



国立大学法人

岐阜大学

**Spring School 2023**

***IIT Guwahati***

**02-15 March 2023**

# Living with Disaster

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**Associate Faculty**

**Center for Disaster Management and Research (CDMR)**

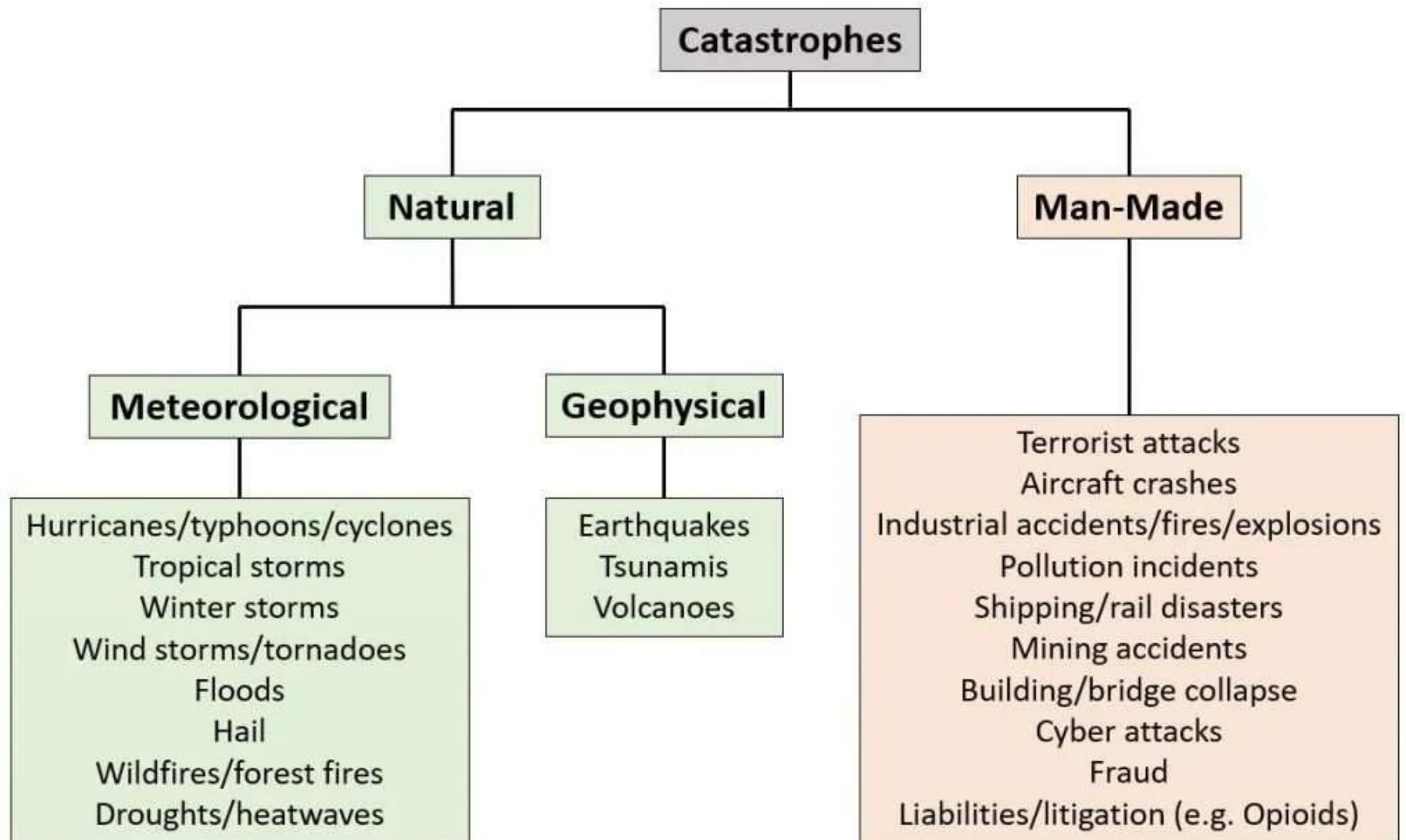
**IIT Guwahati**



## Catastrophes or Disasters



## Catastrophes or Disasters





## Natural Disasters



tornado



volcano



earthquake



tsunami



drought



avalanche



dust storm



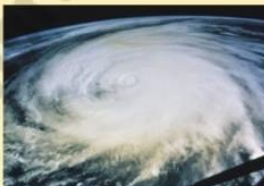
forest fire



thunderstorm



snowstorm



hurricane



windstorm



hailstorm



flood

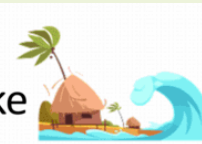


sandstorm



sinkhole

- Tsunami
- Earthquake
- Cyclone
- Famine
- Wildfire
- Forest Fire
- Severe Storm
- Evacuation
- Eruption
- Crater
- Prediction
- Fault
- Flood
- Magnitude
- Drought
- Hurricane
- Tornado

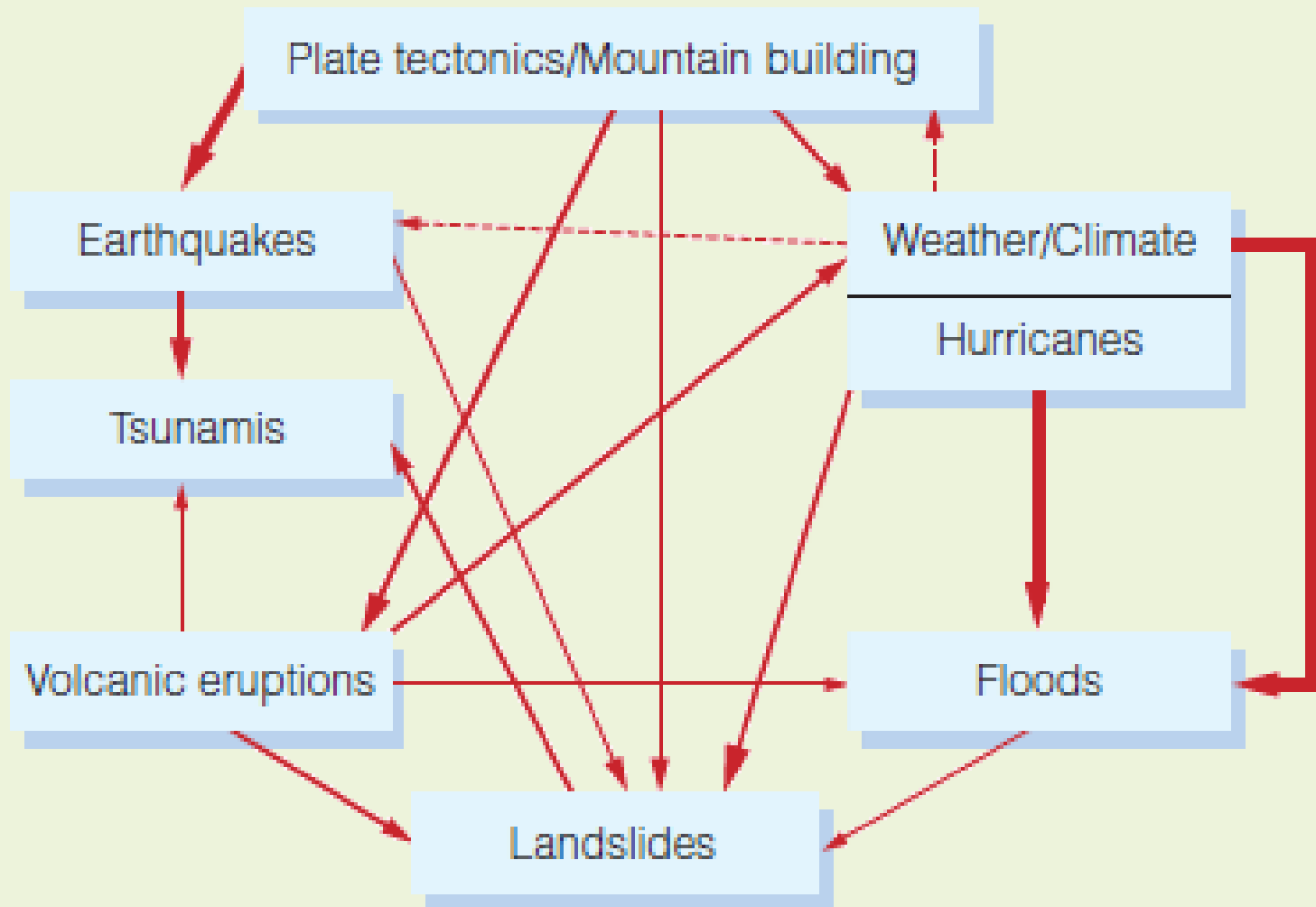


- Landslide
- Hailstorm
- Permafrost
- Volcanic Eruptions
- Lightning
- Twister
- Sandstorm
- Snowstorm
- Avalanche





## Natural Disaster are inter-related



# Man-Made Disasters



TERRORIST ATTACK



WAR



RADIATION EMERGENCIES



PANDEMICS & DISEASES



HUMAN STAMPEDES



BIOTERRORISM



SPORTS STADIUM DISASTERS



RIOTS / CIVIL DISORDER



NUCLEAR ACCIDENT



FIRE



POWER OUTAGE



GLOBAL WARMING



TRAIN ACCIDENT/DERAIL



AVIATION INCIDENT (Plane crash)



SHIPWRECK (Accident)



TRAFFIC COLLISION (Road accidents)



STRUCTURAL COLLAPSE (Building collapse)



BRIDGE COLLAPSE



WILDFIRES - Human negligence like discarded cigarettes



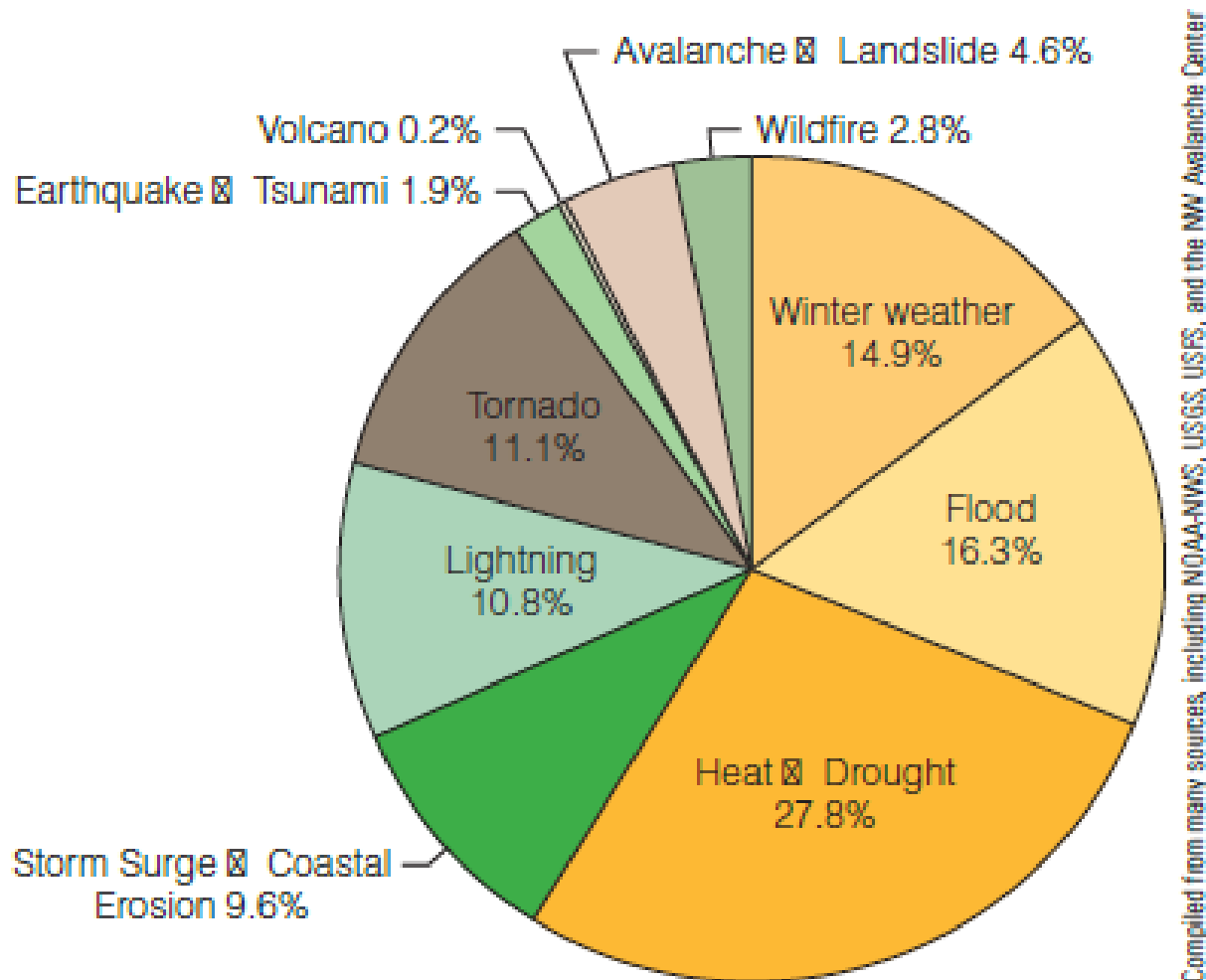
SPACE ACCIDENT



ARSON-The criminal setting a fire with intent to cause damage

## Effect of Disasters

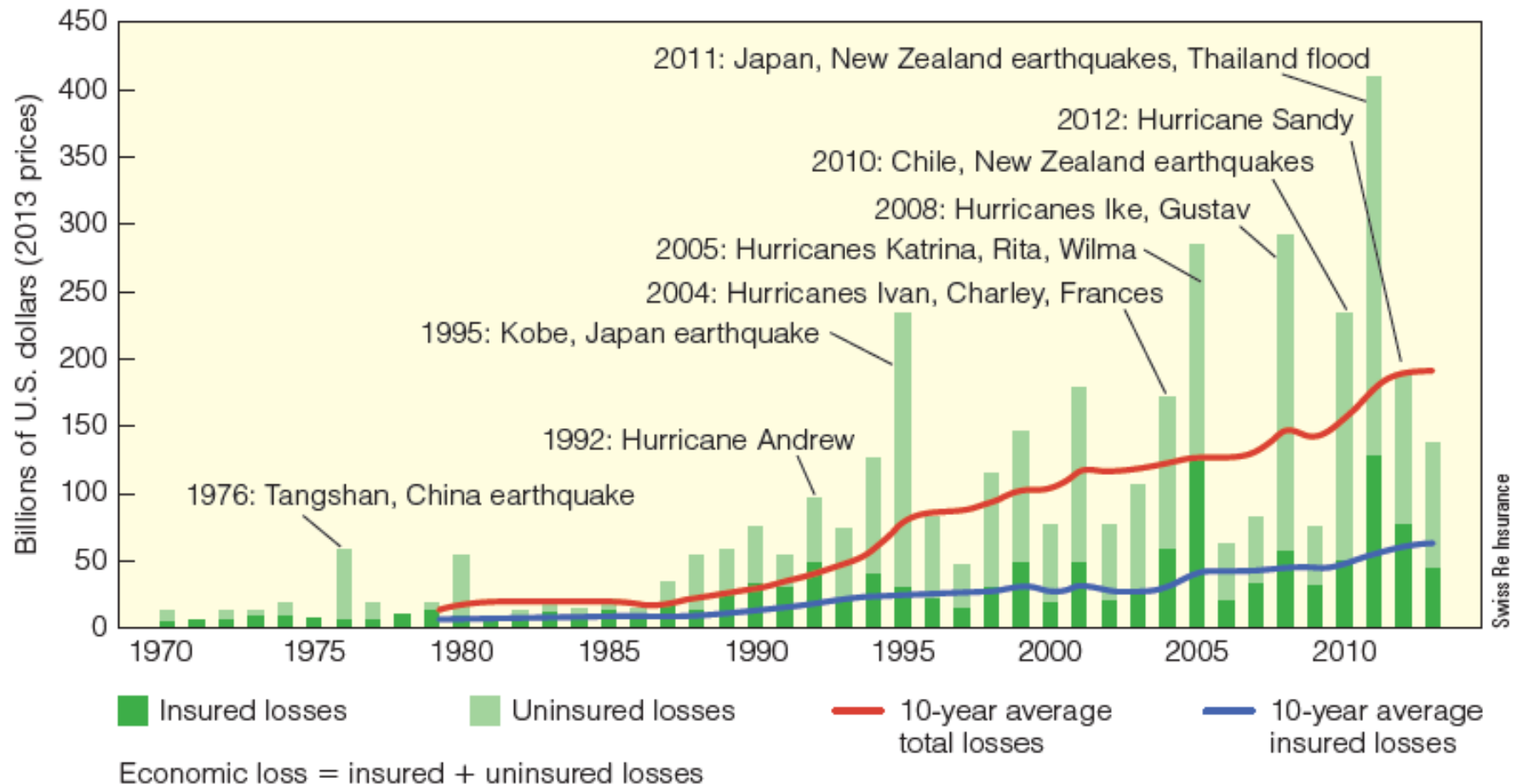
- Deaths and Loss of lives





## Effect of Disasters

- Economic Losses



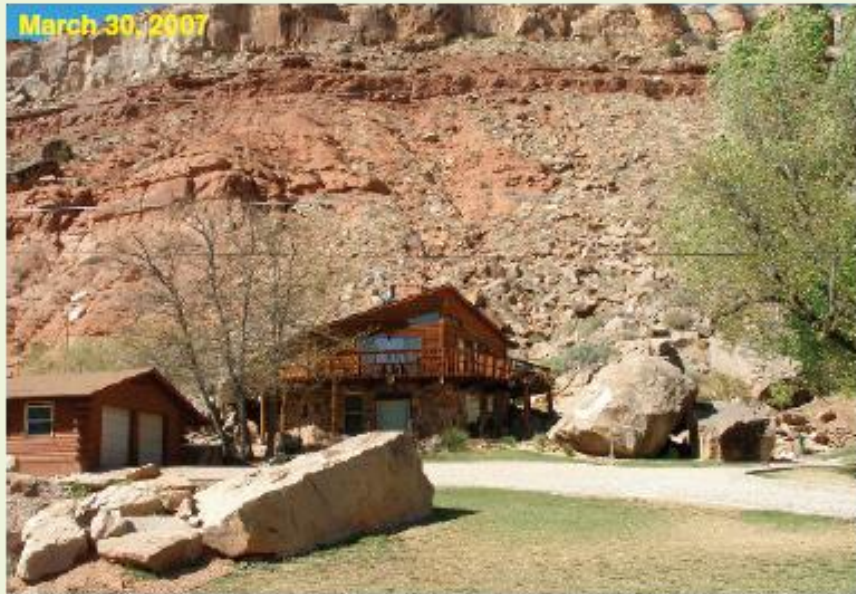
## Effect of Disasters

- Risk to Habitats and Infrastructures
  - ❖ *Submergence of South Vietnam, Mekong River Delta*



## Effect of Disasters

- Risk to Habitats and Infrastructures
  - ❖ *Collapse of building due to Rockfall at Rockville, Utah*

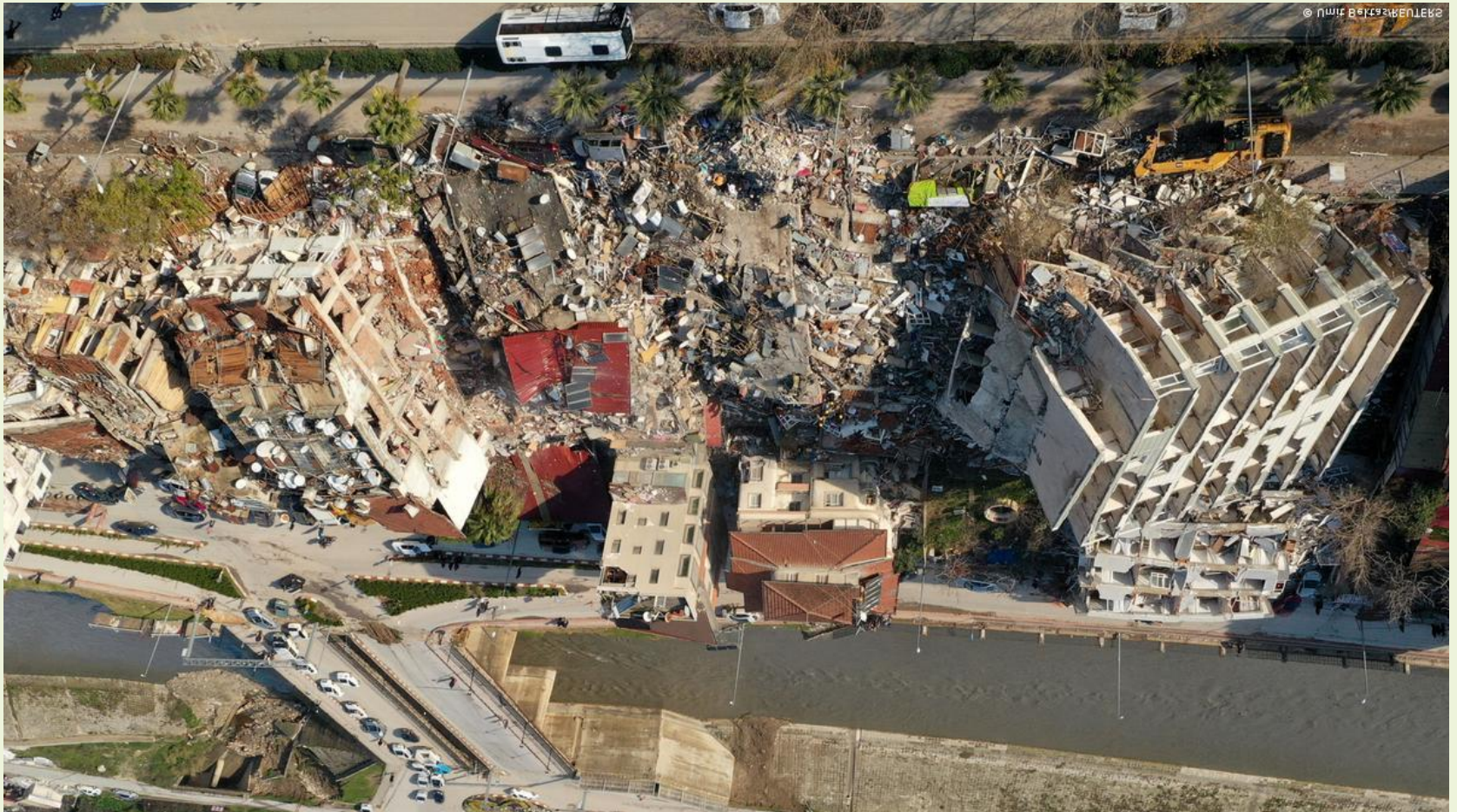




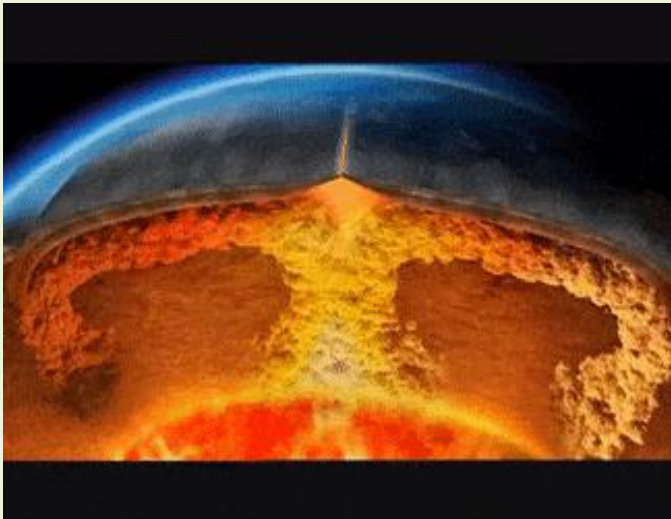
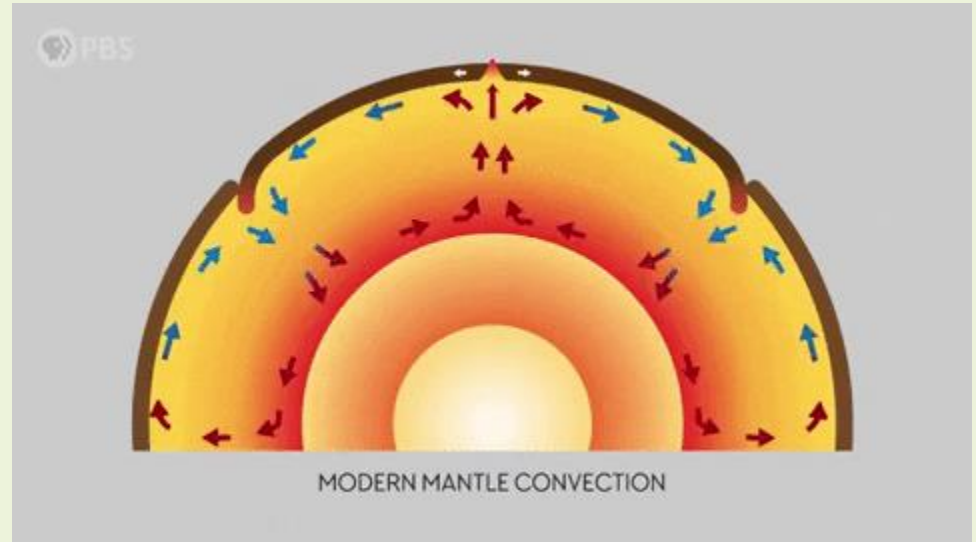
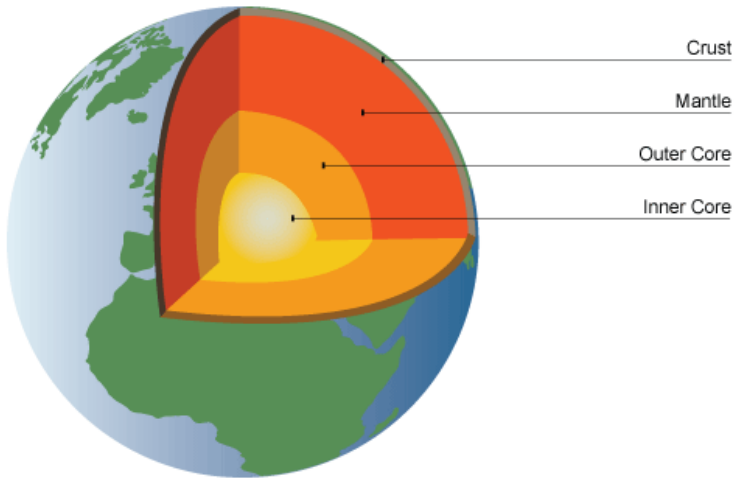
## Effect of Disasters

- Risk to Habitats and Infrastructures

❖ *Widespread devastation in Turkey Earthquake, 2023*

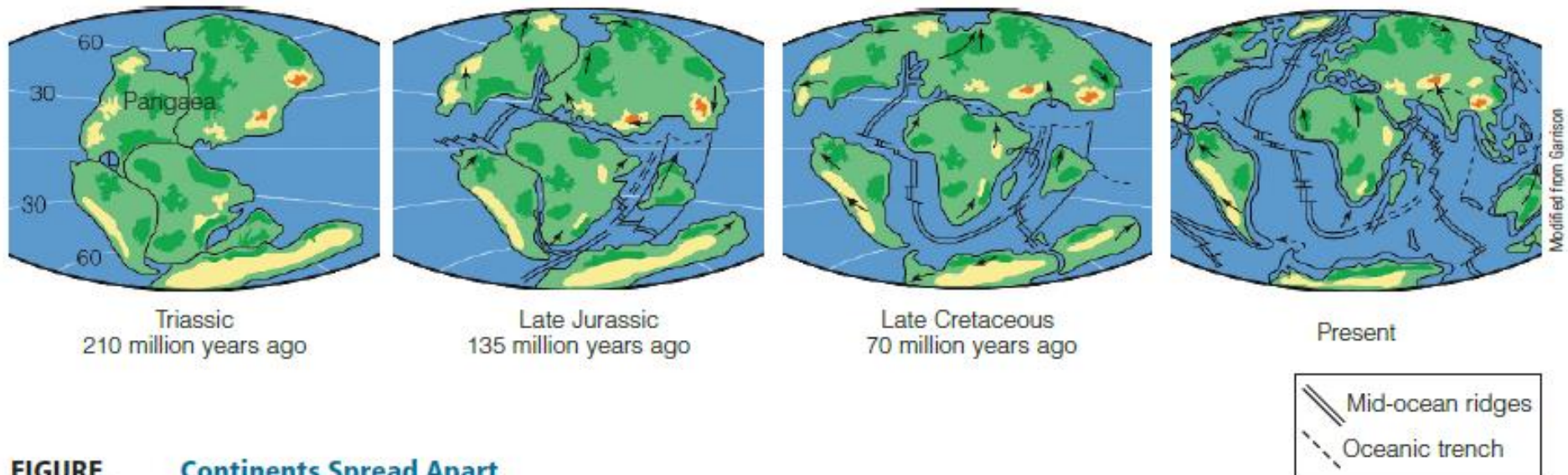


# Earth Structure and Mantle Convection





## Continental Drift: The Pangaea

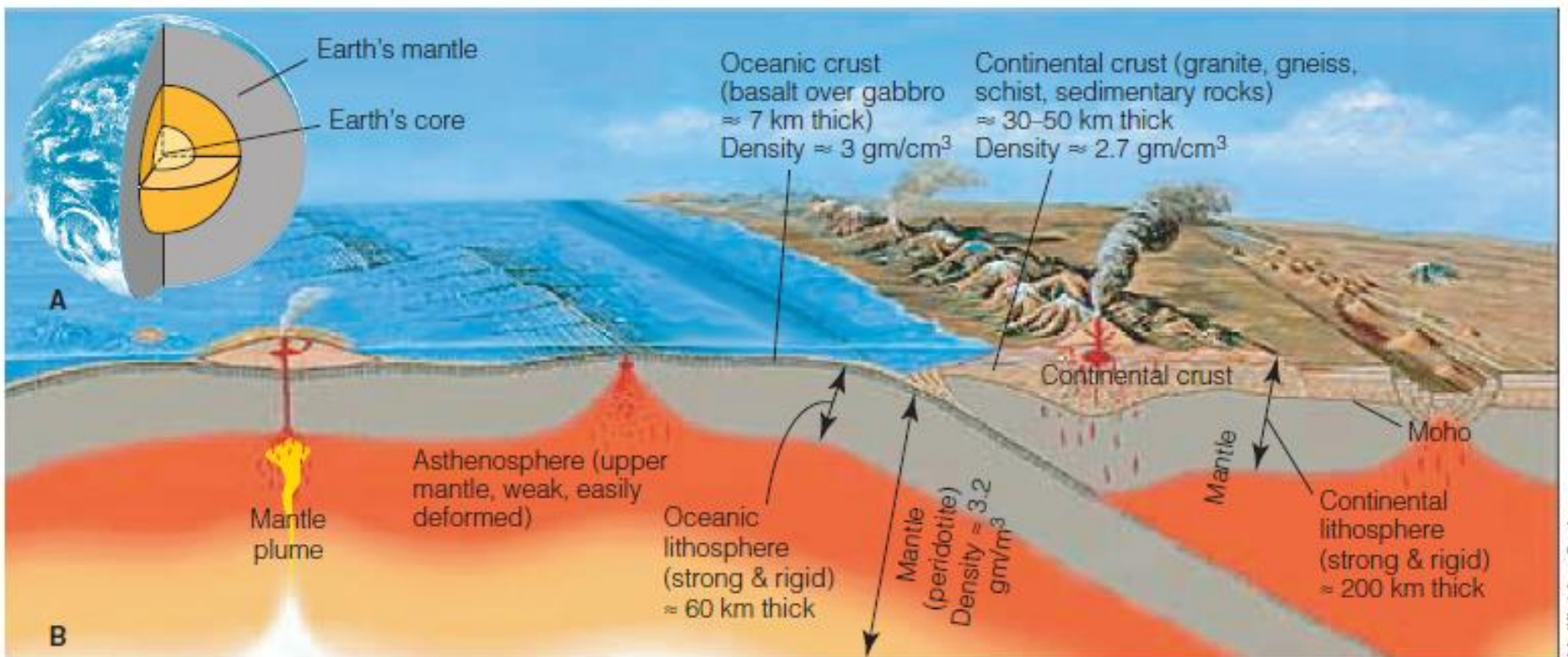
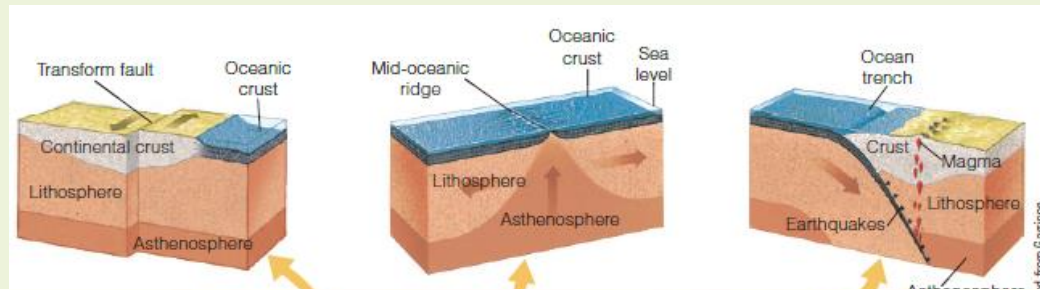


**FIGURE**      **Continents Spread Apart**

The supercontinent Pangaea broke up into individual continents starting approximately 225 million years ago.

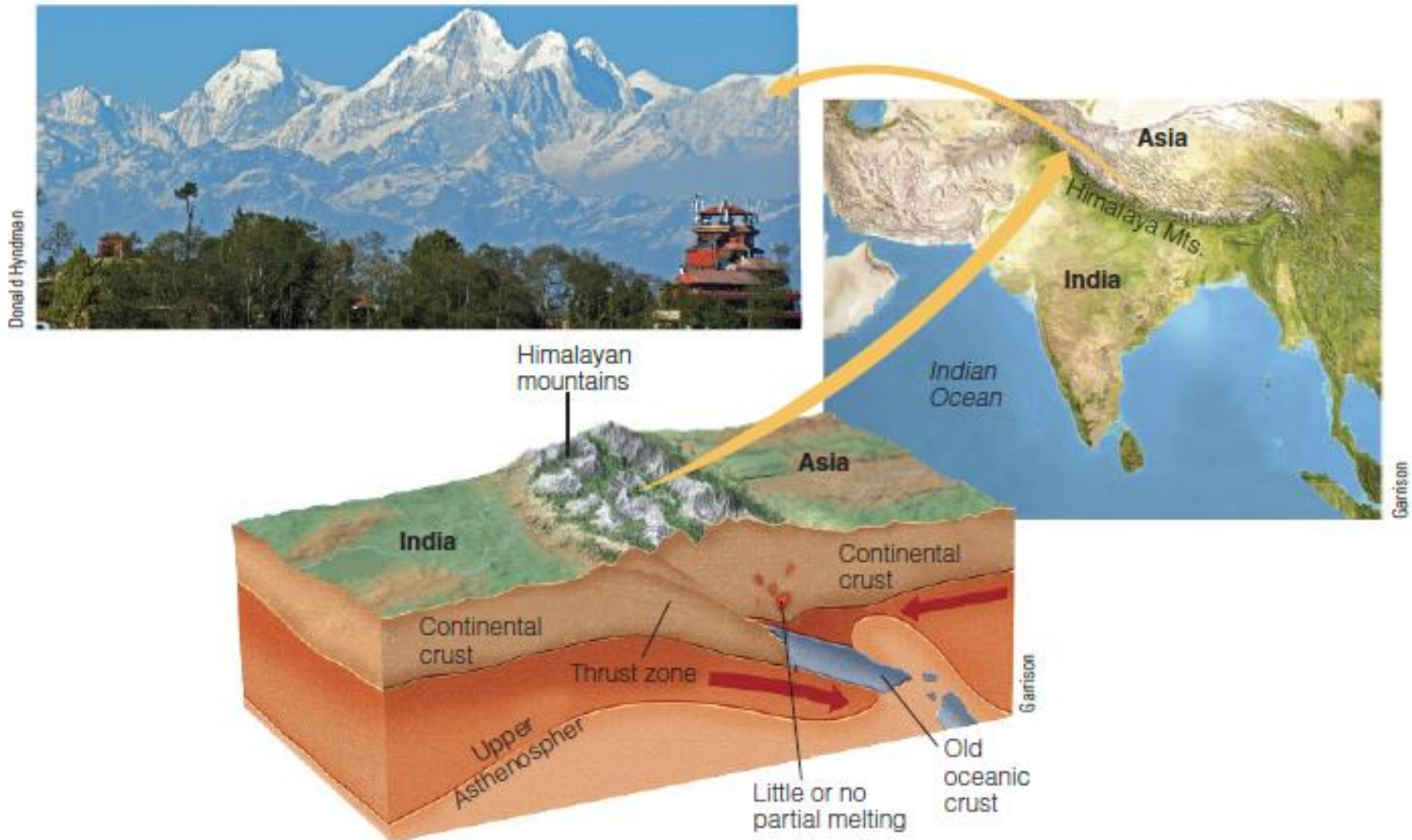


# Earth Structure



**FIGURE** Earth Structure

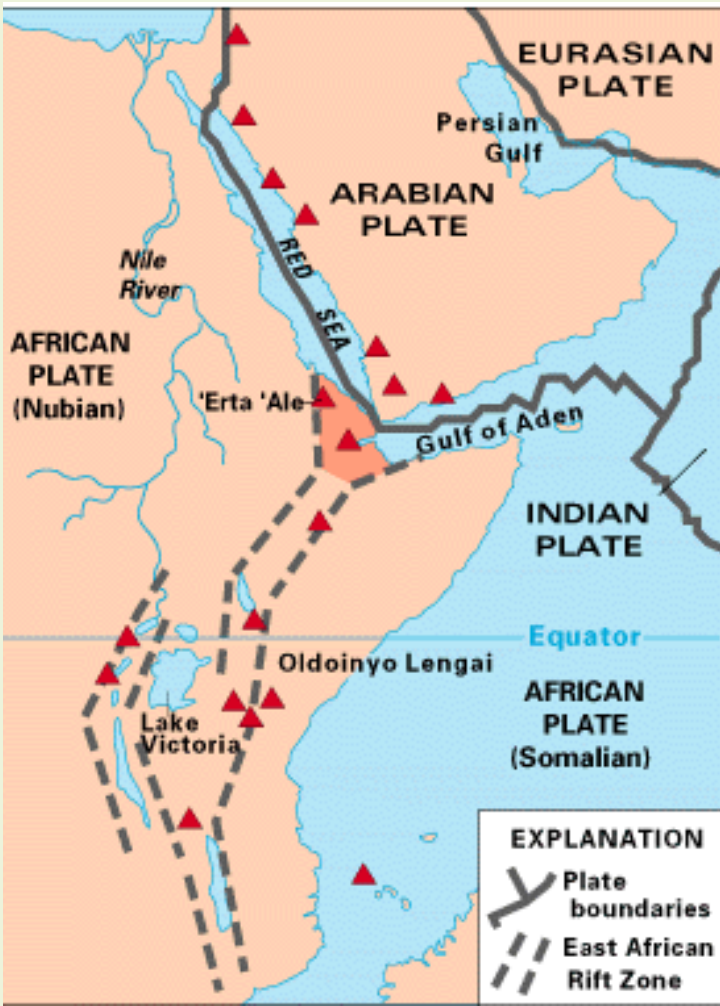
## Continental Collision Zones





## Rifts and Spreading Ridges

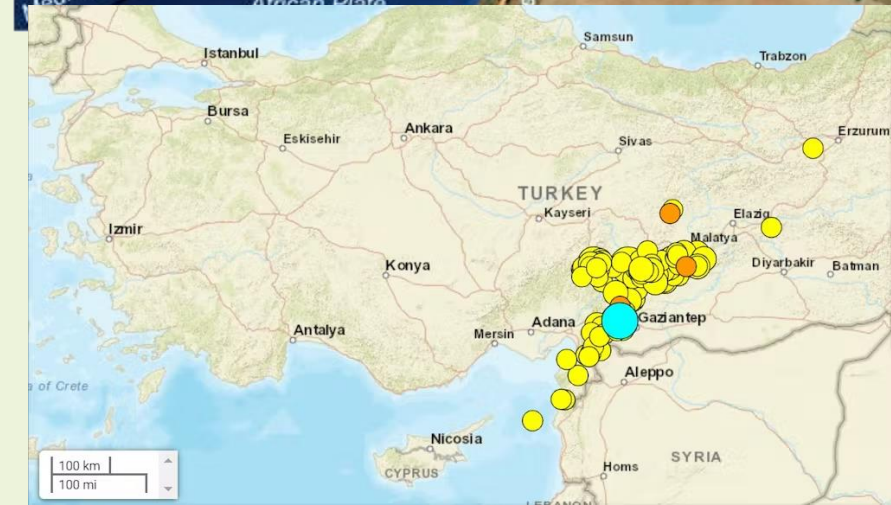
- East African Rift



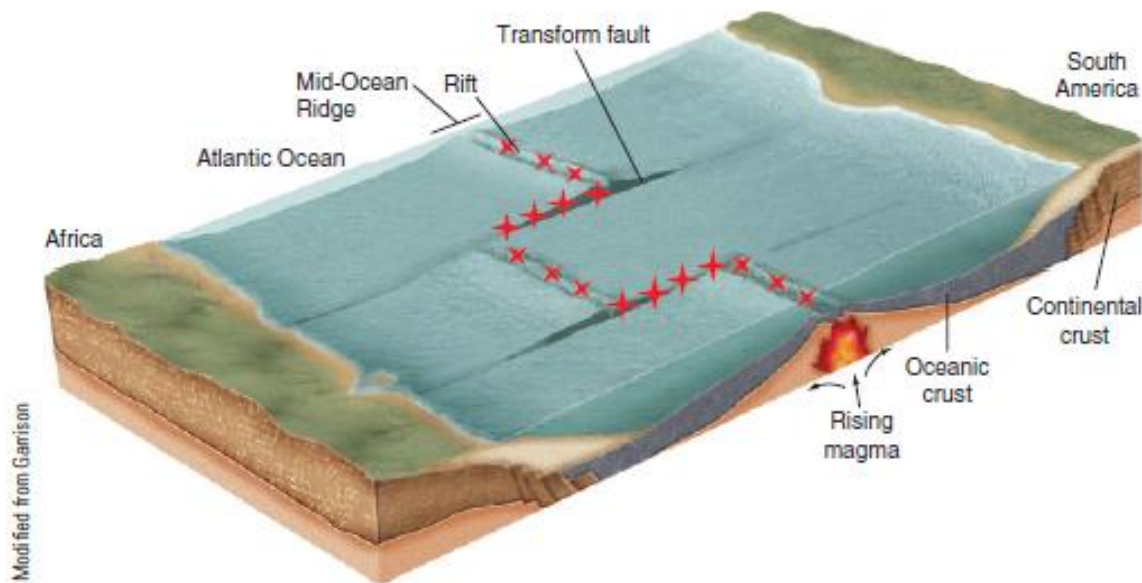


## Rifts: Land mass moving away from each other

- Turkey-Syria Earthquake 2023 and East Anatolian Rift



## Transform Faults



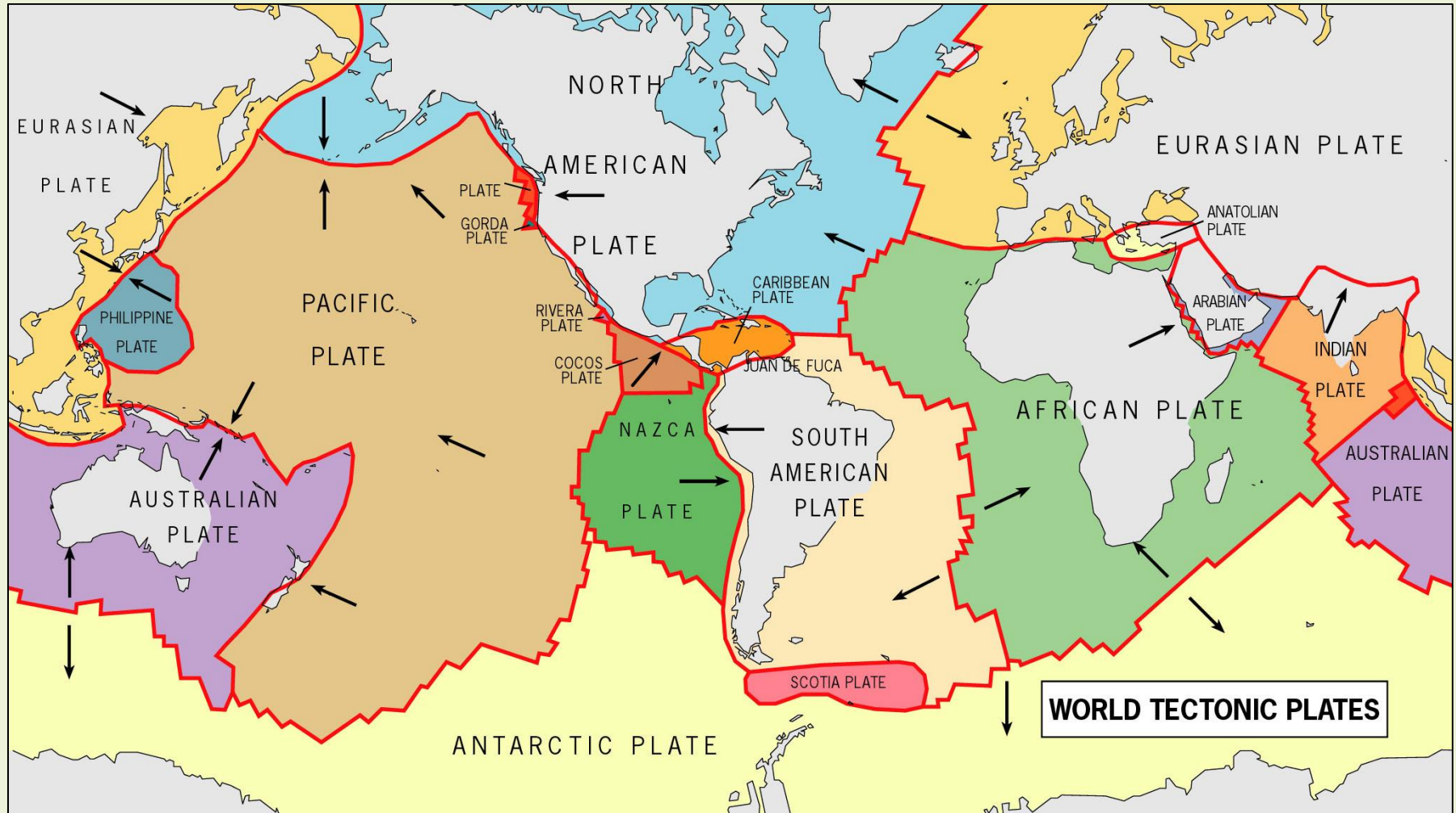
### FIGURE Transform Fault

A. In this perspective view of an oceanic spreading center, earthquakes (stars) occur along spreading ridges and on transform faults offsetting the ridge.

B. The San Andreas Fault, indicated with a yellow, dashed line, is an example of a continental transform fault. Shown here is the heavily populated area that straddles the fault just south of San Francisco.

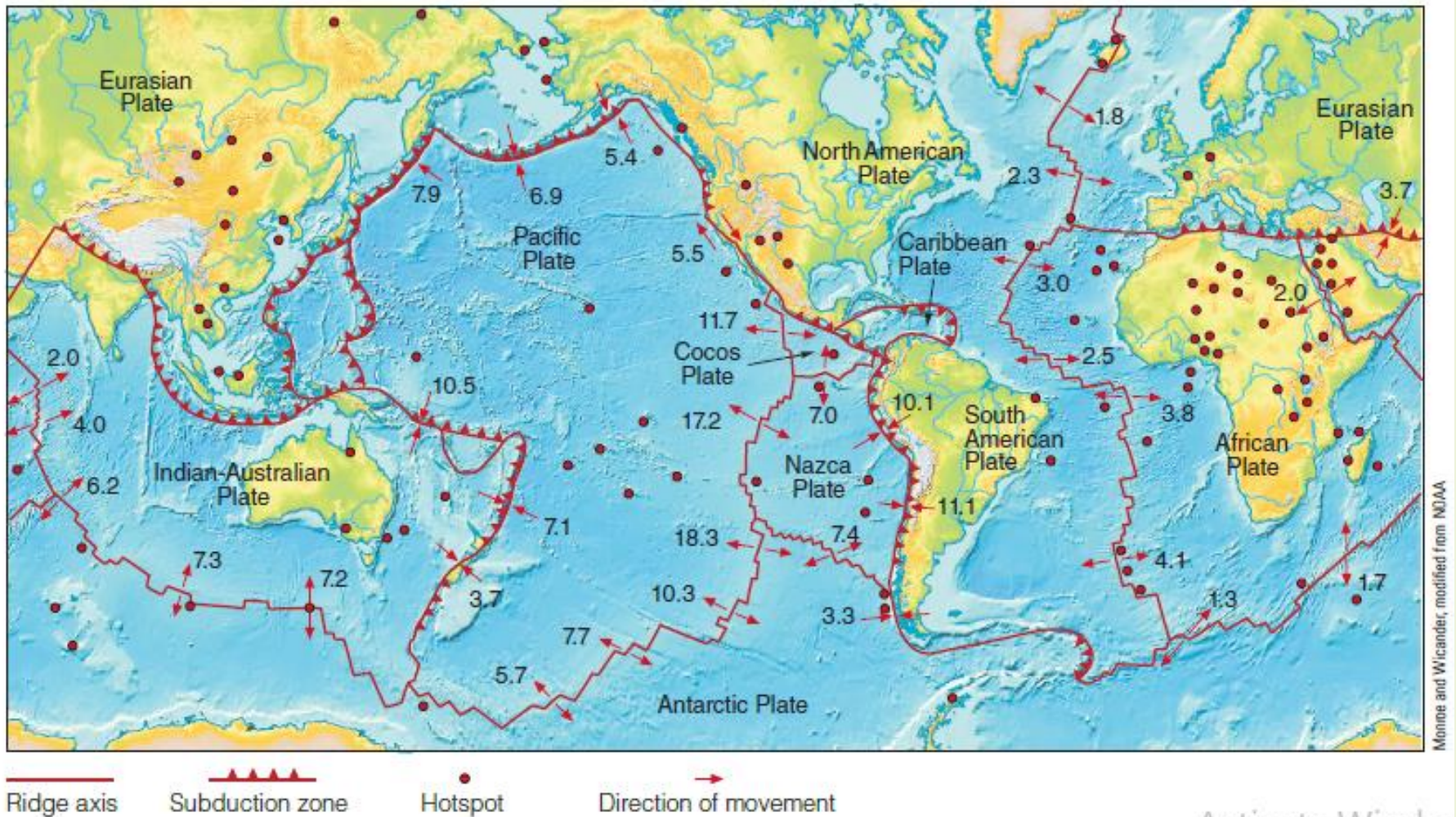


## Movement of Tectonic Plates

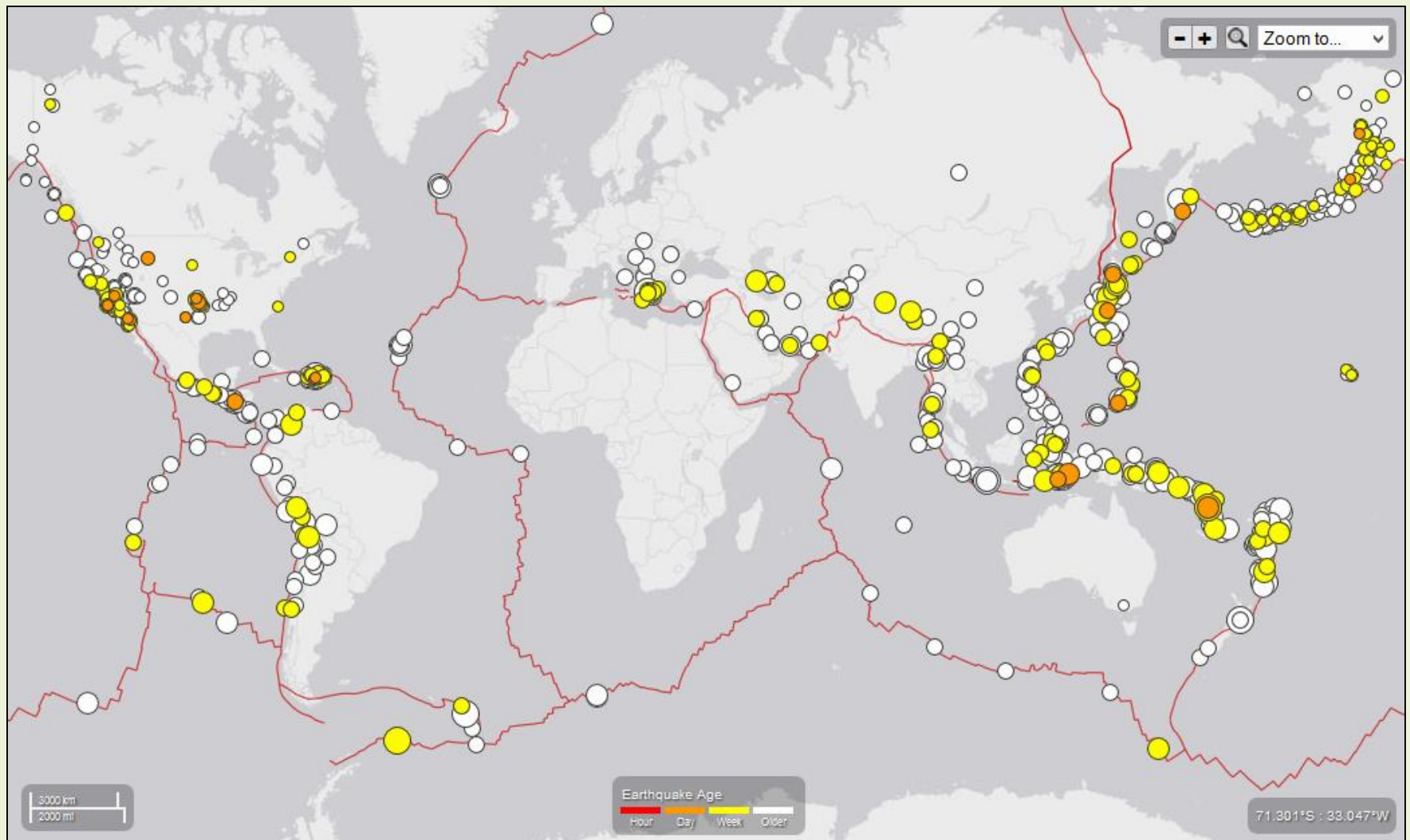




## Plate Tectonics and Earthquakes

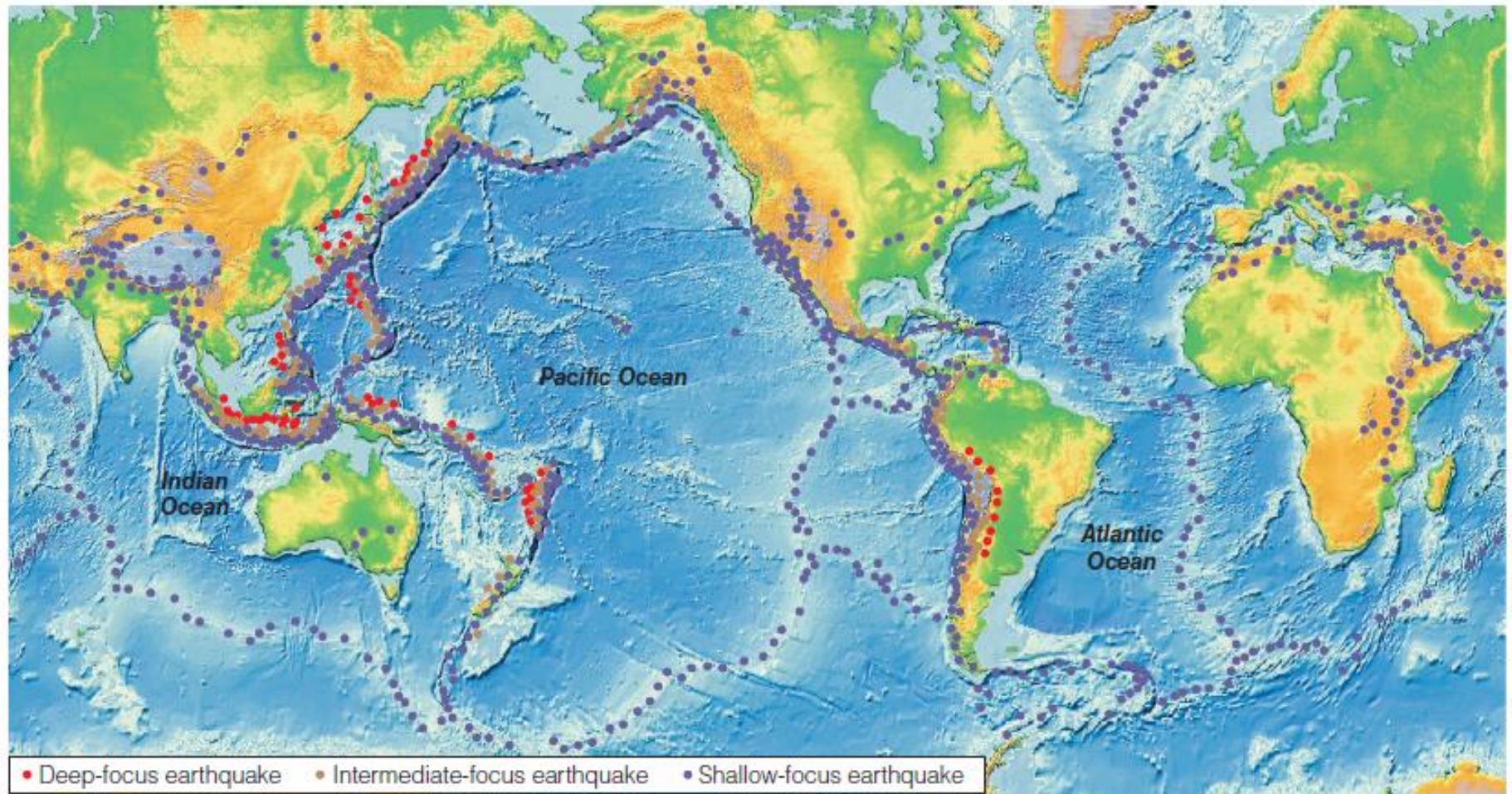


## Earthquakes at Plate Boundaries and Faults





## Earthquakes at Plate Boundaries



Monroe and Wincander, modified from NOAA

**FIGURE** Earthquakes at Plate Boundaries



## Earthquakes caught in CCTV in Turkey 2023



## Earthquake Effects

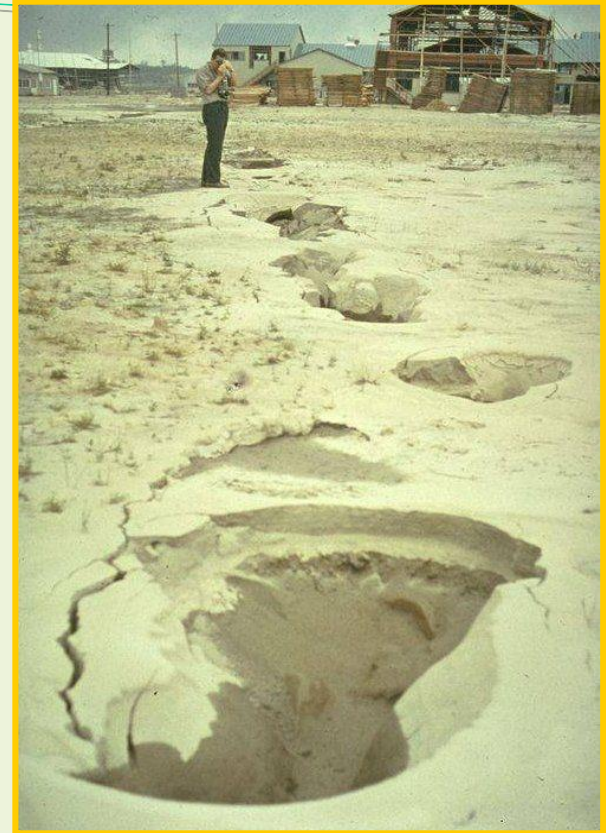
- Massive tilting of buildings (**Niigaata Earthquake, 1964**)





## Earthquake Effects

- Huge sand boils or Sand volcanoes





## Earthquake Effects

- Pier movements – Showa bridge collapse (**Niigata Earthquake, 1964**)
  - ❖ *Loss of lateral support on piles extending through liquefiable layers*



## Earthquake Effects

- Surface heave (**Chi-Chi Earthquake, Taiwan, 1999**)



## Earthquake Effects

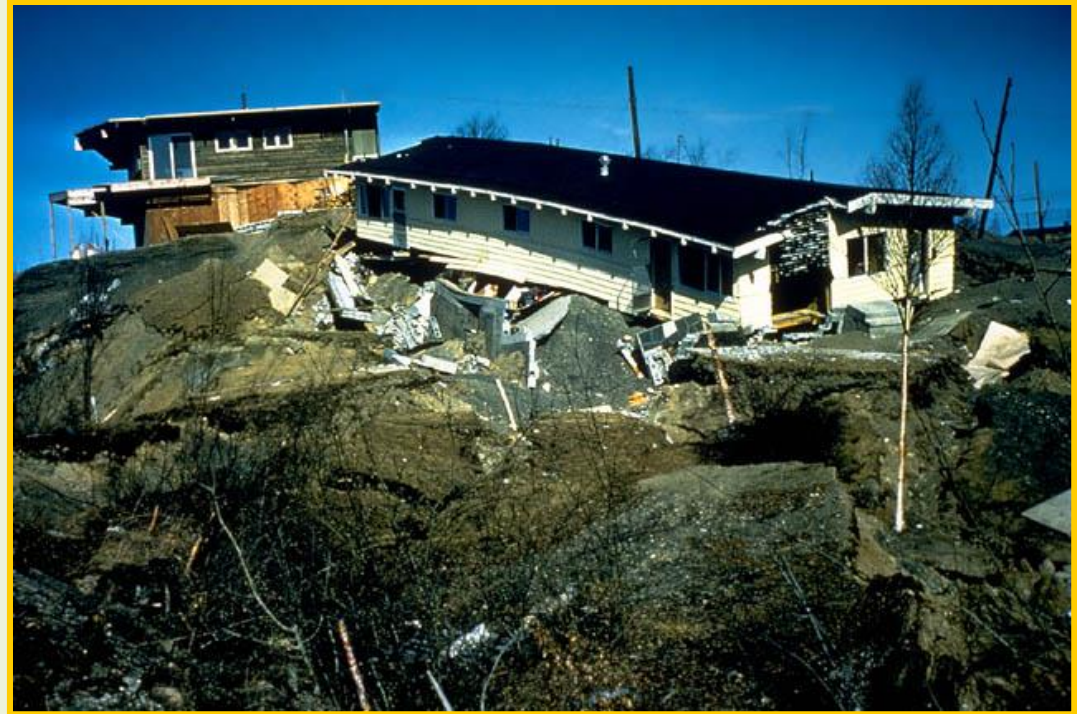
- Dam abutment failure (**Chi-Chi Earthquake, Taiwan, 1999**)
  - ❖ *Loss of lateral support on abutment foundations*





## Earthquake Effects

- Building foundation failure (**Chi-Chi Earthquake, 1999**)



## Earthquake Effects

- Shallow foundation failure (**Kocaeli Earthquake, Turkey, 1999**)





## Earthquake Effects

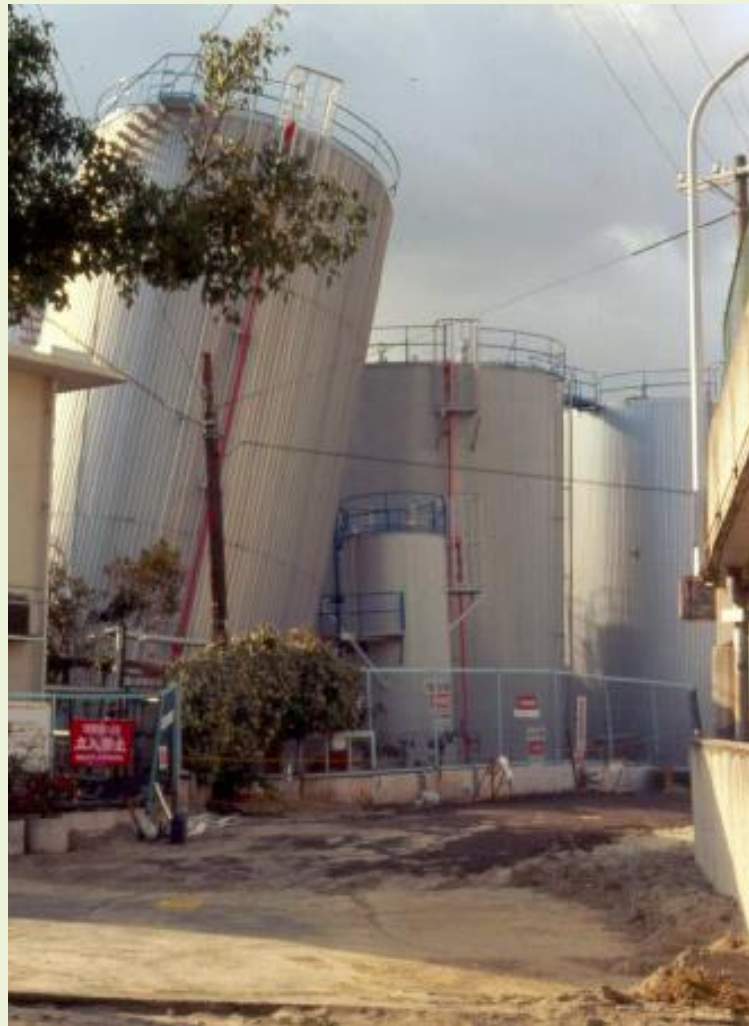
- Pancake collapse of buildings (**Turkey Earthquake, 2023**)



Vex

## Earthquake Effects

- Floatation of tanks on liquefied ground (**Kobe Earthquake, 1995**)





## Shake Table Tests



## Earthquake Effects

- Hanshin expressway collapse (**Kobe Earthquake, 1995**)





## Earthquake Effects

- Damage to harbors and wharves (**Haiti Earthquake, 2010**)



## Earthquake Effects

- Devastating dam failure (**San Fernando Earthquake, 1971**)
  - ❖ *Massive lateral flow and extensive liquefaction*





## Earthquake Effects

- Devastating slope failure (**San Fernando Earthquake, 1971**)
  - ❖ *Liquefaction induced failure of upstream slope*



## Brumadinho Tailing Dam Collapse, Brazil, 2019

•

**The  
Guardian**



# Earthquake Induced Tsunami



## Tsunamic in India 2004 and Japan 2011

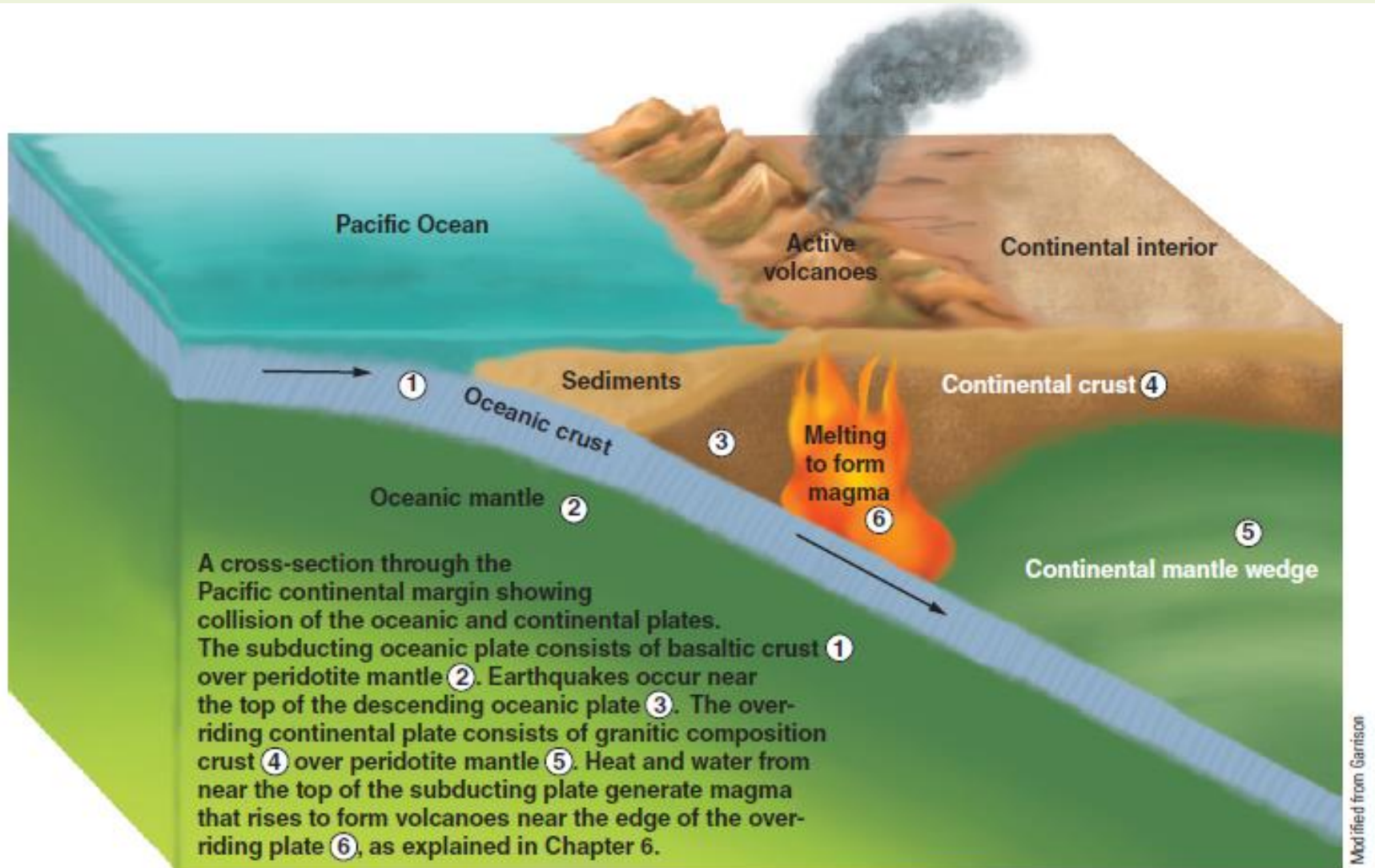
**Začalo to v roce  
2004 v Asii**



## Tsunamic in Kanyakumari, India, 2004



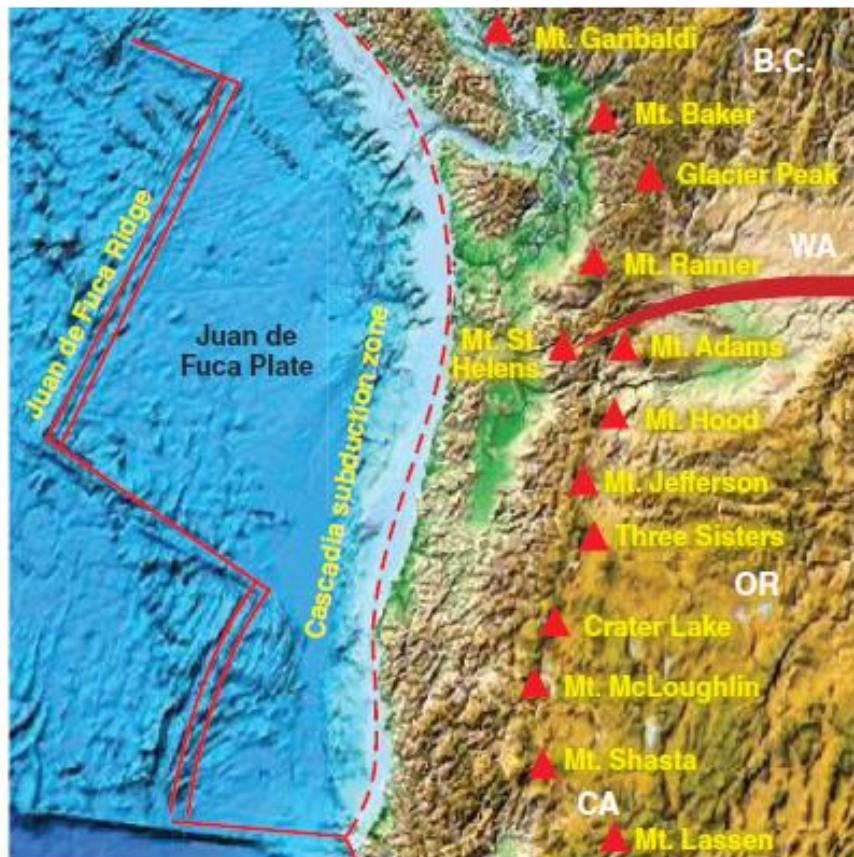
## Subduction Zones and Volcanoes





## Subduction Zones and Volcanoes

- Cascadia volcanic chain at Pacific Northwest (Canada, USA)

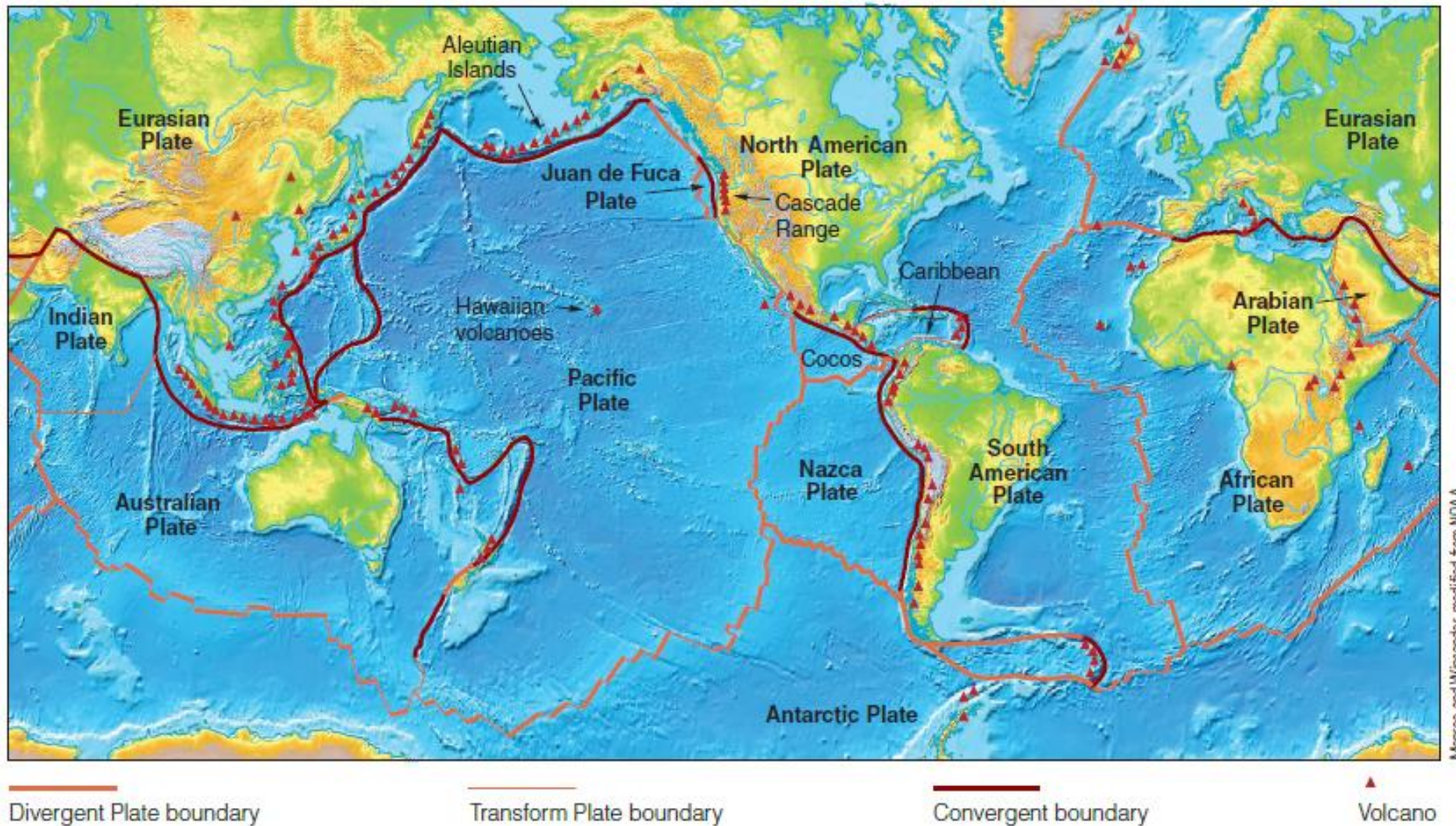


**FIGURE** • **Volcanoes Near Subduction Zones**

The Cascade volcanic chain forms a prominent line of peaks parallel to the oceanic trench and 100 to 200 km inland. Mt. St. Helens (in foreground) and Mt. Rainier (behind, to the north) are two of the picturesque active volcanoes that lie inland from the Cascadia subduction zone.



## Volcanoes near Plate Boundaries



**FIGURE 2-6 Volcanoes Near Plate Boundaries**



## Mt. Kilauea Volcanic Lava Flow, Hawaii, 2018



THEN  
& NOW\_

40 YEARS OF ERUPTIONS: KILAUEA VOLCANO



—

## Stromboli Volcanic Eruption, Italy, 2022

**Stromboli volcano Italy!**

  
**Angry**  
**Nature**

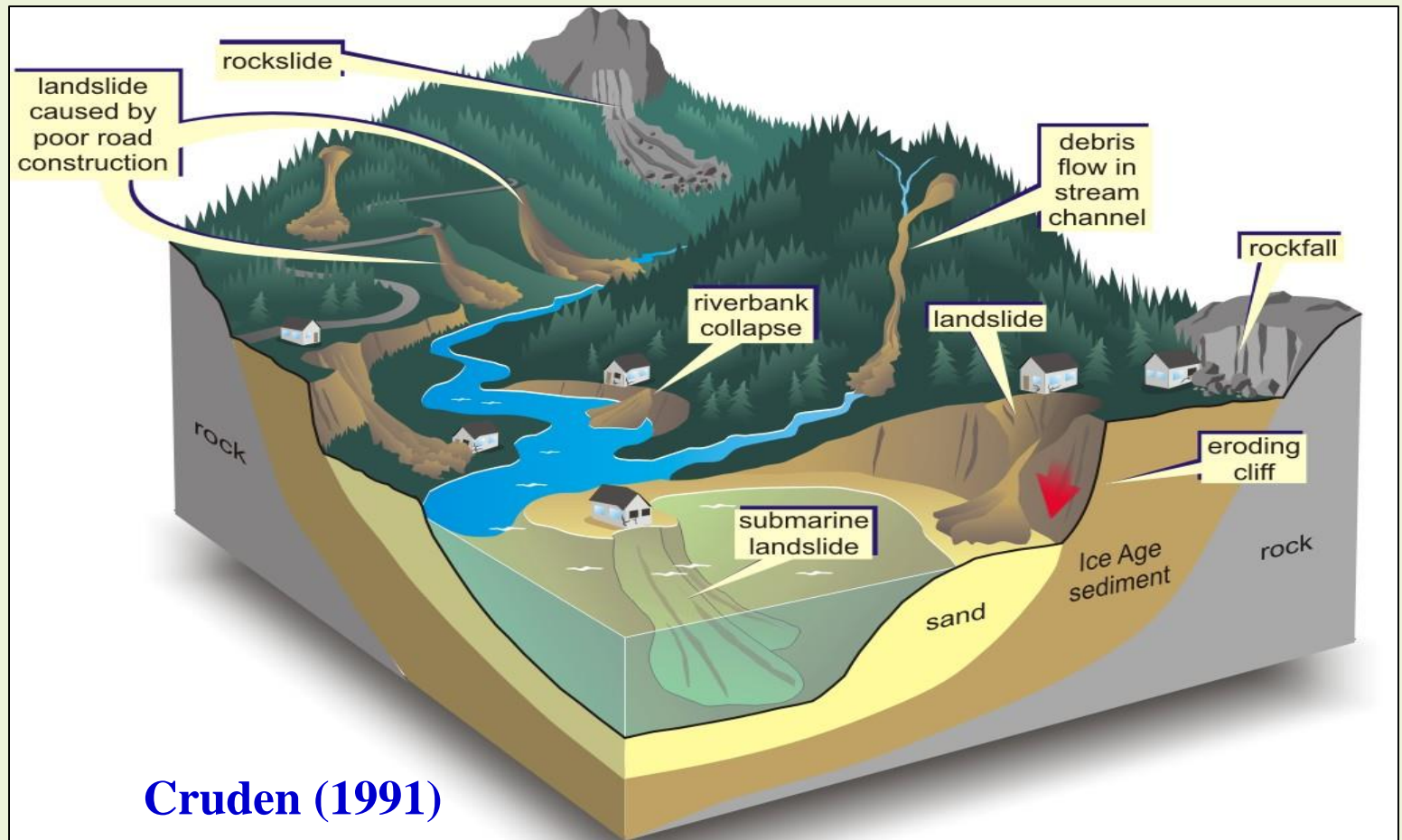
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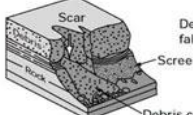


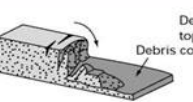

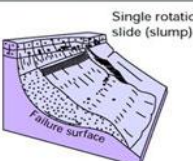
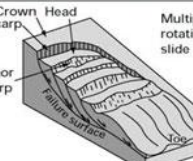
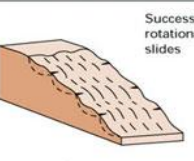
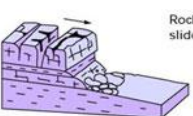


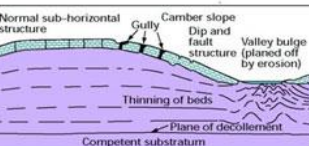
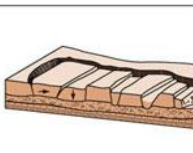
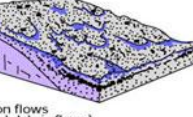


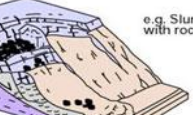

## Slope Instabilities and Landslides

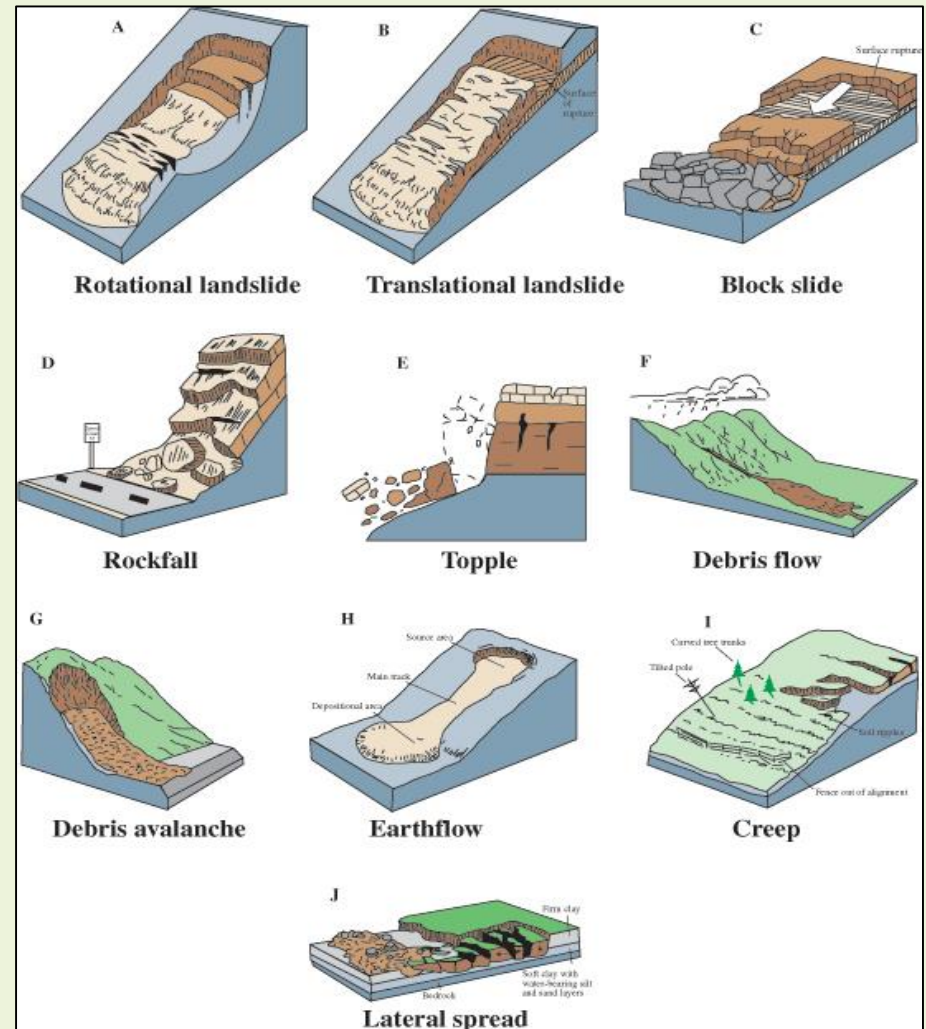
Movement of mass of rock, debris or earth down a slope



Cruden (1991)

# Classification of Slope Instabilities: Types of Failure

Material		ROCK	DEBRIS	EARTH
Movement type				
FALLS		 Scar Rock fall Rock fall debris Debris cone	 Scar Debris fall Scree Debris cone	 Scar Earth fall Colluvium Debris cone
		 Rock topple	 Debris topple Debris cone	 Cracks Earth topple Debris cone
SLIDES	Rotational	 Single rotational slide (slump) Failure surface	 Crown Head Scarp Minor Scarp Failure surface	 Successive rotational slides
	Translational (Planar)	 Rock slide	 Debris slide	 Earth slide
SPREADS	 Normal sub-horizontal structure Cap rock Clay shale Thinning of beds Plane of decollement Competent substratum Camber slope Dip and fault structure (planned off by erosion) Valley bulge structure (planned off by erosion) e.g. cambering and valley bulging			 Earth spread
FLOWS	 Solifluction flows (Periglacial debris flows)		 Debris flow	 Earth flow (mud flow)
	 e.g. Slump-earthflow with rockfall debris		 e.g. composite, non-circular part rotational/part translational slide grading to earthflow at toe	





## Classification of Slope Instabilities: Velocity of Failure

Velocity Class	Description	Velocity (mm/sec)	Typical Velocity	Probable Destructive Significance
7	Extremely Rapid			
		$5 \times 10^3$	5 m/sec	Catastrophe of major violence; buildings destroyed by impact of displaced material; many deaths; escape unlikely
6	Very Rapid			
		$5 \times 10^1$	3 m/min	Some lives lost; velocity too great to permit all persons to escape
5	Rapid			
		$5 \times 10^{-1}$	1.8 m/hr	Escape evacuation possible; structures, possessions, and equipment destroyed
4	Moderate			
		$5 \times 10^{-3}$	13 m/month	Some temporary and insensitive structures can be temporarily maintained
3	Slow			
		$5 \times 10^{-5}$	1.6 m/year	Remedial construction can be undertaken during movement; insensitive structures can be maintained with frequent maintenance work if total movement is not large during a particular acceleration phase
2	Very Slow			
		$5 \times 10^{-7}$	15 mm/year	Some permanent structures undamaged by movement
	Extremely SLOW			Imperceptible without instruments; construction POSSIBLE WITH PRECAUTIONS

Cruden and Varnes, 1996

## Causes of Landslide

### Natural Causes

#### Geological Causes

- Weathering
  - Chemical
  - Physical
  - Biological
- Structure
  - Stratification
  - Orientation

#### Morphological Causes

- Topography
- Surface Cover
- Slope inclination
- Erosion
  - Toe erosion
  - Gully erosion
- Subterranean
  - Solution
  - Piping
- Deposition
  - On slope face
  - On crest
- Tectonic activities
  - Uplift

#### Hydrological Causes

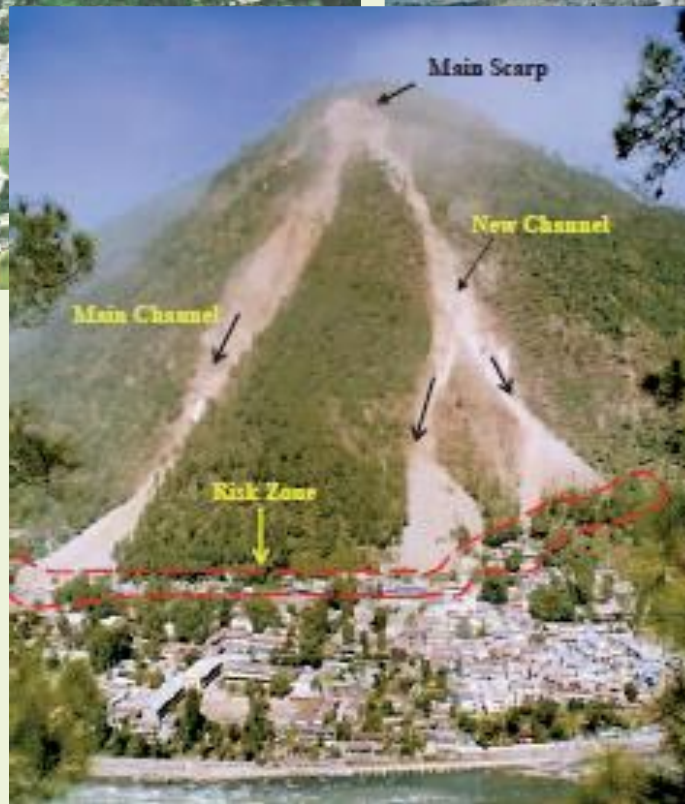
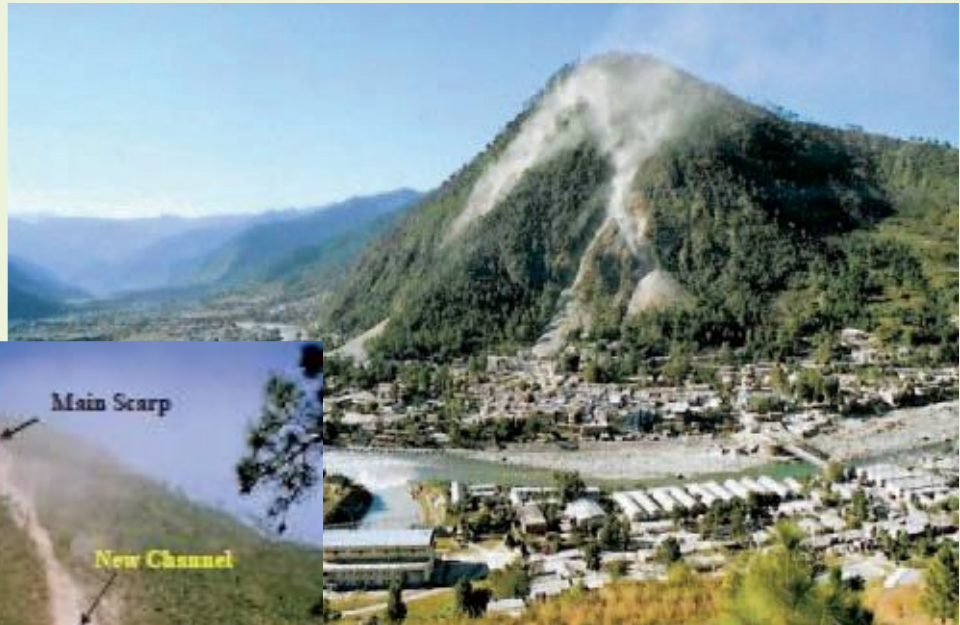
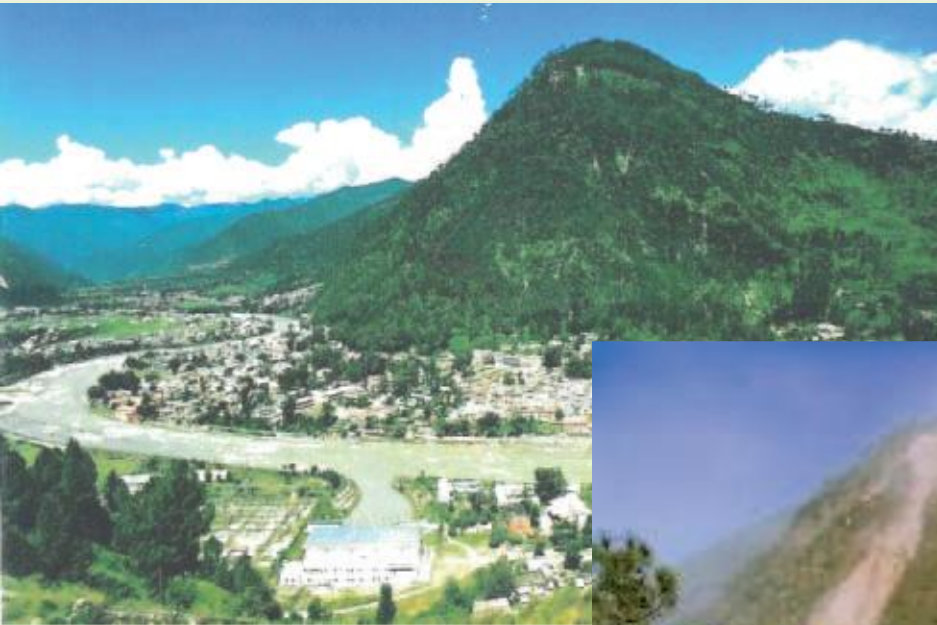
- Rainfall
- Runoff
- Infiltration
- Percolation
- Seepage

### Anthropogenic Causes

- Encroachment
- Unscientific cutting of hill slopes
- Deforestation
- Unplanned drainage and Sewerage system
- Unplanned construction of roads



## Typical Examples of Landslides



**Varunavat Parvat  
Landslide**

**Uttarkashi,  
Uttarakhand**

**24 September 2003**

## Typical Examples of Landslides



**Malegaon Mudslide**

**Malegaon, Pune,  
Maharashtra**

**30 July 2014**





## Earthquake Induced Landslide

- Palu, Indonesia, 2018



## Earthquake Induced Landslide

- Palu, Indonesia, 2018





## Typical Examples of Landslides



**Some Landslides  
in Assam**

**2013**



## Typical Examples of Landslides



**Some Landslides  
in Guwahati**

**2012**



## Typical Examples of Landslides



**Rockfall at  
Guwahati-  
Shillong Road**

## Rockfall at Sangla Valley, Himachal Pradesh, 2021





## Cliff Topples, Brazil, 2021



## Typical Examples of Landslides



Landslide in  
Sonapur  
2011



## Typical Examples of Landslides



**Banderdewa  
Mudslide  
Arunachal Pradesh  
2013**



## Typical Examples of Landslides



**Seismic Slope  
instability in  
Saiphum,  
Mizoram**

**2013**



## Typical Examples of Landslides



**Slope instability  
due to faulty  
excavation  
technique in  
North Guwahati  
due to Steep  
Excavation**

**2015**



## Typical Examples of Landslides

Landslide just now at Gauripur, North Guwahati



**Gauripur  
Landslide,  
Opposite to IIT  
Guwahati**

**2020**

**Landslide near Narayana Hospital, 2020**





## Debris Flows, Nepal, 2021



## Assam Flood and New Haflong Debris Flows 2022

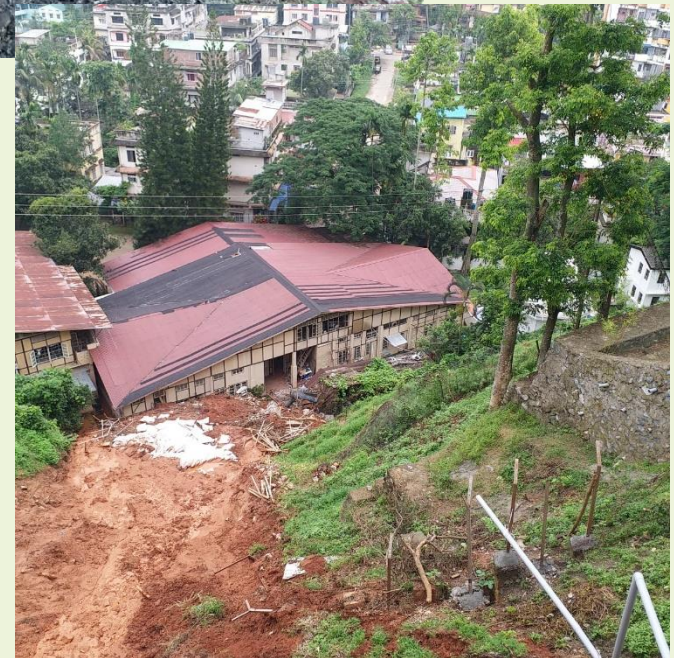




## Typical Examples of Landslides



**Landslide  
beneath Raj  
Bhawan  
Guwahati  
2020**



## Sirmaur Valley Landslide, Himachal Pradesh, 2021





## Glacier Wall Breakoff, Kinnaur, HP, 2021



## Avalanche at Kedarnath, 2021





## Chamoli Glacier Outburst, Chamoli, 2021



## Hurricanes and Cyclones

- Hurricanes/Cyclones form from disturbances in the atmosphere over warm, tropical ocean water





## Hurricanes

- Hurricane Sandy, 22 October-2 November 2012
  - ❖ *Worst affected areas: New York and New Jersey, USA*



■ During Hurricane Sandy the east end of the Mantoloking Bridge, at left, was submerged, and houses on the barrier island battered. Some like the one in the lower left floated off their foundations.

Mark Olson, NJ Army National Guard

## Flooding from Cyclones Yash and Aamphan, Bangladesh





## Flooding from Cyclones Yash and Aamphan, Bangladesh



## Kedarnath Disaster 2013: Natural or Man Made?

**REVISITING KEDARNATH FLOODS 2013** **KedarnathCalling**  
**WORST CALAMITY TO HIT INDIA SINCE TSUMANI '04**

INDIA  
TODAY  
9:41 AM



FILE

**THE FLOOD THAT RAVAGED UTTARAKHAND**

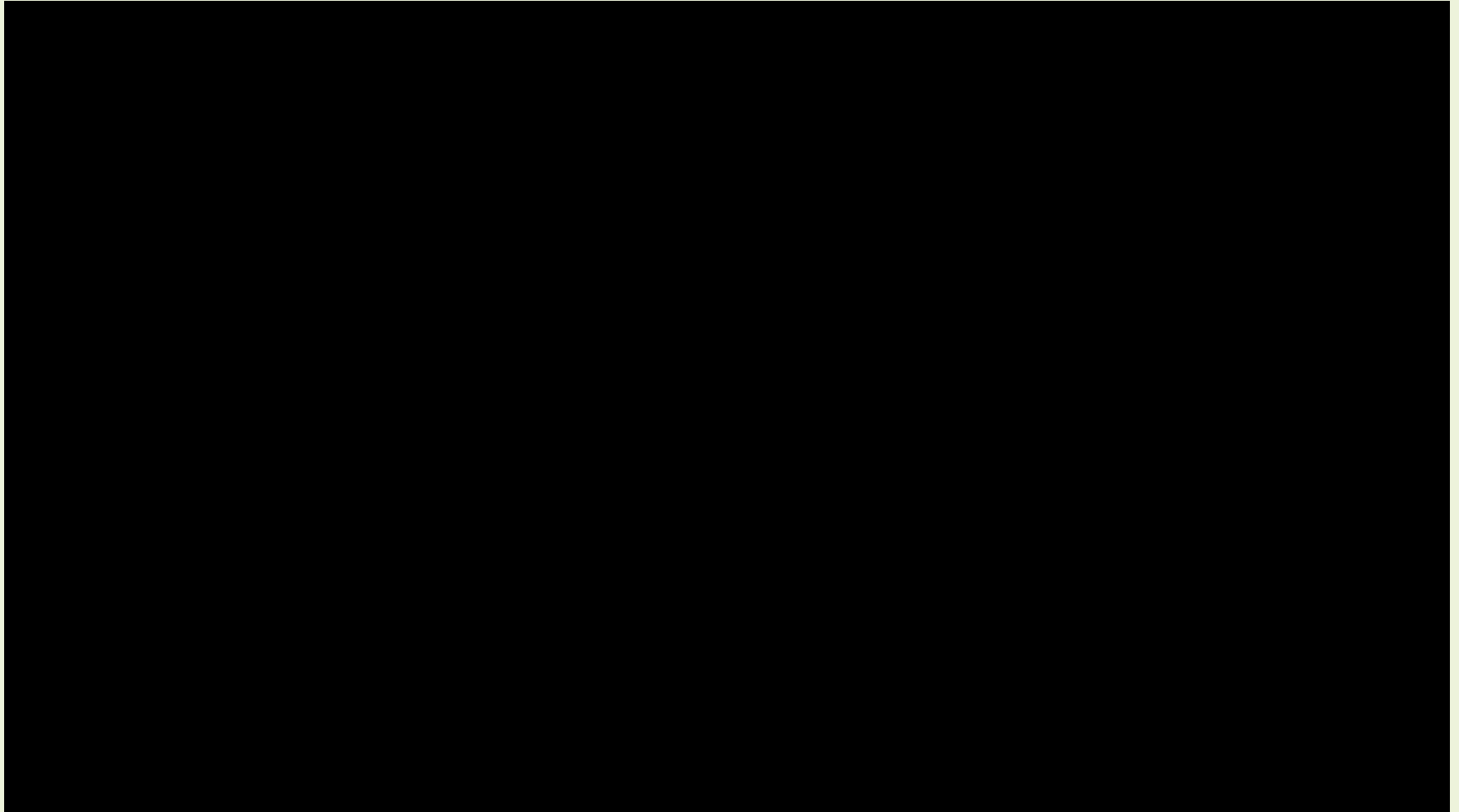
**17**

**U.S TO START VACCINATING  
5-11 YR OLDS FROM NOV 10**





## Kedarnath Disaster 2013: Natural or Man Made?



## Beirut Explosion 2020: Man-Made disaster





## Beirut Explosion 2020: Another View



## Kaziranga Rhinoceros





## Jaldapara Reserve Forest Tragedy, West Bengal



## Salute to The Rescue Teams









<http://www.iitg.ac.in/arindam.dey/homepage/index.html#>

[https://www.researchgate.net/profile/Arindam\\_Dey11](https://www.researchgate.net/profile/Arindam_Dey11)