

Hunga Tonga-Hunga Ha’apai Volcano Eruption and The Effects on Earth’s Dynamic Spheres



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Abstract

Earth is a very dynamic and complex system involving interactions between the hydrosphere, biosphere, atmosphere, and geosphere. In particular, this system consists of interactions and feedbacks through the exchange of matter and energy between the spheres. On January 15, 2022, the Hunga Tonga-Hunga Ha’apai volcano erupted in the Pacific Ocean. Volcanoes are a strong destructive force that can have harsh effects on our planet’s climate and human populations. Research on volcanic eruptions such as this one help illustrate how a dramatic event impacts each of Earth’s dynamic spheres, and thus can give us a better understanding of the long-term and short-term effects on our planet.



(wisebox, 2020) Fig. 1

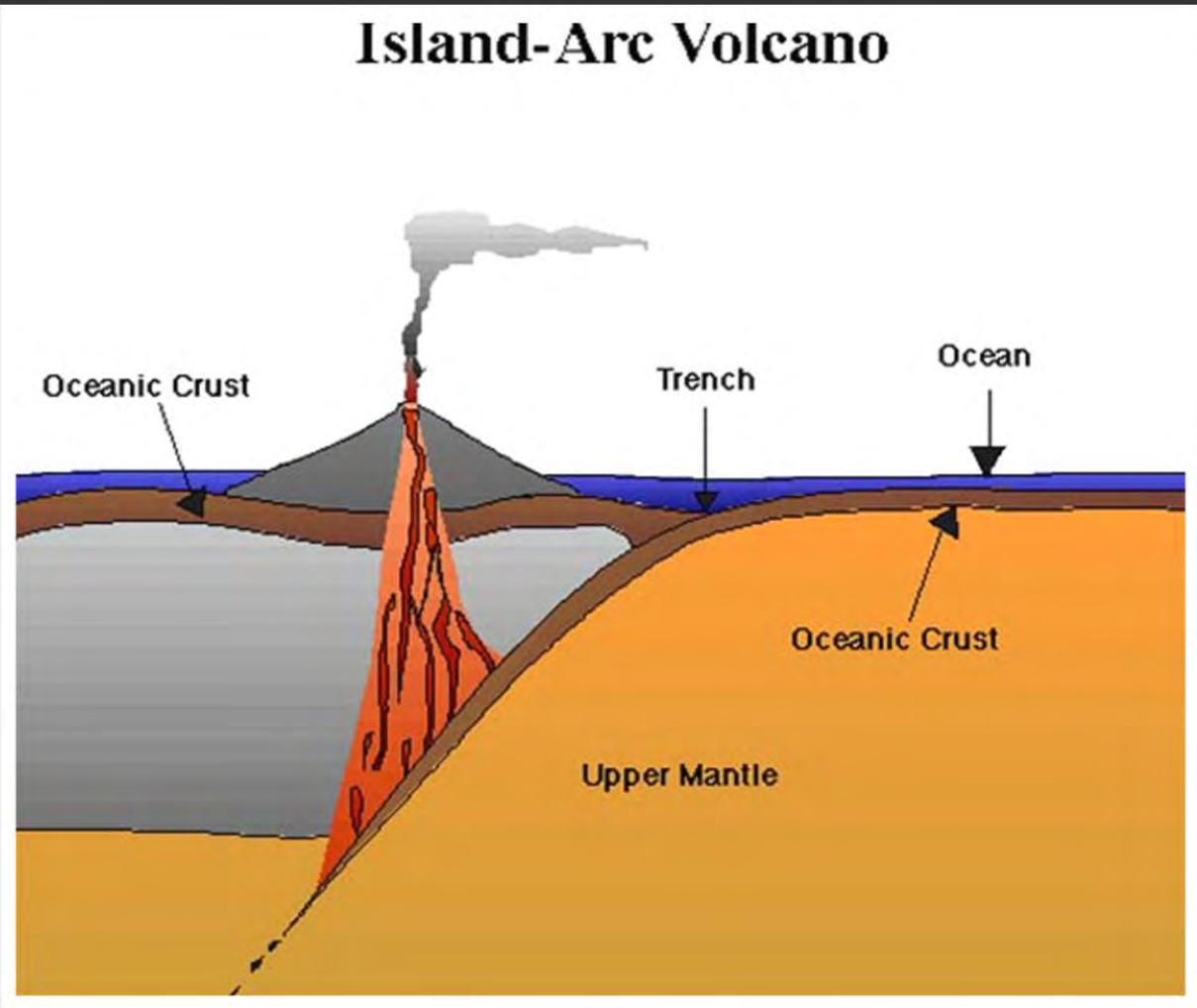
Geologic Setting

The Hunga Tonga-Hunga Ha’apai volcano is located at the Pacific and Indian-Australian convergent plate boundary. The volcano was formed by the subduction of the Pacific Plate underneath the Indian-Australian Plate. There is evidence of a volcanic eruption around 1000 years ago at that location. The volcano erupted as recently as 2009 and 2014-15 . Neither of these had as much power as the 2022 eruption (Fig.6) but they did form the connection between the two original islands of Hunga Tonga and Hunga Ha’apai (Fig. 3-4) (Smithsonian Institution).

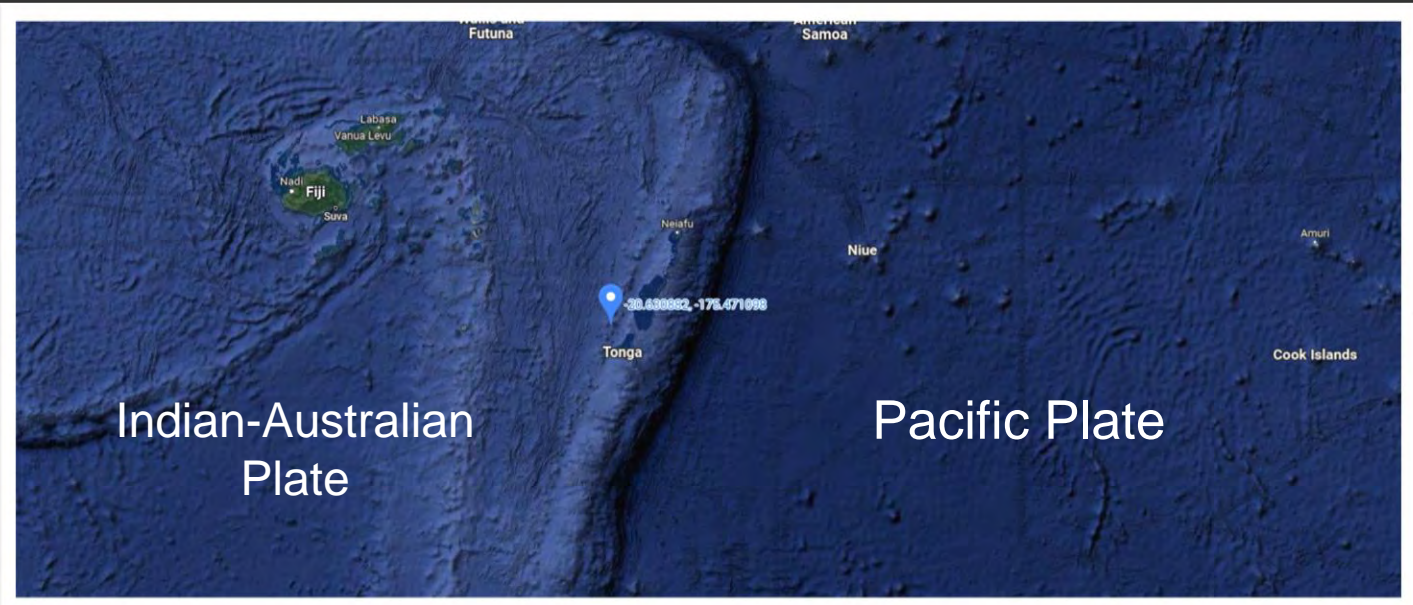


Geosphere

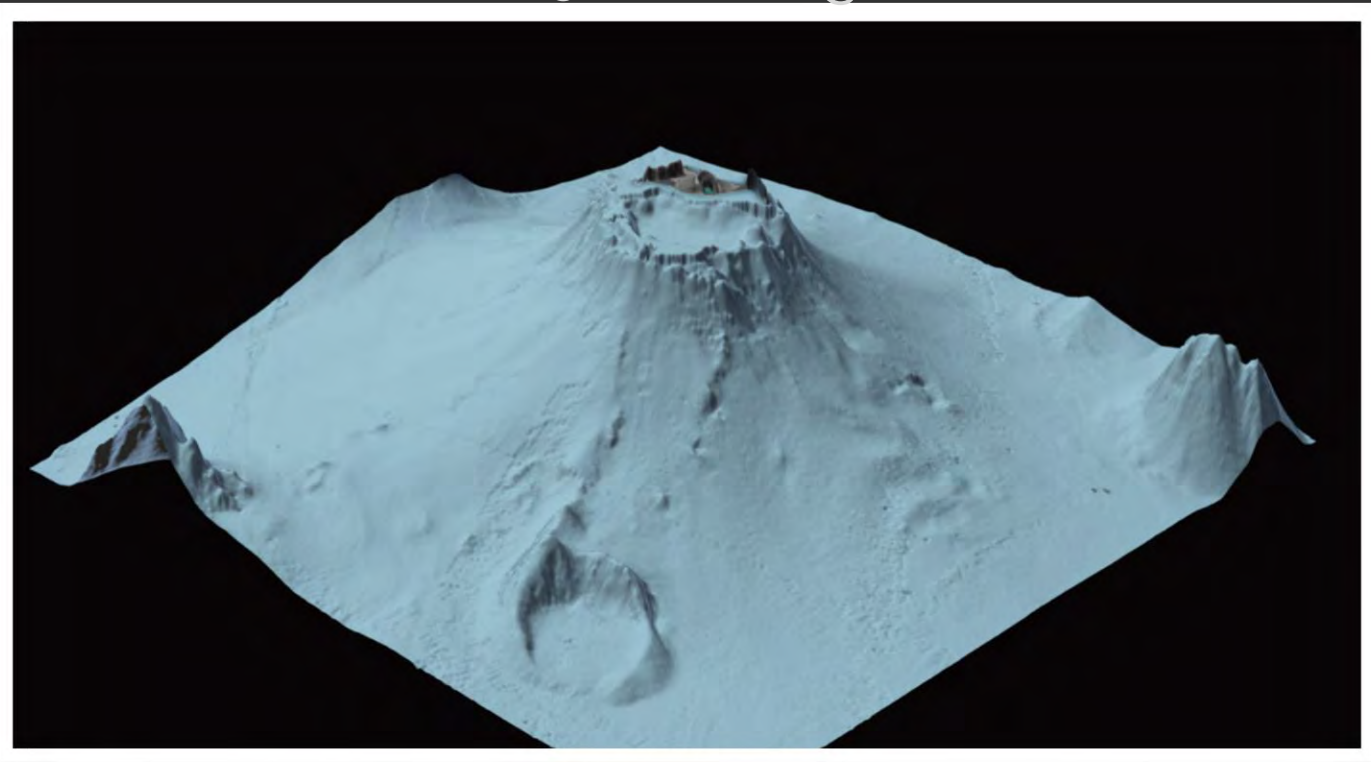
-The eruption event is due to plate tectonics. At the location of this eruption, the Pacific plate is subducting beneath the Indian-Australian plate. At the point of subduction, the Pacific plate experiences partial melting in the mantle to produce andesite magma. Volcanic eruptions on the seafloor slowly built a submarine volcano over millions of years. Eruptions today occur from the volcanic island portion of the volcano. The January 15 eruption was equivalent to 10 megatons of TNT (James Garvin NASA).



(Leeman) Fig. 8



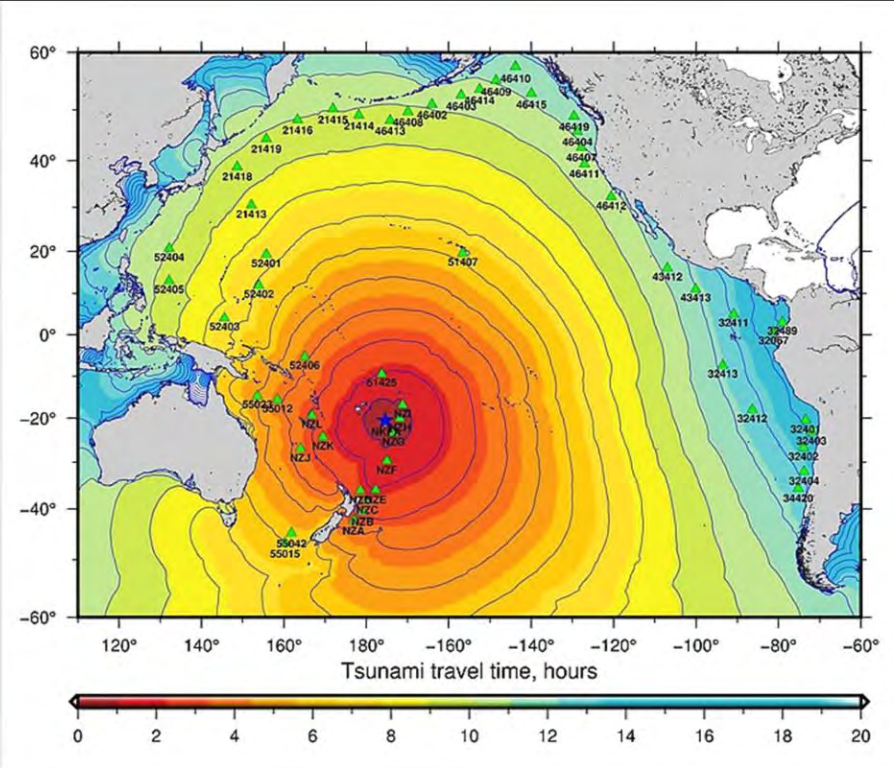
(Google Earth) Fig.9



(vizulaism) Fig.10

Hydrosphere

- A tsunami occurred due to the explosive power of the volcano. Tsunamis do not normally occur from volcanic eruptions, but because the Hunga Tonga-Hunga Ha’apai volcano is at sea level a tsunami was an effect of the eruption.
- A tsunami from a volcano is a rare and unique event. It was difficult for experts to estimate the tsunami landfall (Kreiger, 2022)



(NOAA's National Geophysical Data Center, 2022) Fig.11

-The Western Coast of the main island of Tongatapu faced “significant damage”-New Zealand High Commission (Fig. 12)



(sakakimoana, 2022) Fig. 12

-High waves hit the West Coast of North and South America as well as Japan and other locations around the Pacific Ocean

Atmosphere

- Ash plume Reached 98,000 Feet in the Air and encapsulated the entire island
- Ash plume is a combination of hot gases- H2o, SO2 and CO2 and rock fragments
- 400,000 Lightning Flashes captured on GLD360. Lighting flashes occur when ash and crystals move quickly causing friction which turns into lightning. The lightning also produced ozone (Fig. 13)
- No long-term effects were caused by the ash plume. The climate impact is expected to be a 0.004 C decrease in temperature over the next year (Meng, 2022).



(Fakaenatula, 2022) Fig. 13

- Only the local atmosphere was affected by the ash
- Shockwaves caused temporary pressure changes that were detected by the United Kingdom’s weather systems
- It was reported that Alaskan citizens heard the initial explosion; roughly 6000 miles away

Biosphere

- Located in the South Pacific Ocean, near Fiji the Kingdom of Tonga, or Tonga can be found. An archipelago of roughly 170 islands is home to 105,000 residents.
- 86,213 people are within 100km of the volcano.
- The surge of the tsunami washes seawater and other contaminants onto the land damaging drinking water.
- Due to ash being a combination of small particles and glass, the inhalation hazard was substantial.
- The Ashfall caused a significant impact on agriculture and forestry which has resulted in significant harm to the economy of the locals.



(Maxar Technologies) Fig. 14

- The Internet line running on the seafloor was out for 5 weeks and was separated into 6 separate spots.
- 3 Deaths and 14 injuries in the Kingdom of Tonga.
- 2 Drowning deaths from high waves in and an oil spill in Peru.
- 3 injuries in the United States
- 2 injuries in Japan
- The World Bank Estimated US90.4M in damages.
- First COVID-19 cases reported to the WHO occurred following the explosion and due to outside aid.

Conclusion

The Hunga Tonga-Hunga Ha’apai eruption illustrated how a singular event impacts the tightly connected relationship between each of Earth’s dynamic spheres. The effects of this event however appear to be short-term as each of Earth’s spheres are returning or has returned to normal. A relatively small event such as this makes an excellent case study to show the interactions between each of Earth’s spheres and aids our understanding of larger events in the future as these larger future events are bound to have significant long-term impacts on the planet.