Big History at Lands End

Prepared by Chris Lewis for the International Big History Conference, Dominican University of California, August 6th, 2014.

Introduction:

Geologists apply the scientific method and scientific principles to understanding the history of the Earth. In doing so, geologists must be able to see how specific observations fit into a bigger picture in both space and time and over a wide range of scales. Geologists use space-based remote sensing tools as well as electron microscopes to make observations over many orders of spatial magnitude. Similarly, geologists consider the impact of events happening over timescales ranging from a few seconds to billions of years. In many ways, geology embodies the spirit of "seeing the whole of the past."

Today we will observe and discuss the history of this part of San Francisco in exactly such a fashion, looking at how events and processes that took place over a broad range of spatial and temporal scales has shaped the dramatic landscape before us, and impacted the lives of people both locally as well as across the planet.

As we practice reading the history embedded in this landscape, think about how you could develop similar instructional frameworks in your own area. What outcomes do you want to achieve? What are the activities students will complete to reach those outcomes? What local resources support these activities?

What follows here is a brief synopsis of the major geologic and historic events evident here, as well as sample questions and outcomes we might want for students.

Today:

Water meets the land

Energy carried by the ocean interacts with the shore here.

a. What is the vehicle of this energy, how does it manifest?
b. What is the original source of this energy?
c. What evidence do we see that shows the effects of this interaction over longer periods of time?
d. What hazards/services does this interaction present to people today and in the future?

On the edge of the continent: The San Andres Fault Zone

Look at the satellite image of the San Francisco Bay. We are on the western edge of the North American Plate, at a tectonic boundary with the Pacific Plate to the west. Average motion across this boundary is a few centimeters per year, with the Pacific Plate moving northwest, relative to the North American Plate.

a. What evidence do you see in the image of fault activity?

b. Where is the San Andreas Fault relative to us right now?
c. What hazards/services might these features present to people today and in the future?

Paleozoic (545 Ma to 248 Ma) and Pre Cambrian (4.5 Ga to 545 Ma)

<u>A passive margin</u>

Little to no direct evidence from these time divisions can be found here. The coastline of North America was somewhere in eastern Nevada and Colorado. A broad, shallow continental shelf, much like that found on the East Coast today extended west from that shore. Remnants of the sediments deposited on that shelf remain in the high Sierra and the mountains to the east.

a. Though not directly evident here, did or do any of the major events during this time affect us here today?

Mesozoic (248 Ma to 65 Ma)

<u>Active tectonics</u>

During this time, most of the rocks we see here today were being formed, though none of them in this exact location. These rocks formed elsewhere and were later emplaced here through a tectonic process known as accretion. See the table below for descriptions of these rocks, their formation environments and emplacement histories. The shoreline during this era was somewhere along the foothills of the modern Sierra, about 100 miles east. A chain of volcanic mountains much like the Andes of today rose above that coast. Beneath these volcanoes, The Sierra Nevada Batholith (granites) and the Mother Lode gold veins were forming. By the end of the Mesozoic, the tectonics shifted, ending subduction and transitioning from convergent to transform motion.

a. As we look at the rocks themselves, what evidence do you see that indicates where they might have formed?
b. How can we determine when these rocks formed?
c. What do the physical properties of these rocks tell us about potential hazards?
d. How do these physical properties help us to explain the coastal features we see here today?

Cenozoic (65 Ma to present)

<u>Age of Mammals and the first wave of human migration</u>

This era begins with the mass extinction of as many as 70% of all plant and animal species, including the dinosaurs. The North American plate overrides the spreading center in the Pacific and subduction stops. By 24 Ma BP, the San Andreas Fault system, a transform plate boundary between the North American and Pacific plates, becomes active. Many of the rocks we see here today have been moved hundreds of miles from the south by this fault system, and it's activity clearly affects us today. A long global cooling period also takes place during the Cenozoic, and by the Pleistocene epoch (2.6 Ma to 11.7 Ka BP), Earth's climate begins to fluctuate between ice ages and interglacial periods.

a. Although this area was never glaciated, how would the physical geography of this area be affected by processes resulting from this climatic change?
b. Look at the sonar images provided, what evidence of these changes can be inferred?
c. Has the rise of sea level after the last ice age created hazards here? What evidence of these hazards do we observe?
d. What role have ice ages played in the migration of humans to this area?

Recent Past: 1966 to 1776 CE

Yerba Buena to San Francisco

Literature, film, music and visual and other art forms are rich with stories from this time period, though it represents perhaps the thinnest sliver of time relative to all the evidence before us. During this era, the Spanish missionaries established the first European settlements near here, sparking the abrupt replacement of the Ohlone culture that thrived here for millennia. In 1821, Spain's rule over Alta California ended and San Francisco became Mexican territory. Granted large parcels of land, the Californios, as they were called, began to develop the region as an agricultural center. Two dramatic events happened in 1848: Mexico lost the war with the United States, ceding both Texas and Alta California to the U.S., and gold was discovered in the foothills of the Sierra Nevada. San Francisco expanded rapidly, as people poured in from all over the world seeking fortune. As Mother Load gold production waned, the Comstock silver discoveries and building of the Transcontinental railroad infused the city with new wealth. By the end of the 19th century, San Francisco had become one of the largest cities on the west coast. Extravagant mansions, theaters and hotels appeared, Golden Gate Park was created and the Cliff House and Sutro Baths were built. On April 18th, 1906 the Great Earthquake and Fire reduced much of this to smoldering rubble. The city rebuilt, and continued to grow as one of the major commerce and culture centers of the world.

a. How are the events of this era linked to the geologic events and processes that occurred millions of years in the past?
b. What consequences, both creative and destructive, might have resulted from the diverse migrations that took place during this time?

References:

1. William P. Elder, *Geology of the Golden Gate Headlands*, National Park Service, viewed online 6/21/2013 at: http://pubs.usgs.gov/bul/b2188/b2188ch3.pdf
2. Doris Sloan, *Geology of the San Francisco Bay Region,* University of California Press, 2006, 360 pages.
3. Rand Richards, *Historic San Francisco: A Concise History and Guide*, Heritage House, 2011, 300 pages.
4. G. Brent Dalrymple, *Ancient Earth, Ancient Skies: The Age of the Earth and its Cosmic Surroundings*, Stanford University Press, 2004, 247 pages.
5. John Imbrie and Katherine Palmer Imbrie, *Ice Ages, Solving the Mystery*, Harvard University Press, 1986, 224 pages.

A. Abbreviations used in geologic time:

CE – Common Era

BP – Before present

Ga – Giga annum, or billion years

Ma – Mega annum, or million years

Ka – Kilo annum, or thousand years

B. Terranes and Lithologies of San Francisco (from oldest to youngest)

Name	Description	Formation Environment
San Bruno Mountain Terrane	Greywacke sandstone, siltstone and mudstone. Sometimes massive, sometimes well bedded and may show turbidite features such as graded bedding.	Sands, silts and muds eroded off the continent and dumped into submarine canyons off shore by streams and underwater landslides (turbidity currents)
City College Melange Zone	A sheared and broken mix of rocks from adjacent terranes, including sandstone, chert and serpentinite.	Represents the thrust fault zone between two successively accreted terranes.
Marin Headlands Terrane	Altered sea floor basalt (greenstone) with pillow structures and deep sea sediment (chert).	Volcanic rocks formed at a mid ocean ridge, later covered with biogenic sediment (microscopic shells of planktonic organisms).
Hunters Point Melange	A sheared and broken mix of rocks from adjacent terranes, dominantly serpentinite.	Represents the thrust fault zone between two successively accreted terranes.
Alcatraz Terrane	Greywacke sandtones, similar but younger than San Bruno Mountain.	Sands, silts and muds eroded off the continent and dumped into submarine canyons off shore by streams and underwater landslides (turbidity currents)

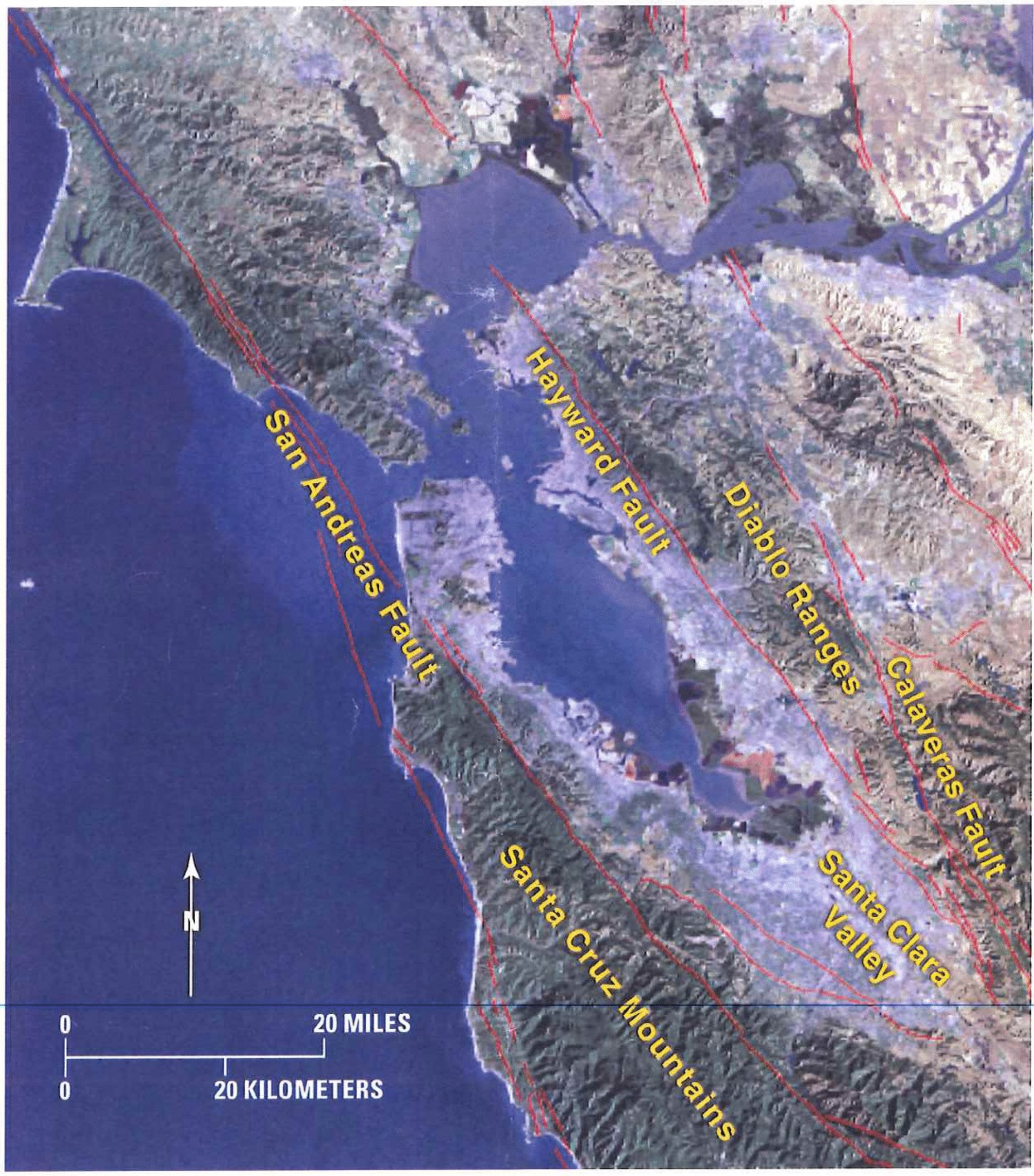

Figure 3.1. Satellite image of San Francisco Bay area showing major faults and geographic features discussed in text (modified from U.S. Geological Survey and Pacific Gas & Electric image).

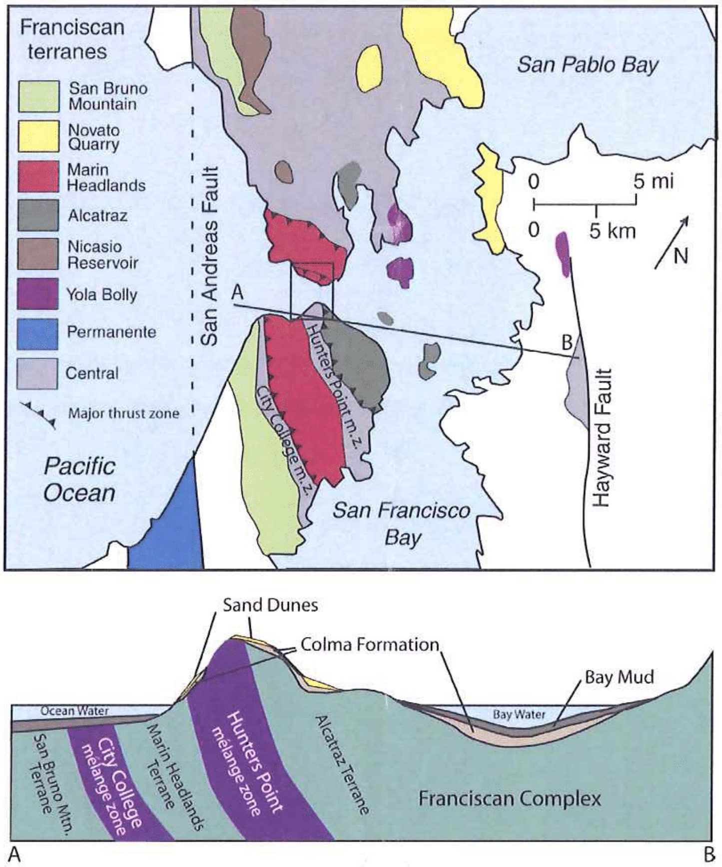

Figure 3.2. Top part of figure shows terranes of the Franciscan Complex in the San Francisco Bay area and dip direction of major thrust faults referred to in text. Cross section A-B for lower part of figure also is indicated (modified from Blake and others, 1984). Bottom part of figure is a schematic cross section through northern San Francisco Peninsula across bay to Oakland (not to scale).

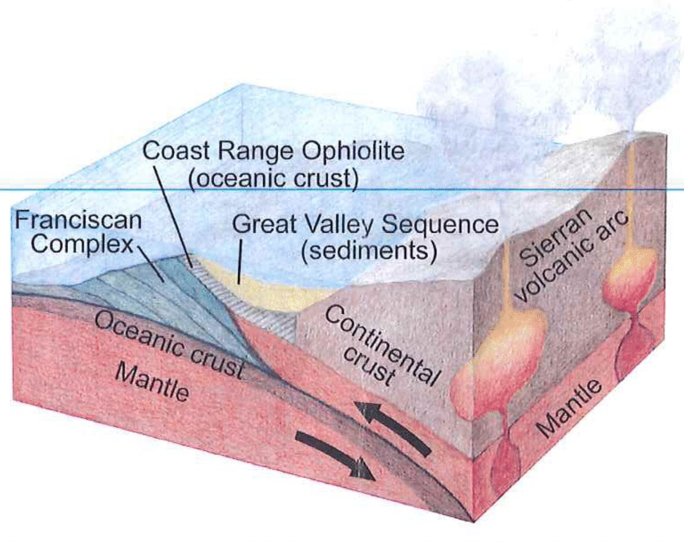

Figure 3.3. Cartoon of the subduction zone present on the West Coast 100 million years ago showing position of the accretionary wedge of the Franciscan Complex.