Non-seismic and complex tsunamis in NWIO

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Non-Seismic Sources

1. Volcanic Activity
    1. Underwater volcanic eruptions can displace large volumes of water, triggering tsunamis.
    2. Violent explosions and collapses of volcanic edifices can generate tsunamis as well.
2. Submarine Landslides
    1. The sudden movement of sediments, rock, or debris on underwater slopes can displace water and generate tsunamis.
    2. Often triggered by earthquakes, volcanic activity, or steep coastal cliffs collapsing into the sea.
3. Underwater Landslides
    1. Similar to submarine landslides, but occurring in coastal or nearshore areas.
    2. Can be triggered by earthquakes, coastal erosion, or other destabilizing factors.
4. Submarine Slumps
    1. Slow and gradual downhill movement of large masses of sediment or rock in underwater environments.
    2. Can be triggered by sediment accumulation, earthquakes, or changes in water pressure.

Non-seismic Source and Local

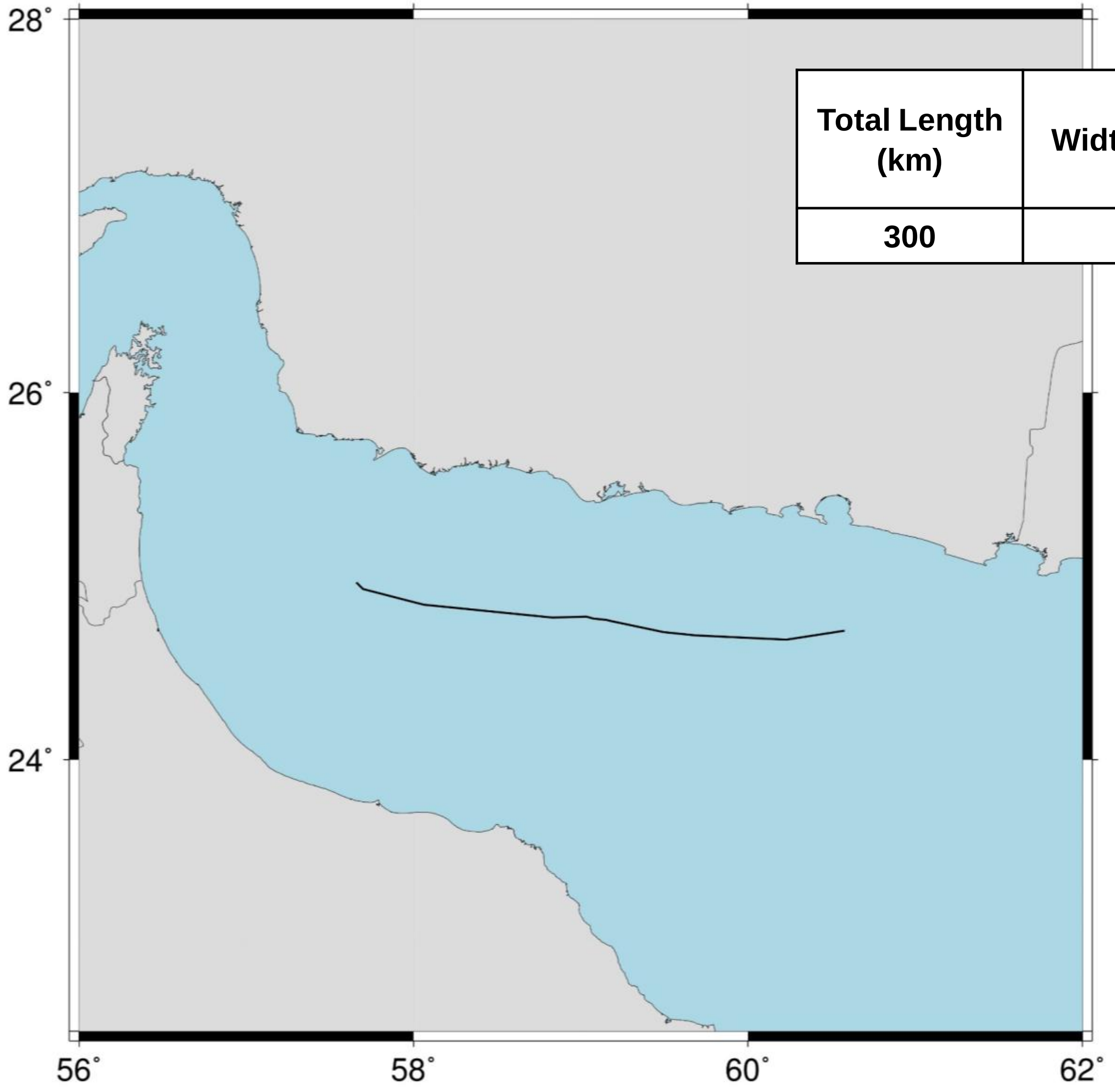
5. Asteroid or Meteorite Impacts
   1. Large impacts in coastal or oceanic regions can generate extremely powerful tsunamis.
   2. The displacement of water caused by the impact creates massive waves radiating outward.

6. Glacier or Iceberg Calving
   1. The breaking or separating of large ice masses from glaciers or icebergs can create tsunamis in ice-covered or nearby water bodies.
   2. Often occurs in polar regions or near ice-covered coasts.

7. Splay faulting

Tsunami numerical simulation for a splay fault in Western Makran

Splay Faulting



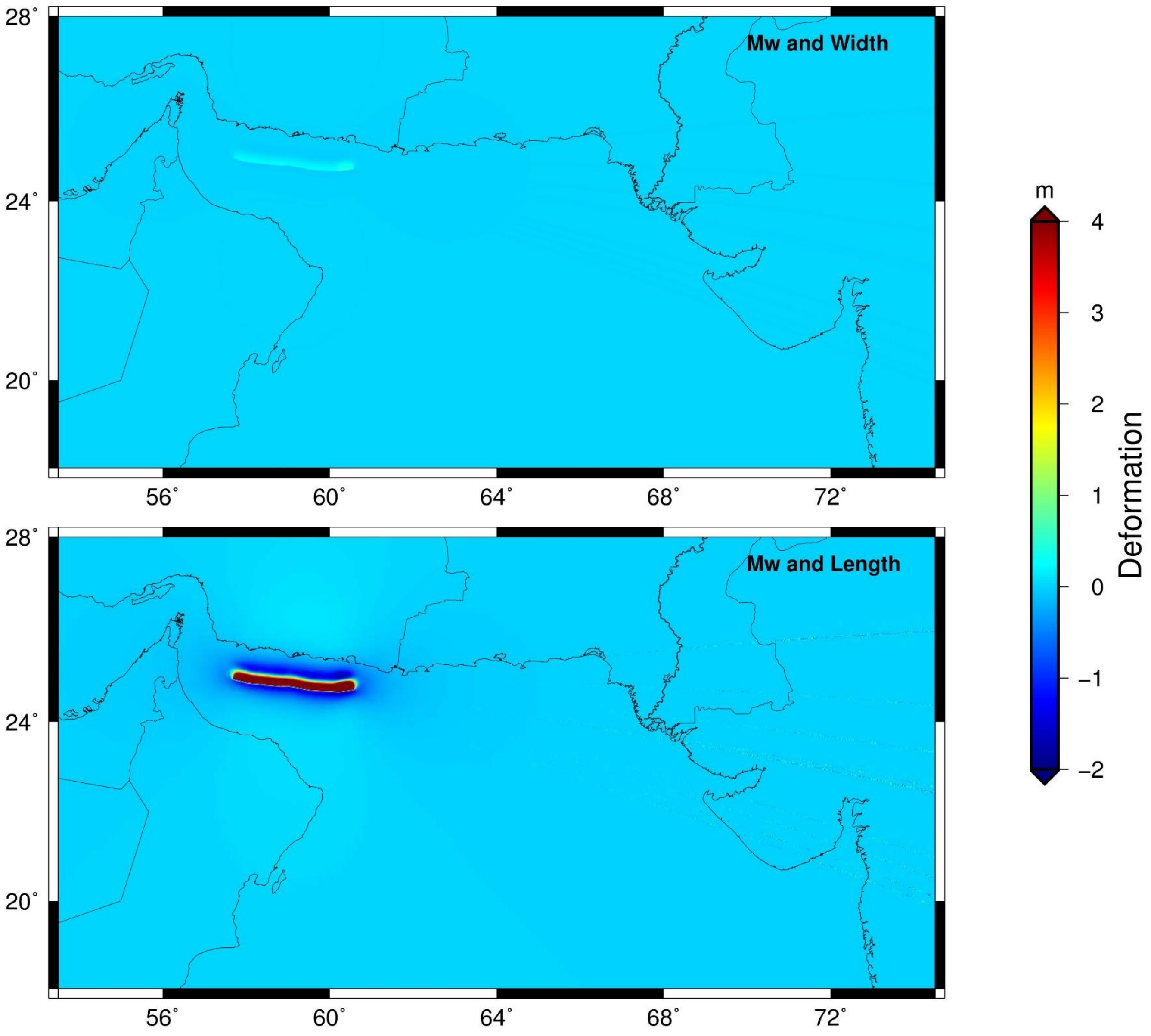
Total Length (km)	Width (km)	Focal Depth (km)	Dip (deg.)	Rake (deg.)	Slip (m)	
					Mw&L	Mw&W
300	27	10	33	90	20	0.5

❖ Slip (m) evaluated using Blaser et al., (2010) scaling relations

Tsunami numerical simulation for a splay fault in Western Makran

Splay Faulting

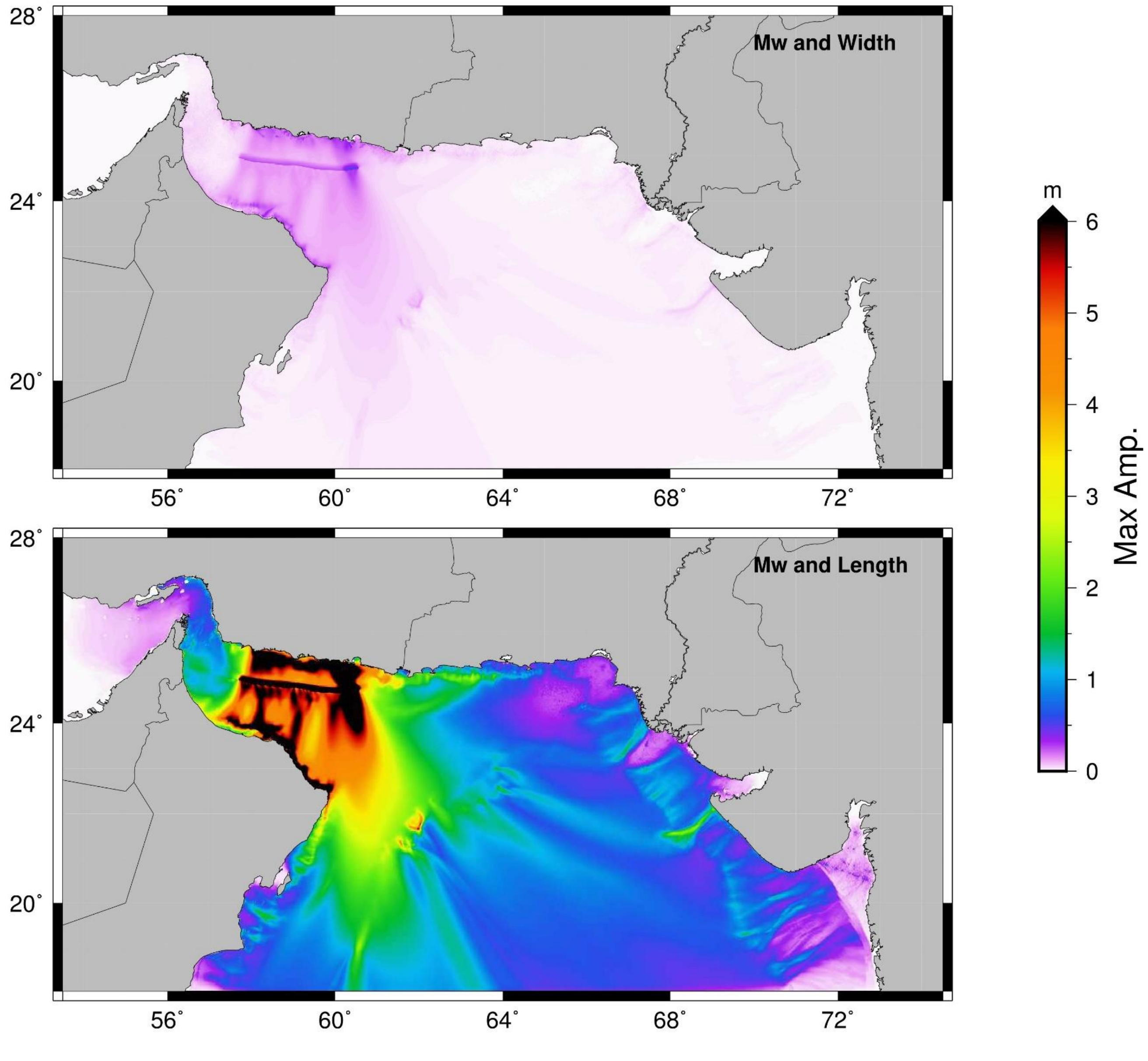
Initial Condition (Static)



Tsunami numerical simulation for a splay fault in Western Makran

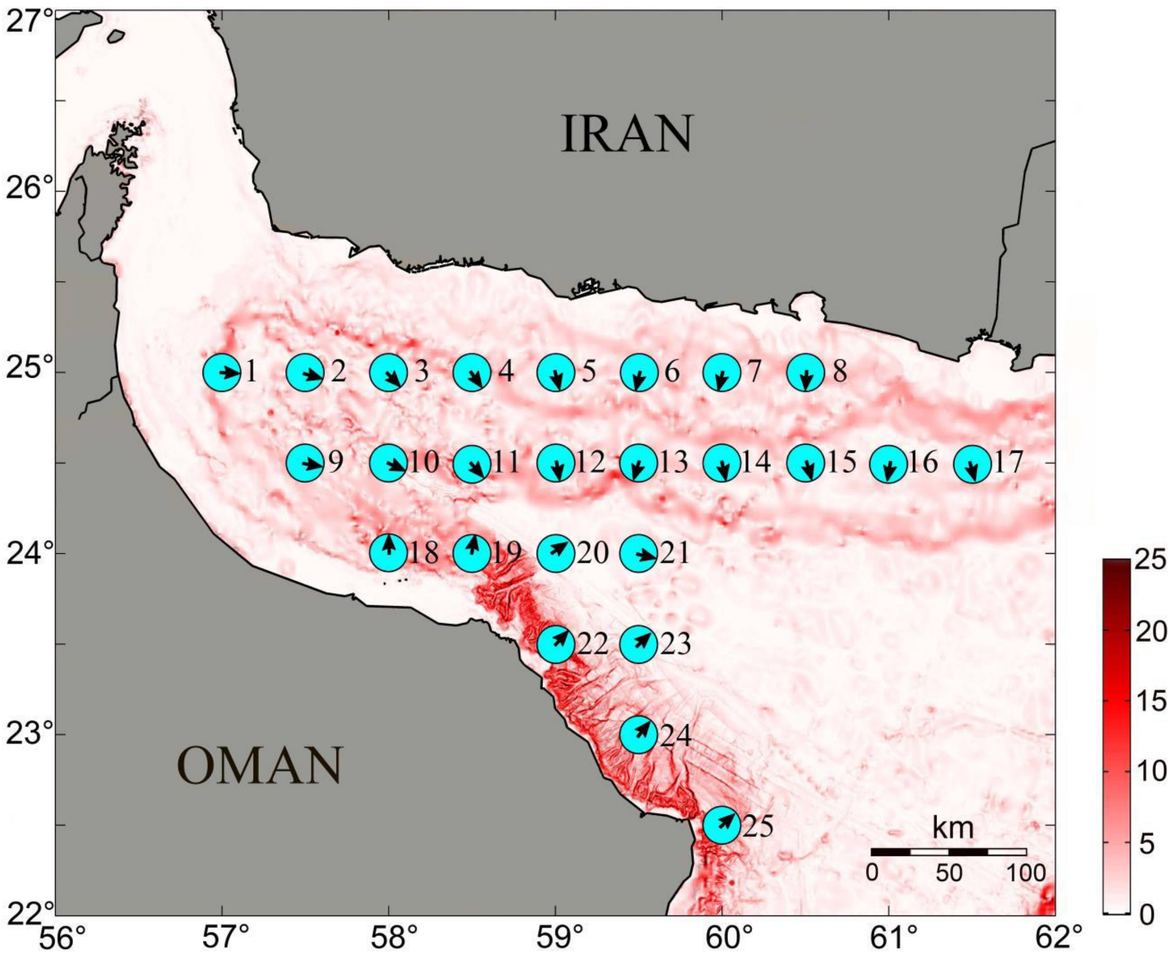
Splay Faulting

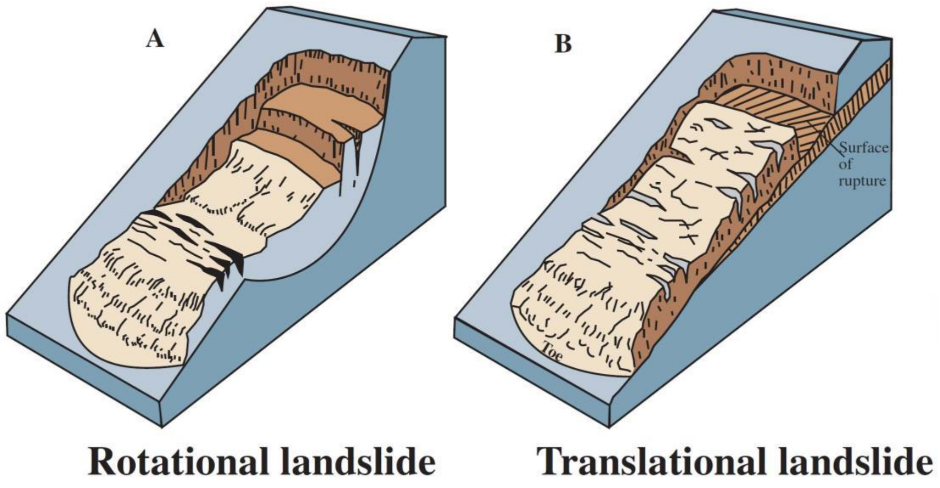
Maximum amplitudes



Tsunami numerical simulation for hypothetical landslides in Western Makran (Nouri et al., 2023)

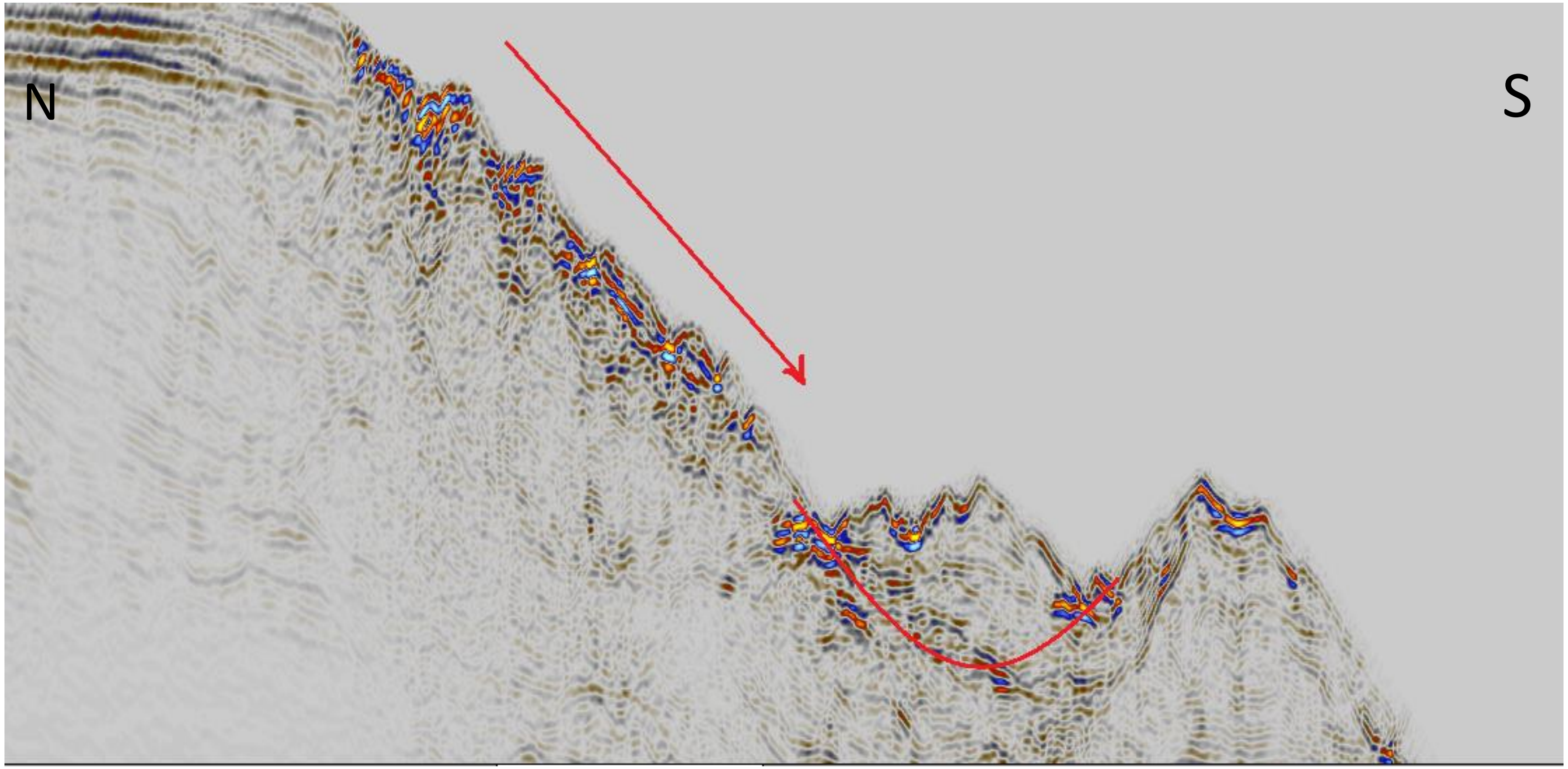
100 rotational slides (10 to 40 km^3)





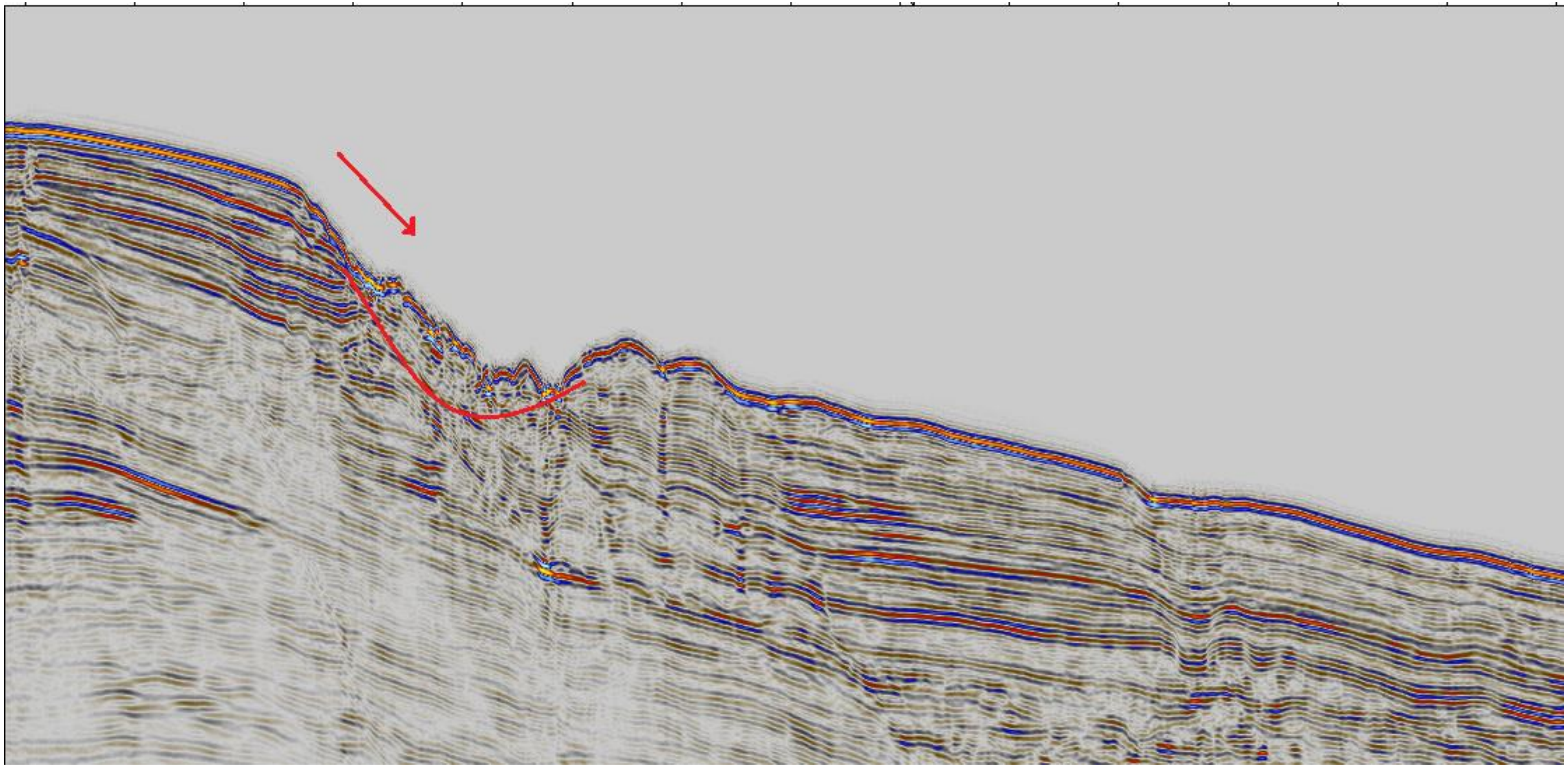
Landslide volumes varying from 10 to 40 km3 in 25 different locations

Reflection seismic data offshore Oman Sea, Mapping of submarine landslide



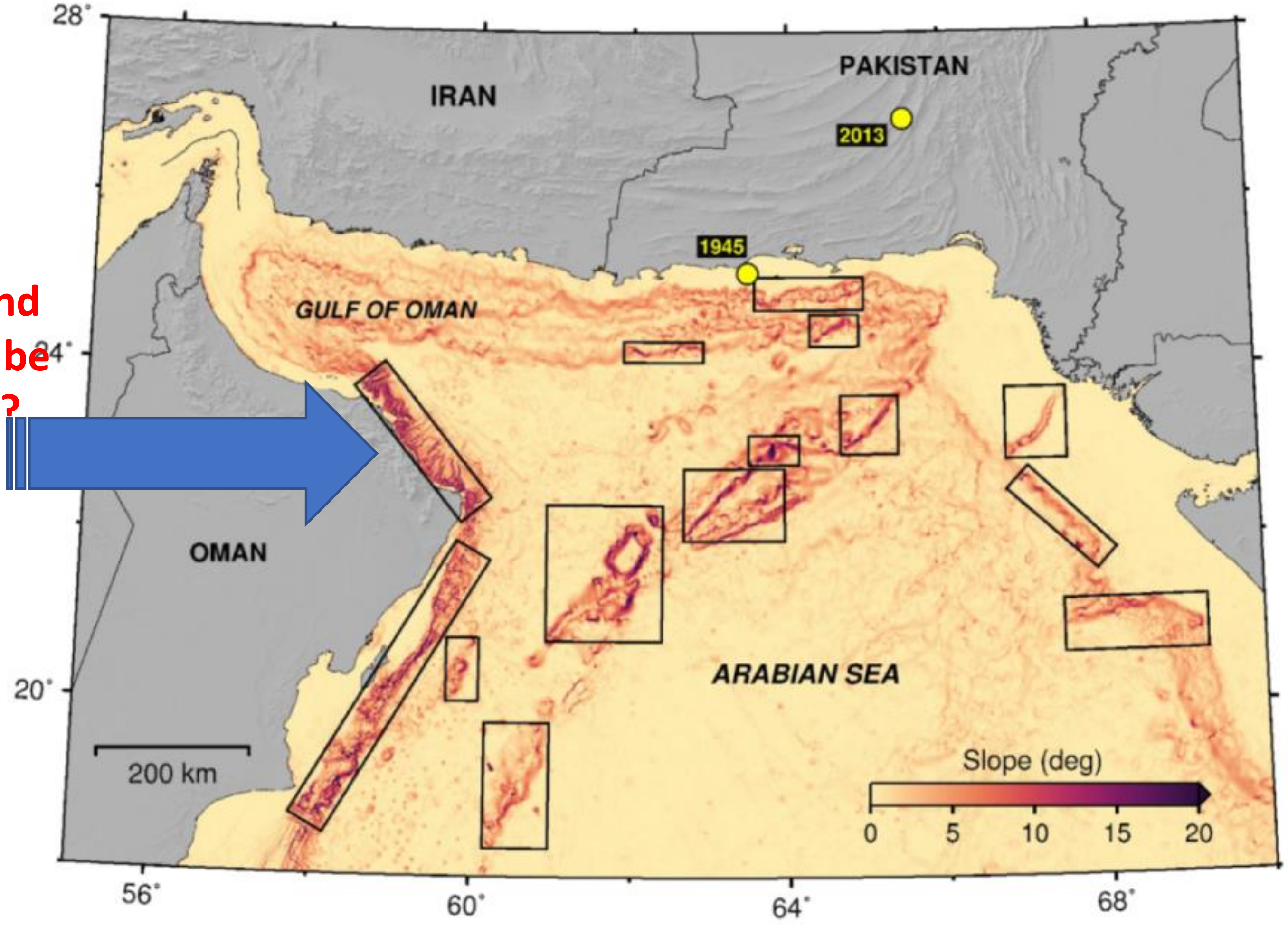
Courtesy of NIOC, PC 2000

Reflection seismic data offshore Oman Sea, Mapping of submarine landslide



Courtesy of NIOC, PC 2000

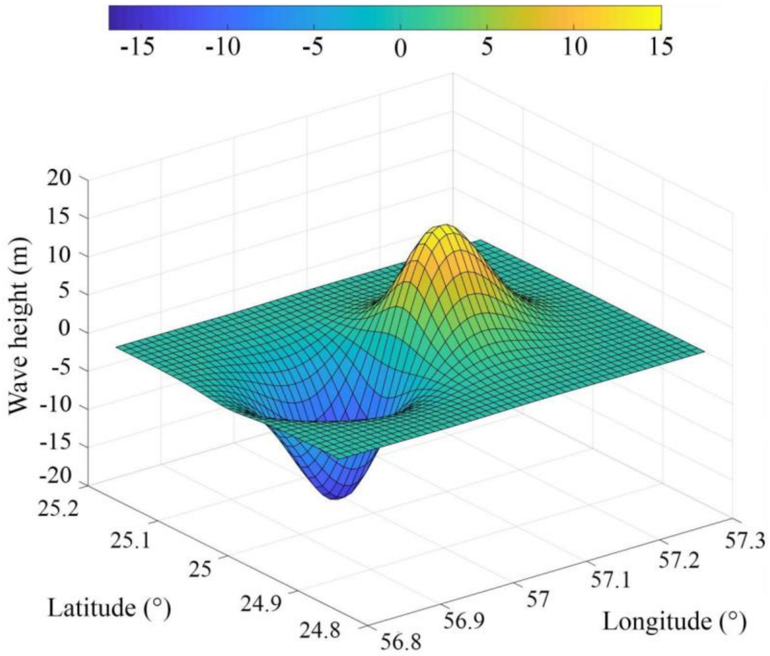
Event of 1723 and Holocene could be a good example?



Slope gradient map of the Makran bathymetry and locations of areas prone to submarine landslides (Rashidi et al., 2020) – the criteria is based on slopes of 3 to 6 percent or 12 to 30 degrees (Salaree and Okal, 2015)

Tsunami numerical simulation for hypothetical landslides in Western Makran (Nouri et al., 2023)

Initial Wave for a 40 km^3 landslide

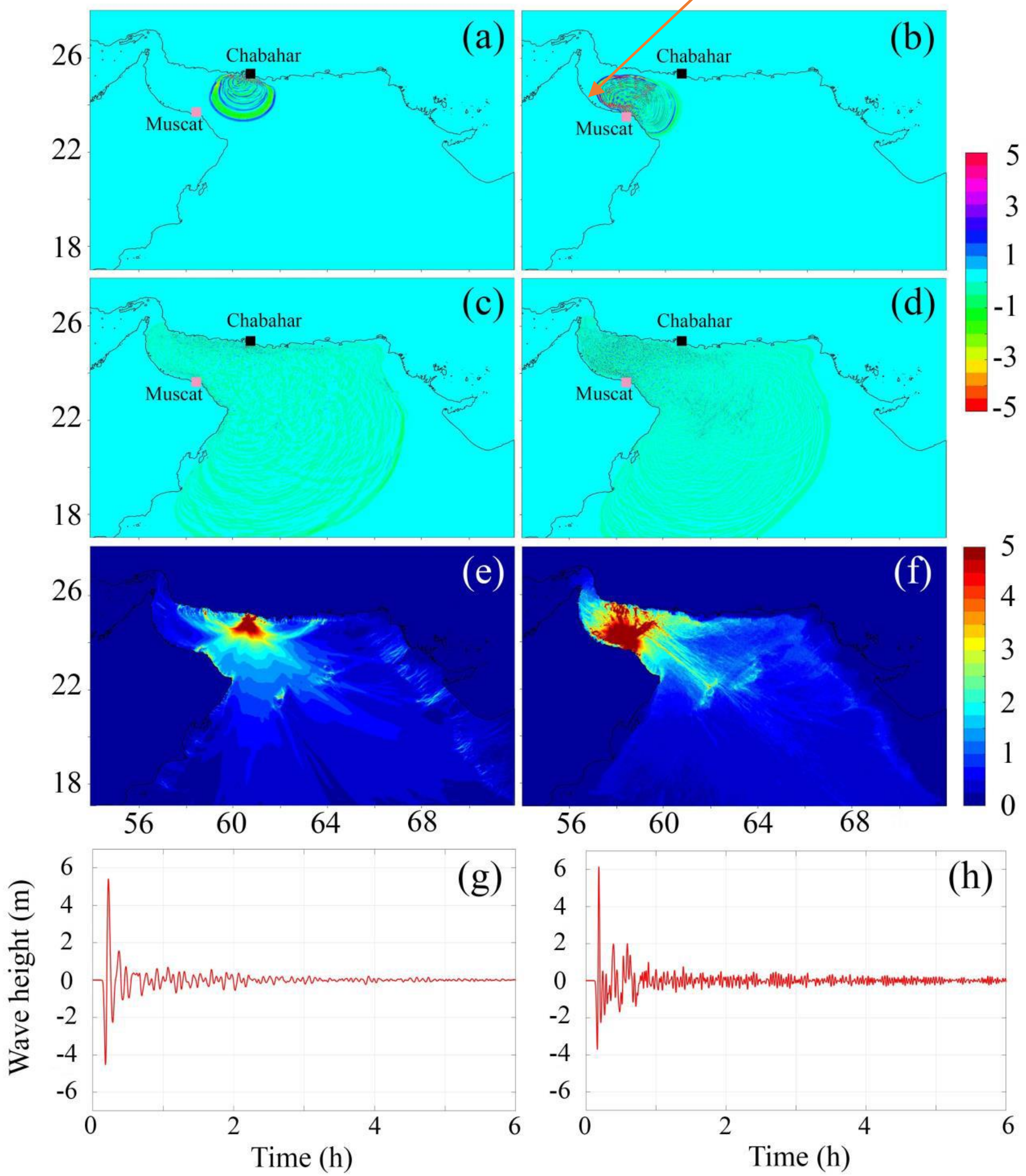


Simulation results

1723 event

Wave height Chabahar

Wave height Muscat



Preliminary hypothetical Landslide scenarios

The results of present simulations reveal that although most of the scenarios do not create waves larger than 0.5 m, both Chabahar, Iran and Muscat, Oman experience severe waves during some scenarios, and that Oman’s coastline is more vulnerable to landslide generated waves.

There is access to real data, so this will be studied more carefully in the future.

Future plan for Landslide

- To identify and characterize potential offshore landslide sources in the Makran subduction zone using existing 2D seismic reflection data, multibeam bathymetry, and other remote sensing techniques.
- To simulate the potential tsunami waves generated by offshore landslides using numerical modeling, and compare them to existing earthquake-generated tsunami scenarios.
- To assess the potential risk of an offshore landslide-generated tsunami in the Makran subduction zone using probabilistic hazard analysis and hazard assessments.
- **Landslide Hazard Zonation map to be prepeard based on actual data**

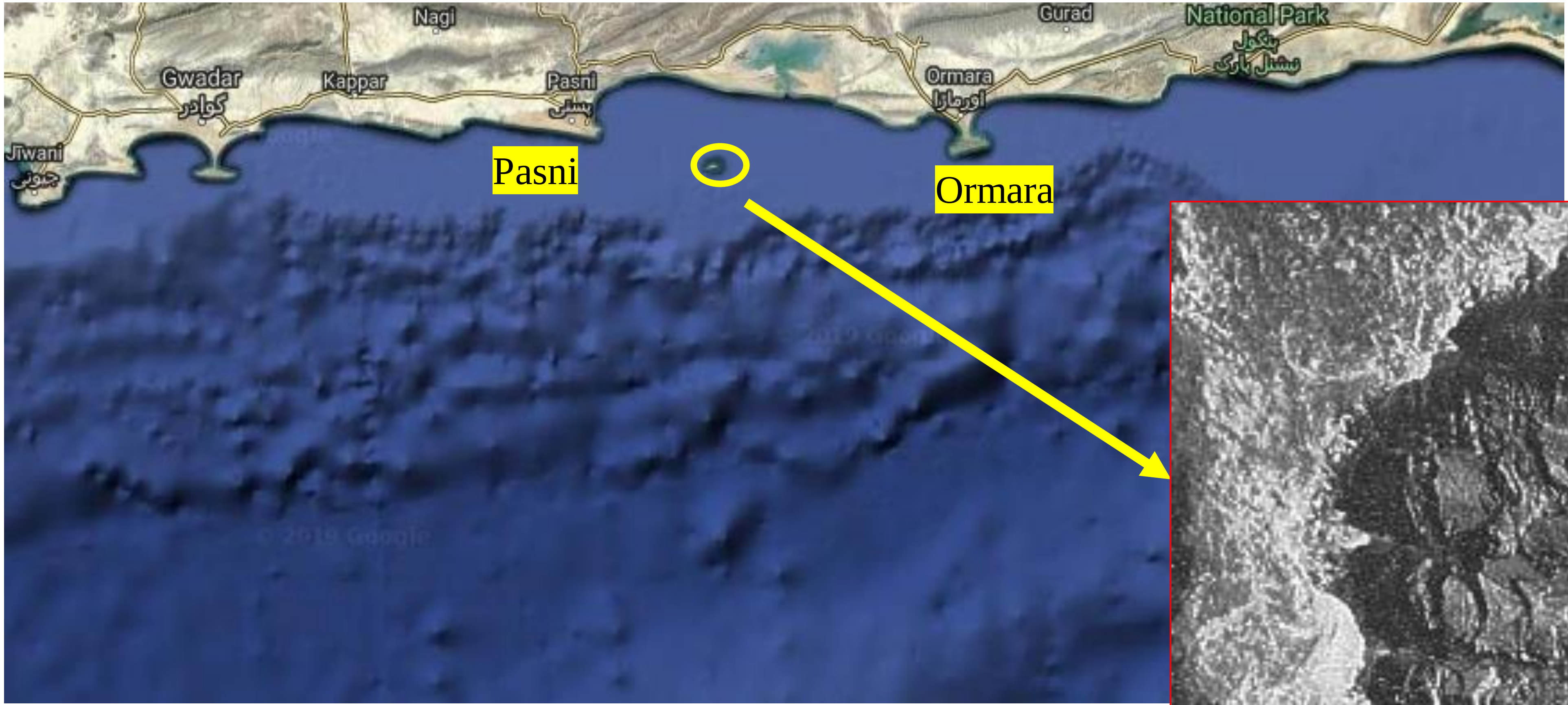
Mud-volcano Not as a source for Tsunami

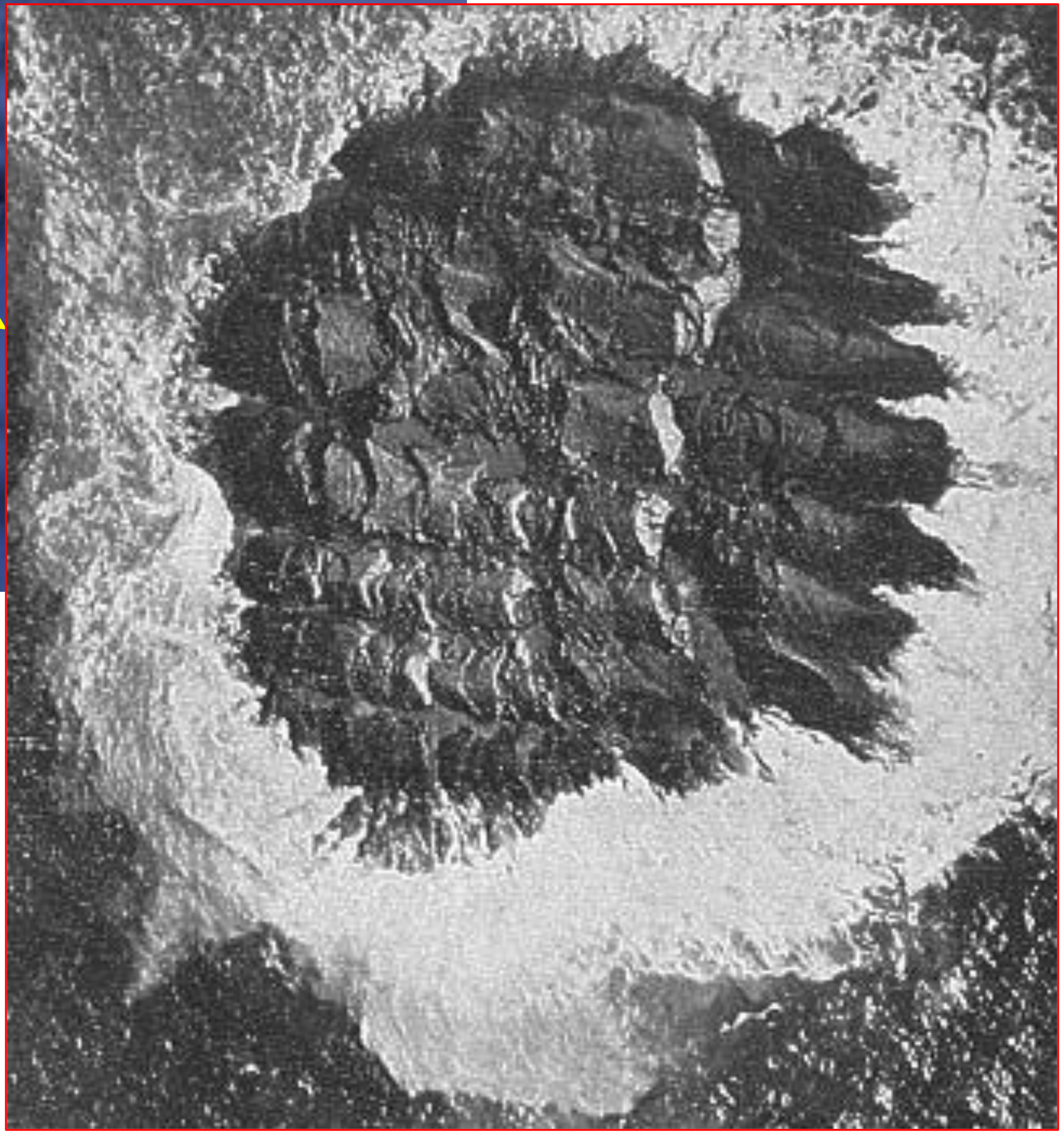
Concerning the Mud-Volcano we would like to think this may not be a source for Tsunami generation, but they caused by seismic source that generate tsunami. So they are not source for tsunami but they can be source for disaster:

Two examples offshore

1) 1945
2) 2013

Example onshore:

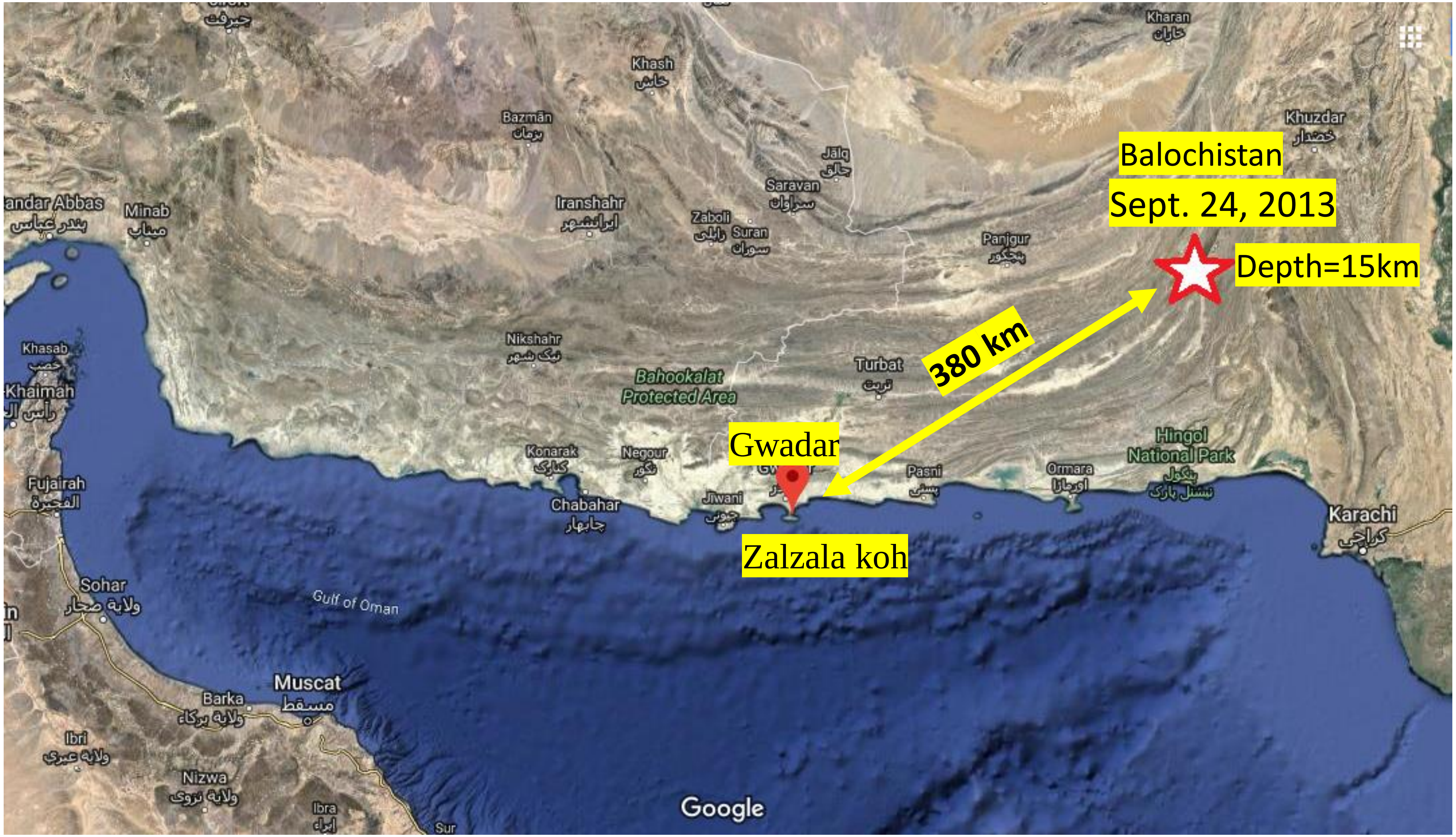




western Ormara Island after 1945 earthquake

Balochistan earthquake/ 2013

tsunami affected NW of India and a big mud island was borne.



Zalzala Koh mudvolcano/ after Balochistan earthquake (2013)