# Unit 7: Dynamic Planet: Earthquakes & Volcanoes

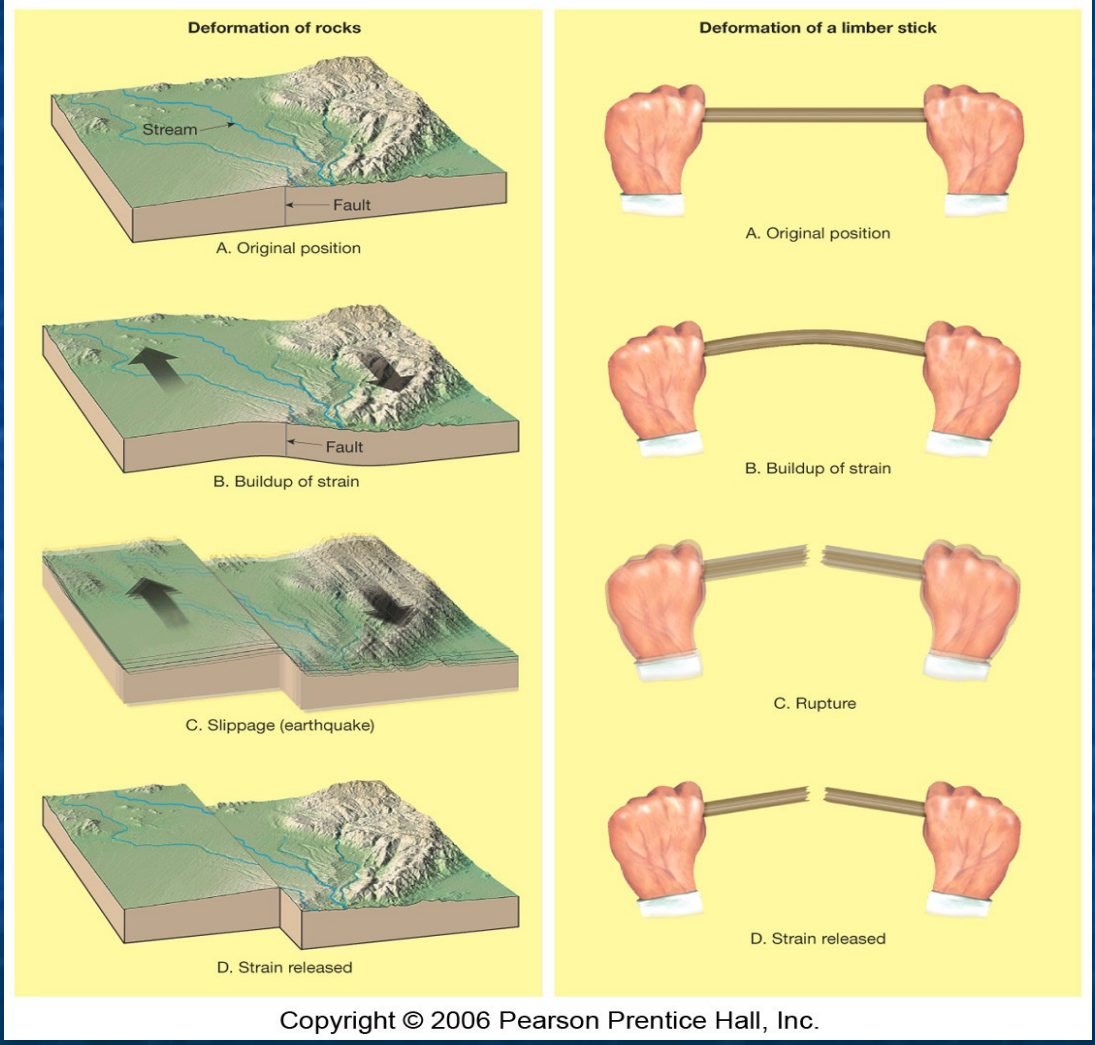
Lecture 3

## Objectives:

E3.4C - Describe the effects of earthquakes and volcanic eruptions on humans.

E3.4f - Explain why fences are offset after an earthquake using the elastic rebound theory.

# Elastic rebound



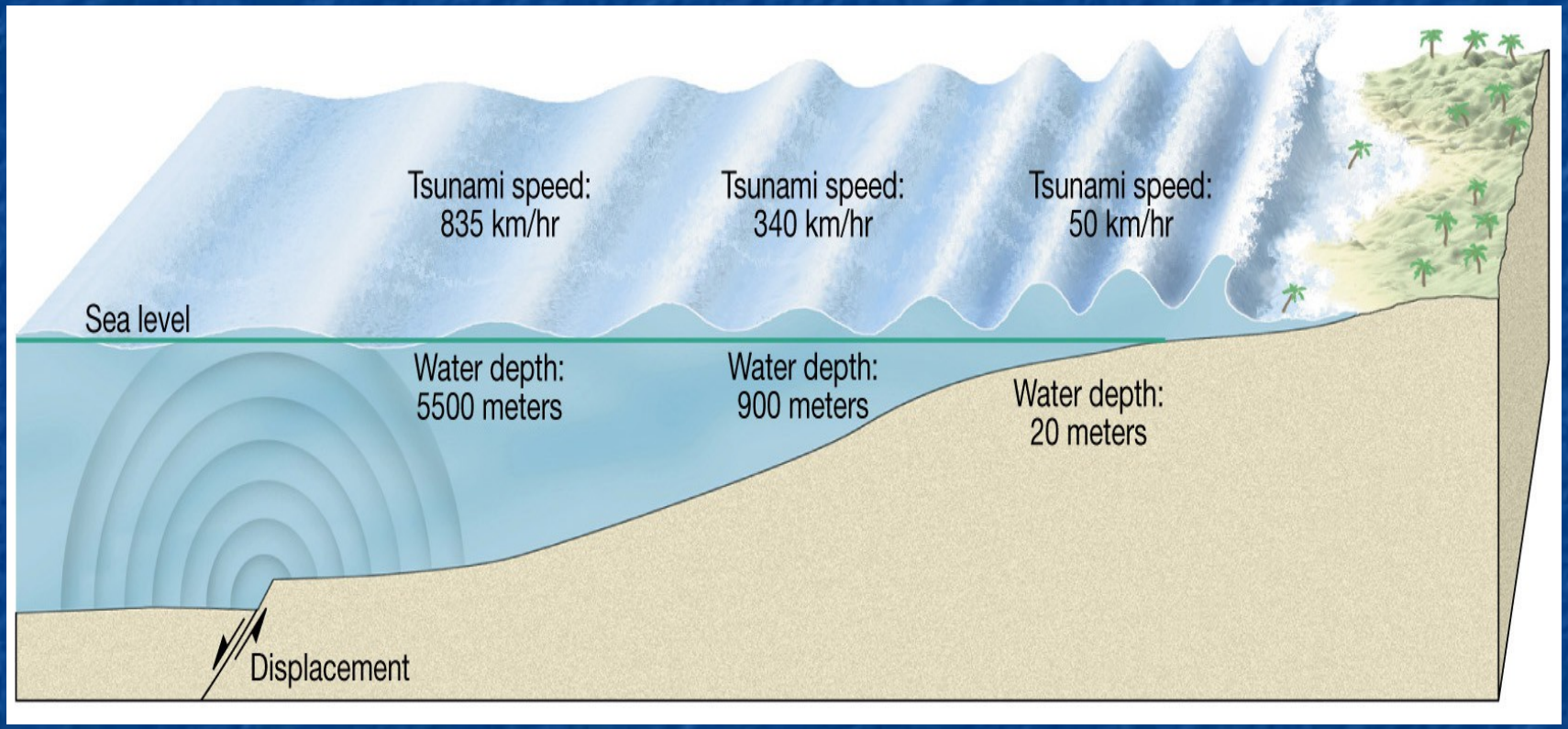
# Earthquake Damage*

- Earthquakes can cause damage in a number of ways
  - Tsunami waves
  - Seiche waves
  - Landslides
  - Liquefaction
  - Fire
  - Disease

# Tsunami

- Gravitational sea wave produced by any large-scale, short-duration disturbance of the ocean floor
- Disturbances caused principally by a shallow submarine earthquake, but also by submarine earth movement, subsidence, or volcanic eruption

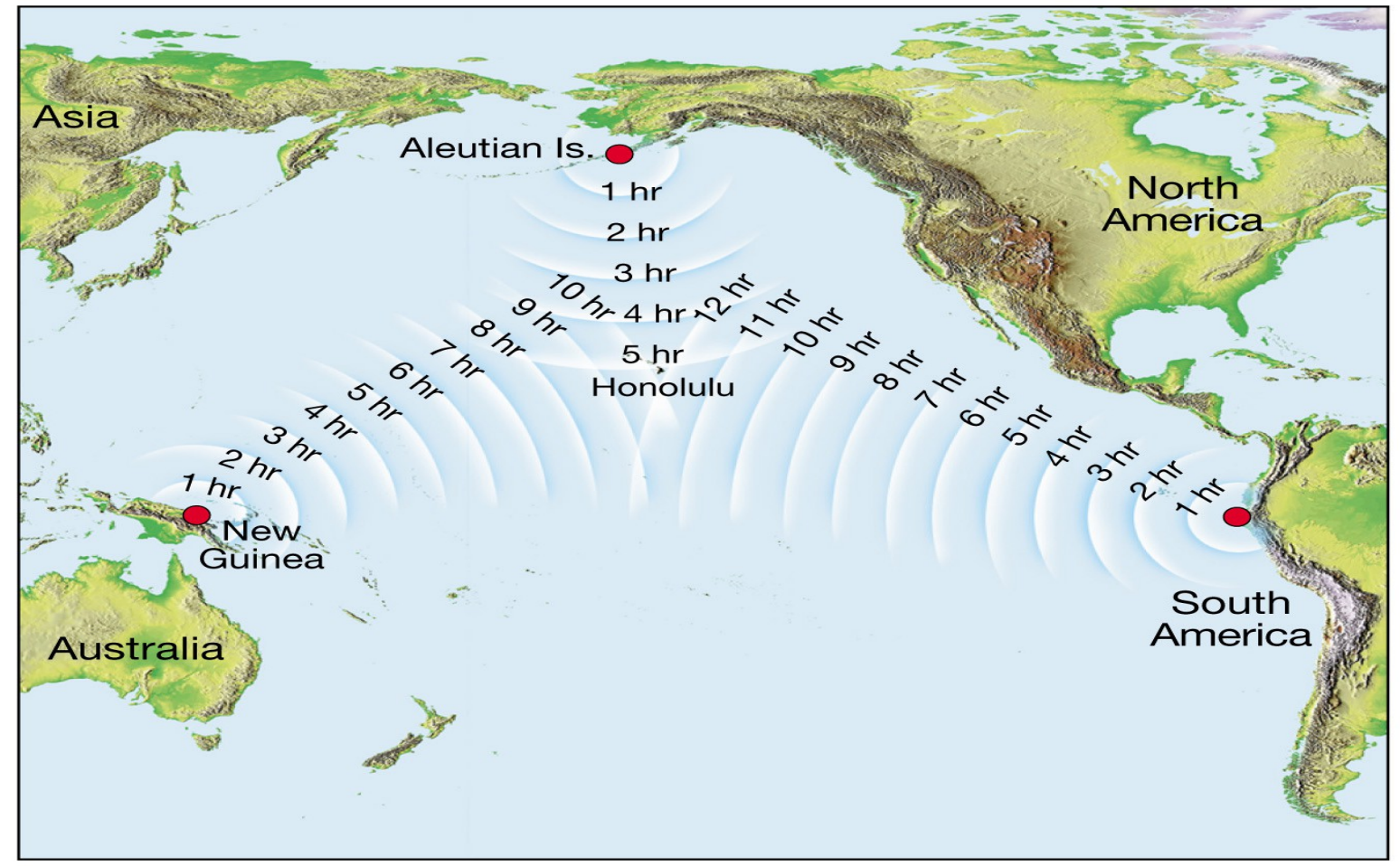
# Formation of a tsunami



# Tsunami Continued

- Characterized by:
  - Great speed of propagation (up to 950 km/hr)
  - Long wavelength (up to 200 km),
  - Low observable amplitude on the open sea
- May pile up to heights of 30 m or more and cause much damage on entering shallow water along an exposed coast (often thousands of kilometers from the source)
- Etymology: Japanese, "harbor wave"

# Tsunami travel times to Honolulu



# Tsunami Damage

- Painting of a tsunami wave approaching the coast

# Tsunami Damage

- Seward, Alaska after Anchorage, Alaska earthquake, Mar. 27, 1964
- Photo: Kirkpatrick

Steinbrugge Collection, Earthquake Engineering Research Center, University of California, Berkeley

# Tsunami in Progress

- Magnitude 8.1 quake
- Steinbrugge Collection

- Village of Kiritoppu, near Kushiro Harbor, Hokkaido
- The Tokachi-oki, Japan earthquake, of March 4, 1952, generated the tsunami seen in progress here

# Tsunami Damage


Seward, Alaska

- Photo: Kirkpatrick on March 28, 1964
- Anchorage, Alaska earthquake, Mar. 27, 1964
- Steinbrugge Collection

# Tsunami Harbor Damage

- Niigata, Japan earthquake, June 16, 1964
- Magnitude 7.5
- Photo: Joseph Penzien, Steinbrugge Collection

# December 2004 Tsunami Damage

Before/After Photographs

Images by DigitalGlobe

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

# Kalutara Beach, Sri Lanka

QuickTime™ and a
TIFF (Uncompressed) decompressor
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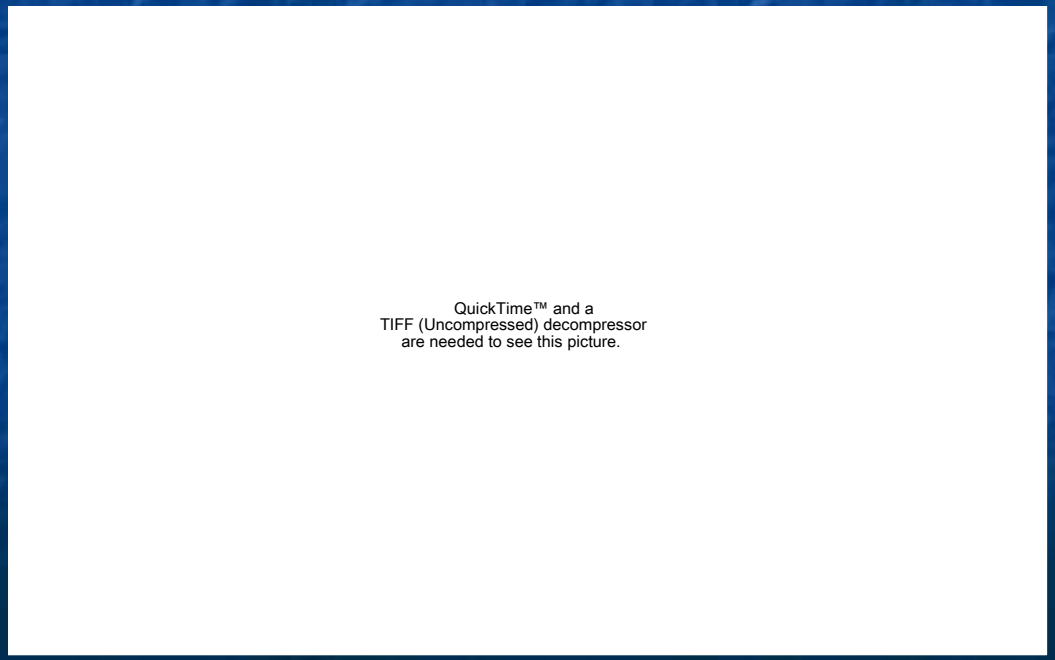
# Kalutara Beach, Sri Lanka


# Kalutara, Sri Lanka


# Kalutara Beach, Sri Lanka



# Banda Aceh Shore, Indonesia

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are needed to see this picture.

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# Banda Aceh Northern Shore, Indonesia

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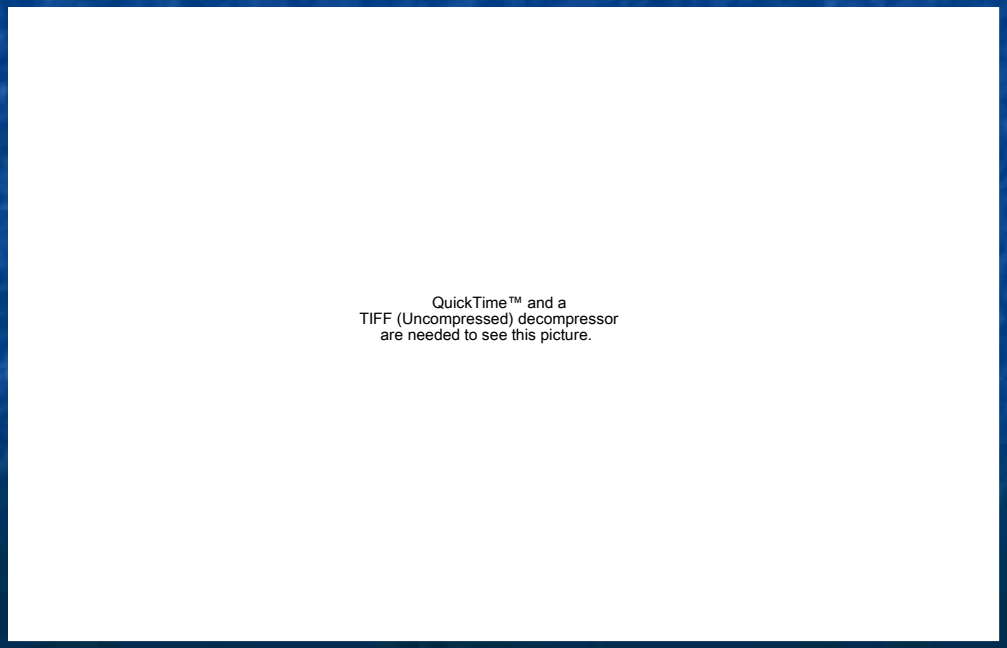
# Banda Aceh, Indonesia

# Banda Aceh, Indonesia

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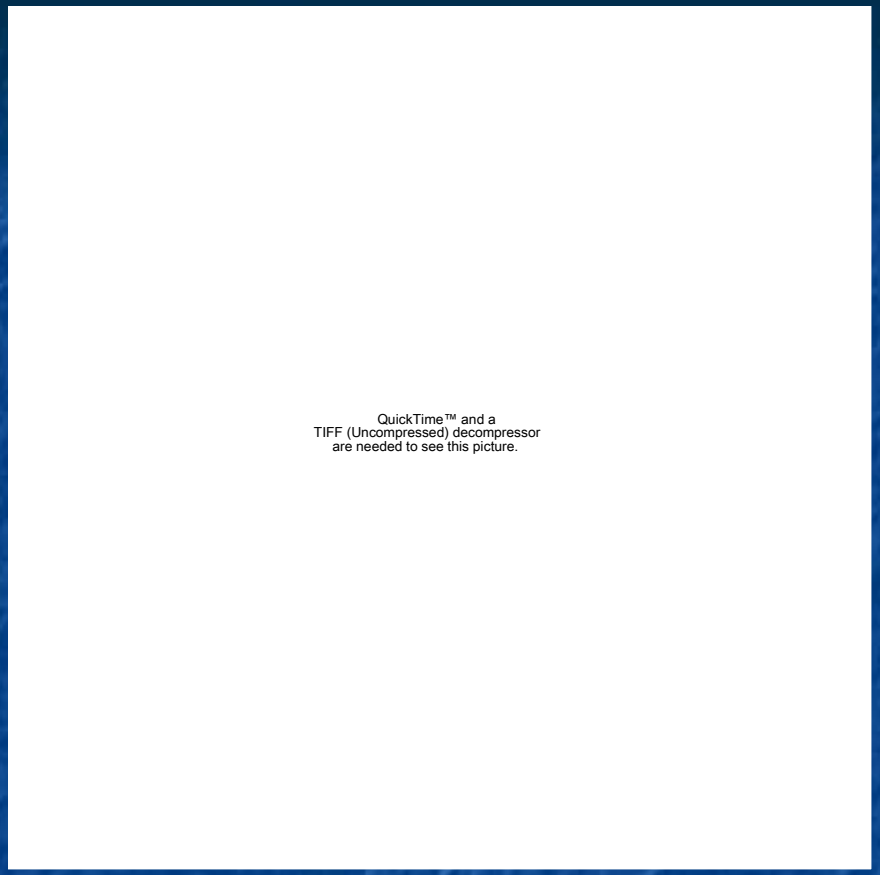
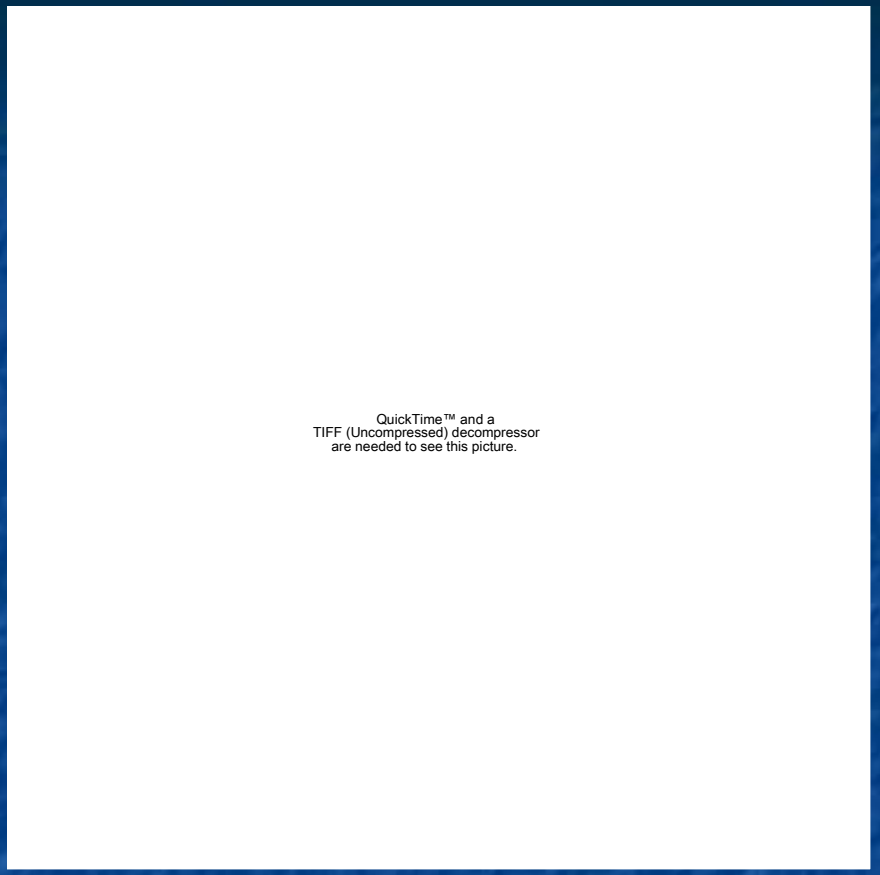
# Banda Aceh, Indonesia


# Banda Aceh Grand Mosque, Indonesia


# Banda Aceh, Indonesia


# Gleebruk Village

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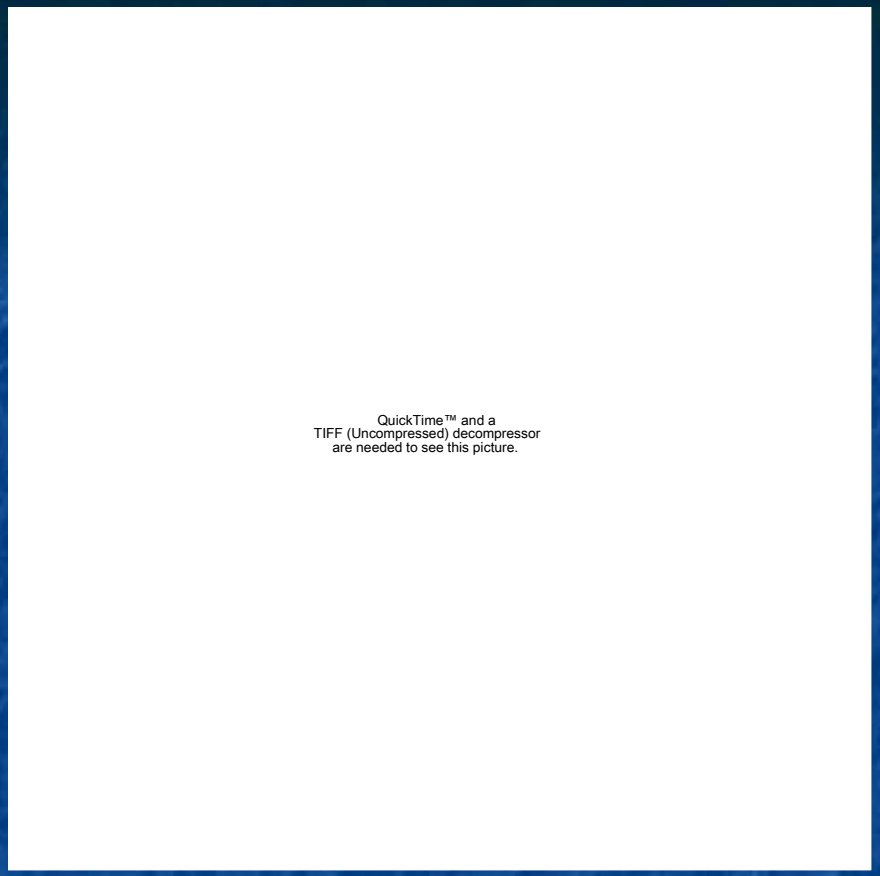
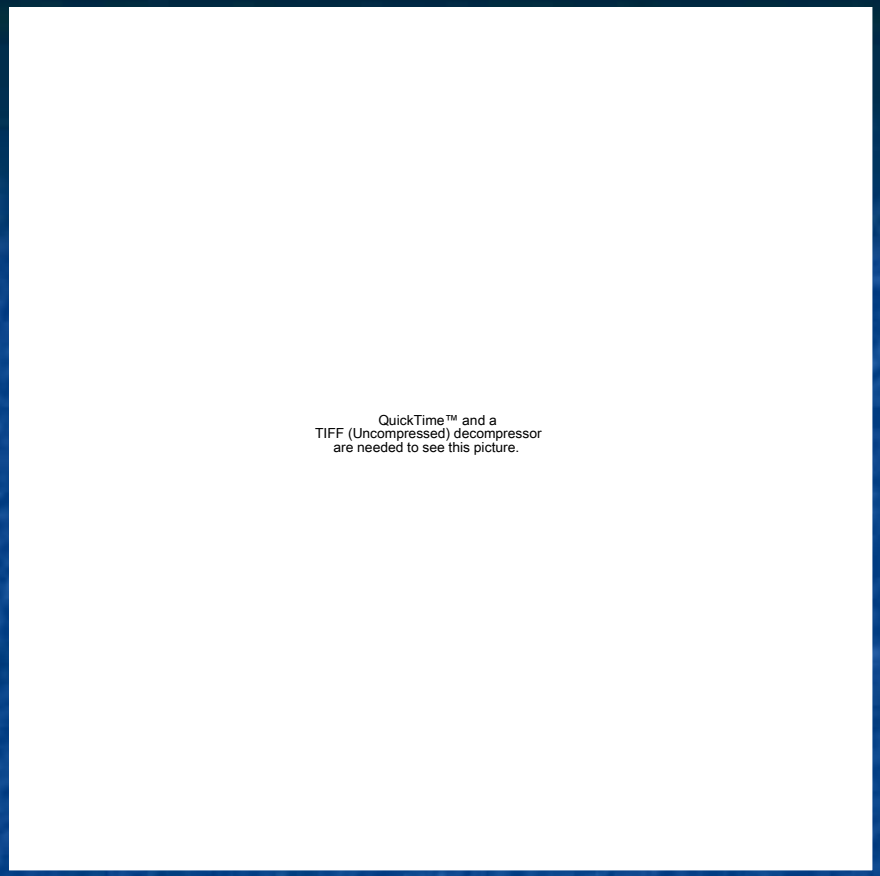
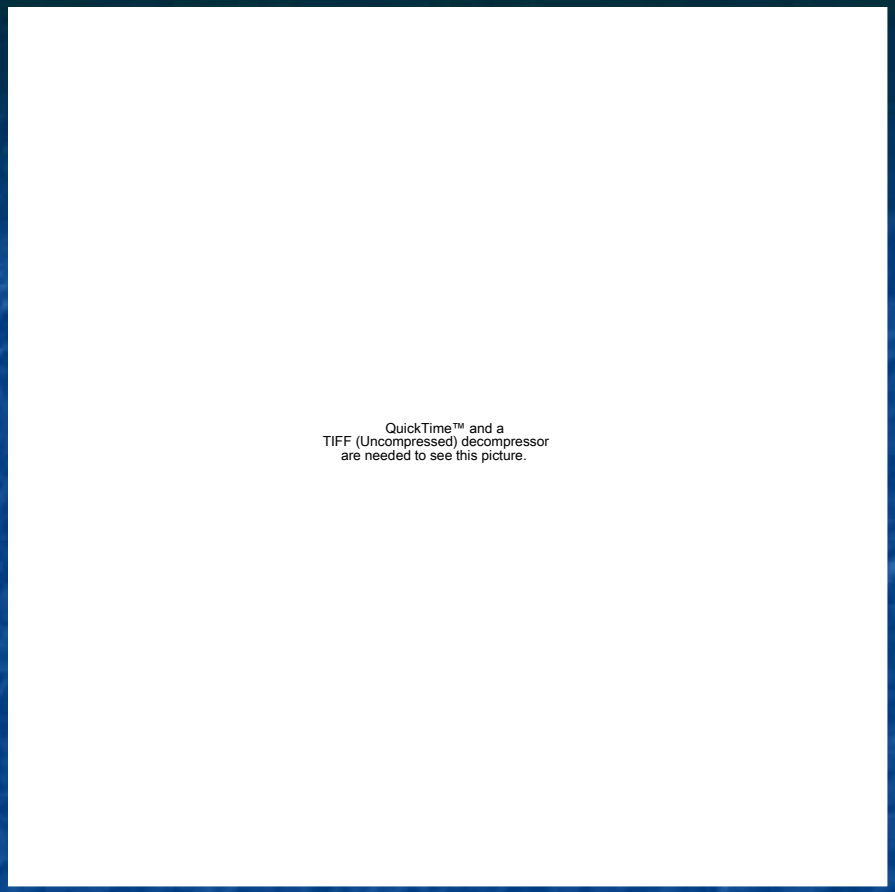
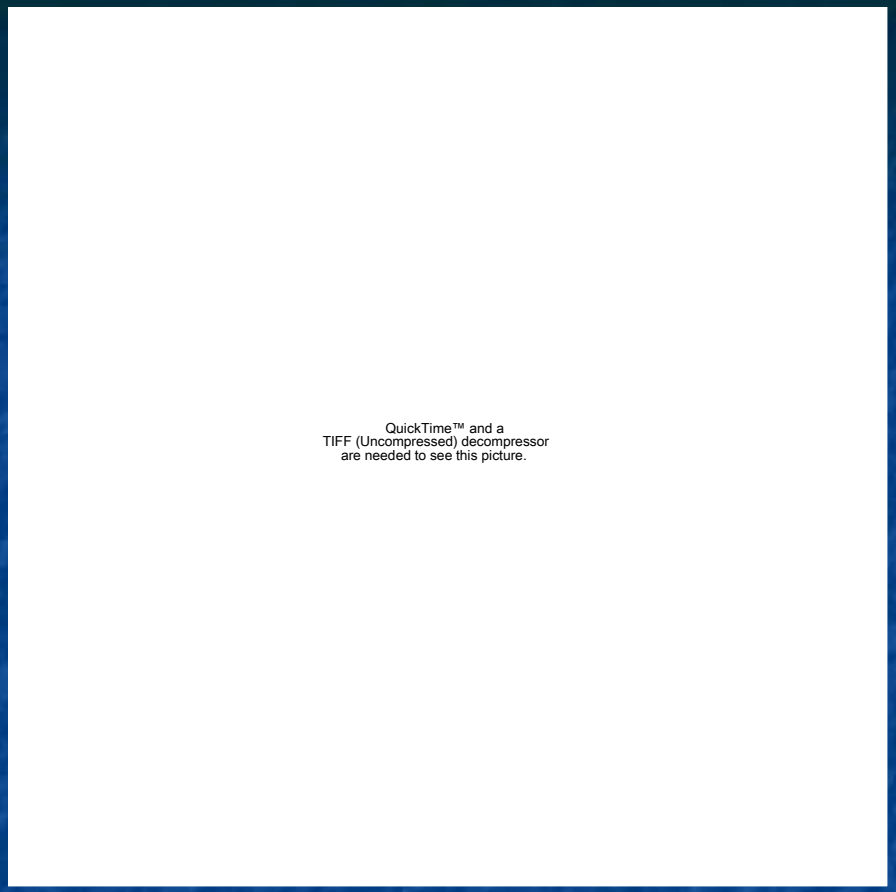



# Gleebruk Village




# Meulaboh, Indonesia

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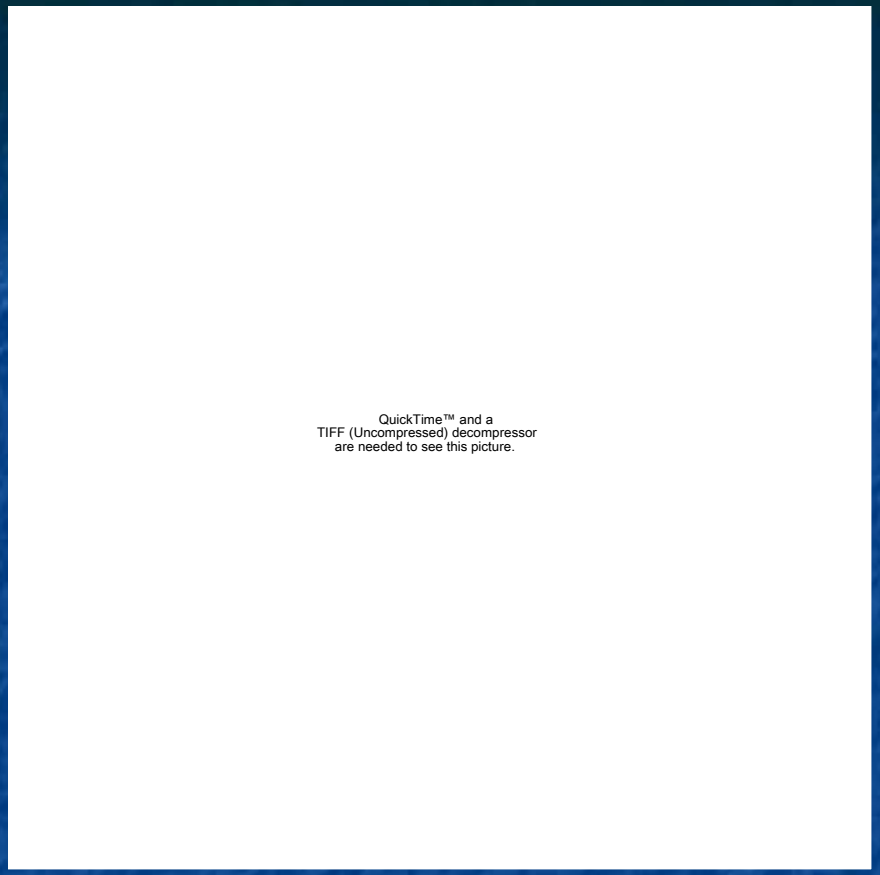


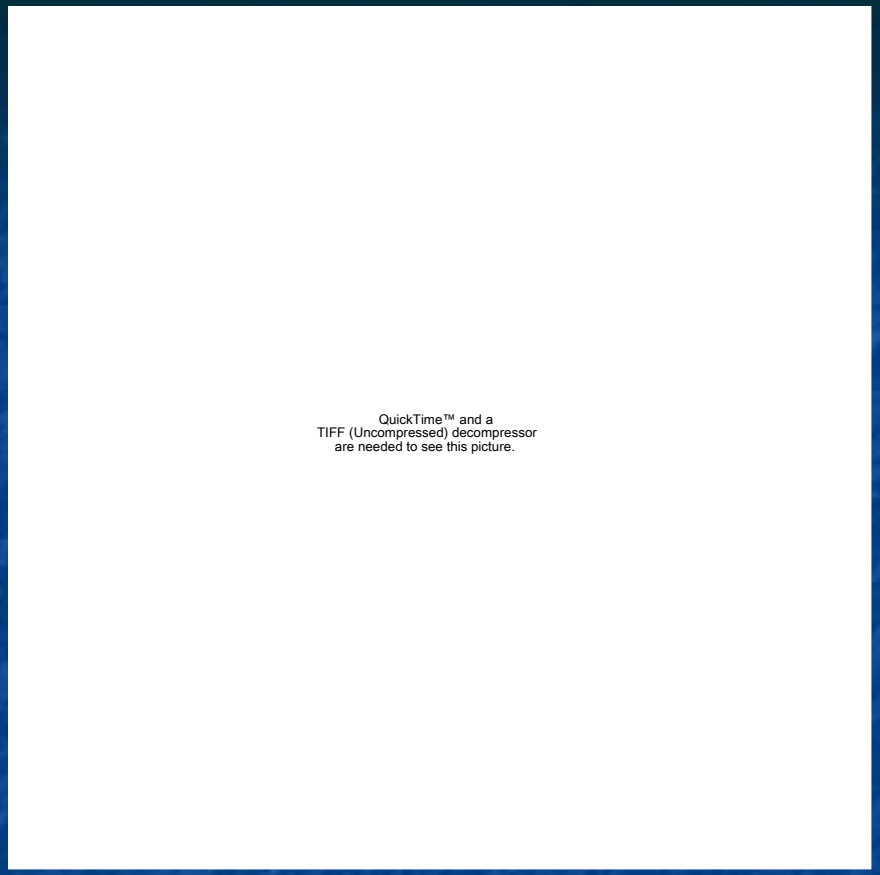


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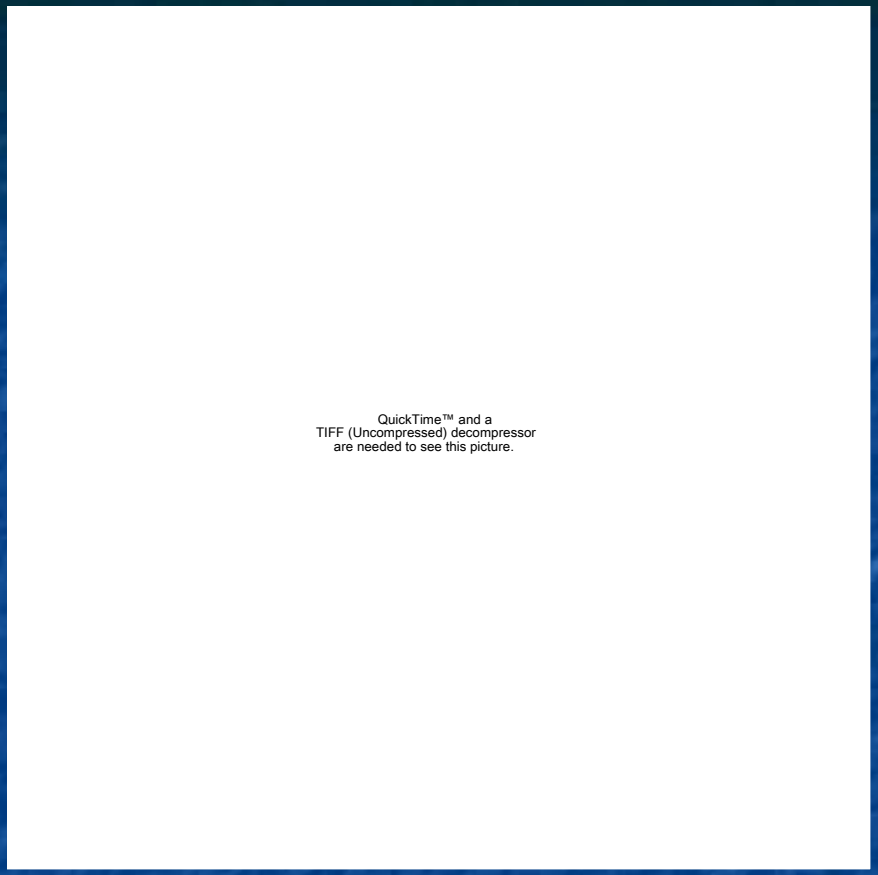


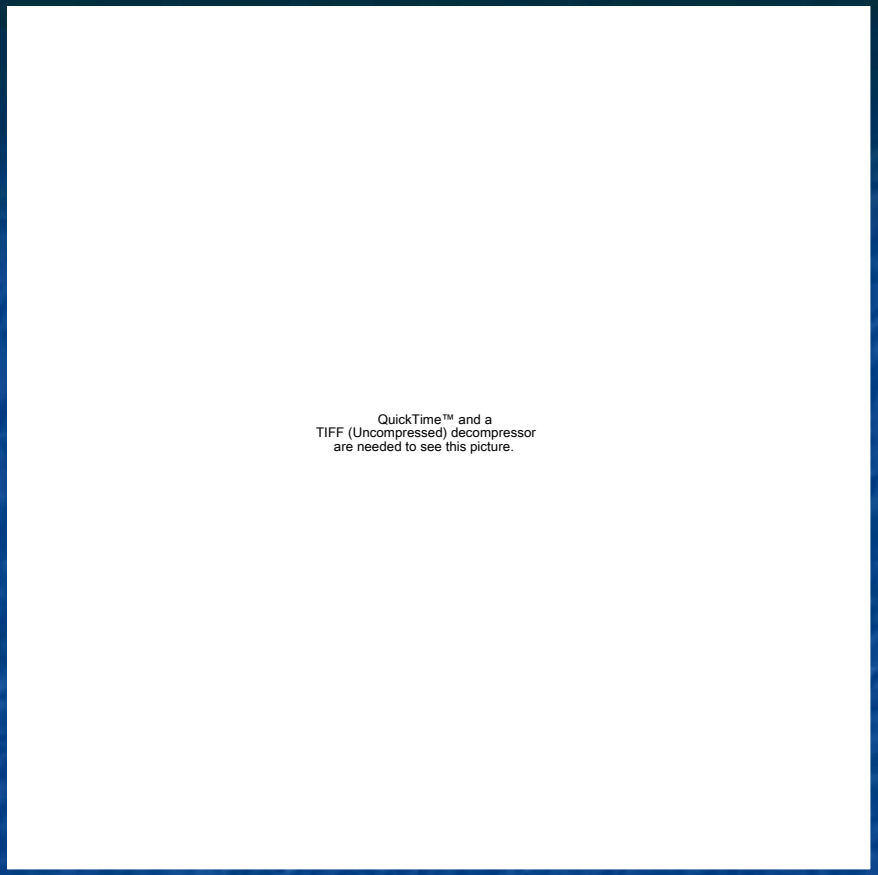


# Meulaboh, Indonesia

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# Meulaboh, Indonesia


# Seiche

- Free or standing-wave oscillation of the surface of water in an enclosed or semi-enclosed basin (as a lake, bay, or harbor)
- Varies in height from several centimeters to a few meters
- Initiated chiefly by local changes in atmospheric pressure, aided by winds, tidal currents, and small earthquakes

# Seiche Continued

- Continues, pendulum fashion, for a time after cessation of the originating force
- Usually occurs in the direction of longest diameter of the basin, but occasionally it is transverse

# Landslides

- Earthquakes may trigger mass movement of rock and sediment on unstable slopes
- Damage is most likely to occur after fire removes vegetation, or clear-cutting of forests

# Quake Triggered Landslide Damage

- Loma Prieta, California earthquake, 1989
- Magnitude 7.1
- Photo: Jeff Marshall

# Landslide Damage, Continued

- Loma Prieta, California earthquake, 1989
- Magnitude 7.1
- Photo by Jeff Marshall

# House Destroyed by Landslide

- Loma Prieta, California earthquake, 1989
- Magnitude 7.1
- Photo by Jeff Marshall

# Liquefaction

- Liquefaction is a physical process that takes place during some earthquakes that may lead to ground failure
- As a consequence of liquefaction, soft, young, water-saturated, well sorted, fine grain sands and silts behave as viscous fluids rather than solids

# Liquefaction Continued

- Liquefaction takes place when seismic shear waves pass through a saturated granular soil layer, distort its granular structure, and cause some of its pore spaces to collapse
- The collapse of the granular structure increases pore space water pressure, and decreases the soil's shear strength

# Liquefaction Continued

- Pore space water pressure increases to the point where the soil's shear strength can no longer support the weight of the overlying soil, buildings, roads, houses, etc.
- Soil will flow like a liquid and cause extensive surface damage

# Liquefaction Failure

- Niigata, Japan earthquake, June 16, 1964, magnitude 7.5
- Overturned building due to foundation failure
- No damage to interior (doors and windows still function)
- Failure reportedly took a considerable period of time
- Steinbrugge Collection

# Liquefaction Failure

- Photo: Joseph Penzien
- Overturned building due to foundation failure
- Niigata, Japan earthquake, June 16, 1964, magnitude 7.5

# Fire

- Fire often does more damage than the earthquake itself
- Underground pipelines and tanks, as well as above ground tanks, containing fuel may rupture and spill
- Water lines are cut, and streets are blocked
- Downed electrical lines may spark, setting off a fire which is very difficult to fight

# Fire

- San Francisco earthquake of 1906 caused destruction, including cutting of water supply, and blocking of streets
- Fire started and destroyed much of the city
- Photograph by Arnold Genthe, Steinbrugge Collection

# Managua, Nicaragua

- Managua, Nicaragua earthquake, Dec. 23, 1972, magnitude 6.2
- Photo: Karl V. Steinbrugge, Dec 29 1972 - the fires were still burning six days later

# Tilted Gasoline Tank

- Tilted tank at the Karumojima tank farm
- Note the ground cracking
- Kobe, Japan earthquake, Jan. 17, 1995, mag. 6.7

# Disease

- Earthquakes can cut underground sewer and water lines
- No drinking water
- Only available water is contaminated
- Populations in less-developed countries may fare better than those in developed countries, because they may be routinely exposed to water-borne disease organisms from infancy on

# Broken Sewer Pipe, Chile

- Photo: Karl V. Steinbrugge
- Chile earthquake, May 1960, magnitude 8.5
- Two sewer pipe breaks occurred within 5 meters