

## JASs cover story

### Human corpses as time capsules: new perspectives in the study of past mass disasters

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*Looking at the corpses of past natural catastrophes can change completely the conception of how to study human bone remains. The recovery of the Herculaneum victims of the 79 AD Vesuvius eruption was an opportunity for me to adopt a new approach in the study of human skeletons and their context of discovery. During two years of field work, my first aim was to investigate the effects of pyroclastic surges on people and things. The conservation of skeletons and their replacement by fiberglass casts were also provided. This “field laboratory” has developed into a palaeoforensic investigation of the mass disaster caused by the 79 AD natural event. Field and laboratory research, later extended to Pompeii plaster-cast corpses, were also carried out on the victims’ remains, footprints, huts and objects found in the sites buried by the prehistoric “Avellino pumices” eruption (3780 ± 100 BP). The new results obtained from the study of the causes of death of people hit by pyroclastic surges produced by past Vesuvius eruptions have proved essential in hazard evaluation in the Neapolitan district and other volcanic areas.*

In 1980, the excavation of the suburban area of the *Herculaneum* ancient town led to an exceptional discovery: a considerable number of skeletons of human victims killed by the 79 AD eruption were found within the ash surge deposits. In the last few decades, ca. 300 human victims, two horses, a dog, a boat and hundreds of gold, silver, bronze and glass objects found close to the skeletons have been unearthed from the beach and 12 boat-chambers facing the sea. After the discovery of this Roman town with its perfectly preserved houses and some sporadic victims, the scenario of the disaster was finally completed. The catastrophic event of AD 79, which in a few hours permanently buried *Herculaneum*, along with Pompeii, *Oplontis* and other villages around Vesuvius, most probably caused thousands of fatalities. The first documented discovery of 79 AD human victims is the finding in 1768 of several bodies at Pompeii. In 1863, for the first time the shape of a human body was fixed by plaster cast, a new technique adopted by Giuseppe Fiorelli, archaeologist and director of the excavations. Since then, almost 1300 human victims have been discovered, although only a part of them have been preserved until present times.

For at least two centuries, the history of the last minutes of life and the death of the people who lived in Pompeii and its surroundings was based on the assumption that due to the ash component of

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pyroclastic surges, they had all died by slow suffocation. It was assumed that the “smoking gun” evidence was the self-protective posture of victims at death, as apparently testified by hundreds of plaster casts.

During a new campaign of excavation which started in June 1997 on behalf of the Superintendency of Pompeii, I tried to change the approach previously adopted in documenting and recovering the victims’ skeletons. Given their specific origin, I treated their corpses as “time capsules” of living people and not just bone remains, as previously done by other physical anthropologists. During two full years of daily work at the *Herculaneum* site, my aim was to identify the effects of the ash surge on both body and skeletons of victims and the possible causes of death. The study focused on the taphonomical and forensic site evidence detectable on the victims’ corpses, whose bones were later examined by means of laboratory analyses. The site work partly benefited from interaction with geologists’ expertise, focusing on the relationship between geological and archaeological stratigraphy.

Unlike previous investigators, the idea was to answer questions such as: how could it be possible that the skeletons were intact and their postures so perfectly preserved, as well as their anatomical bone joints? And, what mechanism could explain the fact that bodies were floating within the ash bed? Or, why did so many skeletons show widespread cracking of skulls and long bones, or contracted hands and feet? And finally, how could we explain the life-like appearance of the victims’ corpses? All of these questions were answered by site and laboratory investigation. 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 original posture (Mastrolorenzo *et al.*, 2001; Petrone & Fedele, 2002).

Some years before, in San Paolo Belsito, there had been a unique finding for the prehistory of human victims of the Avellino Bronze Age eruption: the skeletons of a man and a woman, who were a dramatic testimony of their unlucky attempt to escape and their consequent death due to suffocation. These victims were buried under a 1-m-thick lapilli bed, ca. 16 km from Vesuvius (Petrone & Fedele, 1996; Fedele & Petrone, 1999). Near by, one of the world’s best-preserved prehistoric villages revealed the abrupt abandonment of a human settlement at the beginning of the eruption. In fact, the moulds of four huts with pottery and other objects left inside, the skeletons of a dog and nine pregnant goat victims found in a cage, and the footprints of adults, children, and cows filled by the first fallout pumice were found. Finally, decisive proof of a massive exodus lies in the extraordinary discovery of thousands of human and animal footprints found in scattered probes within an area of a few square kilometres in the surge deposit located NNW of Vesuvius, only 7 km outside metropolitan Naples. This common direction away from the volcano for hundreds of track paths testifies a very rapid large-scale evacuation from the devastated zone which includes the present-day Neapolitan district (Mastrolorenzo *et al.*, 2006; Hall, 2007).

More recently, the study of the effects of the 79 AD eruption was extended to all the surge victims now available (Mastrolorenzo *et al.*, 2010). The analysis of the postures of about 200 individuals, including the victims’ corpses found at Pompeii and *Oplontis*, showed that most of the people were typically frozen in suspended actions (life-like stance). The widespread preservation of this distinctive

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stance has been shown to be univocally indicative of a condition known as “cadaveric spasm”. This is a rare but diagnostic form of instantaneous muscular stiffening associated with instant violent death, which crystallizes the last activity one did prior to death. Such instant rigor prevents the ordinary onset of muscular relaxation immediately after death, thus avoiding any further substantial modification of body posture. The presence of this stance at Pompeii and close towns 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. Cadaveric spasm commonly involves groups of muscles and only exceptionally the entire body. This last condition has been described in battle situations and in historical eruptions, due to the exposure of victims to extreme heat. The predominance of this rare feature in 79 AD victims, which definitely accounts for the long-lasting preservation of the “frozen” posture of corpses, points to an instant death caused by the high temperature of the surge. Finally, it was also evident that the presumed self-protective stance observed in several Pompeii victims was definitely assumed post-mortem, due to heat induced limb flexures that are a result of dehydration and shortening of tendons and muscles, a stance known as “*pugilistic attitude*”. No appreciable evidence of effects caused by the mechanical impact on victims found both inside and outside buildings was detected.

In order to assess the importance of thermal effects of pyroclastic surges on casualties, macroscopic, light microscopy, histochemical and scanning electron microscopy analyses of ancient bones were also carried out, and data were compared with those of recent bone samples heated to temperatures that range from 100° to 800°C. The results showed that victims were exposed to temperatures of at least 600°C in *Oplontis* and 250-300°C in Pompeii, 7 to 10 km from the volcano, respectively. The exposure time of the victims to high temperature and dusty gas was very short, as results from the lasting passage of the surge cloud in the range of  $30 \div 1.5 \times 10^2$  seconds. This time is consistent with the inferred lethal time for temperatures in the range of 250° - 600° C evaluated from ca. 10 to ca.  $10^2$  seconds. Such a time lapse is insufficient to cause asphyxia which would, in fact, require an exposure time of several minutes, thus indicating that people would be able to survive to suffocation in 0.5 to 2.5 minutes of the surge cloud passage. Therefore, 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 research conducted on 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. The overall evidence detected for these past eruptions highlights the need to strengthen the emergency plans for Vesuvius and other similar explosive volcanoes (<http://ngm.nationalgeographic.com/2007/09/vesuvius/vesuvius-text>).

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