins, P.W. Order and disorder in nature[M]. Moscow: Mir. 1987: 234.

[8] Shpilko, G.A. The 1911 earthquake in the Pamirs and its consequences[M]. St. Petersburg. 1914: 94.

[9] Zeylik, B.S. The problem of space protection to save life on the planet and where to look for mineral deposits[M]. Geology in the XXI century: Materials of the International scientific-practical conference "Satpayev readings" dedicated to the 20th anniversary of independence of the Republic of Kazakhstan (Almaty, April 14-15, 2011). Almaty: IP Volkova N.A. 2011: 85-91.

[10] Gould, S.J. In defense of the concept of intermittent change[M]. The New Uniformitarianism / W.A. Berggren and John A. van Convering (Eds.). Moscow: Mir. 1986: 13-41.

[11] Benson, R.H. Completeness, Continuity, and Common Sense in Historical Geology[M]. Catastrophes and Earth History. The New Uniformitarianism / W.A. Berggren and John A. van Convering (Eds.). Moscow: Mir. 1986: 42-88.

[12] Gretener, P.I. Reflections on a “rare event” and related representations in geology[M]. Catastrophes and Earth History. The New Uniformitarianism / W.A. Berggren and John A. van Convering (Eds.). Moscow: Mir. 1986: 89-100.

[13] Emergy, K.O. Catastrophes and the Modern World[M]. Catastrophes and Earth History. The New Uni-formitarianism / W.A. Berggren and John A. van Convering (Eds.). Moscow: Mir., 1986: 444-456.

[14] Arnold, V.I. Catastrophe theory[J]. Science and life. 1988, 10: 12-19.

[15] Waltham, T. Catastrophe: the violent Earth[M]. Leningrad: Nedra. 1982: 223.

  DOI: https://doi.org/10.30564/jgr.v2i1.2004