Seismic Risk: Pre-Work

Early on the morning of April 16, 1906, a magnitude 7.8 earthquake struck on the San Andreas Fault. The 1906 San Francisco earthquake revolutionized our understanding of the damage an earthquake could do, as well as the possible measures that communities could take to avoid earthquake damage.

The *magnitude* of the San Francisco earthquake only tells part of the story about the earthquake's damage. One way to examine the effects of an earthquake is to assess how strong the ground shook during the tremor. This can be done quantitatively using instruments that record ground shaking (like the accelerometer in your smartphone or computer!), or qualitatively using people's reports of strong shaking.

Before exploring the effects of the 1906 earthquake, watch the video on ground shaking and liquefaction at:

https://www.youtube.com/watch?v=536xSZ_XkSs

The following questions will guide you through your exploration.
1. Based on the video, predict the types of locations that might experience the most earthquake damage due to strong ground shaking and/or liquefaction.

The 1906_san_francisco_earthquake.kmz file contains information about the 1906 earthquake's effects in and around San Francisco. Download the file from the URL below, and examine it in Google Earth.

https://serc.carleton.edu/details/files/42038.html

2. When you open the file in Google Earth, the "1906 Shake Map" layer will appear. This map illustrates the intensity of shaking, based on reports, from the 1906 earthquake. The color scale corresponds to the severity of shaking, with red the strongest shaking. As you might expect, the shaking was very intense near the San Andreas Fault, where the earthquake motion occurred. But there are several pockets of intense shaking far from the fault. Four of these areas – two in the north part of San Francisco Bay, and two in the east – are identified in the Google Earth file. *Note that if you zoom too far in, the geological map will appear (step d).*
    a. Find the four case study areas labeled "North Bay 1", "North Bay 2", "East Bay 1", and "East Bay 2."[1]
    b. Zoom out to see all four case study areas at once. You can do this by double-clicking on the folder icon labeled "Strong Shaking Case Studies" in the Places panel of your Google Earth window. Use the color on the map and the legend to estimate the average shaking intensity in each case study area. Write this in the table below (North Bay 1 is done for you).
    c. Turn off the "1906 Shake Map" layer in the Places panel.
    d. Zoom in fairly close (to an eye altitude of 30000 ft or so) to each case study area for the geology layer to show up. On the geological map, each colored region represents a different rock type and age. Click on the colored regions to see what rock type each one

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[1] Unfamiliar with Google Earth? Navigating in Google Earth, including zooming, is covered in this video from Google: https://www.youtube.com/watch?v=R0_K0Wp1rSU#t=44

represents[2]. Note that the ages are in parentheses. Estimate what rock type or types cover the majority of each case study area.

	North Bay 1	North Bay 2	East Bay 1	East Bay 2
Rock Type	Alluvium (loose river sediments)			
Shaking Intensity	Violent			

In summary, what *groups or types of rocks* might make a region more or less susceptible to shaking in an earthquake? How does this match your predictions from question 1?

The Google Earth 1906 earthquake file has firsthand accounts and photographs of earthquake effects. Explore the information about the 1906 earthquake by turning the "Fault and Shaking Photos" and "1906 Shaking Reports" layers on and off, and by clicking on some of the placemarks. Note that the icons do not match the legend particularly well.

3. Besides the intensity of shaking, damage to structures in earthquakes is due to four main factors: strong shaking, liquefaction, ground deformation, and landslides. In many cases these effects are compounded by construction as well as by fires and other types of post-earthquake damage. Look through the examples of building damage in the photos and damage reports. For each of the earthquake hazard factors listed below, are there particular types of structures that appear to be more affected? Pay attention to the construction material (e.g. brick, wood, etc.) as well as the kind of damage (e.g. collapse, building moves off its foundation, etc.). Make notes here about your observations.

Strong shaking (red icons):
Liquefaction and ground deformation (white and blue square icons):
Landslides (light orange icons; look in far north):

The "Historic Urban Areas" layer illustrates the Bay Area population centers around the time of the 1906 San Francisco Earthquake. Turn the layer on and compare it to Google Earth's imagery, which gives you an idea of the populated areas of present-day San Francisco.

4. Suppose that modern fire and rescue crews, responding to an earthquake similar to the 1906 quake, had to prioritize which of the case study areas (North Bay 1/2, East Bay 1/2), to search first for earthquake survivors and casualties. Which area should get priority? Why?

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[2] Two bodies of rock specific to the region are listed on the geologic map: the Great Valley Complex is composed mainly of marine sedimentary and volcanic rocks that fill the Central Valley of California. The Franciscan Formation comprises mainly marine sedimentary and metamorphic rocks.