One of us (SV and his family) vacationed in the central regions of Italy during the summer of 2019. They visited the historical city of Pompeii and the nearby volcano Mount Vesuvius. At present this volcano is quiet, although minor earthquakes and outgassing occurs occasionally, however, more violent activity could return in future. We briefly report on the origin and volcanic history of Mount Vesuvius. During one of its eruptions the nearby city of Pompeii in its southern neighborhood was destroyed and its population perished under the volcanic ash. We illustrate and describe this natural disaster.

In 1748, while digging the foundation, about 24 km south of Naples to build a summer palace for the Duke of Naples, buildings and streets of a lost city were discovered. This was the lost Roman city of Pompeii which was destroyed by Mount Vesuvius eruption on a summer day of August 24, 79 AD. The eruption continued for one day totally burying this town under layers of volcanic ash. Mount Vesuvius has erupted many times. The eruption in AD 79 was preceded by numerous others in prehistory, including at least three significantly larger ones, including the Avellino eruption around 1800 BC which engulfed several Bronze Age settlements. Vesuvius started forming around 25,000 years ago which was built by a series of lava flows, with some smaller explosive eruptions interspersed between them. Since more violent eruptions in future are expected, Osservatorio Vesuvio in Naples monitors this volcano. It has networks of several geophysical stations (seismic and gravimetric), that monitors magma movement under the volcano by combination of a GPS-based geodetic array and satellite-based synthetic aperture radar.

Figure 1: Topographic map of Italy and surrounding seas showing location of Mount Vesuvius (Google Earth, downloaded on December 16, 2019).
Mount Vesuvius and its eruption history

Although quiet at present, Mount Vesuvius is geologically an active volcano on the Bay of Naples, located on the west coast of Italy (40°49′ N-14°26′ E). It is a complex volcano that last erupted in March 1944 destroying few neighboring villages. At an elevation of 1,281 m above the
Bay of Naples, this volcano is among the best-known volcanoes in the world. Since it will erupt again in future, it potentially endangers lives of people living on and around its slopes. It is one of the most populated active volcanic areas of the world that potentially poses danger to about three million people living in its vicinity.

At present the height of the main cone or 'Gran Cono' stands at 1,281 m while the 'Monte Somma' or adjoining mountain is 1,149 m high. Mount Vesuvius with its large cone is partly encircled by a steep caldera, which was formed by the collapse of Monte Somma. The ‘Gran Cono’ was formed during eruption of 79 AD. The heavily vegetated slopes stretching for over seven km from of the vent of the volcano are marked by lava flows. This mountain consists of layers of lava, volcanic ash and pumice. Quite a few times, the eruptions have covered the whole of southern Europe in ash. During the 472 and 1631 eruptions, the ash from explosion landed in Istanbul, Turkey over 1,200 km away (website 2).

Italian government has declared the area around Mount Vesuvius as a National Park. There is a network of paths around the volcano with an access road to within 200 meters of the summit (website 2).

The 79 AD eruption of Mount Vesuvius ejected a massive cloud of stones, ashes and volcanic gases to a height of 33 km. Molten rock and pulverized pumice came out of the volcano at the rate of 6x105 cubic meters per second, ultimately releasing 100,000 times the thermal energy released by the Hiroshima-Nagasaki bombings. It has been estimated that more than 1,000 people died, but exact numbers are unknown. The only surviving eyewitness account of the event consists of two letters by Pliny the Younger to the historian Tacitus (website 3).

The website 3 provides a detailed description of eruption history of Mount Vesuvius as follows.

“Mount Vesuvius has erupted many times. The eruption in AD 79 was preceded by numerous others in prehistory, including at least three significantly larger ones, including the Avellino eruption around 1800 BC which engulfed several Bronze Age settlements. Since AD 79, the volcano has also erupted repeatedly, in 172, 203, 222, possibly in 303, 379, 472, 512, 536, 685, 787, around 860, around 900, 968, 991, 999, 1006, 1037, 1049, around 1073, 1139, 1150, and there may have been eruptions in 1270, 1347, and 1500. The volcano erupted again in 1631, six times in the 18th century (including 1779 and 1794), eight times in the 19th century (notably in 1872), and in 1906, 1929 and 1944. There have been no eruptions since 1944, and none of the eruptions after AD 79 were as large or destructive as the Pompeian one.”

“The eruptions vary greatly in severity but are characterized by explosive outbursts of the kind dubbed Plinian after Pliny the Younger, a Roman writer who published a detailed description of the 79 AD eruption, including his uncle’s death. On occasion, eruptions from Vesuvius have been so large that the whole of southern Europe has been blanketed by ash; in 472 and 1631, Vesuvian ash fell on Constantinople (Istanbul), over 1,200 kilometres (750 mi) away. A few times since 1944, landslides in the crater have raised clouds of ash dust, raising false alarms of an eruption.”
Figure 3: Topographic map of central Italy showing close-up of Mount Vesuvius and the port city of Naples (A); view of the Mount Vesuvius caldera surrounding the present volcano and ancient flows (B) (Google Earth, downloaded on December 16, 2019).
Figure 4: Topographic map showing close-up of Mount Vesuvius surrounded by its ancient caldera (A); aerial view inside of the Mount Vesuvius crater (B) (Google Earth, downloaded on December 16, 2019).
**Geology and origin of Mount Vesuvius**

Italy lies on the boundary between the Eurasian and the African tectonic plates where earthquakes occur frequently.

Mount Vesuvius is part of the Campanian (Late Cretaceous) volcanic arc, comprising a line of volcanoes formed over a subduction zone created by the convergence of the African and the Eurasian tectonic plates. The heated crust under the volcano melted into liquid rock forming the magma which was pushed upward, exploding through the surface thus forming this volcano. This subduction zone extends throughout the length of the Italian peninsula and includes volcanoes like Mount Etna, the Phlegraean Fields (Campi Flegrei), Vulcano, and Stromboli (websites 1, 2). Mount Vesuvius cone began to grow inside the caldera of the Mount Somma volcano, which last erupted nearly 17,000 years ago. The viscous Andesite lava of the Mount Vesuvius volcano causes explosive eruptions, making it a dangerous and unpredictable volcano. It also results in huge explosions creating columns of gas, ash and rock that can rise dozens of kilometers into the atmosphere. Such explosions have destroyed ancient cities near Vesuvius with huge ashfalls and pyroclastic flows (website 1).

Geologic history of Mount Vesuvius has been studied from cores, some 2,000 m plus thick taken on the flanks of the volcano. Core samples were dated by potassium–argon and argon–argon dating methods. Such studies have revealed that this area has witnessed volcanic activity for at least past 40,000 years; the lowest layer of eruption material from the Somma caldera lies on top of the 40,000 year-old Campanian ignimbrite produced by the Campi Flegrei complex. Vesuvius started forming around 25,000 years ago which was built by a series of lava flows, with some smaller explosive eruptions interspersed between them (website 3).

**Volcanic hazards and destruction of the city of Pompei**

There were eight major eruptions in Mount Vesuvius during the last 17,000 years. However, beginning 1631, Vesuvius commenced steady volcanic activity. Violent eruptions during early 1700s, 1800s and early 1900s created more fissures, lava flows, ash and gas explosions. Eruption of 1906 caused over 100 fatalities. The latest eruption was in 1944 during the second World War causing problems for the Allied forces in Italy. Ash and rocks from the eruption destroyed planes and forced evacuations at a nearby airbase (website 1).

The 79 AD eruption may have killed over 16,000 people around this volcano. Ash, mud and rocks buried the cities of Pompeii and Herculaneum and many other villages. The citizens of these towns died primarily of suffocation by ash in the air, later they were covered and preserved in details of their clothing and faces (website 1). The 79 AD eruption lasted for 19 hours, generating a cloud of stones, ash and fumes to a height of 20.5 miles releasing about four cubic kilometers of ash and rock that settled over Pompeii and Herculaneum. The towns remained buried for the next 1700 years and were accidentally rediscovered in 1749 (website 2).

The volcanic flows were rapid-moving, dense and very hot, knocking down wholly or partly all structures in their path, incinerating or suffocating all population remaining there and altering the landscape, including the nearby coastline. These were accompanied by additional light tremors and a mild tsunami in the Bay of Naples (website 3).
Figure 5: Views of the ancient city of Pompeii: 1. Body casts of victims displayed in a museum. 2. A store with a counter and a hole where eatables were kept. 3. The oldest Roman Amphitheatre in Pompeii. Gladiatorial contests were held here like the Coliseum in Rome. However, this is much smaller than Rome’s Coliseum. 4. View of Mount Vesuvius from Pompeii. 5 and 8. Streets. Plates on the walls (5) were put by the excavators. 6 and 7: Houses. Behind the covered area (6) excavation work is going on.
Figure 6: Views of the ancient city of Pompeii: 1 and 3. Houses. 2. A street. 4. A site of an ongoing excavation by the archeologists. 5 and 6. City lanes. 7 and 8. Roman public bath houses where water came in through aqueducts and was heated by circulating hot air under the floor and surrounding walls.
By 2003, around 1,044 casts of human bodies and 100 bones were made of impressions found in the ash deposits in Pompeii. Thirty-eight percent of the human bodies were found in the ash fall deposits, while the remaining inside buildings. These people were killed by multiple causes such as roof collapses, larger rocks thrown out by the volcano, pyroclastic surge deposits, suffocation through ash inhalation and debris, and high temperatures etc. Excavation work is in progress, more casualties are expected to be unearthed (website 3).

Since more violent eruptions in future are expected, Osservatorio Vesuvio in Naples monitors this volcano. It has networks of several geophysical stations (seismic and gravimetric), that monitors magma movement under the volcano by combination of a GPS-based geodetic array and satellite-based synthetic aperture radar. Gases emitted from fumaroles are also chemically analyzed. At present no magma has been detected within 10 km, thus it is classified by the Observatory as at a Basic or Green Level (website 3). Future volcanic eruptions may be catastrophic, but the loss of human life will certainly be minimized by advanced warning from this observatory.

**Taal volcanic eruption, Philippines: a recent example of volcanic eruption similar to Mount Vesuvius eruption**

At the time writing this article, Philippines has witnessed a similar volcanic event like Vesuvius. However, loss of human life is minimal due to advance warning. Located 50 km south of Manila, Philippines, the Taal Volcano is a large caldera filled with a lake. It erupted violently on Sunday, Jan. 12, 2020, triggering waves of earthquakes and blanketing the area in a layer of ash. More than 30,000 people have fled their homes in nearby towns and villages. The eruption sent a plume of ash, steam and rock six to nine miles into the sky, while lava spewing fountains of red-hot molten rock about half a mile-high in the sky and finally gushing into the surrounding lake. Clouds of ash have drifted more than 60 miles north of the volcano, reaching the capital city Manila.

Tall is the second most active volcano in Philippines, with 34 recorded historical eruptions. This volcano last erupted in 1977. In a 1965 eruption, more than 200 people were killed. There are signs that another, possibly larger eruption was coming.

**Impact of intense heat on human body in Herculaneum**

A recent research published on January 22, 2020 (website 4) in The New England Journal of Medicine states, “Enveloped in a surge of hot ash, the victim's brain had been burned to twisted black bits through a process called vitrification. The glassy material “encrusted” the surface of the man's skull.”

During eruption of Mount Vesuvius in 79 AD, the volcano released floods of gas and rock hot enough to boil blood, vaporize flesh and even transform bits of brain tissue into glass. This research was carried on a dead person found in Herculaneum who was found with an exploded skull and glass-like brain tissue. People in Herculaneum had fled to boathouses during the Vesuvius eruption, died from the extreme heat of the volcanic explosion.
Figure 7: Views of the ancient city of Pompeii. 1. A bigger house of a wealthy person decorated with art on the floor. 2. Statue of Centaur, a mythical creature who was half man and half horse. 3. Pompeii Forum with Mount Vesuvius in the background. This was the main square of the city where institutions like churches, temples, courts, administrative offices etc. were located. 4. Temple of goddess Venus is overlooking the Gulf of Naples. People prayed her before sailing. 5. Entrance to the town. 6. Entrance to the amphitheatre. 7. Inside the amphitheatre. Background area covered with grass was for the spectators. The floor of the amphitheatre was covered with sand so that the blood of the gladiators could be soaked. 8. A street.
This town lies about 20 km from Pompeii and sits closer to the base of Vesuvius. This proximity to the volcano ensured that people in this town met with gruesome death. Steam let off by their boiling blood generated intense pressure in their skulls, causing their heads to explode. Analysis of the charred wood found near the corpse revealed that temperatures reached a maximum of 520 degrees C.

There is a video in the website 4 that describes what happened to the volcanic refugees of 79 AD eruption who somehow managed to escape this catastrophe.

References
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