Generation of Tsunamis from Earthquakes: A Literature Review

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Research Question

What is the link between tsunamis and earthquakes?

Introduction

- Tsunamis are a series of ocean waves produced by the sudden displacement of great volumes of water (Ruff, 2003).
- Underwater earthquakes are primarily responsible for the generation of tsunami waves (Ruff, 2003).
- About 80% of tsunamis are the result of strong submarine earthquakes (Nosov, 2014).
- Submarine earthquakes cause ocean bottom deformation, which can dislocate a few to tens of cubic kilometers of water (Nosov, 2014).

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Methods

Ward, 1980

- Dislocation models simply visualized earthquake parameters such as slip direction, rupture velocity, etc.
- Demonstrated effects of displacement on SNREI model Earth
- Normal mode theory displayed relationships of tsunami origination and earthquake moment, mechanism, and depth

Nosov, 2014

- Used deep-water stations, such as DART and JAMSTEC, to record tsunami and earthquake parameters, including seismometers, pressure sensors, current meters, etc.
- Used numerical models, such as TUNAMI and MOST, to simulate tsunami waves

Ruff, 2003

- Compared tsunami generation by earthquake vs. landslide
- Used kinematic models to represent correlation between earthquakes and tsunamis
- Examined energy balance regarding seismic sources and waves
- Algebraic equations linked earthquake parameters to tsunami wave energy

Results

Ward, 1980

- Tsunami excitation relies on earthquake moment, mechanism, and depth
- Dip slip earthquakes produce tsunamis 3-4x larger than strike slip earthquakes
- Earthquakes of greater depth produce tsunamis of greater frequencies

Nosov, 2014

- Residual deformations occur immediately on the seafloor following an earthquake (process can last more than several hundred seconds)
- Tsunamis rely on earthquake source mechanisms
- Not every submarine earthquake leads to the formation of massive tsunami waves

Ruff, 2003

- Tsunami wave energy is always less then 1% of minimum earthquake energy
- Larger earthquakes generate larger tsunamis
- Combining seismic moment, fault size, and orientation can be used to calculate the amount of displaced water

Earthquake starts tsunami

Stuck area ruptures, releasing energy in an earthquake
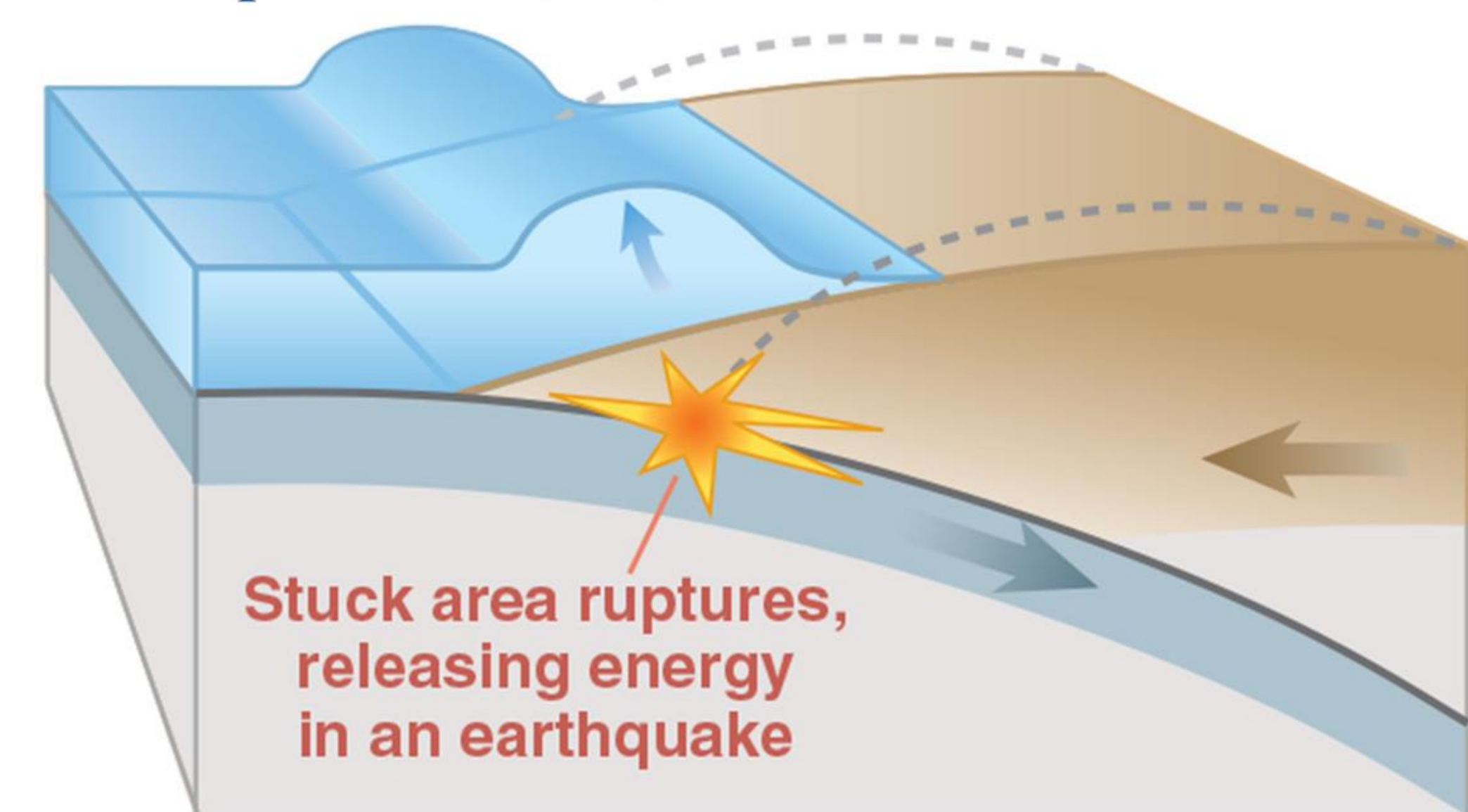
USGS (1999)

Conclusion/Recommendations

- Tsunamis form from water displacement by residual ocean bottom deformation (Nosov, 2014).
- Earth is virtually at a node for tsunami generation, hence the infrequency of significant tsunamis and the need for large parent earthquakes (Ward, 1980).
- Large tsunamis require substantial parent earthquakes because more than 96% of their energy is stored in the ocean (Ward, 1980).
- Less than 1% of earthquake energy is converted into tsunamis; However, this is still enough energy to produce large and destructive tsunamis (Ruff, 2003).
- Submarine landslides can also trigger tsunamis (Ruff, 2003). Further investigation may be initiated to examine the correlation between submarine landslides and tsunamis.
- Additional studies may be proposed to determine the possibility of calculating and forecasting tsunamis in real time.

Acknowledgments

Akiyo/iStock/Getty Images Plus (n.d.)

Mainichi Shimbun (n.d.)