

New Discovery of Geo-heritage in Wudalianchi UNESCO Global Geopark, China



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Abstract: The Wudalianchi UNESCO Global Geopark, known as the “Natural Volcano Museum”, preserves the complete and well-formed volcanic geo-heritage and protects a high level of geological and geomorphology value with spectacular lava landforms and structures. The Laoheishan and Huoshaoshan volcanoes of the Laoheishan scenic area are one of the latest active volcanoes in China with detailed historical records (erupted in 1719~1721 CE and 1776 CE) and extremely high scientific and aesthetic value, which geo-heritages, such as volcanic craters, aa lava, stone river, dribble cones, dribble dish and other volcanic, are typical and even rare in the world. A large number of investigations and studies have been conducted on the eruption characteristics and mechanism of the geopark, laying a good foundation for the planning and management of Wudalianchi Global geopark. Volcanic eruptions are closely related to volcanic earthquakes induced by volcanic eruptions, according to the focus mechanism of earthquakes. The predecessors mainly researched the relationship between the regional structure and earthquake, and the focal mechanism of the earthquake in Wudalianchi. The focal mechanism of the latest earthquake in Laoheishan and the relationship between volcanic eruption and earthquake have also been studied by seismic network records and historical data, whereas any direct geological evidence of volcanic earthquakes has not been reported yet. Because it is hard to find and distinguish the tectonic deformations caused by earthquakes from the deformations of lava flow in field, the tectonic deformations caused by the earthquake have not been systematically studied so far. Focus scientific problems above, this study interpreted remote sensing geology by Worldview2 data (panchromatic spatial resolution 0.5 m), and then investigated geo-heritage in 1:2000 scale in Laoheishan Scenic Area. The typical volcanic tectonic deformation traces caused by volcanic earthquakes are newly discovered. The new discovery and innovative achievements are as follows: (1) A variety of extensional deformation structures have been found on the lava plateau in Laoheishan Scenic Area, which were visibly different with the characteristics of extrusion deformations caused by lava flows. These tectonic deformations were supposed to be formed under the tensile stress of the seismic fault. According to the volcanic eruption time recorded in the historical data and the transformation of different stages of lava by tectonic deformation

observed in the field, it is preliminarily determined that the type of deformations should be caused by the volcanic earthquakes induced by the latest two volcanic eruptions in 1776 CE and 1719-1721 CE, such as earthquake ruptures (Fig.1), seismic fracture zones, seismic bulges, and seismic ridges (Fig.2). The deformation characteristics are different various caused by seismic deformations and lava flowing. There are different seismic deformation characteristics in different parts of the lava plateau due to different stress properties. The lava developed extrusion deformation due to the fault strike-slip action, and meanwhile developed the tectonic deformation partly by the normal-fault-induced tensile stress. It was impossible for extrusion stress to form the tensile deformation on the surface in lava flowing. (2) A large amount of geological disasters induced by the earthquake have been discovered, mainly including earthquake landslides, earthquake collapse, and lava collapse. The process and mechanism of the earthquake landslides banded at the junction of two lava terraces were that the lava flows erupted in the later period continuously accumulated over the early lava platform, and rapidly cooled to form a lava waterfall at the front of the lava flow, and then landslided by the seismic activity. Therefore, the earthquake landslides were very developed in the transition zone of the two-stage lava plateau in the southwest of Laoheishan volcano. The underground lava tunnel became typical collapse valley due to seismic activity in the west of Laoheishan, and the top of lava tunnel remained to form a large-scale natural lava bridge landscape partially. These geo-heritages of geological disasters further prove the occurrence of volcanic earthquakes in the area. (3) The genetic mechanism of the aa lava was deduced according to the point of volcanic earthquakes in the Laoheishan area. The formation force of aa lava was the most possibility of earthquakes, which can eliminate factors of exogenic force, such as freeze-thaw action, weathering and gravitation. By comprehensive analysis of the deformation and distribution characteristics, and a large number of seismic deformation traces surrounding, it is considered that the aa lava was formed by the strong seismic activity, which shattered the lava flow that had not been completely consolidated, so failed to form a typical flow structure. If it was formed by the transformation of late freeze-thaw action, the flowing structure in the Lava breccia should have been preserved. Therefore, the hypothesis of freeze-thaw action as the main force of the aa lava could be eliminated. (4) The earthquake induced by the latest volcanic eruption of

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Fig. 1. Photograph dextral strike-slip fault—Pull-apart “ground fissure” formed by volcanic earthquakes dextral traction.



Fig. 2. Photograph of Left-order extruded ridges formed by volcanic seismic faults.

Laoheishan may have slightly different seismogenic time at different locations. The earthquake possibly coincided with the volcanic eruption in the eastern of Laoheishan which causing, lava flows to be shattered to form aa lava. Whereas the earthquake occurred in the west of Laoheishan after the volcanic eruption. The underground magma was transported from the west to the east to supply the lava for the Laoheishan volcanic eruption, and then became in deficit due to the eruption intensively from the volcanic neck. The earthquake due to crustal equilibrium adjustment caused the lava tunnel and flows to collapse and fault development on the early lava plateau,

whereas the large area of the new lava plateau was strongly transformed into a lava sea. These phenomena constituting of a complete chain of evidence illustrated the existence of seismic activity in the area of Laoheishan-Huoshashan volcanoes. Above all, the new discovery of geo-heritage about volcanic earthquakes and geological disasters caused by volcanic eruptions in the Laoheishan Scenic Area enriches the geo-heritage types of Wudalianchi Global Geopark. Moreover, through the study on the relationship between earthquakes and volcanic eruptions and the genetic mechanism, it can also provide an important reference for earthquake prediction in the Wudalianchi area.

Keywords: geo-heritage, volcanic earthquake, geological disaster, geopark, Laoheishan volcano, Wudalianchi

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