Austin Journal of Forensic Science and Criminology

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Austin Publishing Group

Letter to the Editor

A New Forensic Approach to Past Mass Disasters: The Human Victims of Vesuvius

Pierpaolo Petrone*, Massimo Niola, Pierpaolo di Lorenzo, Vincenzo Graziano, Mariano Paternóster and Claudio Buccelli

Department of Advanced Biomedical Sciences, University of Naples, Italy

***Corresponding author:** Pierpaolo Petrone, Laboratory of Human Osteobiology and Forensic Anthropology, Department of Advanced Biomedical Sciences, II Policlinico, University of Naples "Federico II" 5, Via Pansini 80135 Naples, Italy, Tel: 39 081 7463471; Email: pipetron@unina.it

Received: October 18, 2014; **Accepted:** October 20, 2014; **Published:** October 20, 2014

Letter to the Editor

The first documented discovery of 79 AD human victims is the finding in 1771 of several bodies at Pompeii [1]. In 1863, for the first time the shape of a human body was fixed by plaster cast, a new technique adopted by Giuseppe Fiorelli, director of the excavations. Since then, almost 1300 human victims have been discovered [2]. After the first discovery of *Herculaneum* in the mid-1700s, new excavations of the suburban area led to the exceptional finding of ca. 350 human victims (Figure 1) [3]. Through a recent palaeoforensic site investigation the scenario of the disaster and the cause of death were finally detected [4]. The catastrophic 79 AD event in a few hours permanently buried all villages around Vesuvius, causing thousands of fatalities. Analysis of the features of hundreds of victims from *Herculaneum*, Pompeii and *Oplontis* showed that people hit from the hot surges died instantly by thermal shock [5].

For at least two centuries suffocation was believed to have killed the inhabitants of Pompeii and Herculaneum assuming as "smoking gun" evidence the self-protective posture of victims at death, as apparently testified by hundreds of plaster casts [6]. In 1997-98, new excavations at *Herculaneum* were based on a multidisciplinary approach aimed to identify the causes of death through the effects of the pyroclastic surge on both body and bones of victims. The study was focused on the taphonomical and forensic skeletal features, and on the relationship between geological and archaeological stratigraphy [7]. The overall evidence showed that a 500°C hot surge caused the instant death of the *Herculaneum* residents as a result of fulminant shock. They were killed in less than a fraction of a second, before they had time to display a defensive reaction. Their hands and feet underwent thermally induced contraction in about one second, and the positions of their bodies were fixed by the sudden deflation of the ash bed occurring over the next few seconds. Their soft tissues were vaporized, their skulls exploded, and their bones and teeth broke. The temperature then fell over a few minutes causing the ash bed to cool and harden, thus preserving the skeletons as "frozen" in their life-like original stance [4].

Some years before, few kilometers north of Naples there had been a unique finding of victims of a prehistoric eruption of Vesuvius: the skeletons of a man and a woman buried under a 1-m-thick lapilli bed, who were a dramatic testimony of their unlucky attempt to escape and their death due to suffocation [8]. Nearby, the abrupt abandonment of a human settlement at the beginning of the eruption was testified by the moulds of four huts with pottery left inside, and the skeletons of a dog and nine goat victims found in a cage. Finally, decisive proof of a massive exodus lies in the extraordinary discovery of thousands of human and animal footprints found in the surge deposit located NNW of Vesuvius, only 7 km outside metropolitan Naples (Figure 2). This common direction for hundreds of track paths testifies a very rapid large-scale evacuation from the devastated zone which includes the present-day Neapolitan district [9].

More recently, the study of the effects of the 79 AD eruption was extended to all victims of pyroclastic surges [5]. The analysis of the postures of more than 200 individuals showed that most of the people were typically frozen in suspended actions (life-like stance). The preservation of this distinctive stance has been shown to be indicative of a condition known as "cadaveric spasm", a rare but diagnostic form of instantaneous muscular stiffening associated with instant violent death, which crystallizes the last activity one did prior to death. The presence of this stance is indicative that people were alive at the time of posture arrest and its widespread occurrence is key evidence that all the victims were exposed to the same lethal conditions. The predominance of this feature in Pompeii and close towns, which definitely accounts for the preservation of the "frozen" posture of corpses, points to an instant death caused by the ash cloud high temperature. Finally, it was also evident that the presumed self-

Figure1: 79 AD victims instantly killed by the first pyroclastic surge (chamber 10, suburban area of *Herculaneum*).

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Citation: Petrone P, Niola M, di Lorenzo P, Graziano V, Paternóster M and Buccelli C. A New Forensic Approach to Past Mass Disasters: The Human Victims of Vesuvius. Austin J Forensic Sci Criminol. 2014;1(1): 2.

Figure 2: Human footprints left in the ash surge deposit by fugitives during the en masse evacuation of the Campanian plain in the first phase of the Old Bronze Age eruption of Vesuvius.

protective stance observed in several Pompeii victims was definitely assumed post-mortem, due to heat induced limb flexures as a result of dehydration and shortening of tendons and muscles, a stance known as "*pugilistic attitude*".

Macroscopic, light microscopy and scanning electron microscopy analyses of ancient bones compared with those of recent bone samples heated to temperatures that range from 100° to 800° C showed that victims were exposed to temperatures of at least 500-600° C in *Herculaneum* and *Oplontis*, and 250-300°C in Pompeii, 6 to 10 km from the volcano, respectively [5]. Despite exposure to high temperature and dusty gas, people would be able to survive to suffocation due to the very short time passage of the surge cloud. The widespread occurrence of life-like postures in the victims reveals that all residents at Pompeii and surroundings within at least 10 km from Vesuvius were killed instantly by the 79 AD pyroclastic surges, including people who were sheltered within buildings as far away as Pompeii.

The overall evidence from both prehistoric and historical Plinian eruptions of Vesuvius show that 3 million residents in metropolitan Naples and close towns would be seriously at risk in the case of a future major event. These results and 25,000 years of eruptive history of the volcano highlights the need to strengthen the emergency plans for Vesuvius and other similar explosive volcanoes [10].

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Austin J Forensic Sci Criminol - Volume 1 Issue 1 - 2014
ISSN : 2380-0801 | www.austinpublishinggroup.com
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Citation: Petrone P, Niola M, di Lorenzo P, Graziano V, Paternóster M and Buccelli C. A New Forensic Approach to Past Mass Disasters: The Human Victims of Vesuvius. Austin J Forensic Sci Criminol. 2014;1(1): 2.