

Popcorn explosion experiment - Materials for disaster education for sudden steam eruption -

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Steam eruption is the most frequently occurring eruption. Like the Kusatsu Shirane Mountain in January 2018, steam eruption occurs suddenly. Therefore, disaster prevention education at the time of non-eruption is important. It is necessary to know that steam eruption accompanies explosion, stone will fly, and be able to respond flexibly in case of emergency.

Mechanism of steam eruption: Steam eruption is an eruption that is generated by rapidly decompressing hot water into steam due to sudden depressurization of pressurized hot water existing in the subsurface shallow (Oikawa, 2014). Pressurized hot water can be in a state higher than 100 °C. For example, under the condition of 10 atm, water and water vapor coexist at about 180 °C. When such high temperature hot water is decompressed due to the movement to a shallow place or the destruction of the wall of the pool of hot water, the hot water will be in a heating state and boiling will occur suddenly leading to an explosion (Taniguchi, 1996, Kitagawa, 1980).

Characteristics as a disaster of steam eruption: Since the explosion of steam eruption occurs in the shallow part of the volcanic body, the surrounding rocks are released at high speed and fly in a ballistic trajectory. In the case of the Ontakeyama 2014 eruption, the release velocity of the boulders is estimated to be 145 to 185 m / s and the landing speed is estimated to be 83 to 85 m / s (Tsunematsu et al., 2014). Due to such high velocity trajectory rock mass, 63 dead and missing people occurred in Ontakeyama eruption 2014, one death occurred in 2018 eruption of Kusatsu Shirane volcano. Also, it is hot water that generates water vapor eruption, and it is difficult to detect its movement rather than magma.

Volcanic eruption and eruption warning level: Eruption of 2014 in Mt. Ontake and eruption of Kusatsu Shirane Volcano 2018 caused eruption in the state of the eruption warning level 1 of Japan Meteorological Agency, and thereafter the eruption warning level was raised.

Emergency evacuation from steam eruption: In view of the failure history of the two eruption predictions of the Meteorological Agency on the steam eruption, a sudden steam eruption that fails to predict may occur in future. Therefore, it is necessary to prepare a disaster education curriculum teaching the method of emergency evacuation from steam eruption.

Explosion of steam eruption and similarity of popcorn explosion: Popcorn explosion occurs by the same mechanism as that of steam eruption. When the cone is heated, a part of the water inside the cone becomes water vapor, but the peel of the original cone of popcorn is strong and the internal temperature pressure rises to 180 °C, 10 bar (= about 10 atm). With this pressure, the pericarp is ruined, the interior of the cone is rapidly depressurized, and the water in the endosperm is rapidly evaporated to form a popcorn (Virot & Ponomarenko, 2015). The explosion of popcorn and steam eruption is consistent in that the pressure container breaks and overheated water explodes. The water contained in a piece of popcorn is 0.02 g, and this experiment is safe. In addition, popcorn is an attractive Kitchen Volcano Experiment for elementary school students, and there is a high possibility that the educational effect will be enhanced due to the synergistic effect with the unexpectedness of experimental materials.

Disaster prevention education curriculum of steam eruption: We developed a trajectory of ballistic trajectory with explosion and taught that stone will fly, and developed a disaster education curriculum to teach the method of emergency evacuation from steam eruption. First, make popcorn with hot plate and feel the energy of explosion of hot water. At this time, since the explosion is much different in scale than

the actual eruption (probably 1 / 1,000 million or less), the explanation is made using the fact that the difference between "elephant and ant body weight" is about 1 billion times . Secondly, we will perform a puddle experiment using paper clay to understand the stone that flying in a ballistic trajectory (Hayashi, 2014). On top of that, let the students think about the way of emergency evacuation.

Teaching practice at elementary school: On February 9, 2018, we tried this curriculum at H elementary school in the Oga Peninsula ·Ogata geopark. The results are currently being analyzed and will be stated at the time of presentation.

Keywords: disaster education, steam eruption, popcorn, Kitchen volcano experiment