EARTH OBSERVATORY OF SINGAPORE
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NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Assessing global trends in lava flow impact events

Elinor S. Meredith[1,2], Susanna F. Jenkins[1,2], Josh L. Hayes[3], David Lallemant[1,2] Natalia Deligne[4], and Rui Xue Natalie Teng[1,2]

[1]Earth Observatory of Singapore, Nanyang Technological University, Singapore; [2]Asian School of the Environment, Nanyang Technological University, Singapore;
[3]GNS Science, Lower Hutt, New Zealand; [4]U.S. Geological Survey, Hawaiian Volcano Observatory, Hilo, Hawaii, USA

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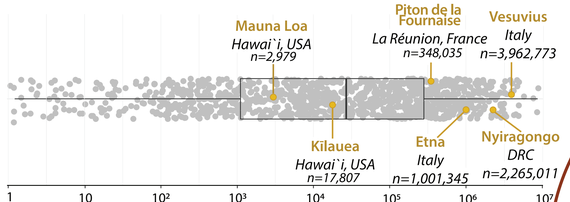
1 Why study lava flow impacts?

- Lava flows that impact the built environment **devastate communities** in volcanic regions (Blong, 1984; Harris, 2015)

- Lava flows impact population centres **twice a decade** (Harris et al., 2016) Is this still the case?

- Populations **live in close proximity** to effusive volcanic centres.



Above: Population (WorldPop, 2020) living <30 km from a Holocene volcano. Each dot represents one volcano. Key effusive volcanic centres highlighted.

- Past impact data can be used to develop impact forecasting models, identify gaps in our data collection and better understand **building-lava interactions**. Particularly because...

- Buildings in contact with lava have been **used post-event** (Jenkins et al., 2017; Tsang and Lindsay, 2020)

Above: Circular structure remains intact in contact with lava during the 2014-2015 Fogo lava flows, Cabo Verde.

- Observations of **range of damage**, and damage at distance from lava flows (Meredith et al., 2022)

Above: Fire damage to vegetation in the direction of prevailing wind during the 2018 LERZ lava flows, Kīlauea.

2 Building a new dataset on Lava Flow Impact Events

Past event compilations: Blong, 1984, Harris, 2015, Jenkins et al., 2017, Brown et al., 2017, Tsang and Lindsay, 2020

Published studies from search *"Lava flow AND [Volcano Name in past event compilation] AND damage OR destroy OR impact"* from search *"Lava flow AND damage OR destroy" Through Google Scholar*

GVP records: mentioning *"lava flow"* and *"impact", "damage"* or *"destroy" Through web-scraping*

Newspaper articles: from search *"lava flow impacts", "impact of lava flow" and "lava flow destroyed"*

Top 10 studies selected per event based on ranking by study type specificity

Event information ranked by scale

Hazard information	Impact information
1. At point of impact	1. Building damage
2. Localised area	2. Number of Buildings
3. Average or max	3. Villages/Cities
4. Qualitative	4. Qualitative

Highest ranked information selected

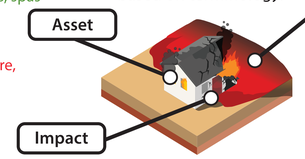
Lava Flow Impact Events Database

Volcano info, Hazard info, Impact info, Notes, References — *Min, Max and Median or Qualitative*

- Lava Flow Impact Events of **impacts to structures** collated through systematic data collection.

Villages, settlements, cities, towns, buildings, houses, roads, ski-lifts, pyramids, farmsteads, railways, spas
Populations, areas, regions, properties
Farms, farmland, agriculture, fences, hiking trails

• Inclusion criteria
Events were included, verified with other records, or not included based on terminology.

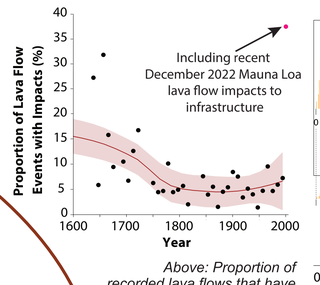


Lava, lava flow
Lava mud, lava flood, cold lava, lava avalanche
Block-and-ash flow, lava dome, nuée ardente

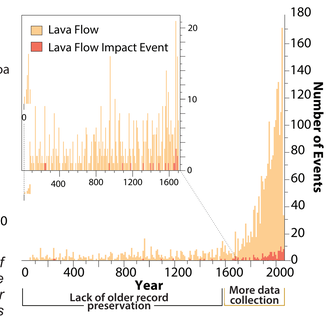
Damaged, destroyed, engulfed, buried, covered, severed, cut, traversed, impacted
Reached
Threatened

3 Lava flow Impact Events increasing

Most comprehensive lava impact dataset: 129 lava flow impact events ~4 per decade

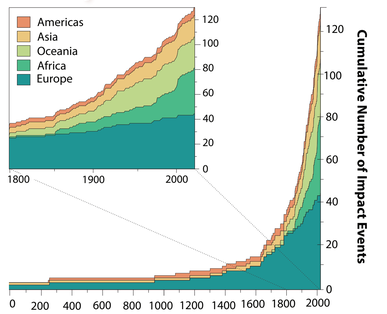


Above: Proportion of recorded lava flows that have documented impacts in our dataset. Proportions calculated over 10-year periods (black dots) and 2020-2022 CE (pink dot). LOESS curve (red line) with 95% confident interval.



Above: Recorded lava flows (yellow) from GVP (2013) and lava flow impact events we collated. Binned by 10-year periods. Final bin contains two years, 2020-2022 CE. Three impact events prior to 1 CE are not shown.

4 Lava flow Impact Event spatial trends

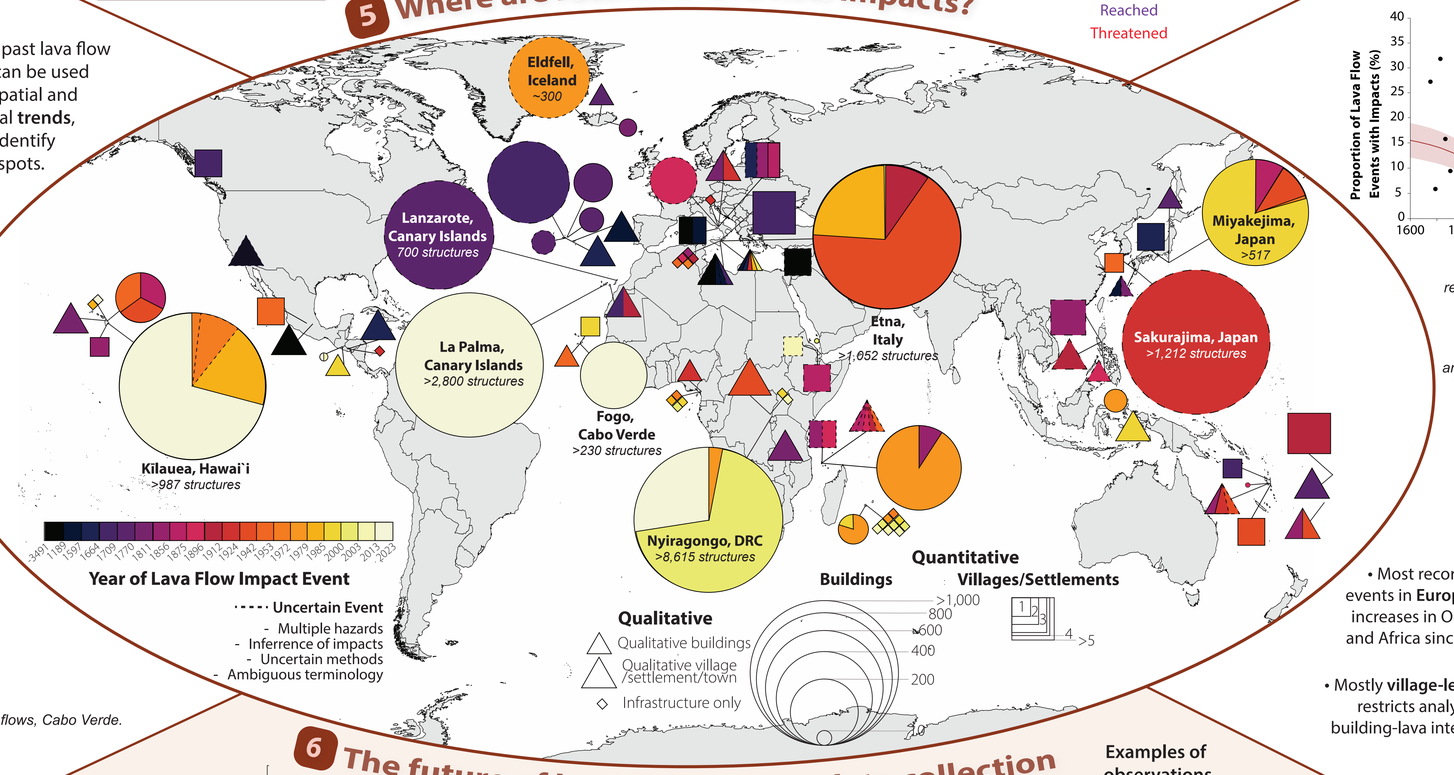


Above: Cumulative frequency of recorded lava flow impact events classified by region. The lava flow events prior to 1 CE are not shown but are included on the cumulative count. Regions defined by UN geoschemes. Hawaiian events (n=11) as Oceania. Réunion events (n=11) as Africa.

- Most recorded events in **Europe**, and increases in Oceania and Africa since 1800.

- Mostly **village-level** which restricts analysis of building-lava interactions.

5 Where are recorded lava flow impacts?

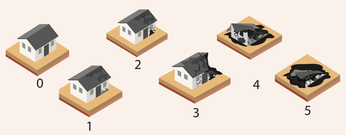


6 The future of lava flow impact data collection

Collecting building-level damage data and precise hazard data can be used to find relationships and assess interactions.

- Few past lava flow impact assessments

- What data to collect?
Damage: Damage states
Hazard: thickness, velocity, dynamic pressure
(Wilson et al., 2014)



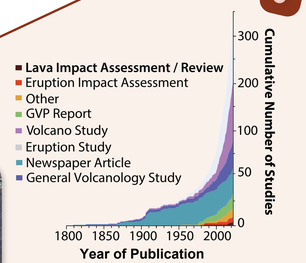
Damage State Schema (Meredith et al., 2022)

Examples of observations

- Damage along flow margins.
- Pāhoehoe through openings
- Pāhoehoe lava overtopping channels causing damage.
- Thin lava surrounding circular structures
- Damage, destruction, burial, collapse and inundation.

Left: Pāhoehoe flowing through openings during the 2014-2015 Fogo lava flow.

Right: Varying building damage along the flow margin of the 2021 Tajogaite lava flow, Cumbre Vieja, La Palma.



Above: Stacked area chart timeline of the cumulative number of records used in this study.

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