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# THE IMPACT OF VOLCANIC ERUPTIONS ON HUMAN ACTIVITY

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**Abstract:** Altogether about 2500 volcanoes exist on Earth, and during the last 3500 years, 959 of them erupted. About 360 mln. people live in dangerous proximity to actve volcanoes. On average about 50 volcanoes erupt each year. Catastrophic events may result from six volcanic processes, viz. 1) ejection of rock debris; 2) lava flows; 3) ejection of volcanic gases; 4) burning volcanic clouds; 5) volcanic landslides; 6) lahars. Each eruption manifests itself in several volcanic processes, but only one or two of them may prevail. First of all volcanic eruptions are dangerous for the following human activities: 1) transportation; 2) agriculture; 3) communication & electricity transmission lines; 4) residential building. Average annual mortality from them is about 800 persons and economic loss amount to $800-900 million.

**Key-words**: economic loss, environmental significance, mortality, protection measures, volcanic eruptions

## QUANTITY AND DISTRIBUTION OF VOLCANOES

Altogether about 2500 volcanoes exist on Earth, and during the last 3500 years, 959 of them (including 811 surface and 148 underwater ones) erupted (Gutschenko, 1983). Volcanoes are attached to zones of high tectonic mobility. Four main volcanic belts can be picked out (Rezanov, 1984): 1) Pacific (about 70 percent of the volcanoes); 2) Mediterranean-Sunda; 3) Atlantic (mainly on the Azores and Iceland); 4) East - African. Besides, there exist several short belts - West African, Hawaiian etc. About 360 ml. people live in dangerous proximity to acting volcanoes (Course …, 1993). On average about 50 volcanoes erupt each year (Smith, 1992). Quite many monographs are devoted to volcanoes (Bolt et al., 1978; Markhinin, 1988; Waltham, 1982; Blong , 1984; Latter, 1989; Scarpa and Tilling, 1996; Simkin and Siebert, 1994; etc.).

## ELEMENTARY VOLCANIC PROCESSES AND THEIR EFFECT ON HUMAN ACTIVITY

Eight volcanic processes may have catastrophic aftermaths: 1) ejection of debris (bombs, lapilli, sand, ash); 2) volcanic gases; 3) lava; 4) burning volcanic clouds; 5) volcanic landslides; 6) volcanic mudflows (lahars); 7) volcanic floods; 8) tsunamis. Any eruption manifests itself in several processes, still, as a rule,

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prevail only one or two of them. Although the cause of such phenomena as *volcanic floods* and *tsunamis* lies in volcanic activity, these can not be classified as volcanic processes (to some extent it holds true also for lahars and volcanic landslides) and therefore they will not be discussed in this article.

Most eruptions are characterized to some or other extent by *ejection of debris*. Depending on the size of particles, the distance of their flight may range from several kilometers (bombs) to several thousands kilometers (ash). For example, in 1912, Katmai Volcano (Alaska) ejected ash precipitating in California (USA) 4000 km away, the boundary line of ash cloud of Quizapu Volcano (South Chile) ran north of Rio-de-Janeiro, that is 3.5 thousand of kilometers away (Koronovsky, Yasamanov, 2003). The finest ash particles may rise to over 20 km, as it occurred on Krakatau island in 1883 and Saint Helen island in 1980. Their atmospheric lifetime usually lasts for 1-3 years (Fellenberg, 1997).

The most vigorous eruptions, according to the data of Muranov (1994), occurred in 1815 (100 $km^3$, Tambora Volcano in Indonesia), 1912 (20 $km^3$, Katmai on Alaska), 1883 (18 $km^3$, Krakatau in Indonesia). Since the year 1500 volcanoes have ejected 330 $km^3$ of pyroclastic material and 50 $km^3$ of lava to make up 1.0-1.5 $km^3$/year that is about 2 to 3 billion tons (Safianov, 1987). Ejection of pyroclastic material, primarily ash, is extremely destructive for economy. Ash covers everything by continuous layer and penetrates into all vents. It has high abrasive effect, because it consists of sharp and solid finest stone fragments and at the same time is slippery, especially when wet. Air-born ash may overshadow sunlight and reduce visibility to zero. This volcanic effect is dangerous first of all for the following human activities: 1) transportation (first and foremost for aviation- and motor); 2) agriculture; 3) electric transmission and communication lines; 4) residential building.

*Transport* maintenance problems arise, *first*, from hampered movement on ash-covered highways and runways. The *second* complicating factor lies in a drastic increase in friction of machine and motor parts, including compressor and turbine vanes; abrasive impact of ash on protruding surfaces of planes (cockpits, front edges of wings and tail rudder, motor cap, fairing of fore radar, etc.). The *third* problem is a dramatic decline in efficiency of jet engines, up to collapse when ash is sucked in, since the melting volcanic glass contains cover injectors, reducing efficiency of fuel mixing with air coming into engine. At least 7 cases of serious damage to jet engines on flight are known. For example, when flying through ash cloud at the altitude of 11 km during the eruption of Galunggung Volcano in Indonesia, in 1983, the engines of two planes «Boeing - 747» were damaged, which required emergency landing (Bernard, Rose, 1990). *Fourth*, ash may disable energy generator and navigation aids. The *fifth* complicating factor is declining visibility, contributing to originating wrecks and catastrophes. Problem *six* is connected with a considerable specific weight of ash, leading to great mechanical loads. The eruption of Punatubo (Philippines) in June 1991 damaged several planes on nearby US Naval air base. Precipitation of ash on wings and tail unit caused imbalance of mass and led to landing on tail (Fig. no 1). Flying through volcanic ash clouds destroyed engines in three of eleven aircrafts.

**Fig. no 1. Structural damage of the CD-10 airplane at U.S. Naval Air Station in the Philippines.** Photo Credit: R.L.Rieger, made on June 17, 1991.

The impact on **plant cultivation** is due to two main factors: 1) decline in incoming solar radiation; 2) ash settling on agricultural plots. The effect of *factor 1* results in a dramatic yield decrease by cooling and reducing photosynthesis. In Northern Hemisphere the most serious events for plant cultivation were the volcanic eruptions of 1452, 1601, 1641, 1666, 1695, 1698, 1816, 1883 and 1912 (Briffa et al., 1988). *Settling ash* causes the decay of plants or retards their growth by various causes (damage to plants under the weight of ash, chemical injury, lesser input of active photosynthetic radiation).

The impact on **animal husbandry** is connected mainly with poisoning of animals eating ash-contaminated forage. For example, one of the aftermaths of ash precipitation of the Hudson Volcano eruption (Argentine) in 1991 was the death of 1/3 sheep herd on adjoining area (Inbar et. al., 1995). A considerable mortality of horses was also observed during the eruption of Hecla in 1947 and 1970. Fluorine poisoning was lethal cause (Koronovsky, Yasamanov, 2003).

The hazard for **electric transmission lines** is due to an additional load of ash settled on wires and supports. Challenges for **residential building** are also connected with excessive weight of ash on roofs (Fig. no 2), filling up and destruction of gutters, clogging sewage systems, etc. It was settled ash (up to 3 m thick) that ruined Pompeii in 24 April 79 A. D. During the eruption of Pinatubo Volcano (Philippines) in June 1991, ash dropouts decayed appr. 200 people and ousted some 200 thousand men (Myagkov, 1995). The 30-sm thick ash blanket deteriorated certain structures on US Navy air base Clark Field, 16 km away from the volcano.

**Fig. no 2. House damaged by the heavy load of ash that accumulated on its roof during the eruption of Rabaul Caldera in Papua New Guinea on September 19, 1994.** Note the thickness of ash deposits on top of the roof that did not collapse (right side). For a layer of ash about 10 cm thick, the extra load on a building can range 100-125 kg/m$^2$. One of two volcanoes that erupted is visible to the left of the house. Photo Credit: E. Endo, October 1994.

The ash also forms at the expense of dramatic cooling when lava gets into water. For example, during the eruption of Laki Volcano in Iceland (1783), the contact of lava with lake water triggered an explosion, resulting in 0.3 km$^3$ ash spit. All pastures were destroyed, 3/4 livestock perished, poor visibility at sea hampered fishing. Famine killed 10521 people, i. e. about 22 percent country's population (Smith, 1992).

**Volcanic gases** present the chief motive force of explosive eruptions. When magma rises to the earth surface, it immensely increases in volume. For example, 1 m$^3$ of rhyolith magma at temperature 900$^0$C and containing 5 weight per cent of dissolved water at pressure drop to atmospheric can yield up to 670 m$^3$ mixture of mineral particles and water vapour (Sparks et. al., 1997). Most often, volcanic gases are represented by carbon oxide and dioxide and water vapours containing admixtures of hydrogen sulphide, muriatic and hydrofluoric acids, sulphureous and sulphuric oxides. Gases may enter the atmosphere not only via volcanic funnel, but also through cracks and cannals in crater (fumaroles), hydrothermal systems and soil.

Atmospheric pollution with volcanic gases is dangerous for people, vegetation (Fig. no 3) and animals. Volcanic eruption may cause acid rains. The effect on vegetation is connected primarily with acid rains of eruptive origin. For example, in the case of not so strong eruption of El Chichon in Mexico (1982) some 20 million tons of sulphuric acid got into the atmosphere (Vysotsky, 1997). From the point of view of atmosphere pollution by gases, the most famous eruptions are those of Masaya-Nindiri in Nicaragua and Irazu in Costa-Rica. Volcanic activity is the only serious natural source of sulphurious anhydrite (Ramade, 1981).

**Fig. no 3. Rampikes in Mammoth Volcano woodlands, the USA**. The loss of trees in this area was first observed in 1990. Since then about 67 ha of trees had perished. Inspection revealed exceptionally high content of volcanogenic carbon dioxide in the subterranean waters and the soil beneath the trees. Photo Credit: S. R. Brantley, September 12, 1996

Volcanic gases pose certain problems for **air transportation**. For example, after the above-mentioned eruption of El Chichon in 1982 aircraft building companies began to receive complaints on very rapid degradation of cockpit glass which started coating with a net of fine cracks, dramatically deteriorating visibility. The causes lay in overflow crater sulphuric compounds due to abnormally high content of this element in magma of El Chichon volcano. Glass renewal in 1983-84 for Japan Airlines Co alone amounted to 6.8 million dollars (Bernard, Rose, 1990).

**Lava flows** may be caused by rim and issue from crevices on volcano's slope or those directly into the earth. Their chemical composition changes from acid, containing over 65 per cent $SiO_2$ to ultrabasic lavas, having less than 45 per cent silicon oxide. Acid lavas are rhyoliths and dacits, to neutral lavas (53 to 65 per cent $SiO_2$) belong andesites (from Andes mountains in South America), whilst basalt lavas (45 to 53 per cent) provide the most common basalts. Ultrabasic lavas - komatiites (from Komati River) - are not common now, but they had been widespread in Precambrian. Effluent lava temperature is by and large higher in basic lava, basalts - 1000 to $1200^0$C, andesites – 950-$1200^0$C, dacites - 800 to $1100^0$C, rhyoliths - 700 to $900^0$C. Lavas' density is also higher in basalts - 2.6 to 2.8 g/$cm^3$, and lesser in andesites 2.5 g/$cm^3$ and still less in rhyoliths- 2.1 to 2.2 g/$cm^3$ (Koronovsky, Yasamanov, 2003).

The flow rate depends on the following factors: 1) type of lava (basalts flow slower than rhyolites); 2) viscosity (depends on temperature, pressure, chemical composition, phenocrysts and gas bubbles content, etc, the fastest, i. e. least viscous are those hottest with minimum silicon and lava phenocrysts content); 3) slope grade; 4) intensity of flow; 5) the form of jet (a narrow channel or wide layer). The 65 km/h speed on Surtsey island in Iceland is considered world record (Kukal, 1987). The speed of the most viscous lavas equals centimeters per hour. The hazard of flows is stipulated by high lava temperature, often resulting in fires, the huge mass crushing through walls, etc. Liquid lavas can in shortest possible times pour down large areas. For recorded history, the most powerful lava flow was reported from Iceland in 1783, when 12 $km^3$ lava flew from 25 km long Laki crevice and covered a territory of 560 $km^2$ (Waltham, 1982). Note that Iceland is the largest isolated land plot of entirely volcanic origin. Its volcanoes have produced nearly the fourth of world's lava, spilled on land during 1945-1985 (Kennett, 1987). Recurrent lava flows of Vesuvius (1872, 1906, 1944) and Etna (1669, 1928) brought heavy losses. Lava flows are most dangerous to residential building (Fig. no 4), highways (Fig. no 5), power and transmission lines etc. The immediate death of people is very rare because of low flow rate and negligible range. The loss of about 600 men under lava flows during the 1917 Nyiragondo Volcano eruption, provides an extreme case (Tanguy et al., 1998).

**The burning volcanic clouds** are a mix of volcanic gases with tephra. The inner temperature attains 700 to $1000^0$C, that is why in spite of short duration of effect, they usually result in death due to burns and suffocation. Apart from high temperature, causing fires, their demolishing effect results from enormous pressure on edifices' walls due to considerable density and speed of displacement (Fig. no 6). The most well-known example of this kind is May 8, 1902 eruption of Mont Pele Volcano on Martinica, when for two minutes the burning cloud passed at a speed of 140 to 170 m/s (500 to 630 km/h) across Saint-Pierre City, lying 8 km away from the volcano. The temperature of burning cloud was about $900^0$C at the crater and 200 to $400^0$C when getting to Saint-Pierre. The town was completely destroyed and all citizens (27-28 thousand people) perished except for one or, perhaps, two men (Tanguy, 1994).

**Volcanic landslides** provide a special case of common landslides, differing in that their motion entangles mountain rocks, piroclastic material and soils of volcanic origin. They may be very big in size. For example, Saint Helens landslide that descended in May 18, 1980, measured 2.5 $km^3$ in volume, advanced at a speed of 50 to 80 m/s (180 to 228 km/h) and formed a ridge over 400 m high 5 km away. Volcanic landslides block river valleys and, by that, form dams and make lakes. They produce waves and tsunamis in lakes and oceans; generate lahars. A large landslide occurred on May 21, 1792 at the slope of Mayuyama Volcano (Kyushu, Japan). Total number of those perished due to the landslide and tsunami has made 15 thousand people (Siebert, 1984).

**Volcanic mudflows (lahars)** are essentially a specific case of mudflows. They form when thick ash layers slip from volcanoes' sides. It is especially dangerous if ash is soaked with water. Lahars affect the following human activities: 1) plant growing, 2) residential building, 3) transportation, etc. The 1919 catastrophe on the Kelut Volcano slope (Java) provides a well-known example of the *first kind*. Lahars dispatched 5.5 thousand people and annihilated 200 $km^2$ of farm land (Bolt et al., 1978; Smith, 1992). Their impact on *residential building* was the demolition of buildings and structures by direct impact of the moving mass and burial with rock debris (Fig. no 7). On that August Day 79 A. D., when Pompeii was buried with ash, a small town Herculanium, situated on the coast of Bay of Naples, off the eastern Vesuvius Foot, was buried under 20 m thick mudstone bed, brought by lahar, having been formed by heavy rains, onto Volcano slops (Vinogradov, 1980). The effect on *transportation* is first and foremost the destruction of automobile and railway bridges. Impact of volcanic eruptions on human activity is systematized in table.

**Fig. no 4. This house caught fire after having contact with lava during the Mauna Loa volcano eruption, the Hawaiian Islands**. USA on May 3, 1990. Photo Credit: D. Weisel, U.S. Geological Survey

**Fig. no 5. Lava blocking the highway No 130 on the South-Western coast of the Hawaii Island, the USA on February 23, 1990**. During multiple eruptions of Kilou volcano in the period of 1983-1998, lava flows blocked nearly 13 km of the highway to the depth of about 25 m. The total buried territory was 99.7 $km^2$. Photo Credit: J. D. Griggs, Hawaiian Volcano Observatory, U.S. Geological Survey, June 6, 1987

**Fig. no 6. Burning volcanic clouds are a mixture of volcanic gases and tephra**. Their destructive effect is determined by high temperature that leads to fires, and by high pressure due to considerable thickness of clouds and high speed of their displacement. This photo shows the ruins of a house in the village of Francisco Leon destroyed by the burning volcanic cloud during the El Chichon volcano eruption, South-Eastern Mexico from March 29 to April 4, 1982. The reinforcing concrete bars in the ferroconcrete wall are bended in the direction of the burning cloud movement. Several clouds of this kind moved in different directions from the volcano from 2 to 8 km. Besides the village of Francisco Leon situated 5 km from the volcano, 8 more villages were destroyed. More than 2,000 persons. Photo Credit: R. I. Tilling, June 1, 1982

**Fig. no 7. Volcanic mudflows (lahars) appear when the water-sodden ash glides down volcanic slopes.** The photo shows the lahar-buried school after the eruption Pinatubo volcano, Philippines which started in June 15, 1991. As thousands other buildings this school was damaged. Photo Credit: T. Pierson, October 12, 1991

Table no. 1.

**IMPACT OF VOLCANIC ERUPTIONS ON HUMAN ACTIVITIES**

| Main objects | Type of impact | Consequences | Mitigation measures |
|---|---|---|---|
| Settlements, transportation, electric transmission lines | Static and dynamic impact due to precipitation of ash and bombardment by debris | Damage to and demolition of buildings and structures due to additional load | Removal of ash from roofs, electric transmission line supports, and means of transportation; use of protective clothing |
| Water supply | Burial of water supply sources with ash, washout of chemical substances from eruption products | Deterioration of quality of potable and technical water, irregularities in water supply | Additional purification of water, closing reservoirs with potable water. etc. |
| Plant cultivation | Decrease in incoming solar radiation due to ash ejects | Reduced crop yield due to cooling and decline in photosynthesis activity | Import of crops from other regions |
| Plant cultivation | Mechanical, thermal and chemical effect of pyroclastic material | Downfall and loss of plants due to chemical burns, damage under load of ash | Import of crops from other regions |
| Pasture cattle-breeding | Effect on gastrointestinal tract of animals when fed polluted forage | Death and diseases of animals due to irritation of mucous membrane, poisoning | Cleaning of forage, forage import flows from other regions |
| Motor transport | Ash clogging of air filters, increased friction of movable parts | Damage, due to high abrasive properties of ash, to bearings, brakes and transmission lines, breakdowns of filters | Limitation of trips during ash fallouts, clearing roads, vehicle repair |
| Air and motor transport | Ash scurf on highways and runways | Problems with takeoff, landing and driving due to mechanical obstacle, accidents due to increased slipperiness | Clearing of roads and runways, cancel of flights and trips |
| Air transport | Abrasive effect of ash on protruding parts of the plane | Damage to cockpits, leading edges, fairings of fore radar, rudders, etc. | Avoiding ash clouds by climbs, fly-rounds (buzzing) or flight cancels; repairs |

| | | | |
|---|---|---|---|
| Air transport | Covering of sprayers with melting volcanic ash when ash is sucked into turbine | Reducing of engine performance index due to fuel and air mixing deterioration | Avoiding ash clouds by climbs, fly-rounds or flight cancels |
| Air transport | Forming of acidic conducting film of moistened ash on elec-tric diagrams' surfaces | Deactivating of electric generators and naviga-tion aids due to short circuits in contacts | Avoiding ash clouds by climbs, fly-rounds or flight cancels |
| Animal husbandry, plant cultivating, forest and wood-working industries, people | Effect of volcanic gases | Death of people and stock, due to suffocation, damage of plants as a result of acid rains | Use of respirators, powdering plants with lime to neutralize acids, building of gas lines to divert gas from crater and its subsequent use |
| Air transport | Interaction of volcanic gases with condensate on glass surface | Damage of acryl glass in cockpit, drastically decreasing visibility | Replacement of glass |
| Settlements, croplands, roads, transmission and communication lines | Thermal and mechanical effect of lava flows on structures | Demolition of settlements, crops, death of people, blocking of highways and railways | Diversion of lava-streams by artificial chutes, erecting protective dams, bombing of craters, cooling lava surface with water |
| Industrial objects, residential buildings, people | Effect of burning volca-nic clouds (mixture of incandescent gases and tephra) | Death of people due to burns and suffocation, destruction of structures by fires and gas pressure | Perfection of forecast, timely evacuation |
| Settlements, croplands, roads | Dynamic and static effect of volcanic mud flows (lahars) | Destruction of crop due to its burial, destruction of buildings by dynamic shock, death of people and livestock | Cutting-though tunnels for crater lake surface lowering, construction of dams, chutes, timely evacuation |
| Construction materials industry | Ash fallout | Use of ash to produce light-weight porous concrete filling agents | |
| Residential buildings, plant cultivating | Water accumulation in extinct volcano craters in rainy periods | Use of water for potable water supply, irrigation, etc. | Pasting crater bottom and sides with special plastic |

| | | | |
|---|---|---|---|
| Astronomy | Noise extinguishing by extinct volcano craters' walls | Use of craters as radio telescope sites | |
| Residential building, industries | Hollows in volcanic craters | Use of extinct volcano craters for waste products storage | |
| Plant cultivating | Soil enrichment with mineral elements con-tained in volcanic ash | Raising of crop yield, acceleration of trees' growth | |

## UNDERWATER ERUPTIONS

Not infrequently underwater volcanic eruptions happen. On the ocean bottom, volcanoes form when lava flows through cracks in the Earth's crust at a depth of three to five kilometers. They grow gradually; still, 90 per cent of underwater volcanoes lose their vigor long before they emerge on the surface. Those reaching the surface usually cease to grow under the effect of abrasion since in most cases they eject readily destructible materials: ash and slag. For example, in Tonga archipelago, after eruptions, there reemerged Falcon island, but each time it turned into the underwater shoal. When lava is poured out, stone island form, more resistant to abrasion. For example, Hawaiian Islands and Iceland have been formed by confluence of several volcanoes (Encyclopedia … 1983). Underwater eruptions seldom affect human activities. A rare example of such effect is the explosion of underwater volcano off the reef Maidjin, which took place in October 1952. The Japanese oceanographic vessel Kaymaru, lying nearby, was overturned by a wave and sank down (Mezentsev, 1988).

## MUD VOLCANOES

**Mud volcanoes** deserve a special notice. The distribution of mud volcanoes shows their clear-cut connection with tectonically active regions. Over 50 per cent of known mud volcanoes are concentrated on Apsheron (world-largest), Kerch and Taman Peninsulas (Natural Hazards …, V. 2, 2000). Sakhalin Island, Italy, Spain, New Zealand, several countries of Central America are other areas of their range. Also, mud volcanoes occur in Romania, Pakistan, Turkmenistan, Indonesia, Myanmar, Albania etc. Mud volcanism occupies a rather modest place among dangerous and especially the catastrophic natural processes. Nevertheless, cases of catastrophic aftermaths of eruptions of mud volcanoes are known. In 1902, shepherds drove their flock of sheep for a night into the crater of mud volcano Bozdag-Gezdets near Baku (Azerbaijan). However, it was this night that this volcano, considered the extinct one, erupted. Ignited gases and powerful stream of black mud took both shepherds and their sheep unawares (Mesentsev, 1988). Sometimes there occur eruptions of underwater mud volcanoes. For example, on February 25, 1953 the old mountain Buzovninskaya Sopka (mud volcano) erupted on NE coast of Apsheron Peninsula four kilometers inshore. About 60 to 70 thousand tons of rock emerged from the earth's bowels which originated an island approx. 70 m across. The island had existed ten days and later on it was washed away by waves. The study of mud volcanoes is needed even as indicators of prospective oil- and gas- bearing territories (Natural Hazards …, V.2, 2000).

## MORTALITY AND ECONOMIC LOSS

As to the loss of people caused by different volcanic processes and volcanic eruptions as a whole, there exists a lot of data, often rather controversial. It stipulates the need to critically distinguish between many publications with different extent of reliability. In many countries reliable statistics of population number prior to and after a catastrophe was absent and determination of the number of victims was approximate. Another complexity lies in that earlier mistakes are repeated afterwards by various authors. The most reliable and well-grounded appears an article by J. Tanguy et. al. (1998), where they analyze mortality due to volcanic eruptions, starting from 1783. According to the data, during this period volcanic activity has claim 220 thousand human lives, accounting for 90 per cent of the deaths registered in human history (associated with volcanoes). Most deaths were caused by subsequent famine or epidemics (30.3 per cent), burning volcanic clouds (26.8 per cent), lahars (17.1 per cent), and volcanic tsunamis (16.9 per cent). In present average annual mortality from them is about 800 persons and economic loss amount $800-900 million (Govorushko, 2003).

## PROTECTION MEASURES

From times immemorial, people used various ways of protection from volcanic activity. To avoid danger they had dug a canal on Etna slope and made a barrier to form a new lava course. On the slope of Kelut Volcano (Java), in 1905, they erected a dam for protection from lahars. As early as 500 years back, in North America close to Rainieir Volcano, a reservoir was built to prevent the progress of lava streams. On Vesuvian slopes farmers had constructed low stone walls against mudflows (Suprunenko, 1999). A more modern way is air bombing capable of destroying volcano cone walls around the vent for the lava to flow in required direction. This method was, in particular, used to change the direction of lava stream during the eruption of Mauna-Loa Volcano near town Hilo on Hawaiian Islands (Rust, 1982). Rinsing lava streams with water as a means of protection has been practiced since long. In this case lava's viscosity increases and lava stops. It was exactly this method that was used to stop lava stream during the eruption on Heimaey Island (Iceland) in 1973 (Suprunenko, 1999).

## UTILITY OF VOLCANOES

Apart from numerous problems for human activities, people may benefit from volcanoes, too. Extinct volcanoes provide a favorable site for installation of *radio telescopes*, because crater walls extinguish radio noise. The world largest parabolic radio telescope (mirror diameter 305 m, area 7.4 hectares) was erected about 30 years ago in the crater of extinct Volcano Aresibo on Puerto-Rico Island. The highest mountainous Canadian-Franco-American radio telescope was established in the crater of the extinct Mauna-Kea Volcano at a height of 4179 m. Volcanic craters are also used as *water storage tanks* to accumulate water in the period of rains. To prevent water soaking inside the mountain, the crater is covered with a special plastic. Such reservoir, 822 thousand $m^3$, was made on Tenerife Island, Canary Archipelago (Suprunenko, 1999). Extinct volcano near Granada Town (Nicaragua) has been used for 20 years for *storing industrial and domestic waste* for the entire region (Krantz, 2003). Often, volcanic ash is used to manufacture *construction materials*. For example, a considerable portion of ash, precipitated in 1973 during the eruption on Icelandic island Heimaey, has been exported to Norway to produce light porous concrete fillers (Suprunenko, 1999).

## ENVIRONMENTAL IMPORTANCE

Volcanic eruptions are of great environmental significance. Ejection of rock debris ash is the most important in this regard. The significance of volcanic ash as *fertilizer* is tremendous. In tropical areas, heavy rains in combination with intensive weathering in a short time lead to the formation of lean leached laterite soils; volcanic eruptions reduce their composition. Ashes contain large amount of mineral substances. For example, during only one day, i. e., March 30, 1956, during eruption of Bezymyanny Volcano (Kamchatka peninsula), ejected ash contained 450 thousand tons of nitrogen, 80 thousand tons of potassium, 36 thousand tons of magnesium, 35 thousand tons of calcium. Ash rejects tell beneficially on crops yields (Markhinin, 1988).

Volcanic ash affects positively the *bioproductivity of water reservoirs*. First, there occurs a sharp outburst in numbers of phyto- and zooplankton, later on - of algae, fishes and mammals. Distribution analysis of biogenic elements in surface ocean water attests that the most productive belts either join the areas of active volcanoes or are connected with the latter by sea currents or atmospheric circulation (Markhinin, 1988).

In some cases volcanic eruptions cause negative effects. Lower atmospheric transparency causes *cooling*. The *effect on insects* is also of importance. The topmost layer of their integument, a so-called wax layer, prevents the body cavity from the loss of moisture. Ash, coming upon, erases wax layer, due to high abrasive to result in dessication and decay of insects. Ash-provoked mass decay of entomophauna in Eastern Washington (USA) took place after the eruption of Saint Helens Volcano in 1980 (Berryman, 1990).

The effect on *ichthyophauna* is also significant. Ash fallouts and subsequent lahars occurring after the selfsame eruption, have led to covering salmon spawning grounds with ash layer on Toutle River, to a change in salinity and suspension content in water of Columbia River which rendered a significant negative effect on invertebrate animals and fishes (Neshyba, 1991).

Photographs and table combine to reflect various aspects of effect of volcanic eruptions on human activities.

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