GLOBAL CLIMATIC CATASTROPHES (VOLCANISM AND IMPACT EVENTS)

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Summary

Presented are the data on the influence of volcanic eruption of the explosive type on the climate and environment, as well as the consequences of collision of large celestial bodies with the Earth. Explosive craters on all the continents (ancient astroblems and younger explosive craters) indicate that large meteorites collided with the Earth many times, probably causing a considerable decrease in solar radiation due to the formation of an aerosol layer in the stratosphere. This could result in a significant decrease in temperature and photosynthesis, which, in turn, could cause the death of living nature.

Also presented are the data on the events at the Cretaceous-Cenozoic boundary when the most significant (over the last 65 million years) extinction of living organisms occurred. Aerosol catastrophes, after powerful explosive volcanic eruptions or a series of such eruptions, can also cause a considerable decrease in incoming solar radiation and surface air temperature. Among the consequences of such eruptions are the death of people and animals.

Storm forest fires and dust storms also result in significant air temperature decrease, but

most often these climate changes are local catastrophes only.

Nuclear conflict can also cause an aerosol catastrophe, which, in turn, may result in death of living nature. The conclusion is drawn that we should do every possible thing to prevent a nuclear conflict.

1. Introduction

The term *natural catastrophes* (or *catastrophic events*) is used in this essay to mean abrupt changes in climate and environments leading to a mass extinction of organic life in sea and on land.

In parallel with global climatic catastrophes, local ones, induced by different atmospheric factors, occur much more frequently. The best-known examples of this kind are the large-scale droughts covering areas of thousands of square kilometers or the long-term strong reductions in temperature. On the other hand, an abnormally hot weather can also cause mass deaths of living organisms. All the local catastrophes have common features. In a number of cases these events produce disastrous consequences, but they rarely cause the complete extinction of many species of animals or plants.

To better understand the mechanism of global ecological and climatic catastrophes caused by increased aerosol mass in the stratosphere (for example during celestial impact collisions or volcanic eruptions), it is very important to assess the effects on living organisms of an abrupt drop in environmental temperature (see *Earth system: History and Natural Variability*).

2. Climatic catastrophes in the Earth's history

The diverse empirical data collected recently expands considerably and changes to some extent our ideas about climatic variations in the geological past. These new views can be summarized as follows:

- Climatic changes even in the warmest epochs of the past appeared to be more complicated than it had been previously supposed;
- Intervals of relatively stable climate were interrupted by rapid (from the geological point of view) changes that in individual cases were of catastrophic nature;
- Drastic climatic variations considerably affect the biosphere as a whole, which in some cases precludes the use of the principle of *uniformitarianism* in the reconstruction of past climates.

A French paleontologist George Cuvier in 1812 in his book *Discours sur les Revolutions de la Surface du Globe* hypothesized that in the past global climatic catastrophes took place from time to time that greatly affected environmental conditions and led to the mass extinction of marine and continental biota. But for a long time, the concept of catastrophism was rejected by many researchers mainly due to the views of Charles Lyell who proposed an actualistic approach to study of the Earth's history. This concept has been accepted by most researchers, although the approach is not universally recognized. There is good reason to believe that the fall of celestrial bodies (asteroids, comets, etc.) on

the Earth and strong volcanic eruptions was the main factors causing mass extinctions.

3. Volcanic explosions and climate

Volcanic eruptions are one of the most violent, effective and stormy manifestations of nature. Millions of people live adjacent to active volcanoes and potential volcanic destruction will always be present in such places.

It has been estimated that during the last 500 years about 240 000 persons lost their lives as a result of the eruptions of more than 500 volcanoes. Some people were killed directly by volcanic eruptions, and others died of starvation because of the destruction of food crops and domestic animals. In addition, some of people were killed by *tsunamis* caused by submarine volcanic eruptions.

In 1815-1816, on the Island Sumatra (Indonesia) some from 66 000 to 92 000 persons lost their lives. In 1902, on the Island of Martinique in the Lesser Antilles, the volcanic eruption almost wholly destroyed the city of St. Pierre and killed about 30 000 people.

3.1 Types of volcanic eruptions

According to B. Bolt and his colleagues (1975) “a volcano is a place where molten rock and/or gas issues from the interior onto the surface of the Earth”. Some volcanoes erupt only once; others erupt many times. The proportion of gas to molten rock issuing at the surface varies widely and the nature of the eruption depends mainly on the scale of gas injection into the atmosphere.

There are two main types of volcanic eruptions in the nature: effusive and explosive. With effusive eruption a mass of liquid easy-fusion lava is outpoured with minimal release of gases into the lower air layer of the troposphere. With an explosive type of eruption an enormous amount of solid and gaseous products are released into the higher layers of the atmosphere, and lava many not be released in any great quantity.

Explosive eruptions are divided into several types:

- An eruption of the *Strombolian* type produces a small amount of microcrystalline matter. The height of the column of ejected material is small, and it falls out in the beginning of the eruption. The area covered by the erupted material is relatively small.
- During an eruption of the *Volcanian* type (the so-called sharp *Strombolian* eruption), a large amount of small dispersion particles is emitted. The column of erupted matter can reach and even penetrate the tropopause. The total volume of released material equals 10^{11} - 10^{15} g. An example of this type of eruption is that of the Agung volcano, Indonesia, in 1963.
- With eruptions of the *Plinian* and the *Ultraplinian* types the column of erupted substance can reach 30 km and more. A large amount of erupted matter rises at a considerable height and scatters over a vast area. The total volume of ejected substance ranges from 0.1 to 50 km^3 (10^3 - 10^{16} g). An example of this type is the Hekla eruption of 1947, in Iceland, when the volume of ejected substance was equal

to 0.18 km^3 and the area of scatter reached 3800 km. The Taupo eruption (in New Zealand, about 186 AD) is an example of the *Ultraplinian* type of eruption, when the total volume of ejected substance was 24 km^3, 80% of which deposited at a distance of 200 km.

- The *Ignimbrite* type of eruption is similar to the *Plinian* one but in this case a lava stream develops converting later into *ignimbrite* or *tufflava* (molten lava). These eruptions produce up to 1000 km^3 of matter and are a significant source of atmospheric dust. The eruptions of this type were those of the Tambora volcano in 1815, Krakatoa in 1883, and Katmai in 1912**.**

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About 80 scientific papers and seven monographs among them:

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