

Liquefaction

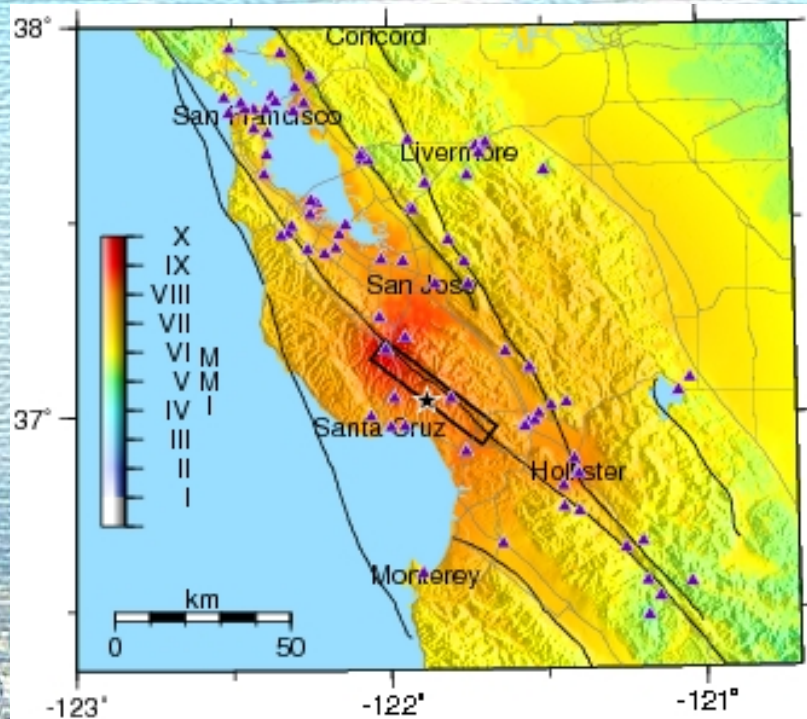
- shaken ground temporarily behaves like liquid
- enhances effects of rel. small EQs

- 16 Jun 1964, Niigata, Japan
- Magnitude 7.6
- houses built to code



Image: Earthquake Engineering Research Center Library, UC Berkeley

17 Oct 1989 Loma Prieta Earthquake



images: Wikipedia

5:04 pm local time

- $M_w=6.9$
- 63 fatalities/\$6 Billion damage
- televised (World series game)
- oblique slip; small tsunami in Monterey Bay

17 Oct 1989 Loma Prieta Earthquake

➤ liquefaction in Marina District



Marina District
developed for 1915 Panama-Pacific
International Exposition

- landfill of sand, dirt, rubble, waste
- high groundwater table

17 Oct 1989 Loma Prieta Earthquake



images: Wikipedia



➤ liquefaction in Marina District

- ground liquefied
- lower/garage floors lost strength
- collapsed



17 Jan 1995 Kobe/Hanshin, Japan Earthquake



(e)

Image: S. Marshak "Earth, Portrait of a Planet"

Earth, Portrait of a Planet, 2nd Edition
W. H. Freeman & Company

5:46 am local time

- $M_w=6.9$
- lasted 20s
- strike-slip
- 6000 fatalities
- \$200 Billion damage
- damage to 70% of railway

liquefaction of
artificial islands such as
Rokko Island, Port Island

Liquefaction Risk in San Diego

- shaken ground temporarily behaves like liquid
- effect worse when sediments water-saturated

magnitude 6.5 possible
in San Diego!!

- Mission Bay
- Lindbergh Field
- North Island

Liquefaction – SIO 15 Beachwalk



Liquefaction

sometimes even on
“solid” ground



(c)

FIGURE 10.31

Earth: Portrait of a Planet, 2nd Edition
Copyright (c) W.W. Norton & Company

Alaska Good Friday Earthquake, 1964
• liquefaction in Turnagain Heights

Image: S. Marshak “Earth, Portrait of a Planet”, Fig. 10.30b

Liquefaction

can also happen on seemingly solid ground:

- weak layer (e.g. sand) near top
- weak layer below hard layer (clay)

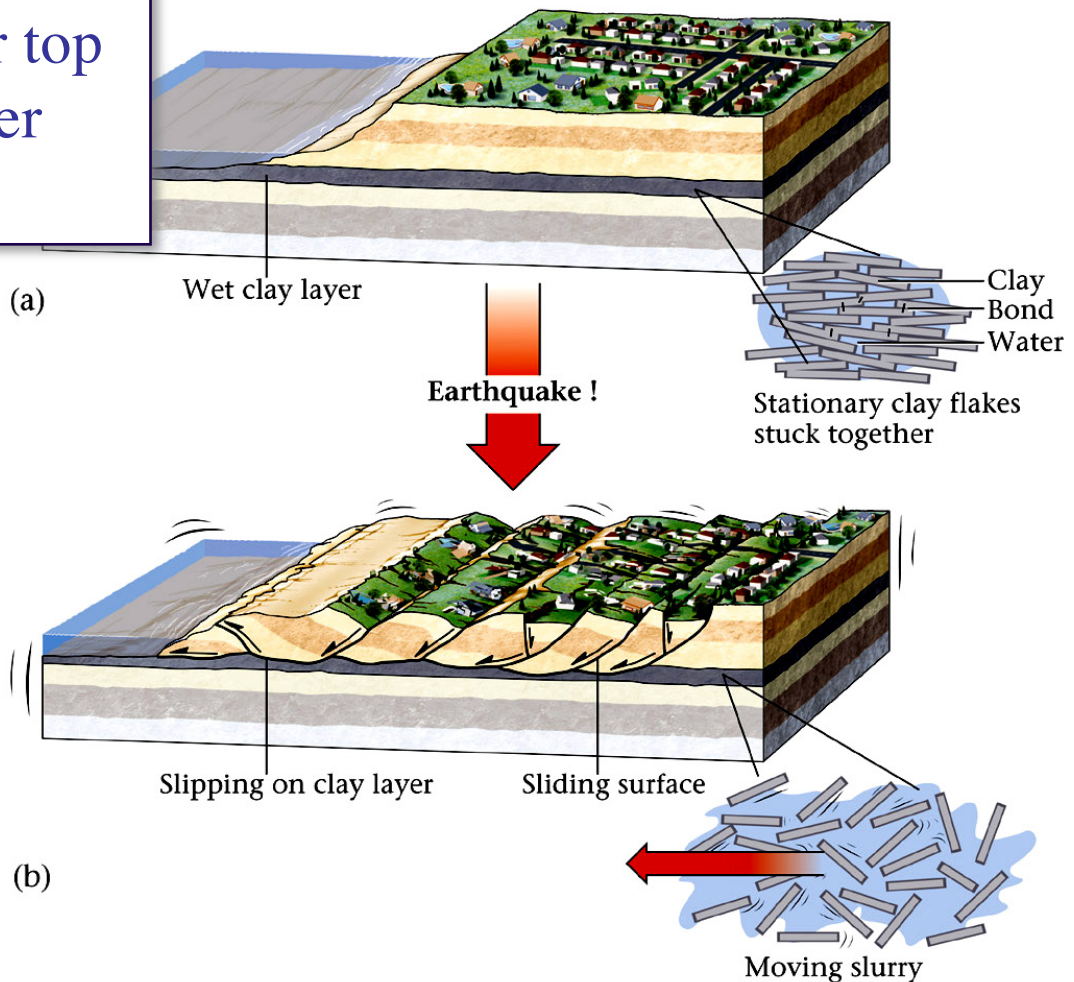


FIGURE 10.31

Earth: Portrait of a Planet, 2nd Edition
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Image: S. Marshak "Earth, Portrait of a Planet"

Liquefaction

- liquefaction of lower layer
- upper layer cracks
- lower layer “erupts” through cracks

- sand or mud volcanoes

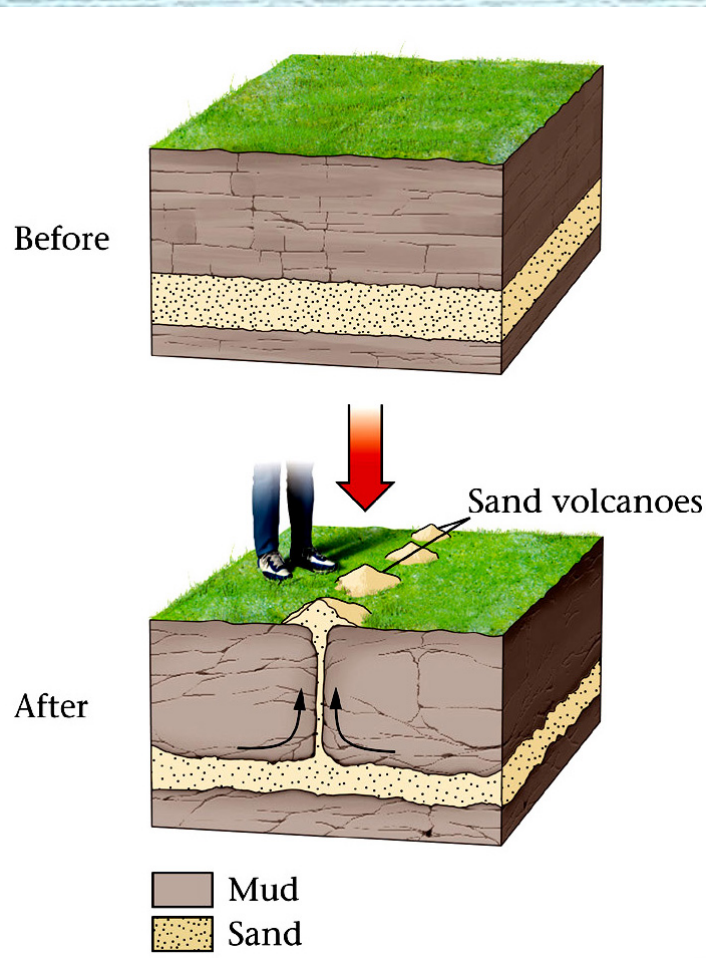


Image: S. Marshak
“Earth, Portrait of a Planet”

Liquefaction - 24 Sep 2013 Pakistan Earthquake



SIO15-Natural Disasters Course shared a link.

2 seconds ago

found by my colleague and friend Debi Kilb. A new island popped up from the ocean during a large earthquake in Pakistan. Most likely, this is a mud volcano as a result of liquefaction.



Pakistan earthquake creates new island, 'mud volcano' to blame - NBC News.com

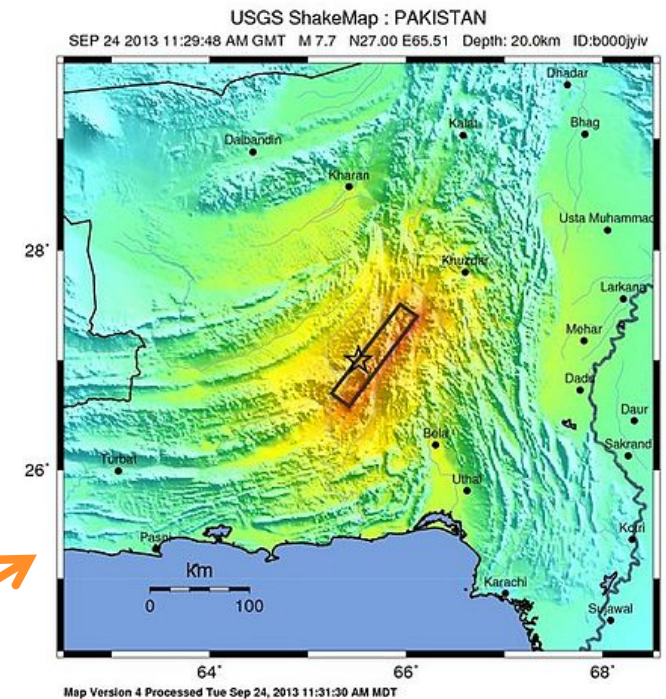
www.nbcnews.com

Mud houses in the mountains crumbled as a 7.7-magnitude

Like · Comment · Share

Mw=7.7
strike-slip earthquake
mountain belt

remote area
➤ 350 fatalities
➤ Gwadar mud volcano through liquefaction



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

Liquefaction - 24 Sep 2013 Pakistan Earthquake

before-after Landsat-8 images



image: NASA Earth Observatory



image: YAHOO

Liquefaction – Lusi Mudvolcano



- 28 May 2006 Lusi, Indonesia mud volcano
- displaced 30,000 people
- will go on for decades
- trigger: EQ or gas drilling?