Subaqueous sediment mobilization: insights into geo-hazards around the Azores volcanic islands, the mid-Atlantic

海底沉積物大遷徙:
以海底山崩與沉積物波看火山島災害的前世今生

張瑜峻 (Yu-Chun Chang)

yu-chun.chang@manchester.ac.uk

contributors

Neil C. Mitchell, Rui Quartau, Armin Freundt, Julie C. Schindlbeck-Belo,
Thor H. Hansteen, Christian Hübscher, Liliana Rusu, Fernando Tempra

2022 Dec. at the NCU seminar

About Me

Yu-Chun Chang

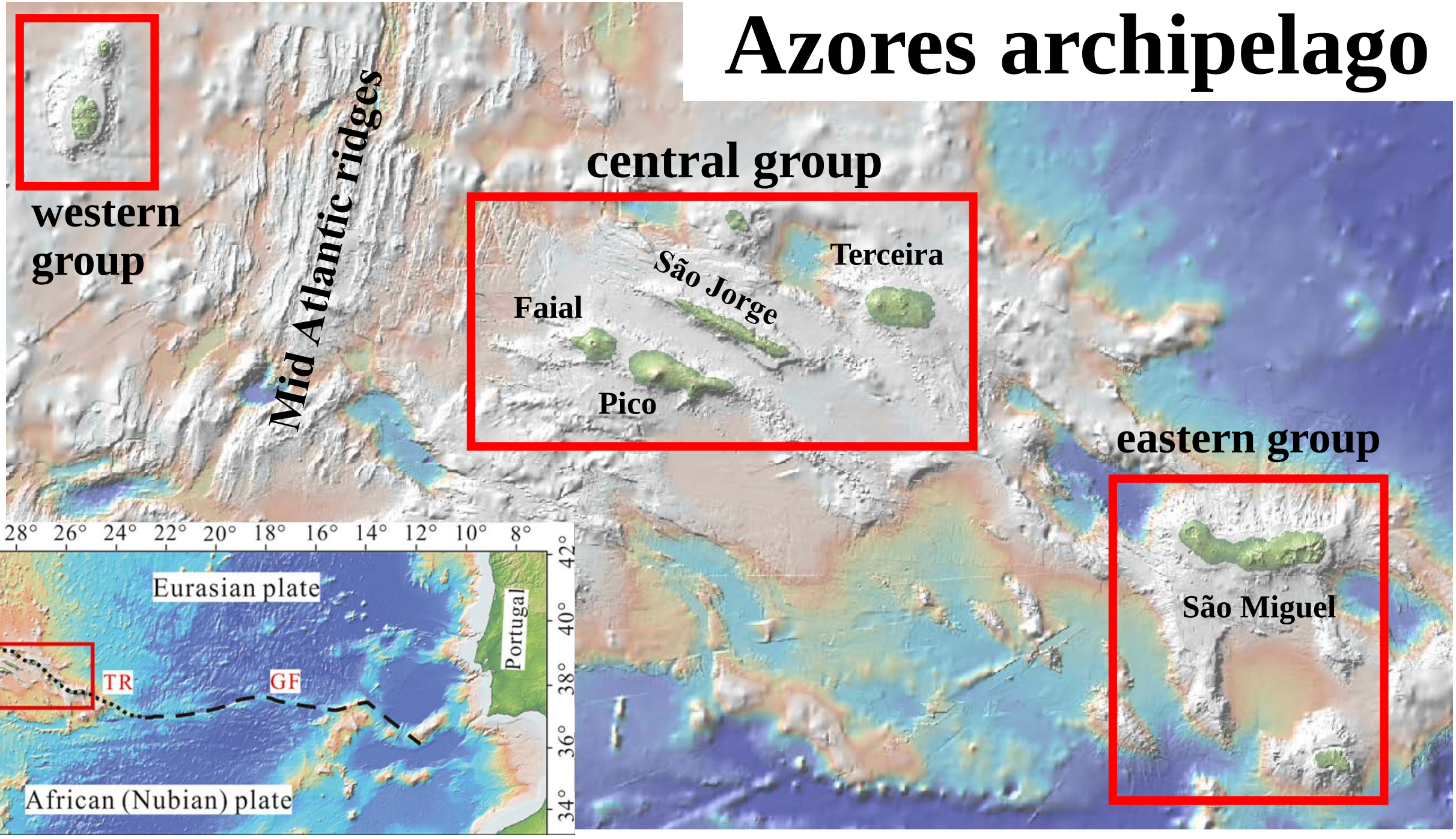
Working on issues of sedimentary processes and geological hazards around the insular volcanic islands by applying multidisciplinary methods.

2023-2025 PostDoc at JAMSTEC
2018-2022 PhD at UoM
2012-2014 MSc at NCKU
2008-2012 BSc at NCKU

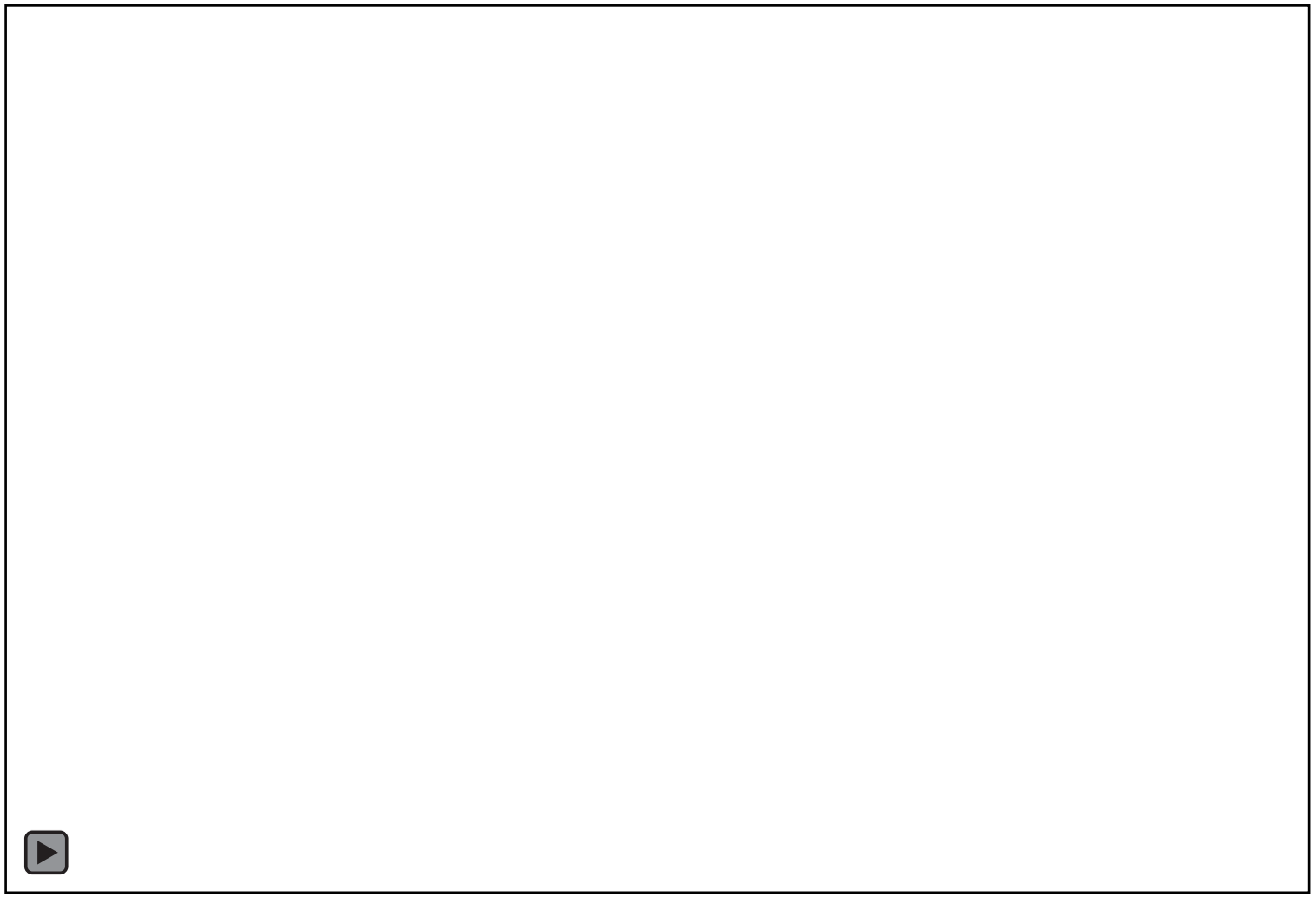
Yu-Chun Chang
@landslide_chang

Yu-Chun Chang

Azores archipelago



Why studying volcanic islands are important?



Search The Guardian UK edition For 200 years News website of the year

Tonga volcano: 84% of population affected by ashfall and tsunami

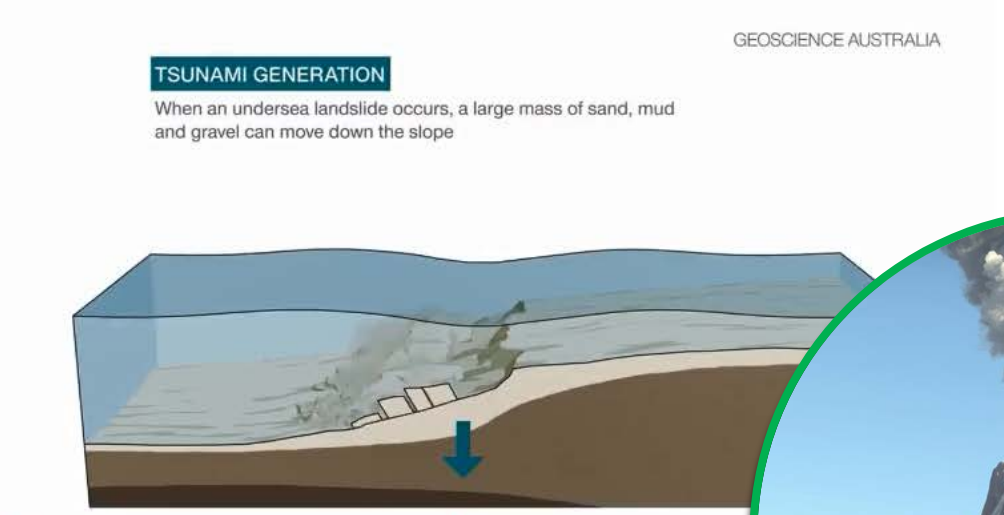
BBC Sign in NEWS

Tonga volcano: Plume reached half-way to space

Source: US_Stormwatch (Twitter)

Hazards around volcanic islands

Submarine landslide

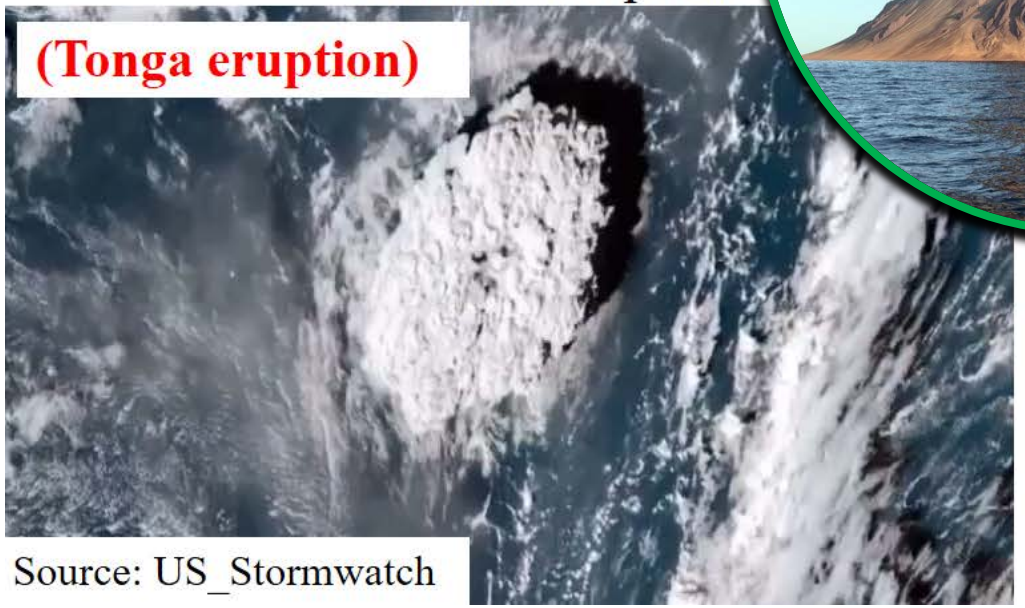


Source: geoscienceAustralia

Earthquake

online source unknown author

Volcanic Eruption

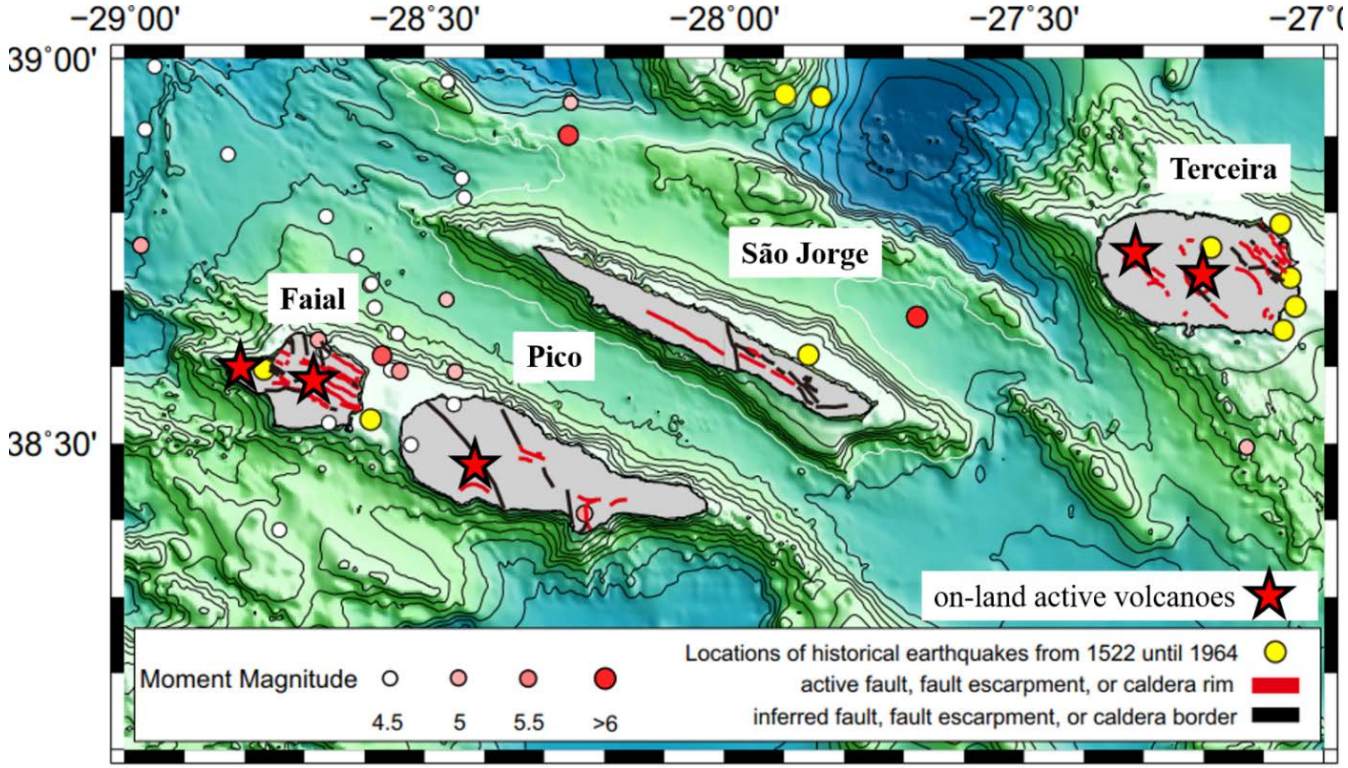


Source: US_Stormwatch

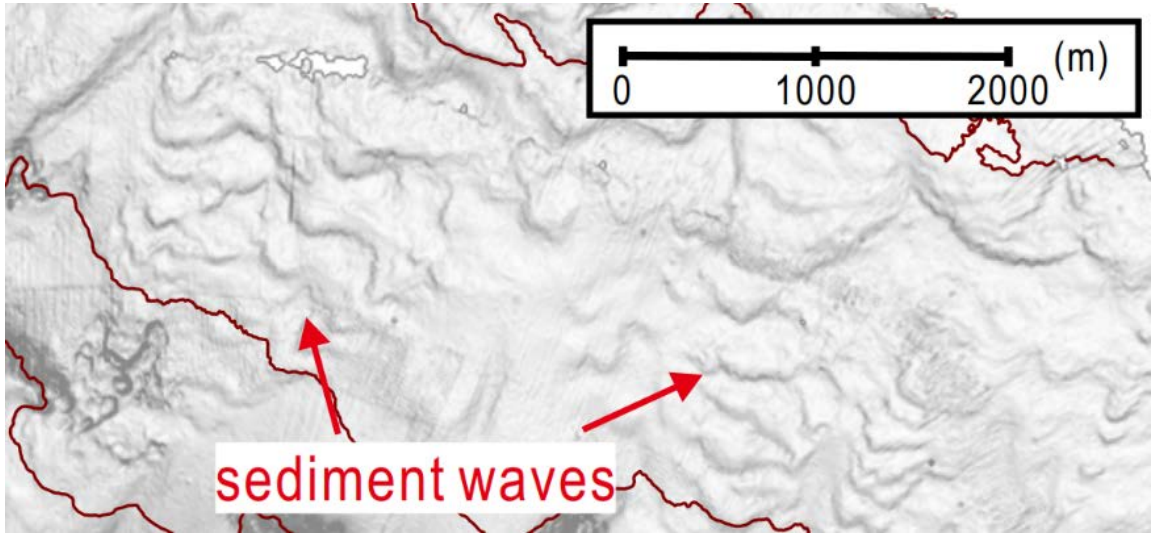
Tsunami

online source unknown author

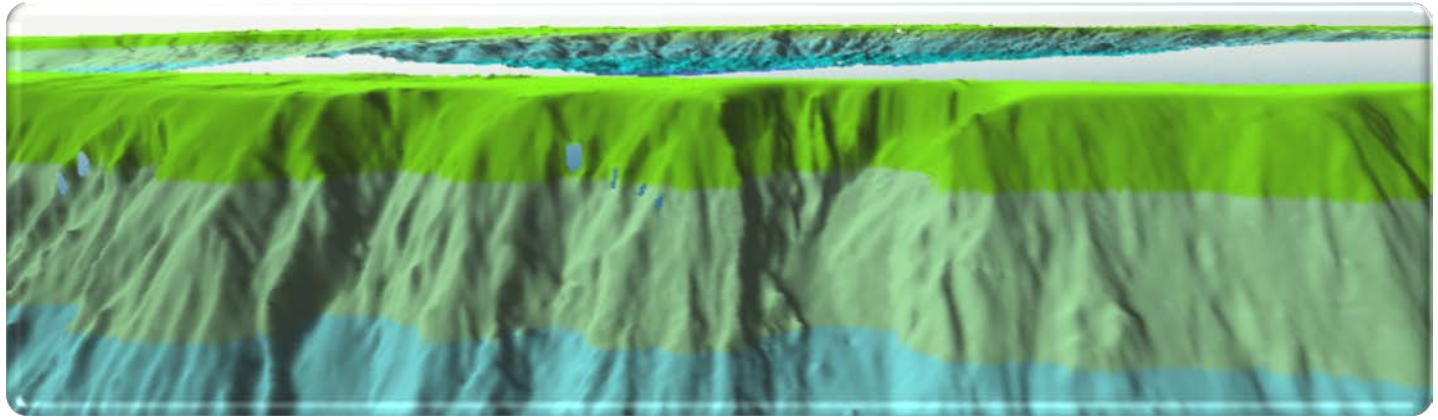
Geological background



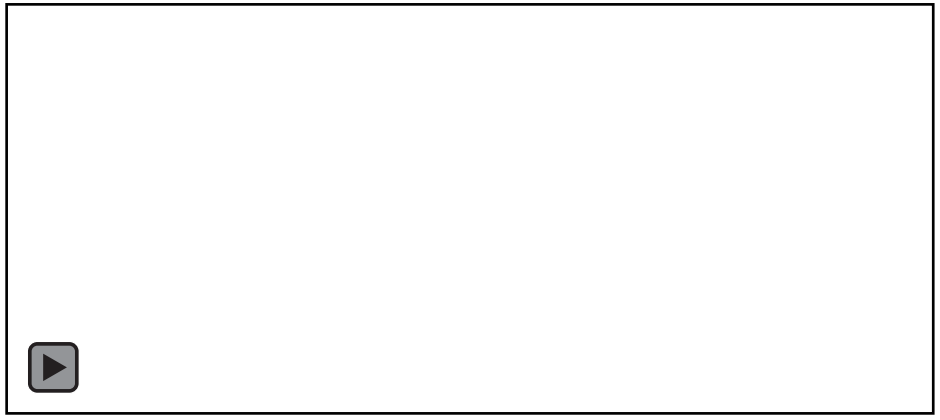
Historical events and structure maps



Sediment waves on the slopes

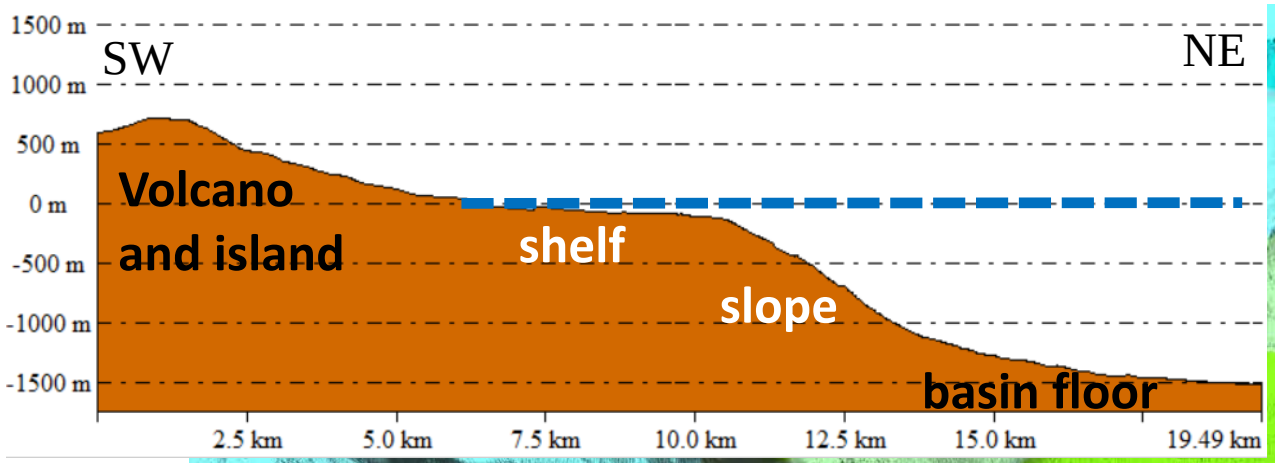


Slope valleys on the shelf edges



Sediment flows transformed from failed mass

Research Aims

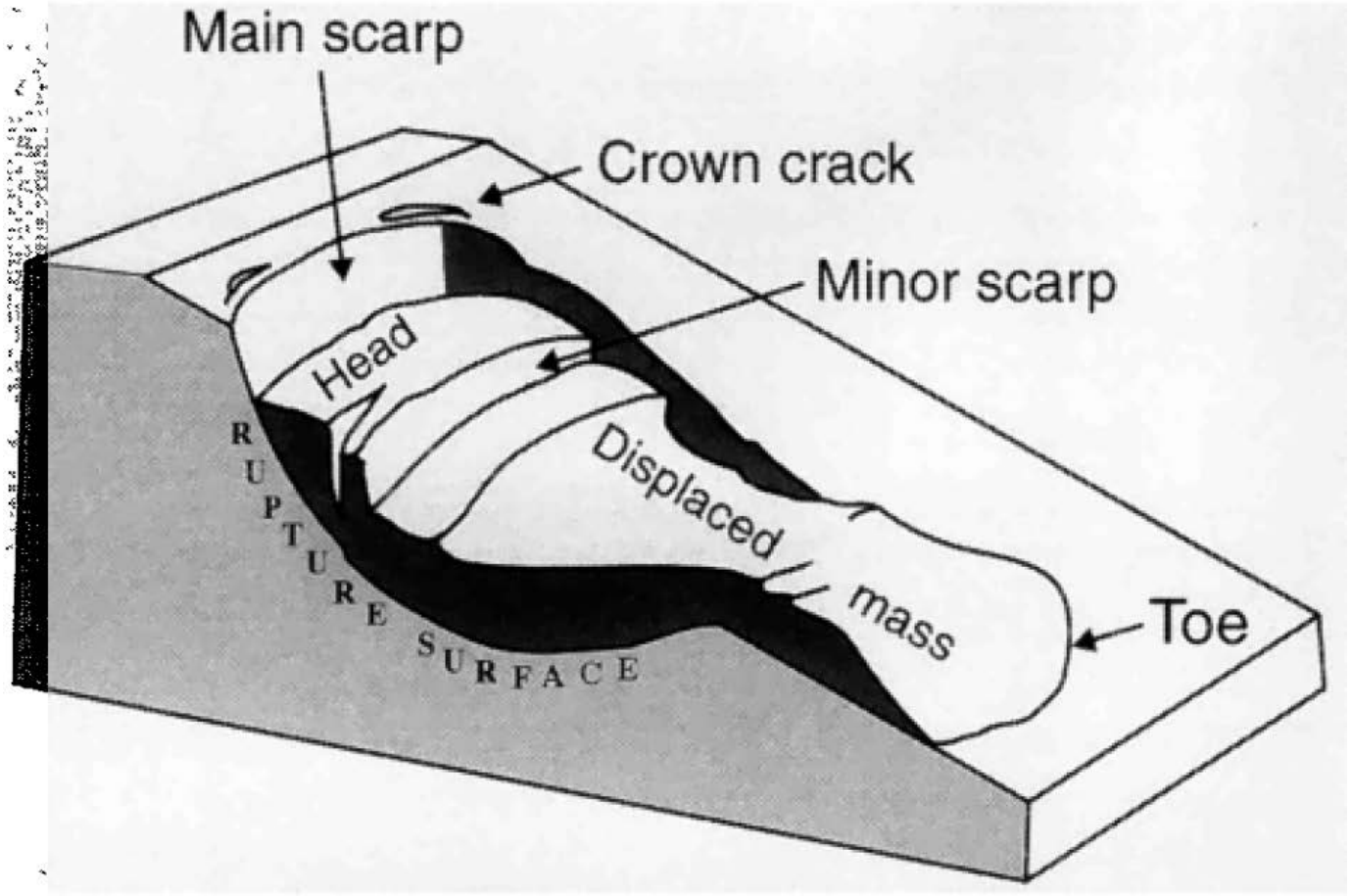


1. Characteristics and causes of
   a. submarine landslides
   b. sediment waves

2. Implications for hazards


Part 1
Submarine landslides on the shelf edges and upper most slopes
Online source

What are the typical features and common causes of (submarine) landslides?



Causes of Submarine Landslides

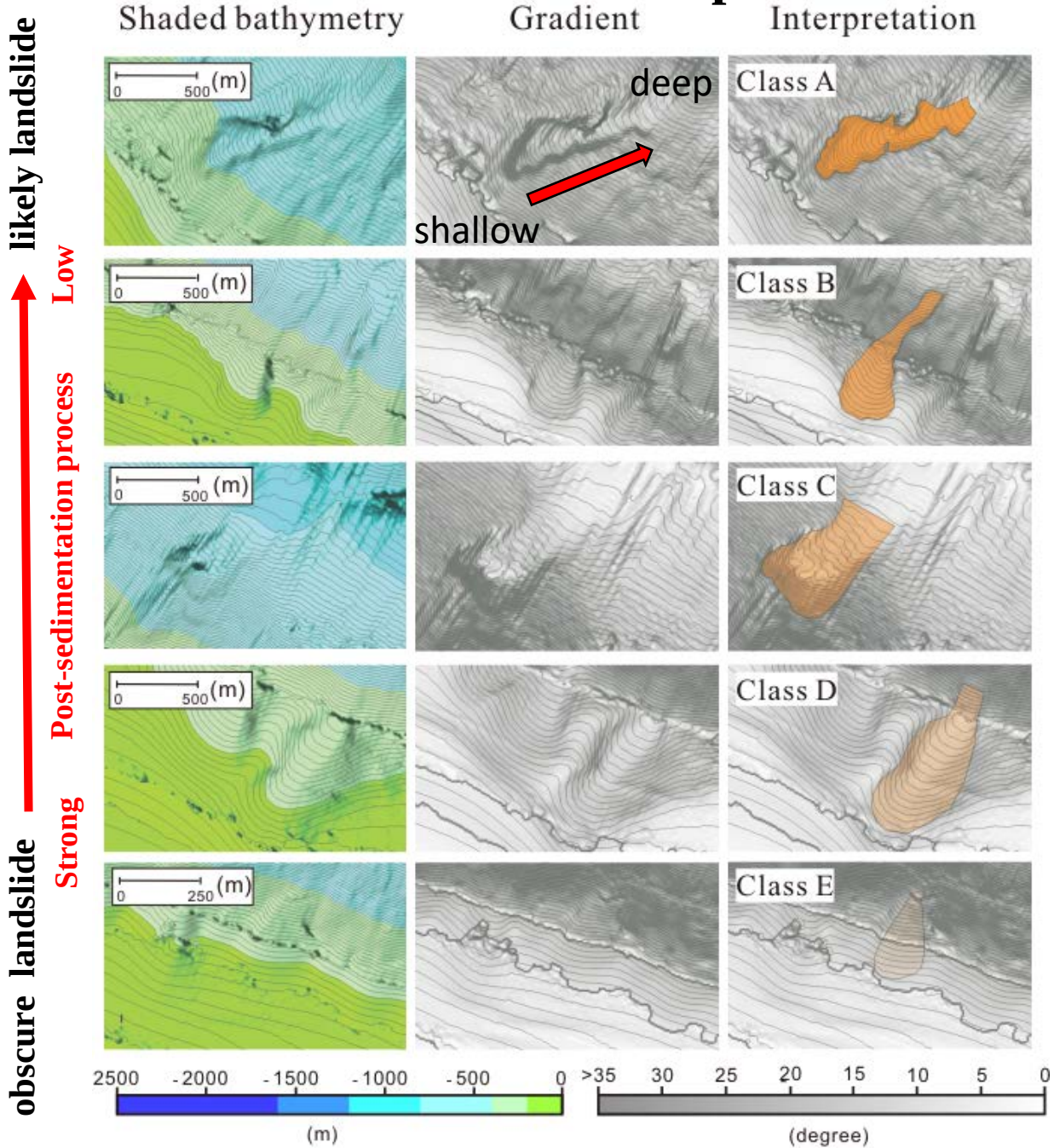
$$F = \frac{\text{Resisting forces}}{\text{Gravitational forces}}$$

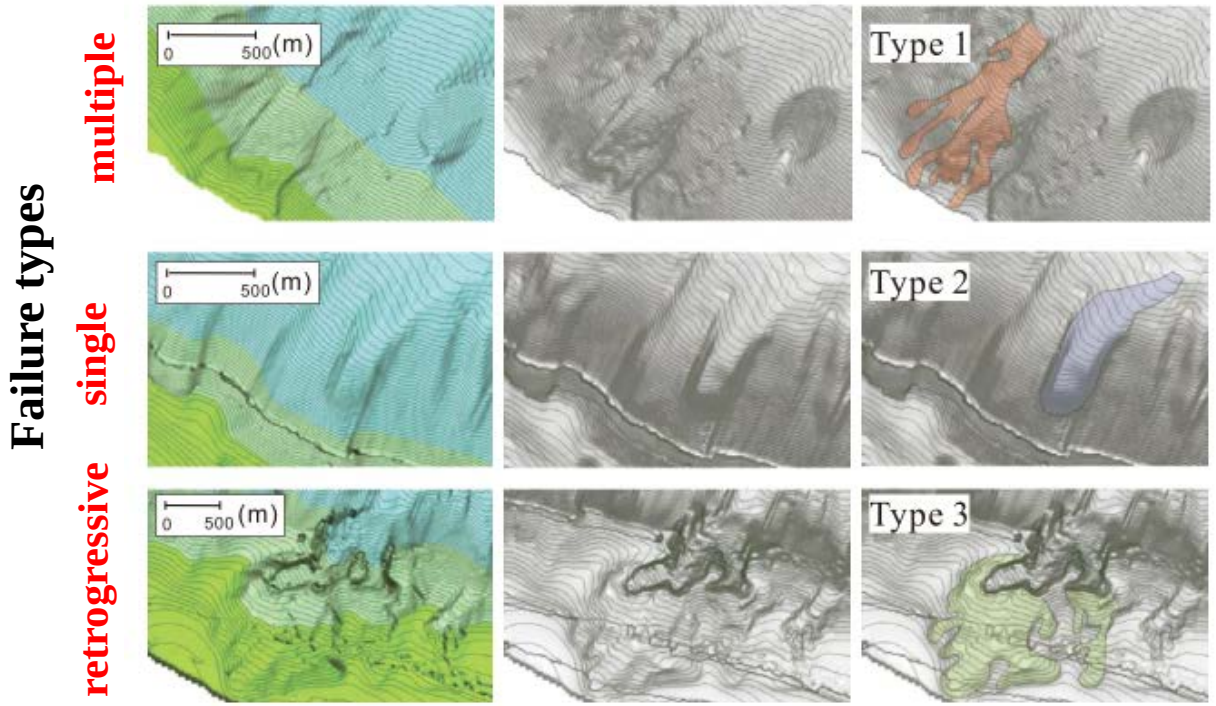
Reducing the strength:	Increasing the stress:
Earthquakes	Earthquakes
Wave loading	**Wave loading**
Tidal changes	Tidal changes
Weathering	Diapirsm
Sedimentation	Sedimentation
Gas	Erosion

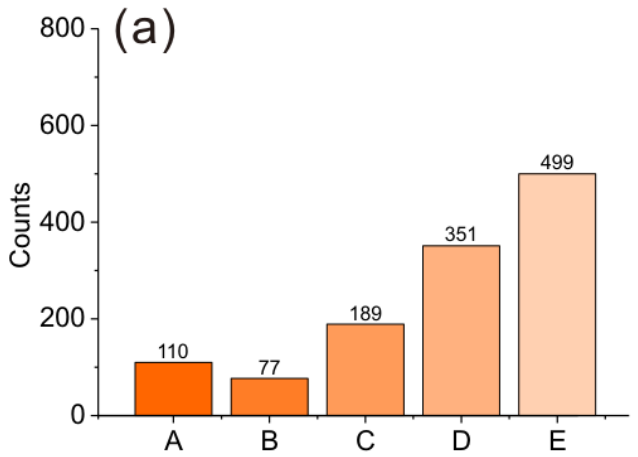
Hampton, 1996

Landslides in submarine slopes of Azores volcanic island

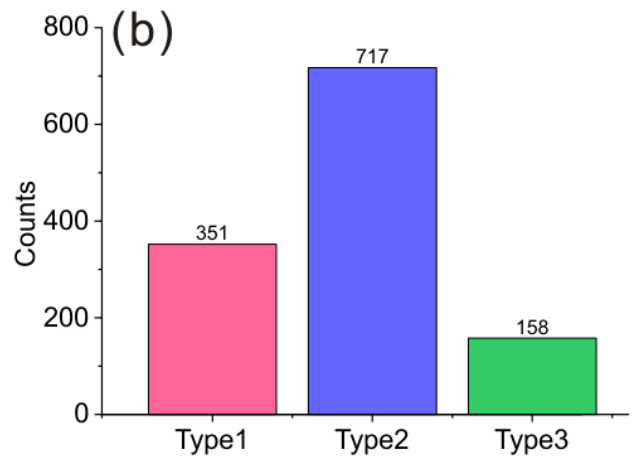
Chang et al., 2021a, G-cubed





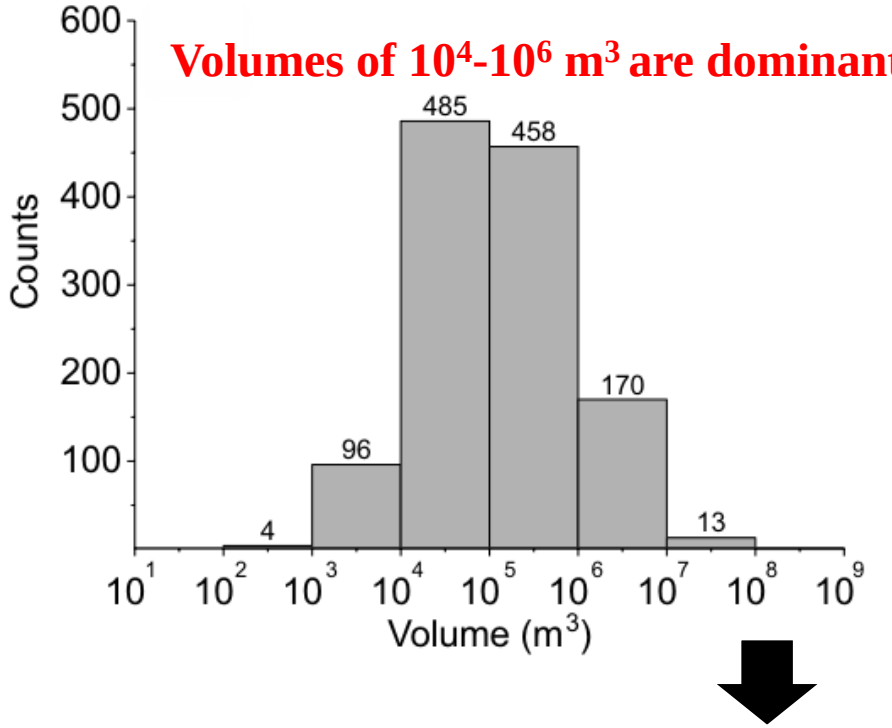


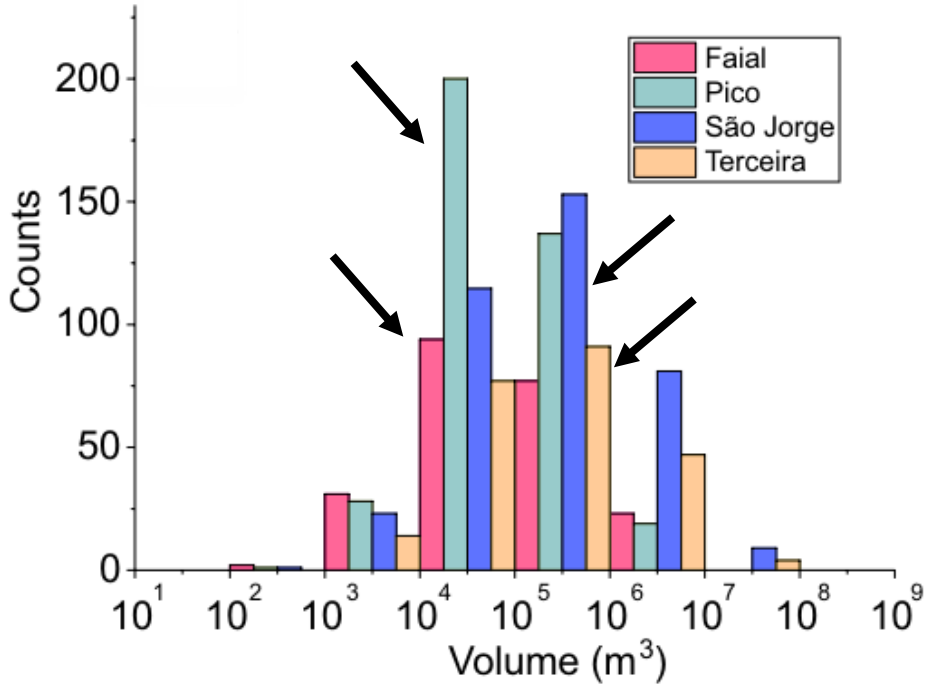
>1200 valleys were mapped

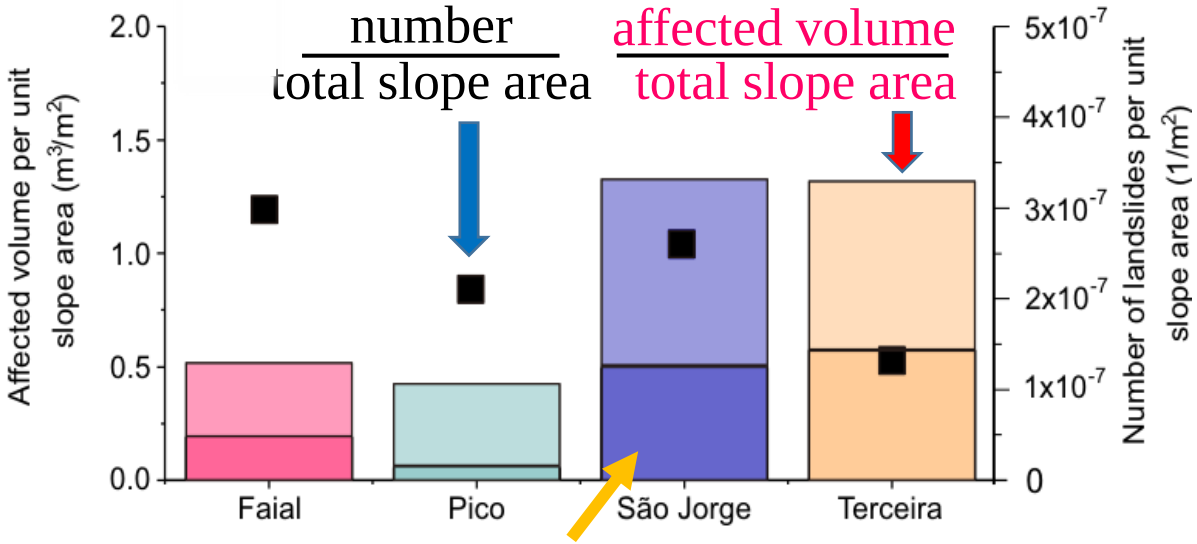


type 2 failure are dominant

Summaries of submarine landslide mapping





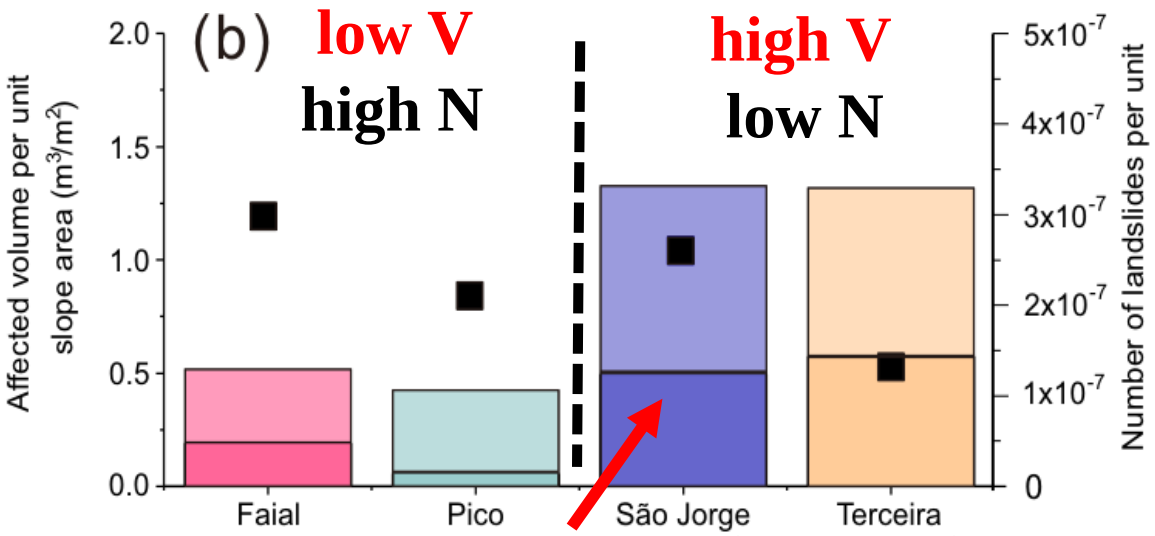


Bold colour: most recognizable and from single failures

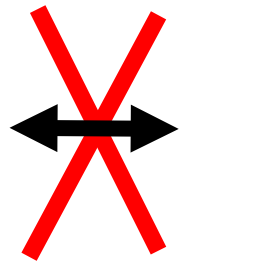
Hazard implications for landslide mapping

Chang et al. 2021a, *G3*

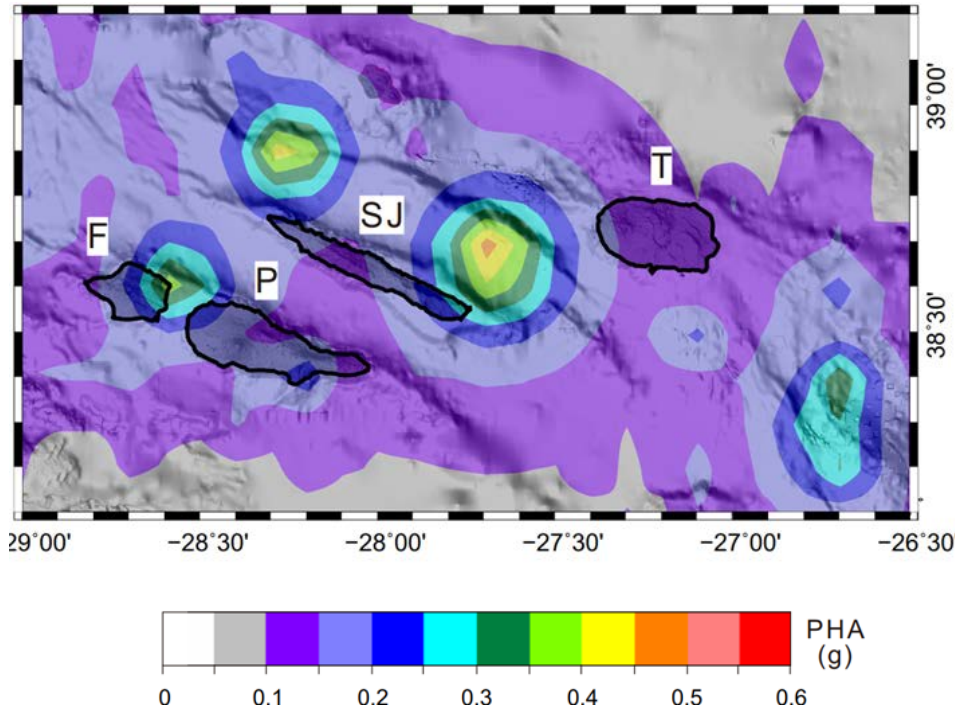
High abundance but small volume landslides around Faial and Pico



Bold colour: most recognizable and from single failures



uncorrelated

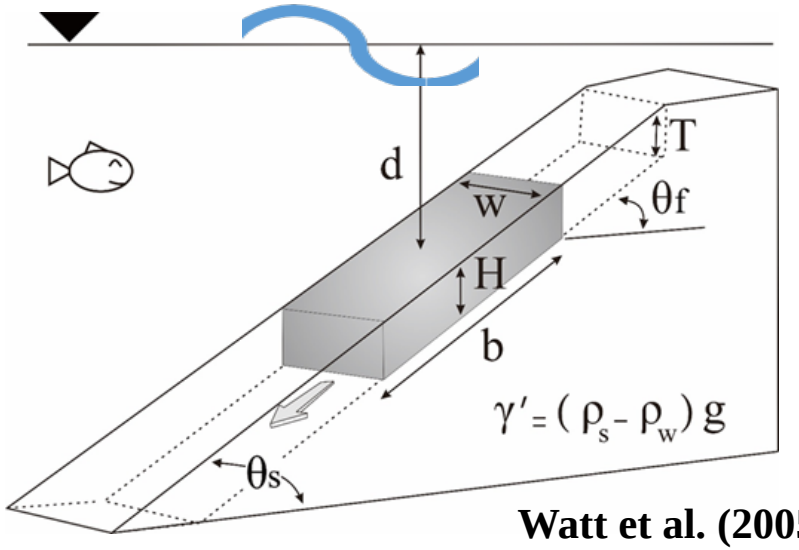


Long-term seismic hazards?

Interpretations:

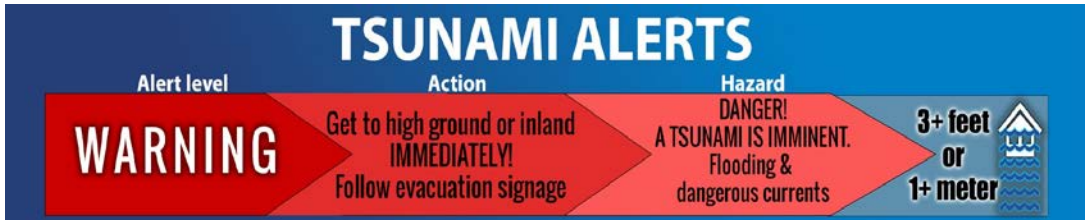
Large earthquakes occur relatively frequent under Faial and Pico, hence shorter interval for sediment deposition.

Tsunami wave height estimate



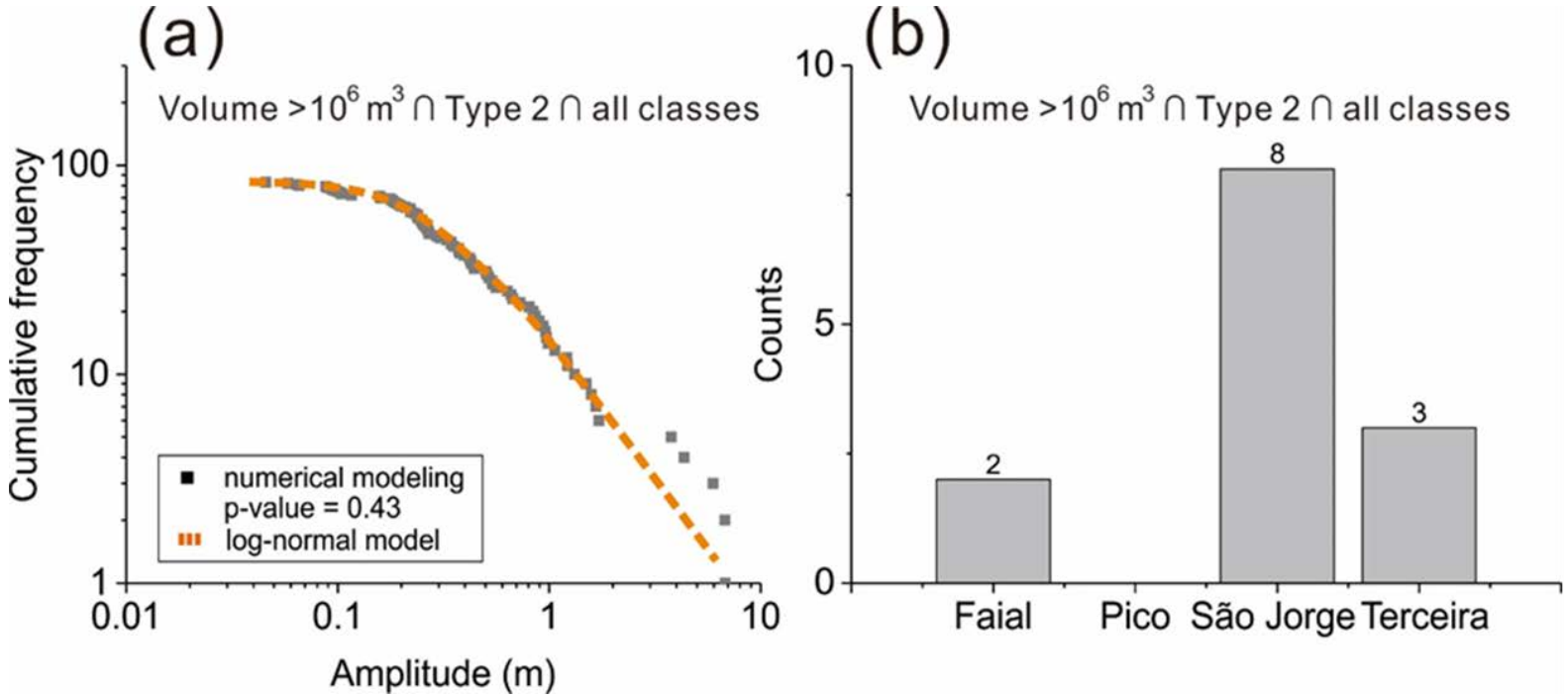
Watt et al. (2005)

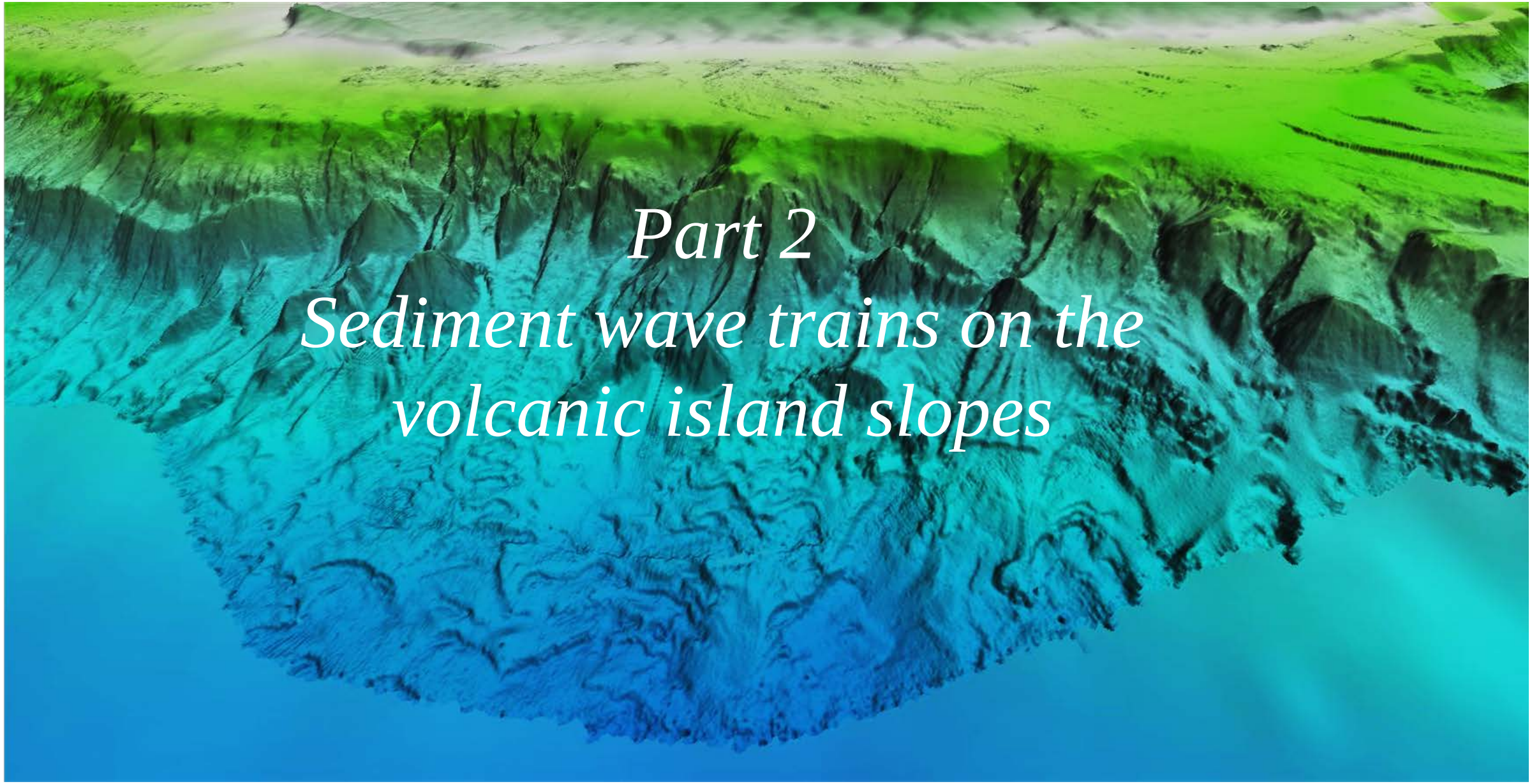
warning level → wave h >1m



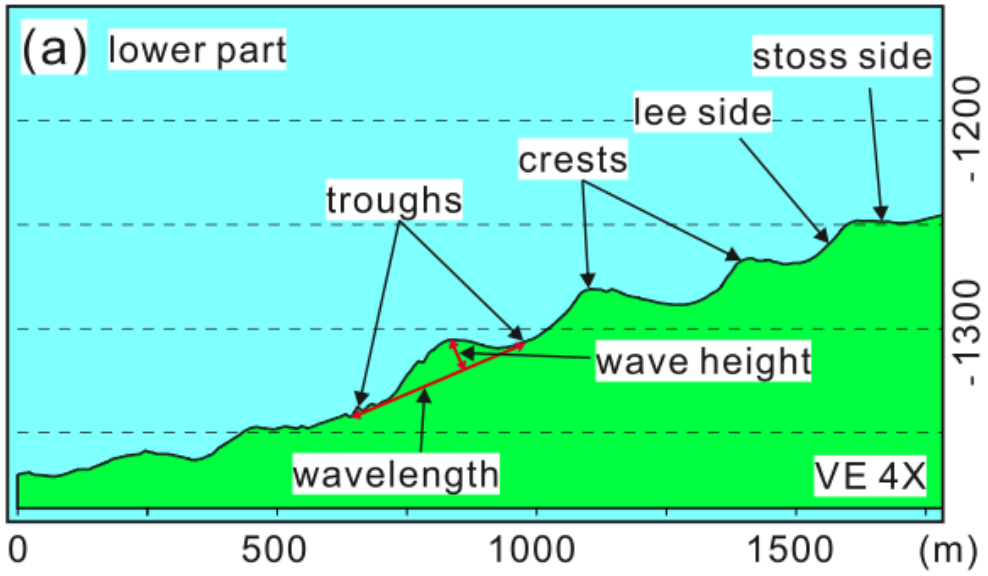
Assume modern sea-level

13 predicted with h>1 m at source and the max. is ~7m.

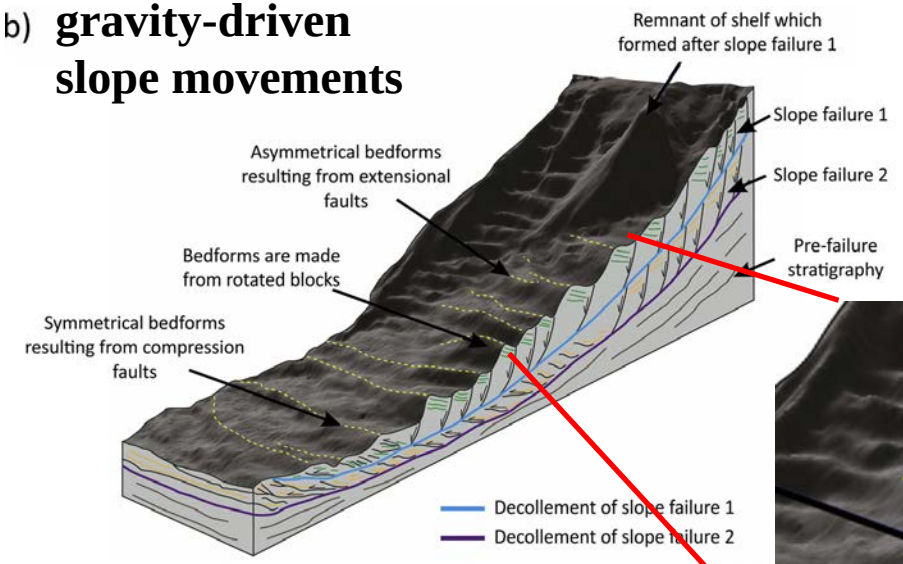



Part 2
Sediment wave trains on the
volcanic island slopes

Submarine bedform morphological features and the processes forming them



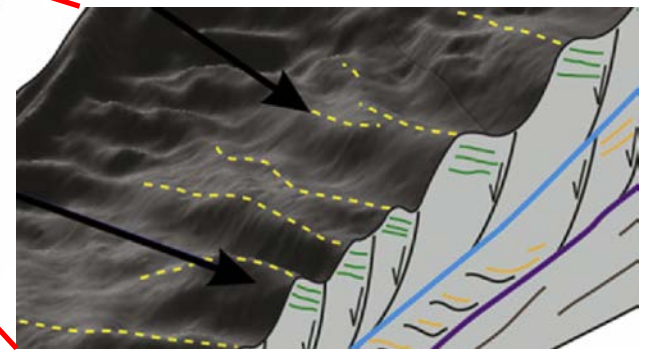
b) **gravity-driven slope movements**



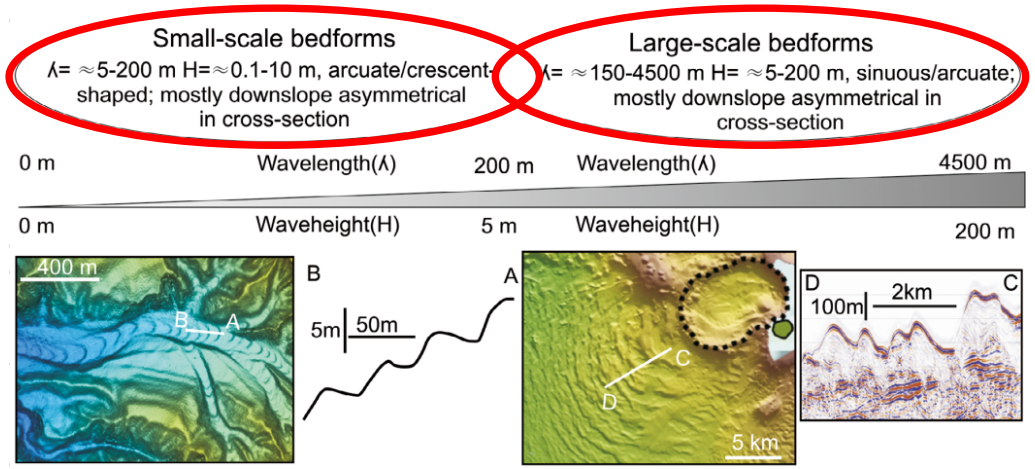
Pope et al., 2018

Internal structures

Basal surface

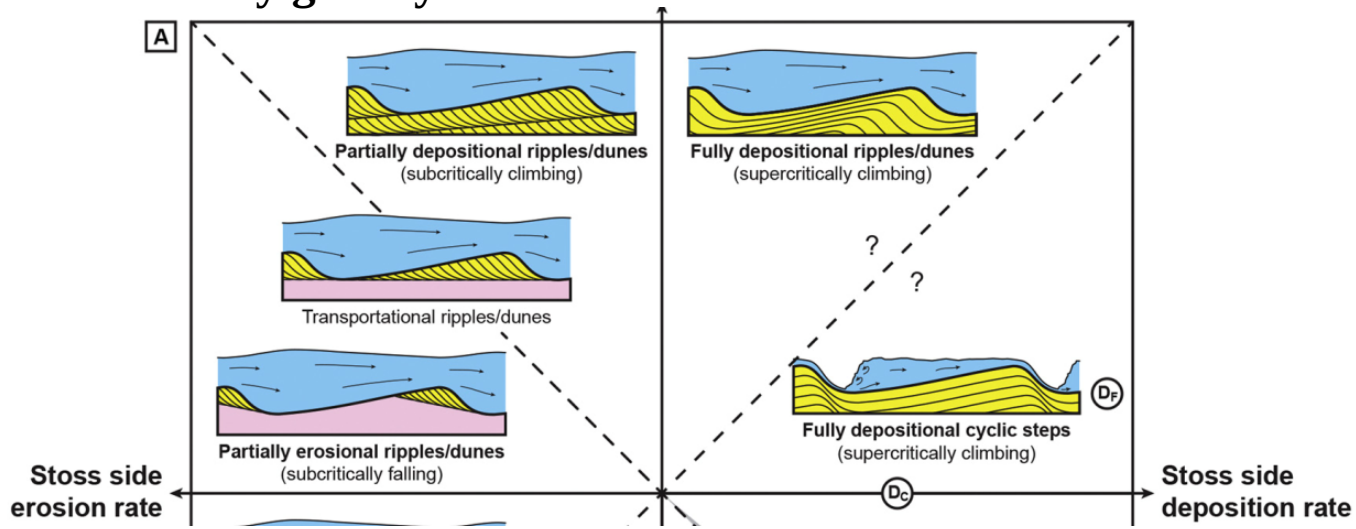


EROSIONAL-DEPOSITIONAL BEDFORMS IN MARINE VOLCANICLASTIC SETTING



Casalbore et al, 2020

Sedimentary gravity flow

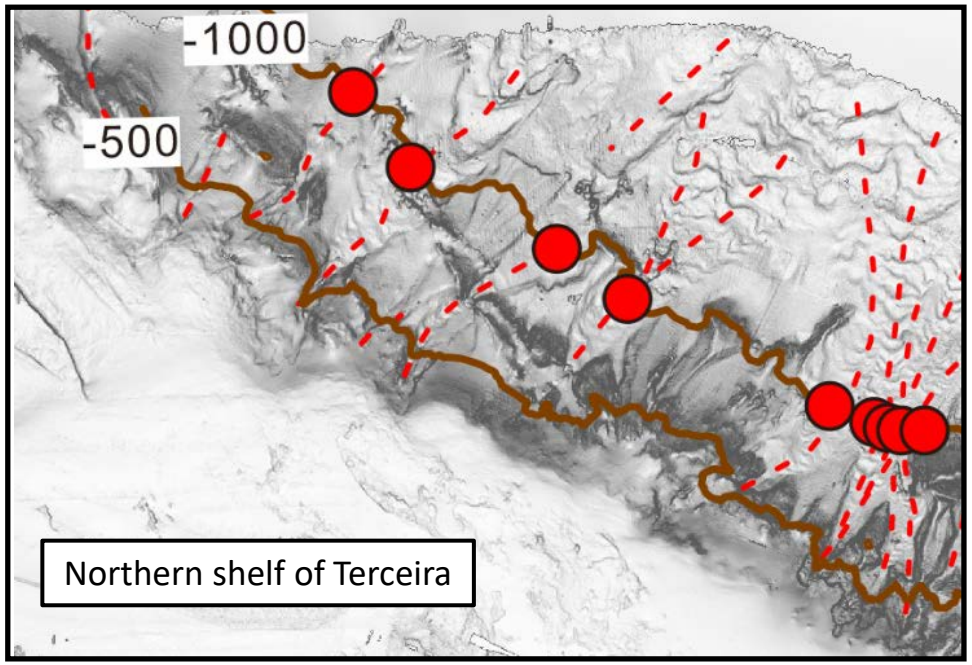


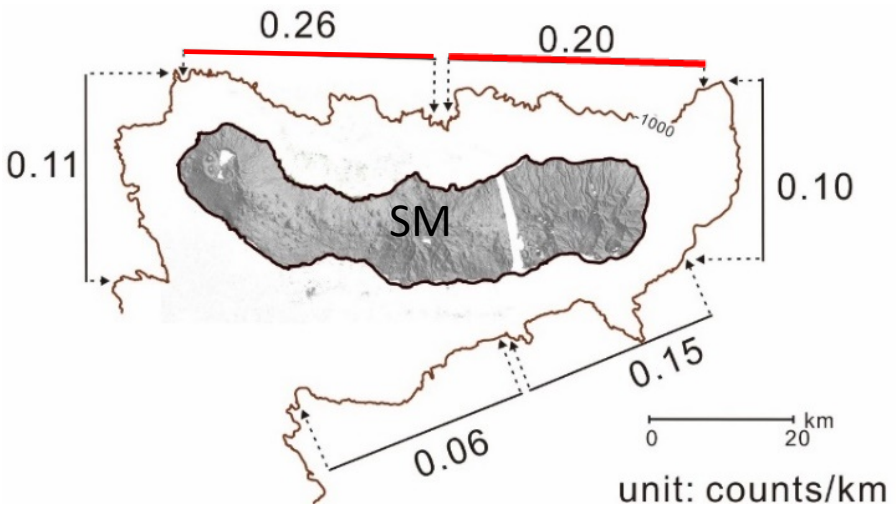
Slootman and Cartigny, 2020

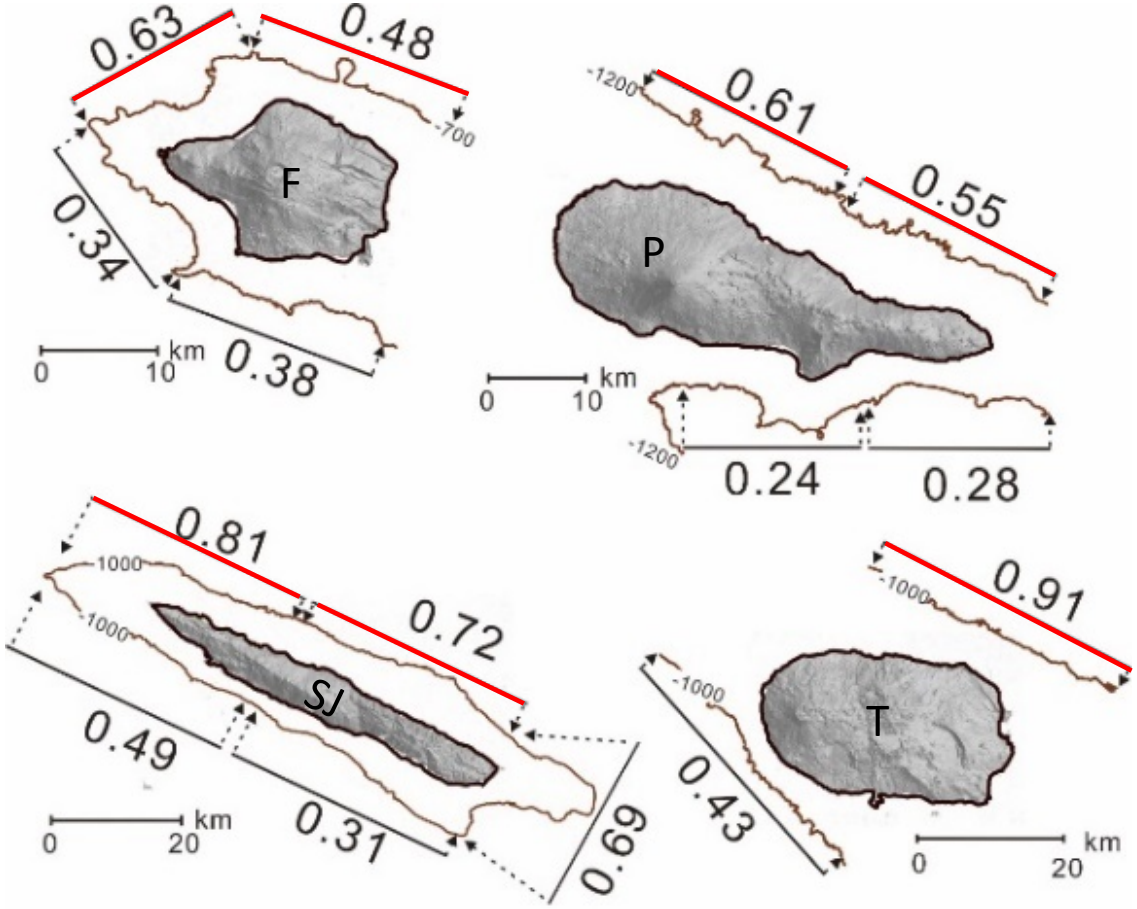
Asymmetric abundances of submarine sediment waves

Chang et al., 2022, *Marine Geology*

Densities of sediment wave trains







The density of sediment wave trains are twice as abundant on the northern submarine slopes of the islands

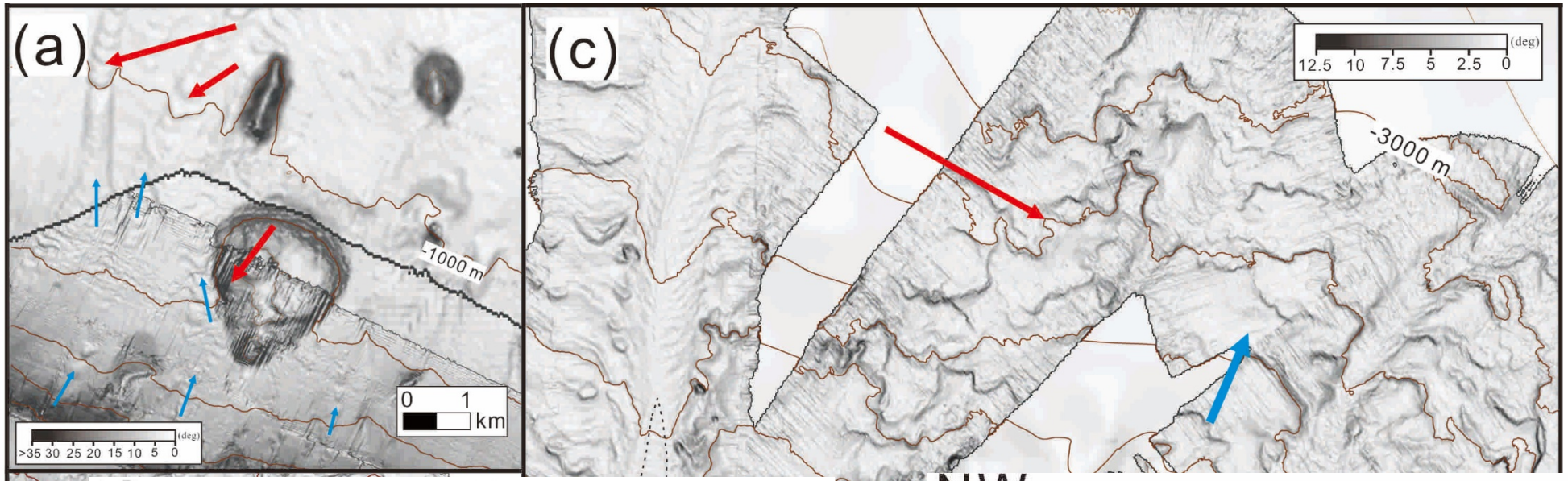
What processes form sediment wave trains?

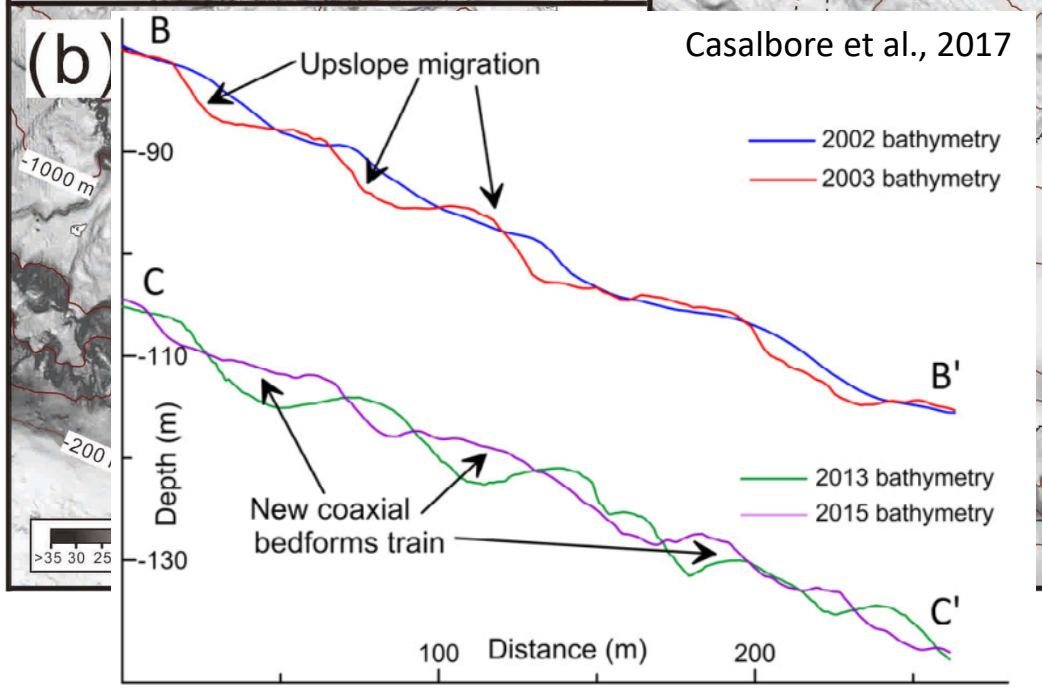
sedimentary gravity flow

gravity-driven slope movements

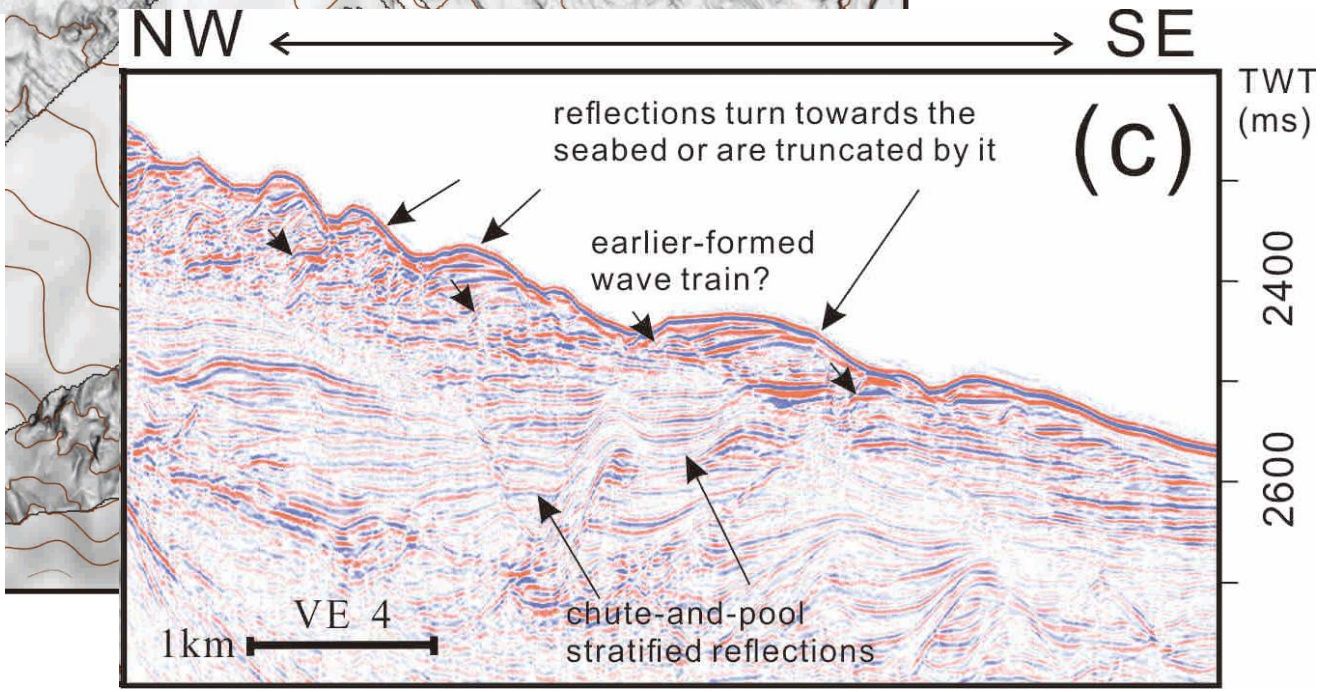
internal waves

deep water bottom currents



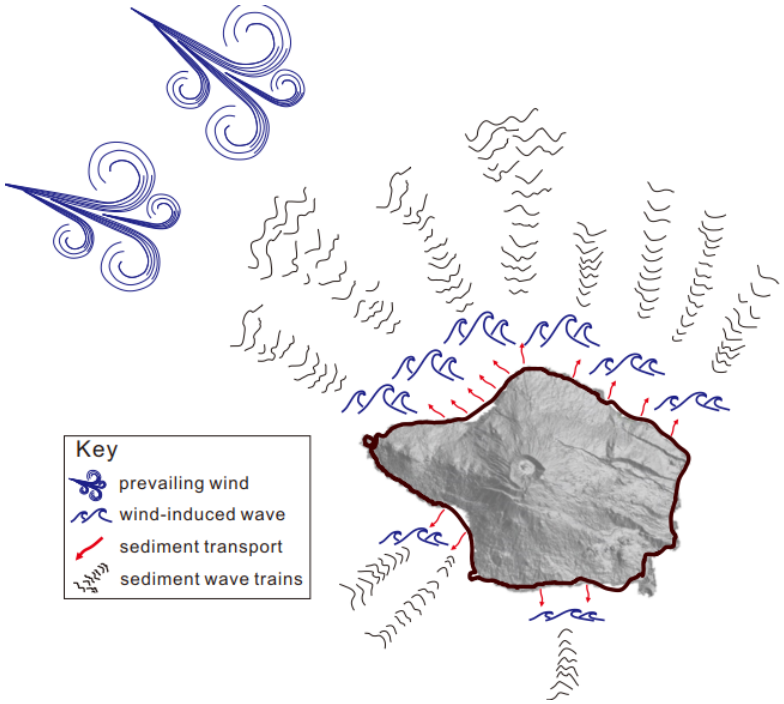


Casalbore et al., 2017

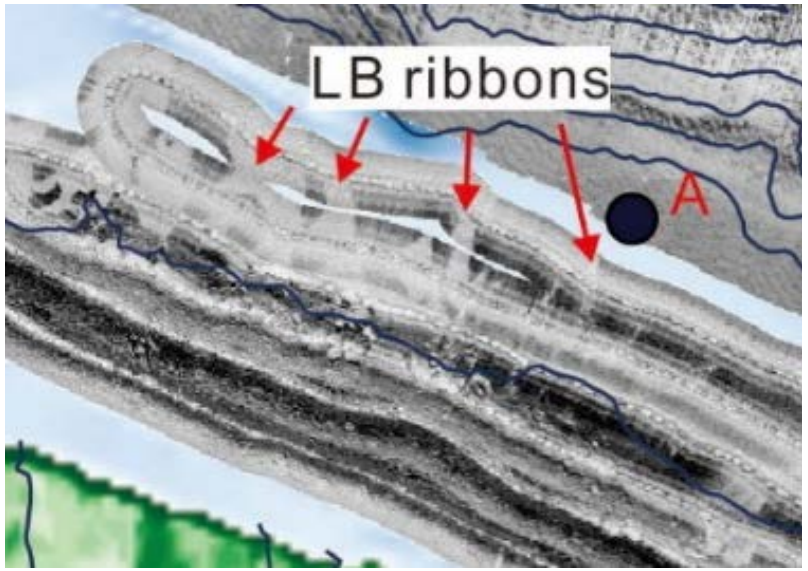


Sediment mobility on the shelves

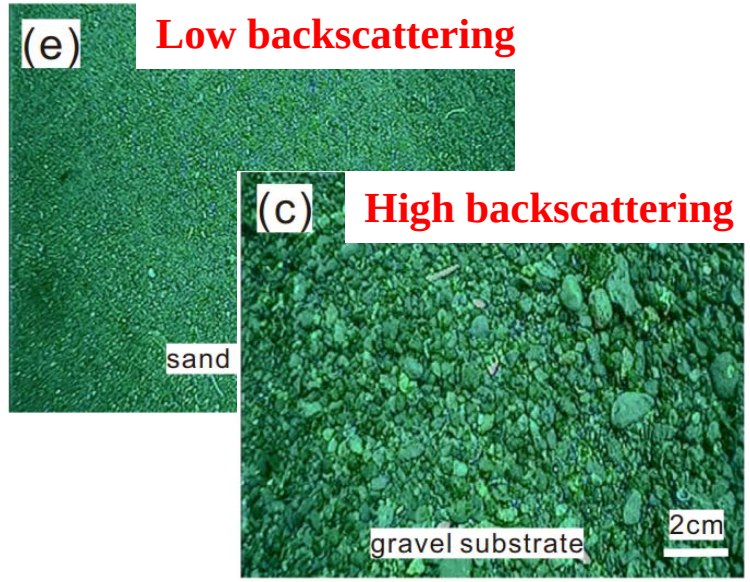
prevailing wind and wave



offshore sediment transport

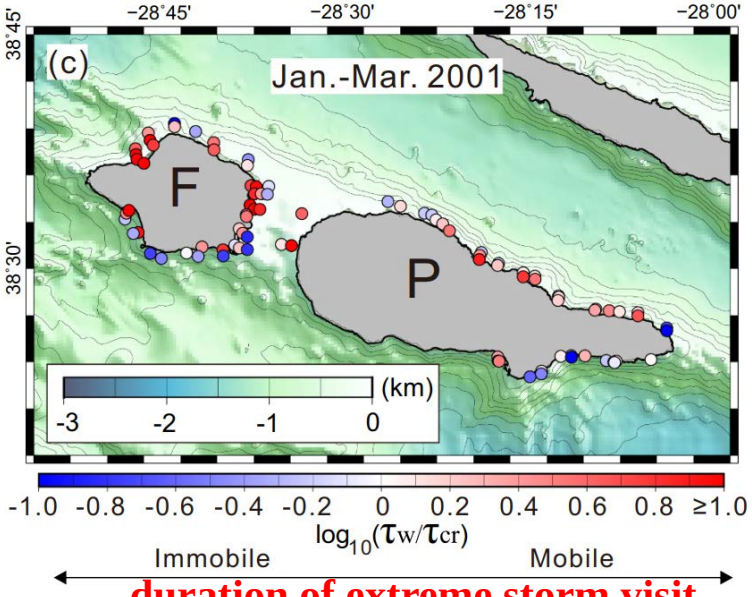


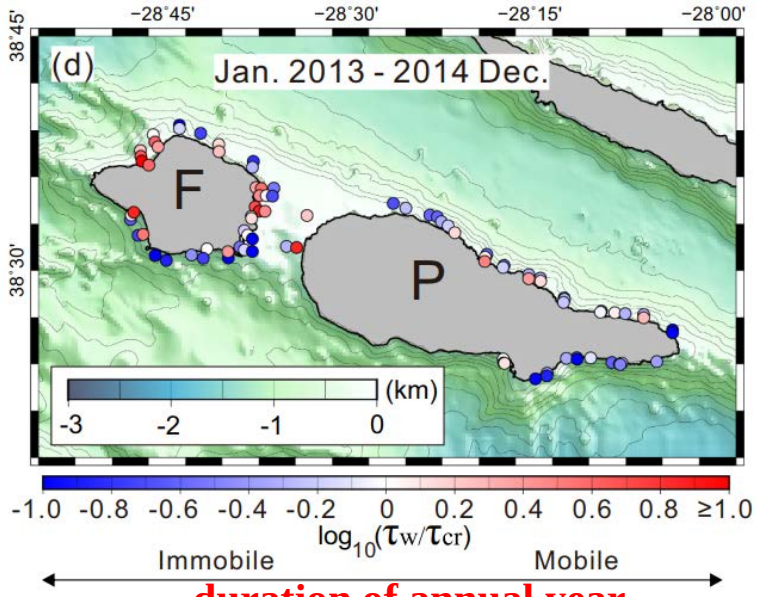
Ground-truth images



Sediment mobility analysis

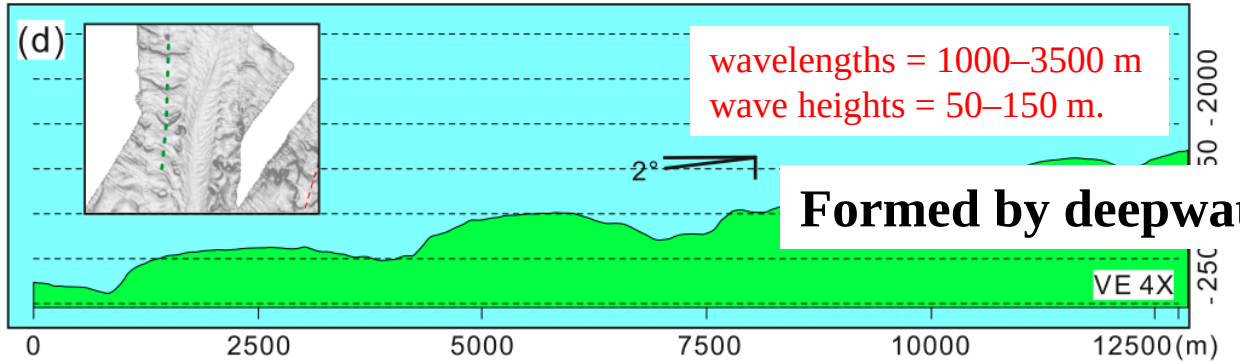
Sediment mobility is higher on the windward (NW) side of the islands resulting from the wave-induced shear stress or wind-driven processes



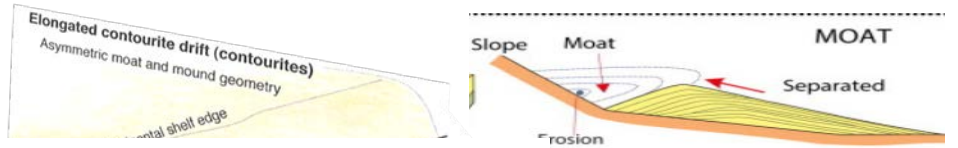


What about the giant wave field in the North of Sao Miguel Island

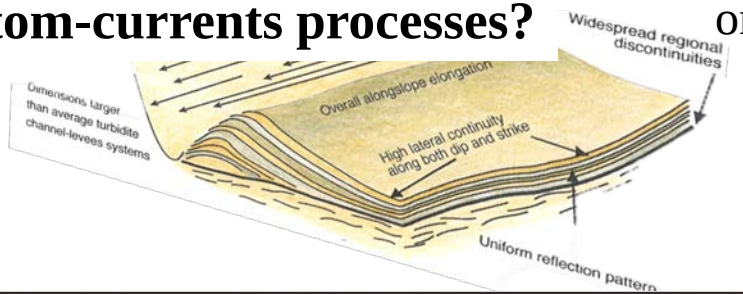
Chang et al., 2022, *Marine Geology*

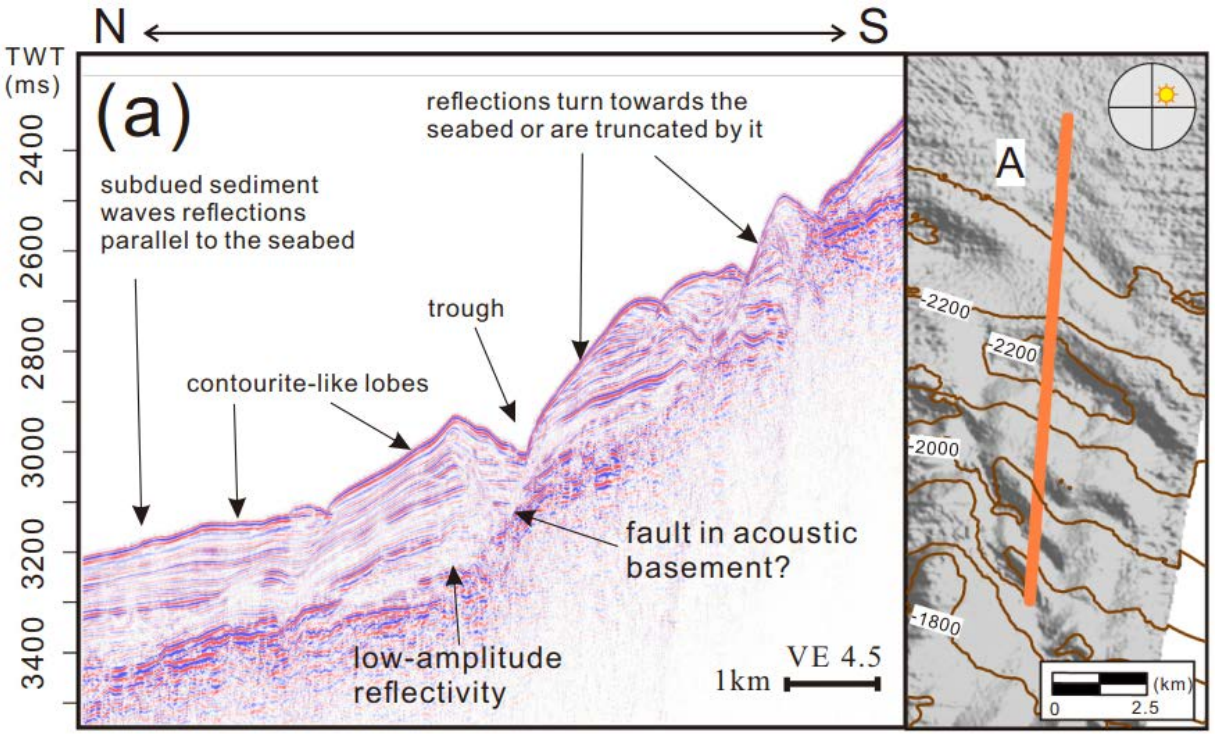


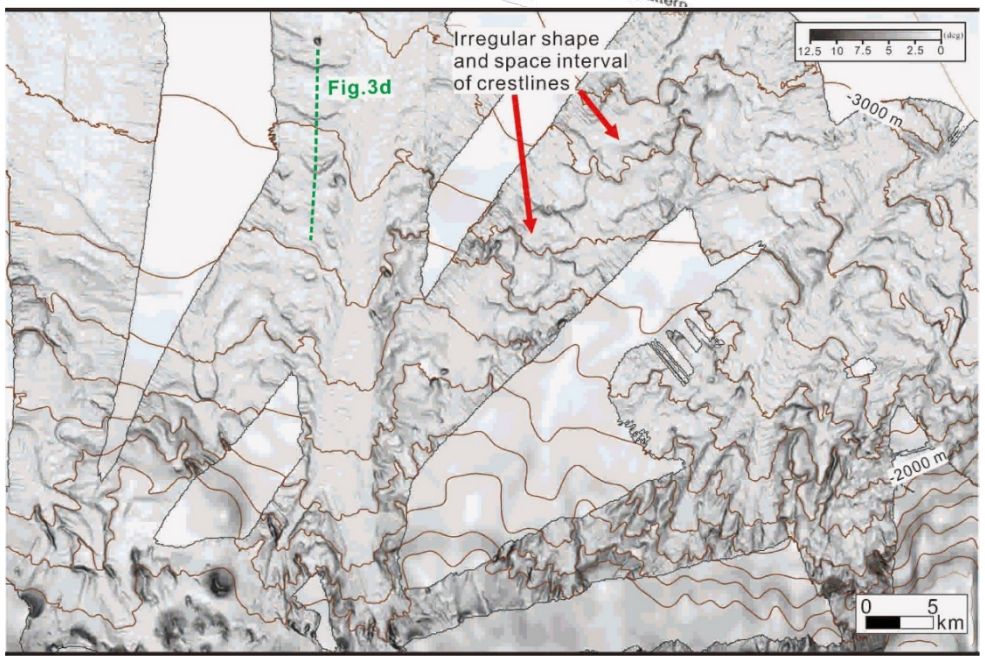
Formed by deepwater-bottom-currents processes?



online source



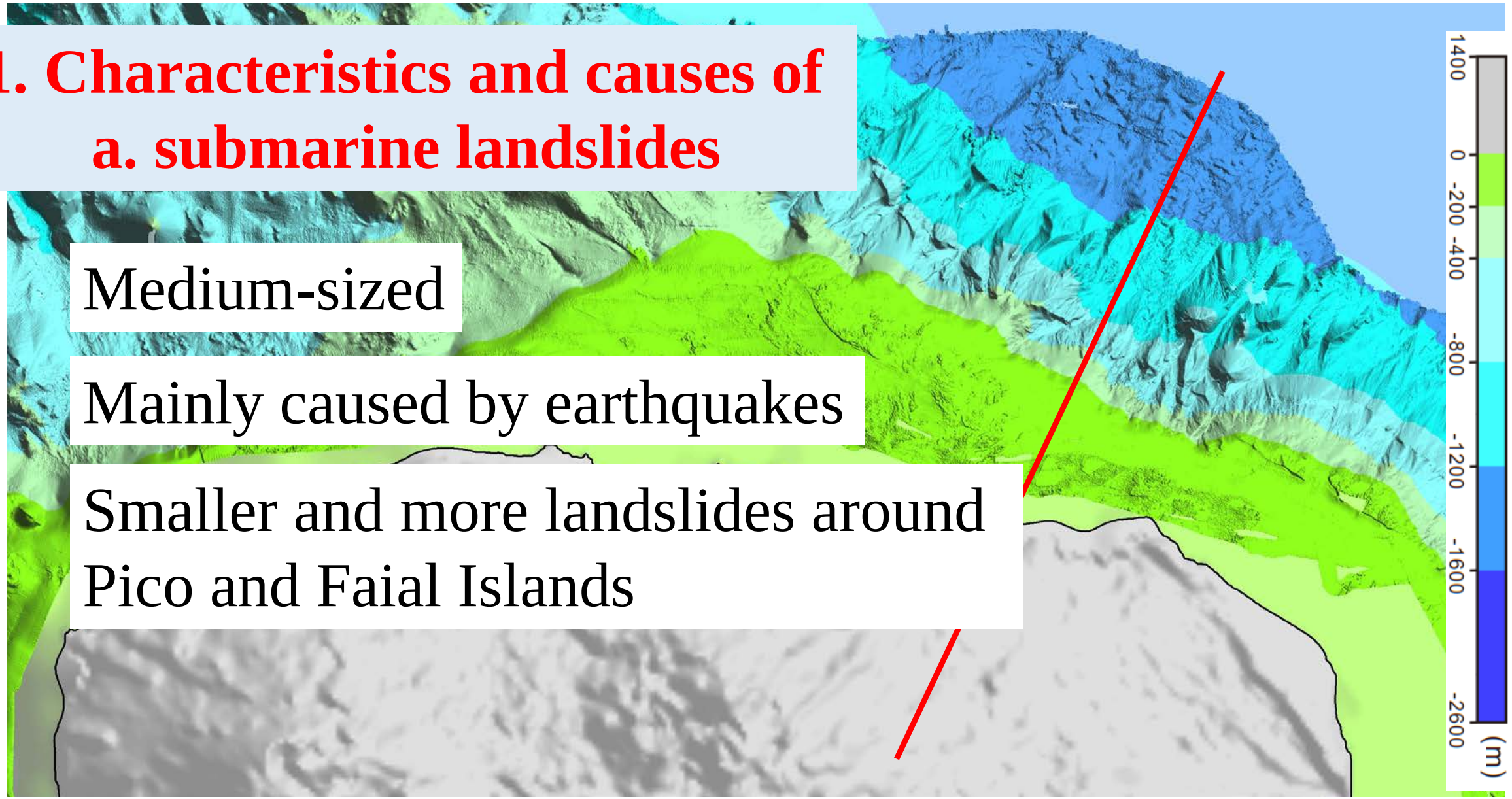




Interpretation: Sediment waves were produced by giant eruption(s), bud later reformed by bottom current processes.

Take away messages

1. Characteristics and causes of a. submarine landslides



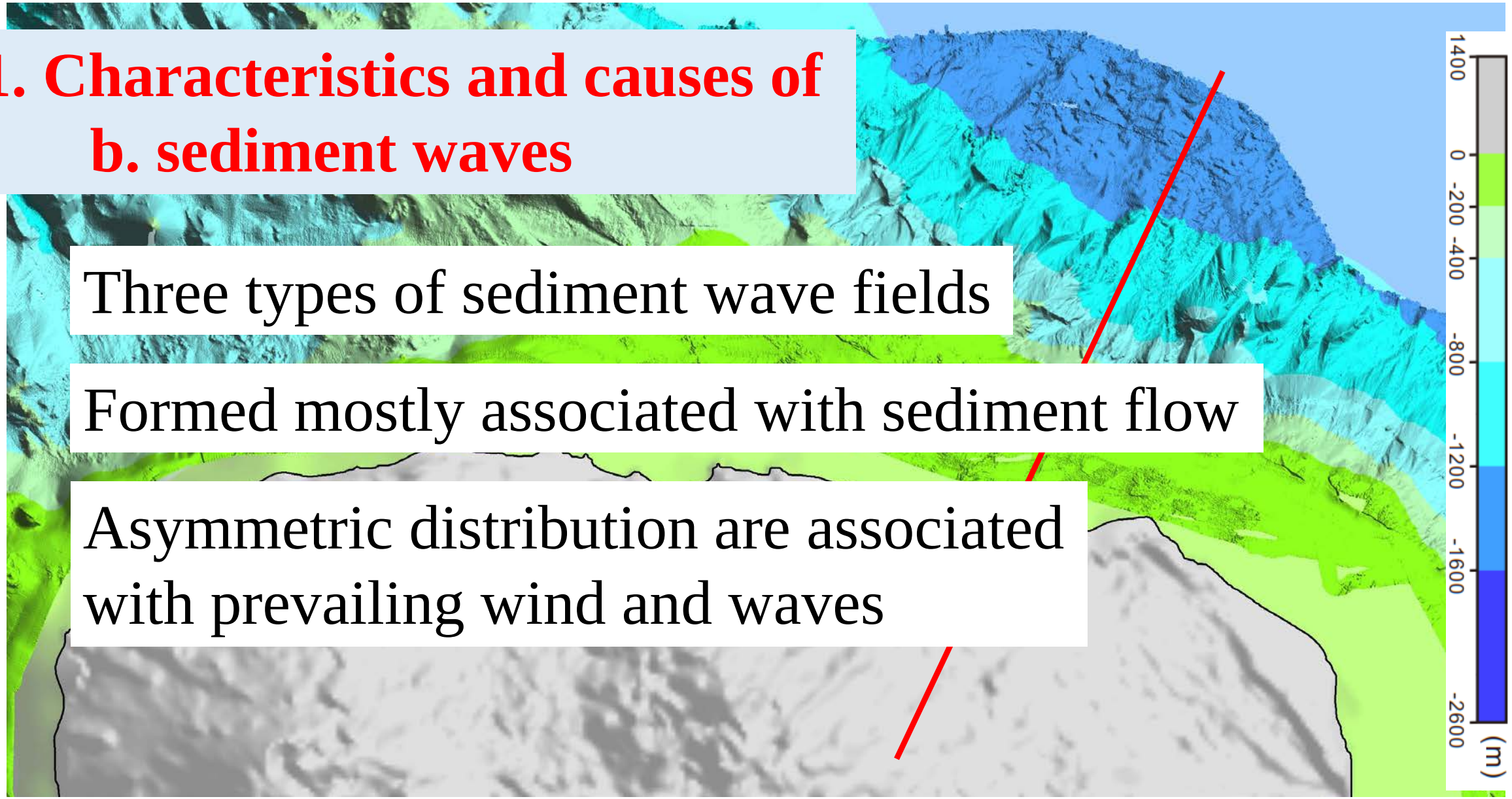
Medium-sized

Mainly caused by earthquakes

Smaller and more landslides around Pico and Faial Islands

Take away messages

1. Characteristics and causes of b. sediment waves

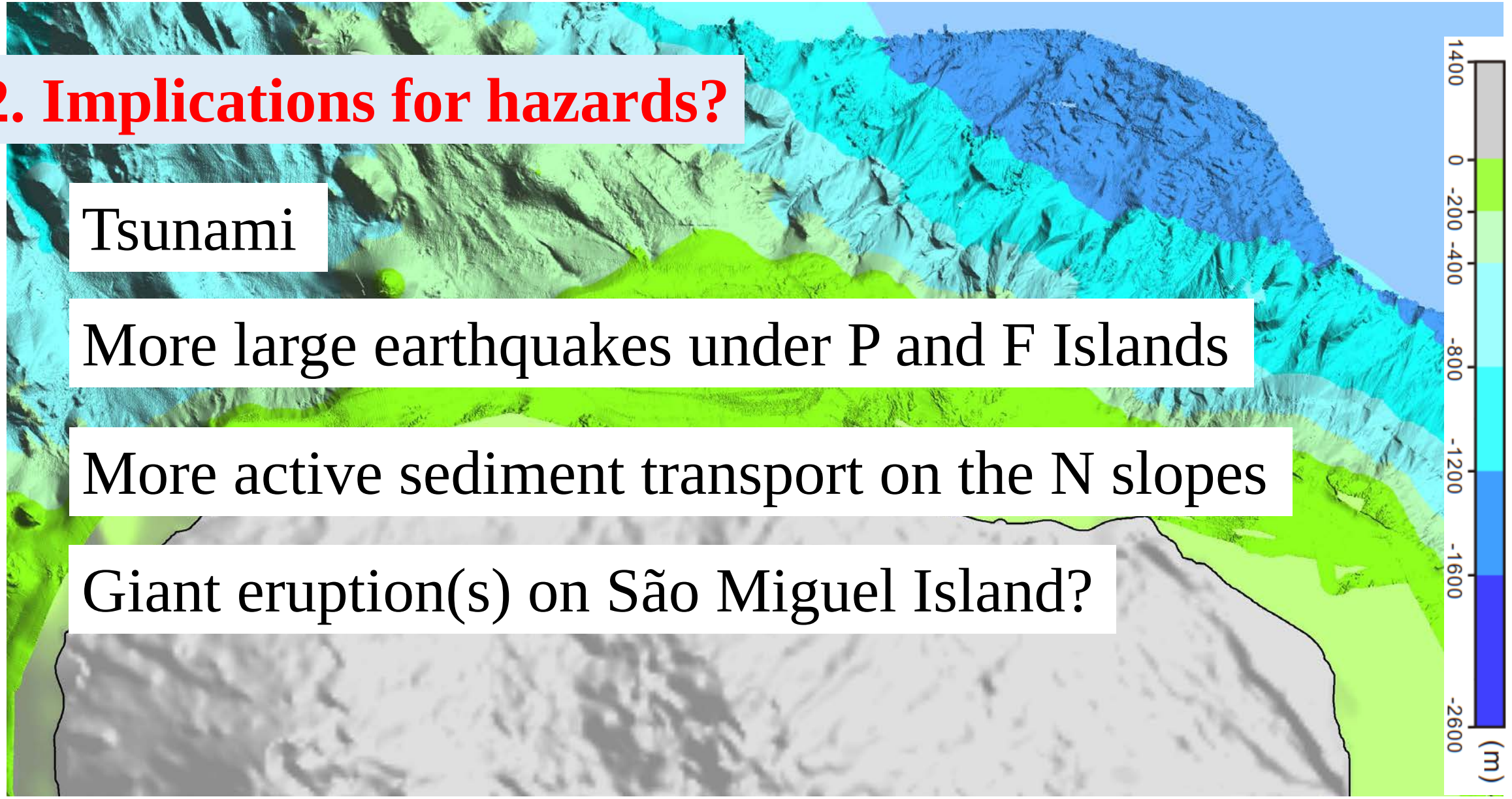


Three types of sediment wave fields

Formed mostly associated with sediment flow

Asymmetric distribution are associated with prevailing wind and waves

Take away messages



2. Implications for hazards?

Tsunami

More large earthquakes under P and F Islands

More active sediment transport on the N slopes

Giant eruption(s) on São Miguel Island?