Earth System Knowledge Platform – the knowledge platform of the Research Field Earth and Environment of the Helmholtz Association, www.eskp.de

Natural hazards · Volcanic eruption

CIVILIZATION MEETS VEI-7 ERUPTION: HUMANITY IS POORLY PREPARED

Thomas Walter [1]

[1] Helmholtz Centre Potsdam - German Research Centre for Geosciences (GFZ)

First published: June 27th, 2018, Volume 5

Digital Object Identifier (DOI): https://doi.org/10.2312/eskp.026

Teaser

Naples lies in the middle of a complex caldera that formed 39,000 years ago, its magma chambers emptied in a huge volcanic eruption and having an impact throughout the world. Several active phases with many larger eruptions followed. Even today, the Phlegraean Fields show many signs of activity and are thus the focus of many geoscientists in Europe. What if such eruptions were to repeat themselves? Experts now warn that nowhere in the world are modern societies well prepared for a truly big eruption.

Keywords

Volcanism, Phlegraean Fields, earthquake, fluids, eruption, caldera, volcanic explosivity index (VEI), magma chamber, volcanic eruption, Monte Nuovo, Naples, Procida, Ischia, Italy

None of our contemporaries has ever experienced a truly massive volcanic eruption. Only meager eyewitness accounts exist of the gigantic eruptions of the Indonesian volcano Krakatau in 1883. This breakout attained the high value of 6 (VEI-6) on the volcanic explosivity index (VEI). Krakatau is located in the immediate vicinity of the capital Jakarta. In 1815 the Tambora erupted with VEI-7. The Tamora lies only a little further southeast of Krakatau on the island of Sumbawa. Since the eruption, it has remained in a dormant phase. In short, the modern and much more densely populated world has not yet had to cope with an eruption that ranks 7 or 8 on the volcanic explosivity index.

In the last 2,000 years alone, more than thirty such global events are known to have occurred. This figure results from studies of tephra, the material ejected by volcanoes and

transported over long distances. However, many other large eruptions could have remained undiscovered so far.

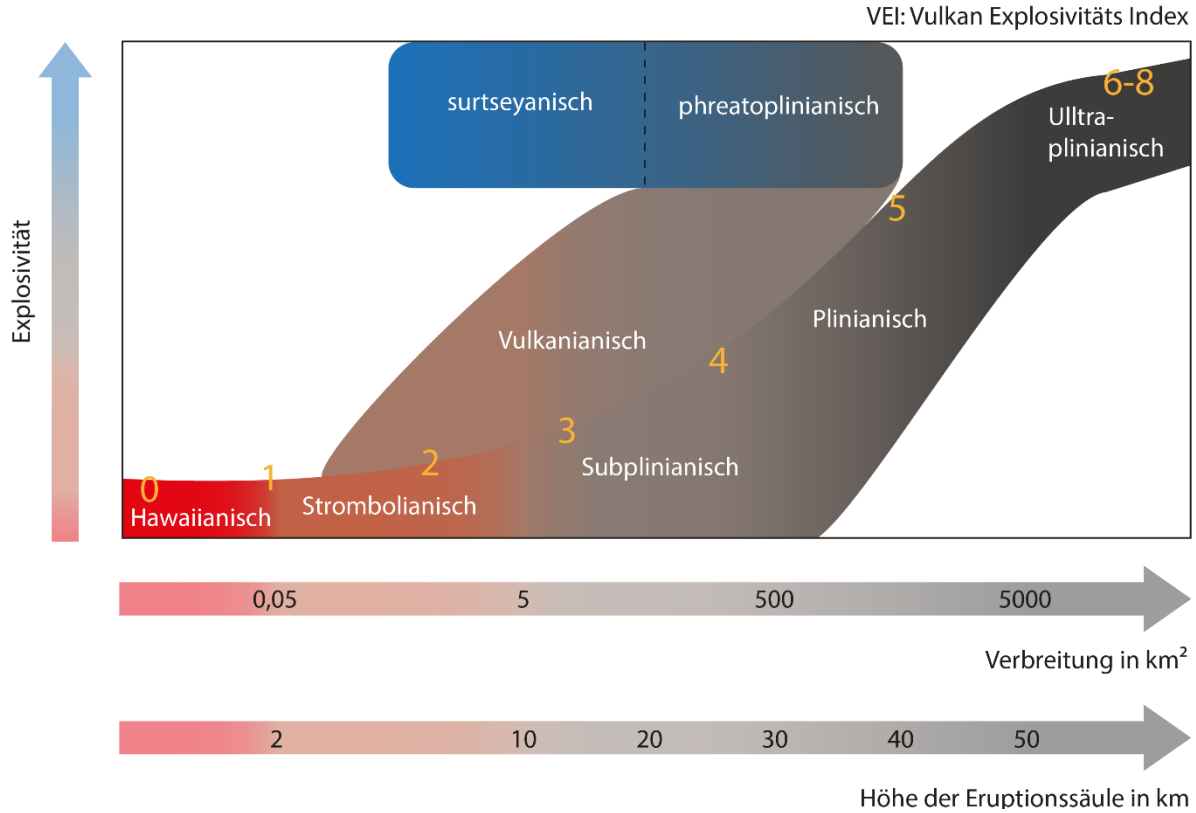

Fig. 1: Representation of the VEI index (yellow numbers = VEI). (Illustration: C. Bonanati/GEOMAR, modified according to Walker 1973)

Only recently, scientists detected a previously unknown massive eruption (VEI-7) of the Indonesian stratovolcano Rinjani in 1257. Huge amounts of sulphur were released into the atmosphere during that period. These cooled the earth to such an extent that a centuries-long cold period ('Little Ice Age') covered our planet. Extremely cold winters and heavy precipitation in the summers were partially to blame for harvest losses and large famines at that time. This was historically well documented, especially for England and Japan.

Europe's problem child: the Phlegraean Fields

The Campi Flegrei (Phlegraean Fields), west of Naples, is one of the most closely monitored volcanic areas in the world and is the only European volcanic area known to have experienced a super-eruption (VEI-7 /8). Therefore earthquake activity, the deformation of the soil and its caldera, as well as a number of escaping gases (CO2 and especially the CO2/CH4 and He/CH4 ratios) are being monitored.

Many different eruption centres have been active in the volcanic area during the last 39,000 years. The volcanically active area includes the Phlegraean Fields, as a part of Naples, the volcanic islands of Procida and Ischia and the northwestern part of the Gulf of Naples.

The geological history of the Campi Flegrei has been dominated by two major eruptions: the eruption of the Ignimbrite Campana (39,000 years ago) and the eruption of the Neapolitan Yellow Tuff (15,000 years ago). These eruptions have produced a complex caldera of which many traces and structures can still be seen today.

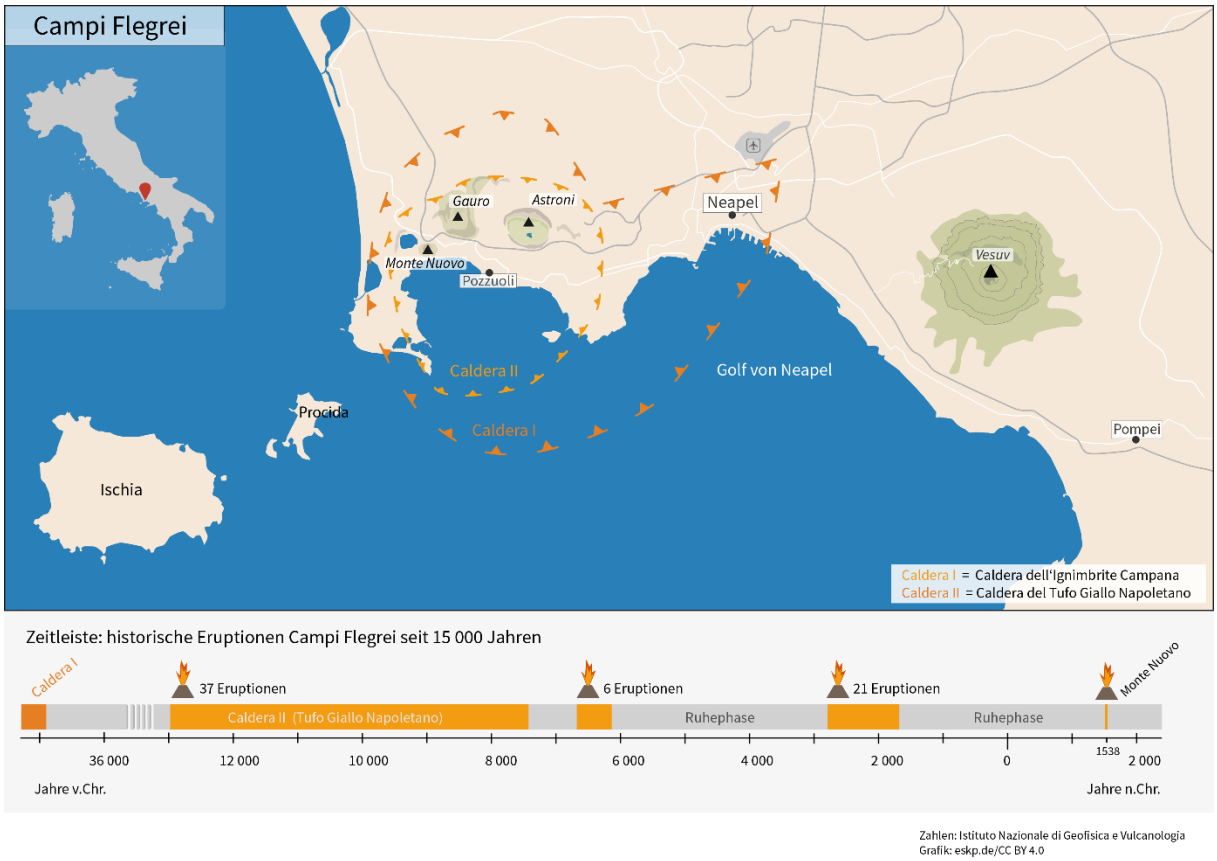

Fig. 2: The map shows the Plegraean Fields (Campi Flegrei), west of Naples. Historic eruptions are shown on a timeline. (Map: Wissensplattform Erde und Umwelt, eskp.de, Licence: CC BY 4.0)

Recent volcanic behavior is concentrated in three periods of intense activity alternating with periods of rest. In the most recent period (between 4,800 and 3,800 years), eruptions occurred on average every 50 years. In 1538, an above-average amount of magma suddenly rose again. Within only one week a new mountain, the Monte Nuovo, emerged. Although this volcanic cone mountain quickly reached a height of 133 metres, scientists consider this event a phase of lower intensity.

For centuries, the soil in the region sank before rising shortly before the eruption in 1538. In the region around Monte Barbaro (Averno), for example, the uplift was so massive that the coast was displaced by several hundred metres. Monte Nuovo is now partly covered with buildings. The entire caldera is heavily populated. This clearly demonstrates how little consideration is seriously given today to the potential consequences of renewed activity.

Seismic waves are likely to trigger uplift events in the Phlegraean Fields

Past eruptions tell scientists a lot about the properties of each volcanic area. However, observations are usually isolated: a volcanic area is intensively monitored, but not associated with distant events, given that the underground processes are too complex.

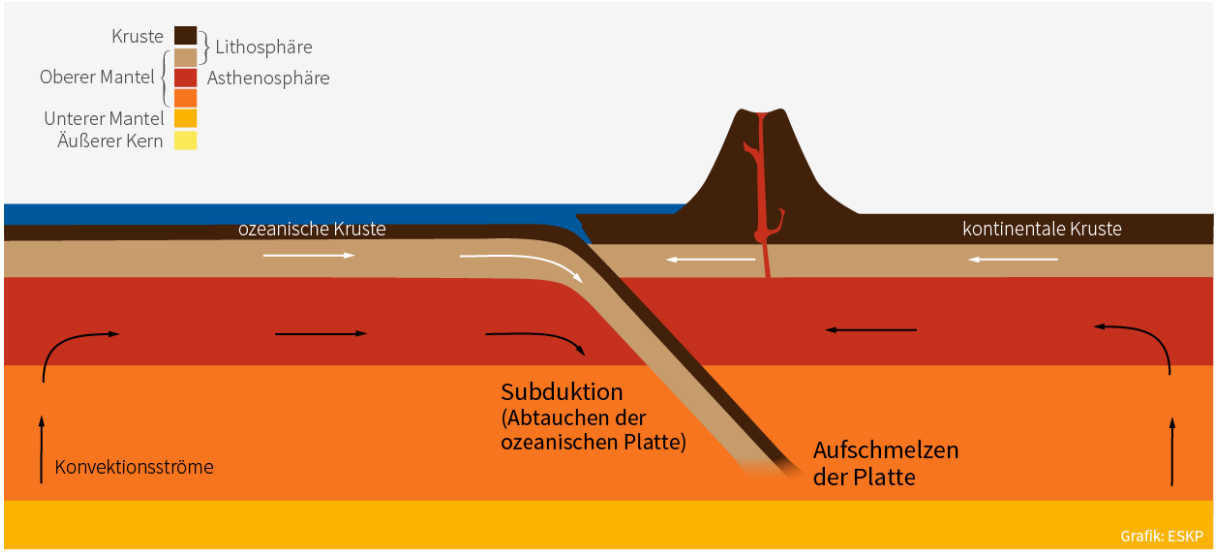

Fig. 3: Subduction zones: The oceanic plate sinks and slides underneath a continental plate. (Illustration: eskp.de, Licence: CC BY 4.0)

Nevertheless, the assumption that volcanic eruptions were largely predictable had been valid up to now, provided that a comprehensive historical catalogue for the area was available and close monitoring was initiated. Now, however, there is evidence that this precise certainty cannot be achieved in the Phlegraean Fields near Naples.

Scientists from the German GeoForschungsZentrum were able to show that distant quakes in the Apennines can lead to increased volcanic activity in the Phlegraean Fields, which in turn makes the predictions of the latter much more unpredictable. According to current knowledge, earthquakes are not predictable, and volcanic activity occurs with a time lag (Lupi et al., 2017).

The new concept implies that geological processes triggered by passing seismic waves do not become visible until several months after the seismic waves have passed. In a time window of 70 years, the team of Dr. Philipp Weis identified 14 uplift events in the Phlegraean Fields, 12 of which were preceded by earthquakes. For eight of these uplift events, up to 1.2 years passed between registered by more distant quakes and the associated uplift in the Phlegraean Fields. Nearby faults, reservoirs and even Vesuvius also show simultaneous uplift events, as results of the GFZ team around Dr. Thomas Walter show; these too are possibly caused by distant earthquakes (Walter et al., 2014).

Presumably the passage of seismic waves promotes the short-term embrittlement of the armor of the magma reservoir, which is otherwise easily deformable. Such embrittlement allows magma and dissolved volatiles to be released from the magmatic reservoir. The fluids then rise above the magmatic reservoir. The largest eruption of the last hundred years, the Pinatubo eruption on the island of Luzon (Philippines), was also preceded by major earthquakes. These mechanisms and the associated inherent uncertainties require further investigation.

The appeal of the volcanologists

The duration of the dormant phases of volcanoes cannot yet be predicted. Most, but not all, colossal volcanic eruptions (VEI-7 and -8) are to be expected where an oceanic plate moves above or below a continental plate (subduction zones).

Careful societal preparation for these very large, albeit very rare, volcanic eruptions is at least as important as for the many smaller eruptions that occur, according to the urgent appeal of experts (Newhall et al., 2018). Our dependence on satellite data is so immense that volcanologists strongly advise us to investigate in detail how volcanic ash in the atmosphere and changes in atmospheric humidity affect the signals from our many GPS systems.

On the other hand, it is very important to gain an even better understanding of how enormous quantities of magma accumulate underground, how magma chambers fill up before a gigantic eruption (greater than or equal to VEI-7) occurs. However, preparing for these very rare events (1-2 per millennium for VEI-7 eruptions worldwide) with potentially disastrous consequences in a globally networked world is a political tightrope act. According to Oxford Economics, the relatively insignificant volcanic eruption (VEI-4) of the Icelandic volcano Eyafjallajöküll in April 2010 alone caused economic losses of five billion euros. Moreover, today many lives would be put in danger.

In the 19th century, most areas were not nearly as densely populated as they are today. 200 million Indonesians live less than 100 kilometres away from dangerous volcanoes. Mount Damavand in Iran is only 70 kilometres outside Tehran. 90% of volcanic risk is concentrated in only five countries (Indonesia, Philippines, Japan, Mexico, Ethiopia). However, in reality, far more countries on earth would have to struggle with the consequences of a major eruption.

A minimum level of concerted monitoring and intensive research is a global task to which experts are once again firmly committed. The most modern satellites are particularly promising in this respect, as they can detect even remote volcanoes and foresee forerunners.

References

Barnes, K. (2011). Europes ticking time bomb. *Nature*, *473*, 140-141. doi:10.1038/473140a

Brown, S. K., Auker, M. & Sparks, R. (2015). Populations around Holocene volcanoes and development of a Population Exposure Index. In S. C. Loughlin, S. Sparks, S. K. Brown, S. F. Jenkins & C. Vye-Brown (Hrsg.), *Global Volcanic Hazards and Risk* (S. 223-232). Cambridge, UK: Cambridge University Press. doi:10.1017/CBO9781316276273.006

Brown, S. K., Crosweller, H. S., Sparks, R. S. J., Cottrell, E., Deligne, N. I., Guerrero, N. O., Hobbs, L., Kiyosugi, K., Loughlin, S. C., Siebert, L. & Takarada, S. (2014). Characterisation of the Quaternary eruption record: analysis of the Large Magnitude Explosive Volcanic Eruptions (LaMEVE) database. *Journal of Applied Volcanology*, *3*:5. doi:10.1186/2191-5040-3-5

Chiodini, G., Selva, J., Del Pezzo, E., Marsan, D., De Siena, L., D'Auria, L., ... Petrillo, Z. (2017). Clues on the origin of post-2000 earthquakes at Campi Flegrei caldera (Italy). *Scientific Reports*, *7*:4472. doi:10.1038/s41598-017-04845-9

Lupi, M., Frehner, M., Weis, P., Skelton, A., Saenger, E. H., Tisato, N., Geiger, S., Chiodini, G. & Driesner, T. (2017). Regional earthquakes followed by delayed ground uplifts at Campi Flegrei Caldera, Italy: Arguments for a causal link. *Earth and Planetary Science Letters*, *474*, 436-446. doi:10.1016/j.epsl.2017.07.006

Newhall, C., Self, S. & Robock, A. (2018). Anticipating future Volcanic Explosivity Index (VEI) 7 eruptions and their chilling impacts. *Geosphere*, *14*(2), 572-603. doi:10.1130/GES01513.1

Oxford Economics. (2010). *The economic impacts of air travel restrictions due to the volcanic ash. A report prepared for Airbus* [www.oxfordeconomics.com]. Oxford, UK.

Ponomareva, V., Portnyagin, M. & Davies, S. M. (2015). Tephra without borders: Far reaching Clues into Past Explosive Eruptions. *Frontiers in Earth Science*, *3*:83, 1-16. doi:10.3389/feart.2015.00083

Walter, T. R., Shirzaei, M., Manconi, Solarod, G., Pepe, A., Manzo, M. & Sansosti, E. (2014). Possible coupling of Campi Flegrei and Vesuvius as revealed by InSAR time series, correlation analysis and time dependent modeling. *Journal of Volcanology and Geothermal Research*, *280*, 104-110. doi:10.1016/j.jvolgeores.2014.05.006

Witze, A. (2018, 6. März). Volcanologists warn world is unprepared for next major eruption. A big blast could hobble global trade, communications and financial systems, *Nature News*. doi:10.1038/d41586-018-02784-7

Cite as

Walter, T. (2018, 27. Juni). Civilization meets VEI-7 Eruption: humanity is poorly prepared. *Earth System Knowledge Platform* [www.eskp.de], *5*. doi:10.2312/10.2312/eskp.026