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The Prevention of Eruptions for Underwater Kikai Caldera

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Abstract: ***This article describes a proposal of a system for prevention of eruptions of underwater volcanoes (SPEUV) based on physical model and a developed energy models of volcanoes. The proposal includes description of business project. Based on the proposed model, (SPEUV) parameters estimates are made for underwater volcano Kikai Caldera. SPEUV allows generating a large amount of clean electricity. The proposed SPEUV is a scientific and technological breakthrough that can save majority of Japan citizens from death. This paper presents information for researchers, government of Japan and companies about creating SPEUV.***

Keywords: prevention of underwater volcano eruptions, energy model, super-volcanoes, volcanoes

1. Introduction

Volcanic activity of the Earth is increasing and the messages below support this statement. The European Science Foundation published a report on 08.04.2015: "Extreme Geohazards: Reducing the Disaster Risk and Increasing Resilience" in which its scientists Plag H.P., *et all* (2015) “announced that an eruption of one of its super volcanoes will take place in the 21st century on the territory of the Earth; the probability of such an event is 5–10%.” What paradigm of saving the population from volcanic eruptions now exists? Only one method of protecting the population is practiced (there were no other methods): volcano monitoring, and then urgent evacuation of citizens. The buildings and infrastructure of cities and towns are being destroyed. This paradigm works for small volcanoes. For super-volcanoes (for example, Campi Flegrei), this paradigm requires the resettlement of Europe's population to Africa.Another paradigm was proposed in (Noppe M.G., 2018). Supposed proposal of a system for prevention of eruptions of volcanoes (SPEV) consists of geothermal and gas power plants, as well as systems for the removal of explosive volcanic gases. The article includes a description of the business project and allows to calculate the required number of power plants based on the energy model. Cited paper informs about SPEVs for two groups of volcanoes: 1) super calderas Yellowstone, Caldera Long Valley (USA) and Campi Flegrei (Italy); 2) small volcanoes: Vesuvius, Ruapehu, Popocatépetl and Etna. The relevance of third group of systems for prevention of eruptions of volcanoes: for underwater volcano is substantiated in (Tatsumi, Y. & Suzuki-Kamata, K. 2014): “Finally we show that there is a 1% probability of a catastrophic eruption in the next 100 years based on the eruption records for the last 120 ky. Although we are unable to identify exactly which volcano will cause such a catastrophic eruption in the future, we think it is likely to be located in central Kyushu (Kikai Caldera). The reasons for this are twofold: (i) catastrophic caldera-forming eruptions have occurred repeatedly (seven times in the last 120 ky) in Kyushu Island, (ii) as tephra distribution is strongly influenced by the prevailing wind, which in Japan is from the west, an eruption on Kyushu would be the worst case scenario for disruption from the tephra in the most densely populated regions in Japan to the east. Ignimbrite and ash fall thicker than 50 cm will cause immense disruption, leading to the areas affected being abandoned and mass migration. Currently 40 million people live in the areas that we predict would be covered by such thick amounts of ash and ignimbrites. Where ash fall is less than 50 cm but thicker than 20 cm, all utilities and transport will stop completely; we predict this would affect a further 70 million people.“ Our article is devoted to the creation of a system for prevention of eruptions of underwater volcanoes (SPEUV) for third group of volcanoes: for underwater *volcano* Kikai Caldera. Thus, the increased volcanic activity of the Earth makes the development of (SPEUV) extremely urgent. The proposed SPEUV is a scientific and technological breakthrough that can save majority of Japan citizens from death.

2. The Underwater Kikai Caldera

Kikai Caldera is a massive, mostly submerged caldera up to 19 kilometres in diameter in the Ōsumi Islands of Kagoshima Prefecture, Japan. It is the remains of the ancient eruption of a gigantic volcano (Kikai Caldera, Wikipedia). Multi functional research surveys of the T/S Fukae Maru in this caldera, including multi-beam echosounder mapping, remotely operated vehicle observation, multi-channel seismic reflection survey, and rock sampling by dredging and diving, provided lines of evidence for creation of a giant rhyolite lava dome (~32 km^3) after the caldera collapse. This dome is still active as water column anomalies accompanied by bubbling from its surface are observed. The diameter of the dome reached 10 kilometers, the height - 600 meters. Its peak is only 30 meters from the surface of the ocean. The dome pulls out boiling water, bubbles with volcanic gases and continues to grow (Tatsumi, Y. *et all*, 2018). Various hydrothermal manifestations are observed both on and off-shore, including high (>800°C) and low temperature fumaroles, hot springs and gas bubbling (Fauré, E. *et all*, 2002). We propose mechanisms and measures to prevent underwater volcanic eruptions in the next section.

3. Mechanisms for Preventing Volcanic Eruptions for Underwater Volcanoes

To clarify the physics of the present measures and mechanisms of SPEUV, in this section we will present a number of provisions of Gilat A. and Vol A. theory (Gilat A. and Vol A., 2005), (Gilat A. and Vol A., 2012). During the Earth's accretion period, primordial hydrogen and helium, comprising 98%–99% of space matter, were trapped and stored in the Earth's core and mantle as a solid and liquid solutions and chemical compounds, with help of endothermic reactions. Since the stabilization of the planet, the energy expended on the capture of H and He is quasi-continuously released by the exothermic reactions of degassing of the Earth. The resulting heat and continuous explosions produce all manifestations of magmatic activity in general and volcanic eruptions in particular. Analyses of gases from fresh lavas of Kamchatka volcanoes made by I.I. Glustchenko show that primary explosive gases uncontaminated by meteoric water and air (H_2, Cl_2, CO, OH, F_2, Br_2, H_2S, CH_4) comprise 10%–70% of total volcanic gases. Gases, saturated with energy, form passages for magma into magmatic chambers, break through fragile rocks and supply energy for volcanic eruptions. Basing on the theory of Gilat A. and Vol A. we describe the proposed mechanisms for preventing volcanic eruptions, which altogether represent the system for prevention of eruptions underwater volcanoes (SPEUV). We propose to lower the pipe above the top of the underwater volcano into an area with a high temperature (t> 800 ° C) for underwater volcano (Fauré, E. et all, 2002) and pumping boiling water with a shallow depth of about 30m onto the platform or barge on which is located a geothermal power plant (PP). To use the mass of explosive gases in the water, we recommend removing volcanic gases from water pumped back into the casing by using the System for the Removal of Volcanic Gases (SRVG) from water. The basis of SRVG can be membrane degassing of water. Industrial equipment for membrane degassing of water under the brand Liqui - Cel is manufactured by the corporation Polypore International, Inc. Thus, the mass of the explosive gas with SRVG, located on the geothermal PP, use to get new energy in the gas PP. Thus, we propose to use [the geothermal PP+SRVG+the gas PP] system, which we call the system for prevention of eruptions of underwater volcanoes (SPEUV). We listed above the proposed mechanisms and measures to prevent volcanic eruptions, which will be used in SPEUV for Kikai Caldera in the next section.

4. Estimation of SPEUV parameters for Kikai Caldera

We will evaluate the SPEUV parameters of Kikai Caldera in this section basing on (Noppe M., 2018). We assume that the eruption will occur in 2090, then

$$T_2 = 2090\text{-}1934 = 156 \text{ years.} \quad (1)$$

Table 1

	VEI	Q_0(J)
Krakatoa, 1883	6	10^{19}
Tambora,1815	7	10^{20}

Parameters of Volcanic Explosivity Index VEI and energy of eruptions Q_0(J) of Krakatoa 1883 and Tambora 1815 are presented in Table 1. In the first column of Table 1 presents information about the name of volcano. The second column shows VEI. The third column presents energy of eruptions Q_0(J). We describe a thermal energy Q_0 (J) by the formula

$$Q_0(J)=10^{VEI+13} (J). \quad (2)$$

We estimate the Volcanic Explosivity Index VEI of Kikai caldera as VEI = 6.1. Then, using (1), we obtain $Q_0(J)= 10^{19.1}$ (J). We estimate a total rate of thermal energy in the system with help of q_e:

$$q_e= Q_0(J)/T_2=10^{19.1} (J)/156year=2559 \text{ MW} \quad (3)$$

Thermal energy in the system with use N PPs increases at a rate of q_{es} (see (3b) and (5) in (Noppe M., 2018)). In order to cool the system, we need

$$q_{es}= q_{em} -N\, M_1/E_f <0, \quad (4)$$

where M_1 is the power of PP, we will consider M_1 = 140 MW - the power of the Olkaria IV geothermal power plant in Kenya (Ullman G. (2014)); E_f is efficiency of the binary geothermal PP; we assume E_f =0.3, see Fig.10 in (Moon, Zarrouk, 2012). The minimum number of PPs N_0 needed to meet the requirement (4) is equal to

$$N_0 = E_F\, Q_0/T_1M_1=[5,48]+1=6. \quad (5)$$

The sold capacity of all PPs equals to MS

$$M_S=N\, M_1. \quad (6)$$

If we put the cost of one PP equal to S1 (we will take S1 = $ 126 million); it is the cost of geothermal power plant. Olkaria IV in Kenya), then the cost of all PPs is equal to

$$S=N\, S_1. \quad (7)$$

Selling electricity to consumers at C0 = 0.078 dollars per kW*h, the annual income will be equal to

$$S_Y= C_0\, M_S\, (8760 \text{ H/YEAR}). \quad (8)$$

Payback period of N PPs will be equal to

$$T= S/S_Y. \quad (9)$$

The results of SPEUV parameter calculations for three variants: 1st option (strict requirements, N=10), 2nd option (moderate requirements, N=8), 3rd option (weak requirements, N=6).

Table 2: Results of calculation of SPUEV parameters for Kikai volcano

1	2	3	4	5	6	7
K	N	q_{es}(MW)	M_S (MW)	S_y (billion dollars/year)	S (billion dollars)	T (years)
1	10	- 2108	1400	0.956	1.26	1.32
2	8	-1174	1120	0.755	1.008	1.32
3	6	- 241	840	0.574	0.756	1.32

In the first column of Table 2 K indicates the number of the option. The second column presents information about the number N of PPs. The third column presents information about the rate qes(MW) of thermal energy in the system {Earth's crust and magma chamber}. The fourth column shows MS, which is equal to the sold capacity of all PPs.

The 5th column presents Sy, which is the annual income. The 6th column shows S, which is the cost of all PPs. The 7th column presents T, which is the payback period of all PPs. Table 2 shows the results of calculations for the cost of PPs. The cost of [SRVG+the gas PP+(annual income of gas PP)] is unknown.

5. Discussion

The super volcano Campi Flegrei (Italy) is caldera, lying mostly underwater, including the Gulf of Pozzuoli. Therefore, in the Gulf of Pozzuoli, the existence of a giant lava dome is possible, similar to Kikai Caldera. Therefore, it is necessary to study the Gulf of Pozzuoli similar to the study of Kikai Caldera.

6. Conclusions

6.1 Based on physical models, the mechanisms for a underwater volcanic eruption prevention system (SPEUV) are proposed as: [the geothermal PP+SRVG+the gas PP] system.

6.2 SPEUV allows generating a large amount of clean electricity.

6.3 This article describes a proposal of a system for prevention of eruptions of underwater volcanoes (SPEUV) based on physical models and a developed energy models of volcanoes. The proposal includes description of business project. Based on the proposed model, (SPEUV) parameters estimates are made for underwater volcano Kikai Caldera. The proposed SPEUV is a scientific and technological breakthrough that can save majority of Japan citizens from death. This paper presents interesting information for researchers, government of Japan and companies about creating SPEUV.

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Author Profile

M.G. Noppe graduated from Novosibirsk State University, Department of Physics (at 1971). Ph.D., specialty is a geophysicist (at 1979); supervisor was academician M.M. Lavrentiev. M.G. Noppe has Academic Status - Associate Professor in Department of Applied and Theoretical Physics of Novosibirsk State Technical University. He is Senior Member of IEEE. M.G. Noppe proposed and uses a new paradigm to prevent volcanic eruptions. This proposal can save majority of humanity from death due to "volcanic winter" - the climate change during eruption of super-volcanoes (Yellowstone (USA), Campi Flegrei (Italia), Long Valley(USA)); of underwater volcano Kikai Caldera and will prevent human casualties and material losses from the eruption of small volcanoes (Vesuvius, Ruapehu, Popocatépetl, Etna and other).