

How volcanoes explode in the deep sea

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Most volcanic eruptions take place unseen at the bottom of the world's oceans. In recent years, oceanography has shown that this submarine volcanism not only deposits lava but also ejects large amounts of volcanic ash.

"So even under layers of [water](#) kilometers thick, which exert great pressure and thus prevent effective degassing, there must be mechanisms that lead to an 'explosive' disintegration of magma," says Professor Bernd Zimanowski, head of the Physical-Volcanological Laboratory of Julius-Maximilians-Universität (JMU) Würzburg in Bavaria, Germany.

Publication of an international research group

An international research group led by Professors James White (New Zealand), Pierfrancesco Dellino (Italy) and Bernd Zimanowski (JMU) has now demonstrated such a mechanism for the first time. The results have been published in the journal *Nature Geoscience*.

The lead author is Dr. Tobias Dürig from the University of Iceland, a JMU alumnus and former Röntgen Award winner of the JMU Institute of

Physics. Before he went to Iceland, Dürig was a member of the research groups of Professor Zimanowski and Professor White.

Diving robot sent to a depth of 1,000 meters

The team did research at the Havre Seamount volcano lying northwest of New Zealand at a depth of about 1,000 meters below the sea surface. This volcano erupted in 2012, and the scientific community became aware of it.

The [eruption](#) created a floating carpet of pumice particles that expanded to about 400 square kilometers—roughly the size of the city of Vienna. Now a diving robot was used to examine the ash deposits on the seabed. From the [observational data](#) the group of James White detected more than 100 million cubic meters of volcanic ash.

The diving robot also took samples from the seafloor, which were then used in joint experimental studies in the Physical-Volcanological Laboratory of JMU.

Experiments in the Physical-Volcanological Laboratory

"We melted the material and brought it into contact with water under various conditions. Under certain conditions, explosive reactions occurred which led to the formation of artificial volcanic ash," explains Bernd Zimanowski. The comparison of this ash with the natural samples showed that processes in the laboratory must have been similar to those that took place at a depth of 1,000 meters on the sea floor.

Zimanowski describes the decisive experiments: "In the process, the molten material was placed under a layer of water in a crucible with a diameter of ten centimeters and then deformed with an intensity that can also be expected when magma emerges from the sea floor. Cracks are formed and water shoots abruptly into the vacuum created. The water then expands explosively. Finally, particles and

water are ejected explosively. We lead them through an U-shaped tube into a water basin to simulate the cooling situation under water." The particles created in this way, the 'artificial volcanic ash,' corresponded in shape, size and composition to the natural ash.

Possible effects on the climate

"With these results, we now have a much better understanding of how explosive [volcanic eruptions](#) are possible under water," says the JMU professor. Further investigations should also show whether underwater volcanic explosions could possibly have an effect on the climate.

"With submarine lava eruptions, it takes a quite long time for the heat of the lava to be transferred to the water. In explosive eruptions, however, the magma is broken up into tiny particles. This may create heat pulses so strong that the thermal equilibrium currents in the oceans are disrupted locally or even globally." And those very currents have an important impact on the global climate.

Info Box: Volcanoes on the ocean floor

There are around 1,900 active volcanoes on land or as islands. The number of submarine volcanoes is estimated to be much higher. Exact numbers are not known because the deep sea is largely unexplored. Accordingly, most submarine volcanic eruptions go unnoticed. Submarine volcanoes grow slowly upwards by recurring eruptions. When they reach the water surface, they become volcanic islands—like the active Stromboli near Sicily or some of the Canary Islands.

More information: Deep-sea eruptions boosted by induced fuel–coolant explosions, *Nature Geoscience* (2020). [DOI: 10.1038/s41561-020-0603-4](#) , www.nature.com/articles/s41561-020-0603-4

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