
Karin Rice
Page Museum

Where we're going:

- Tectonics
- Rocks
- Oil
- Water
- Fossils

First, a little exercise…

Don’t think of an elephant.

Not so easy, right? (It’s a mammoth but close enough.)

Okay, next…

Page Museum
La Brea Tar Pits

You're not alone if this is what you think of when you hear Tar Pits.

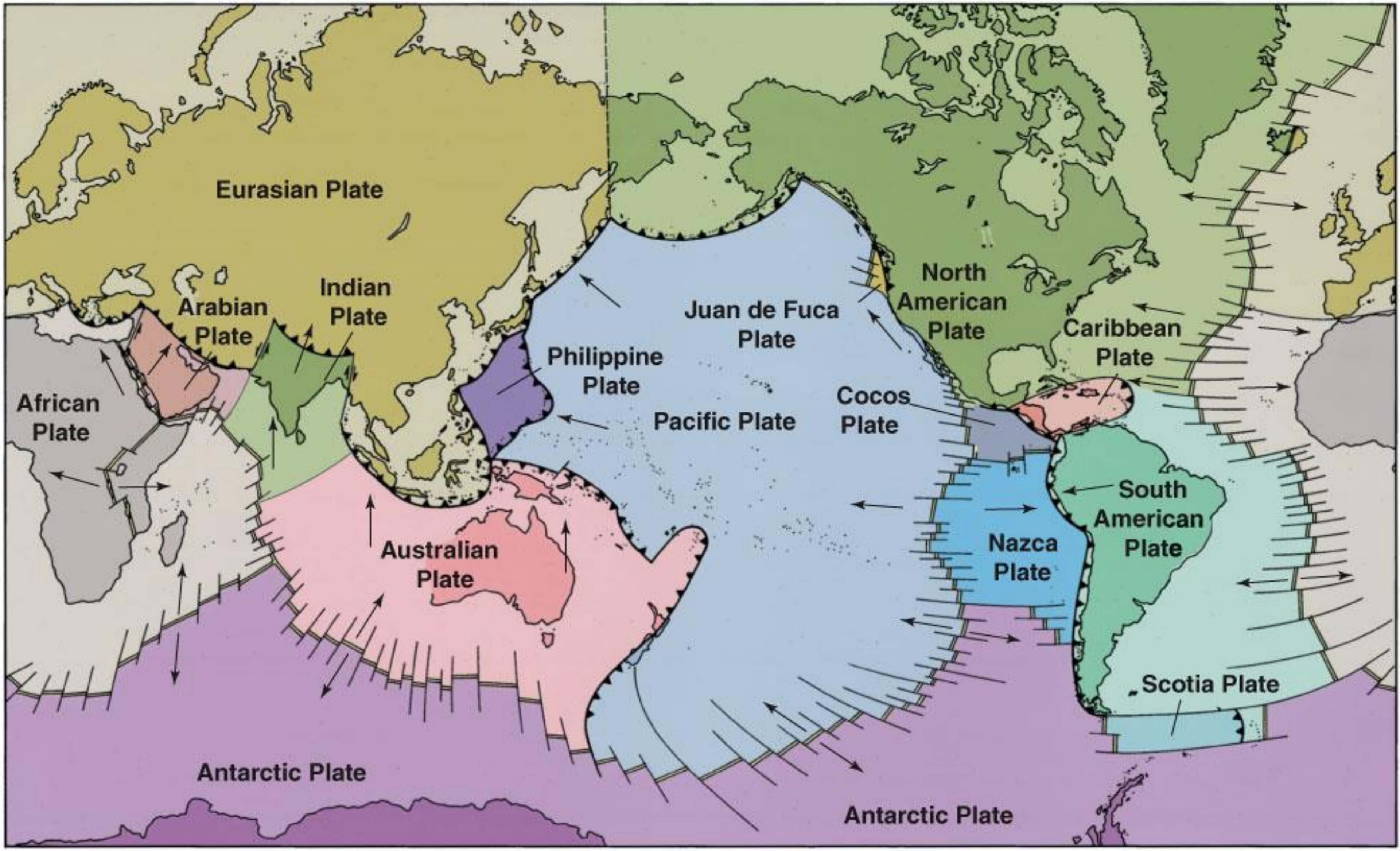
The name implies a certain scenario, right?

The reality may have been more seep than pit. McKittrick oil field seep.

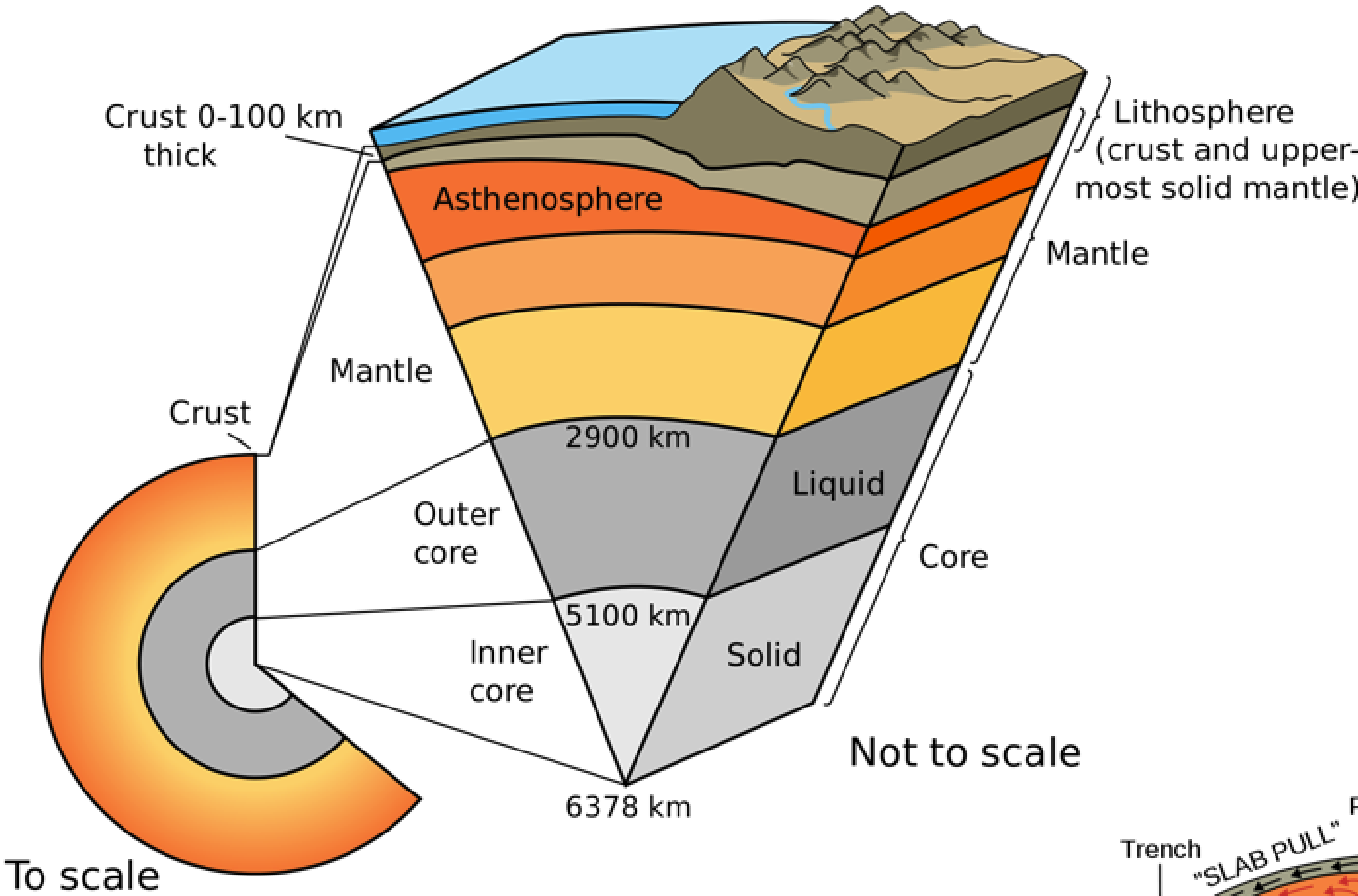
Simi Valley seep

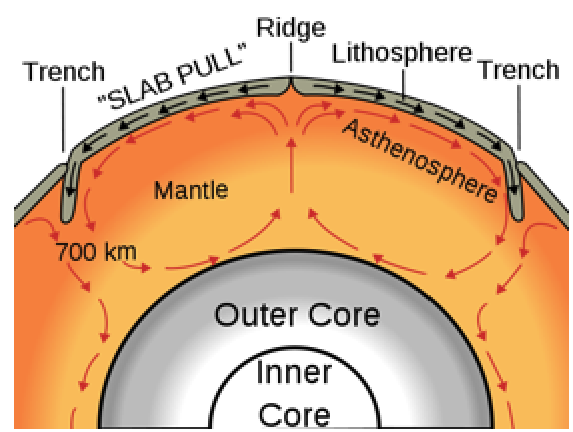
Seeps around Santa Paula and Sylmar

Tectonics makes it sticky.

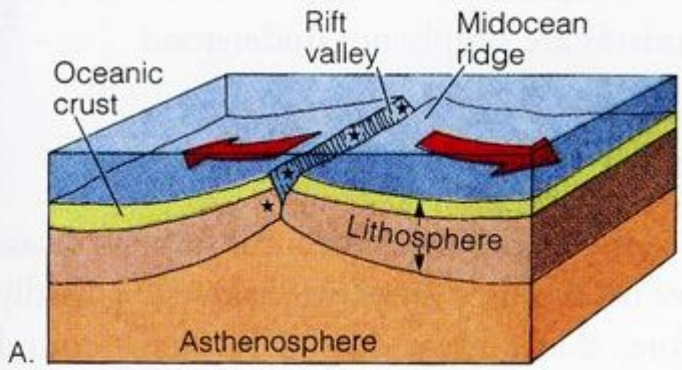


Earth’s tectonic plates

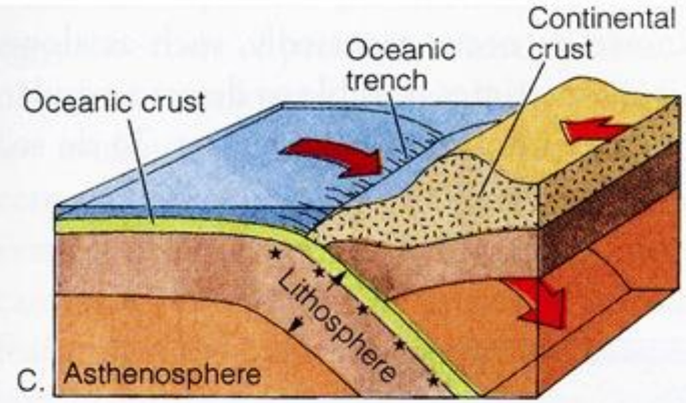




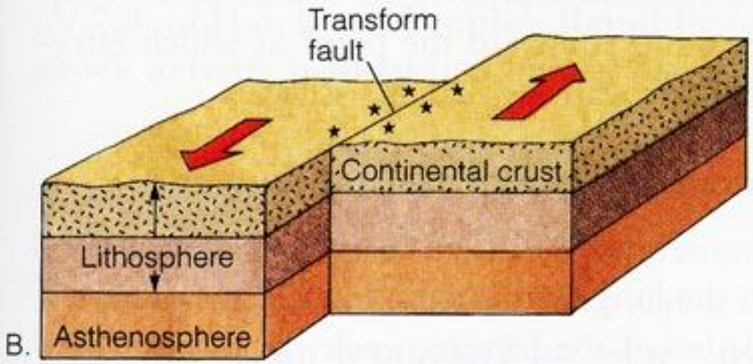
Structure of the Earth



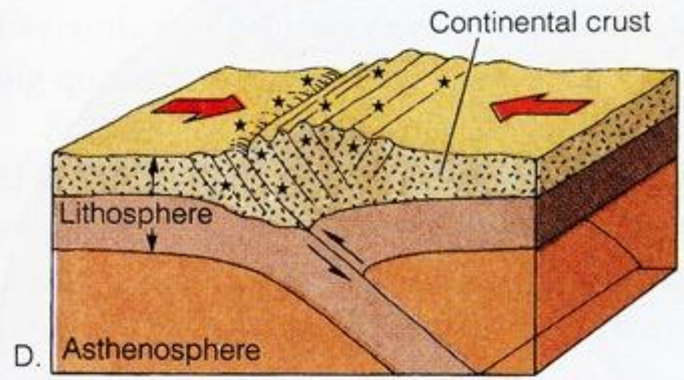
Divergent



Convergent (oceanic-continental)



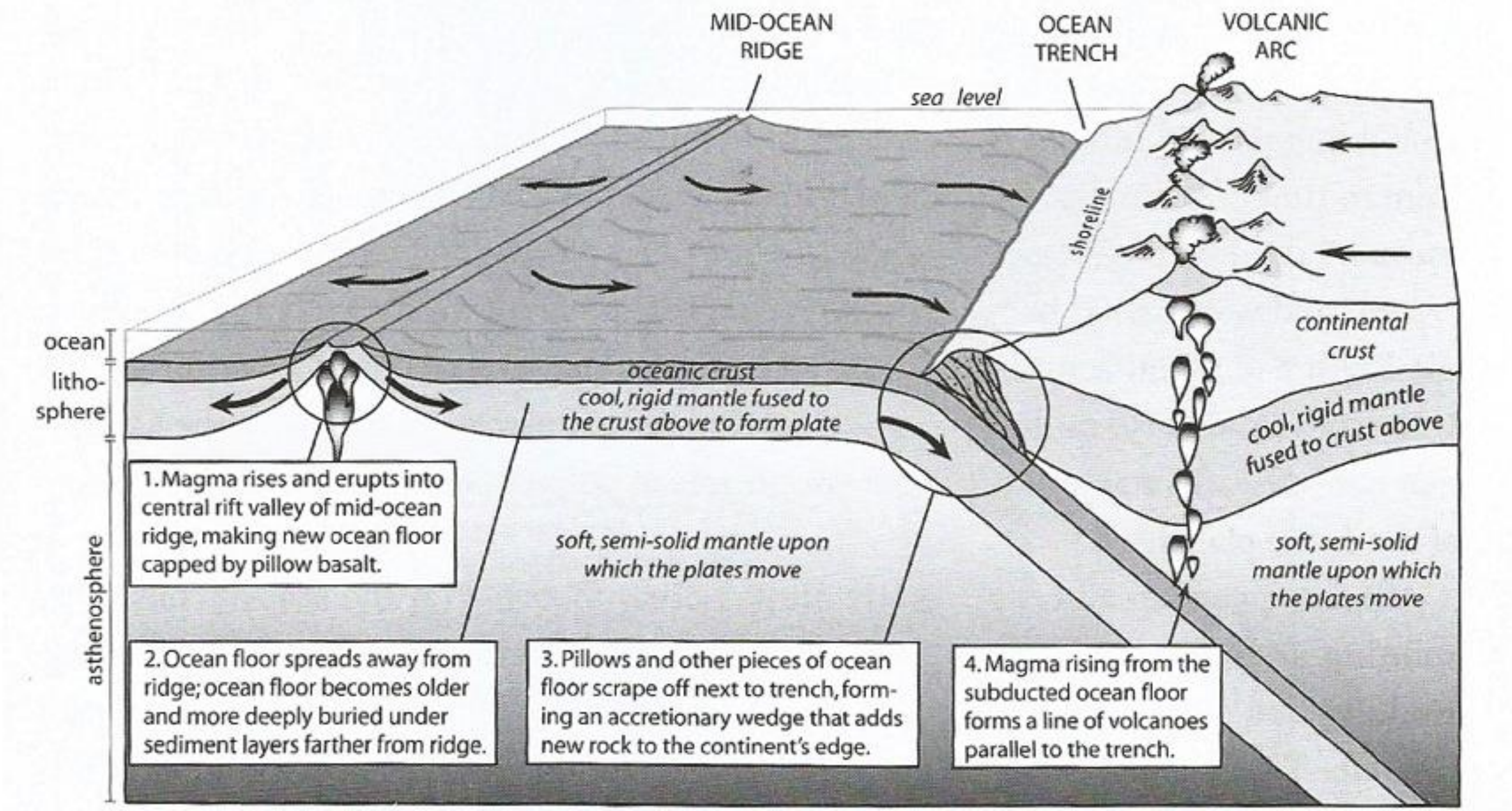
Transform



Convergent (continental-continental)

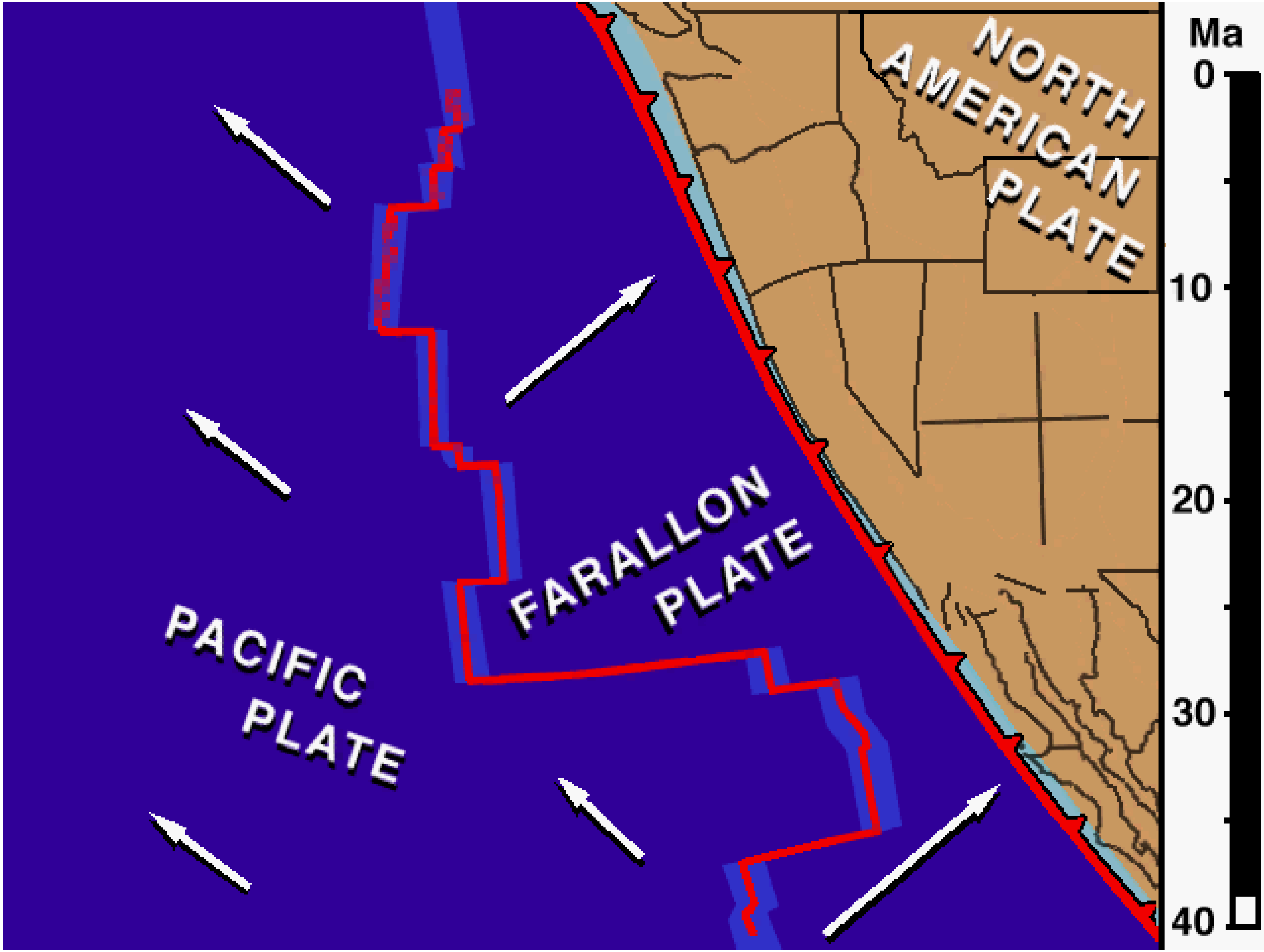
Three main types of plate boundaries/plate interactions

Tectonic plate interactions along west coast of N. America before San Andreas Fault



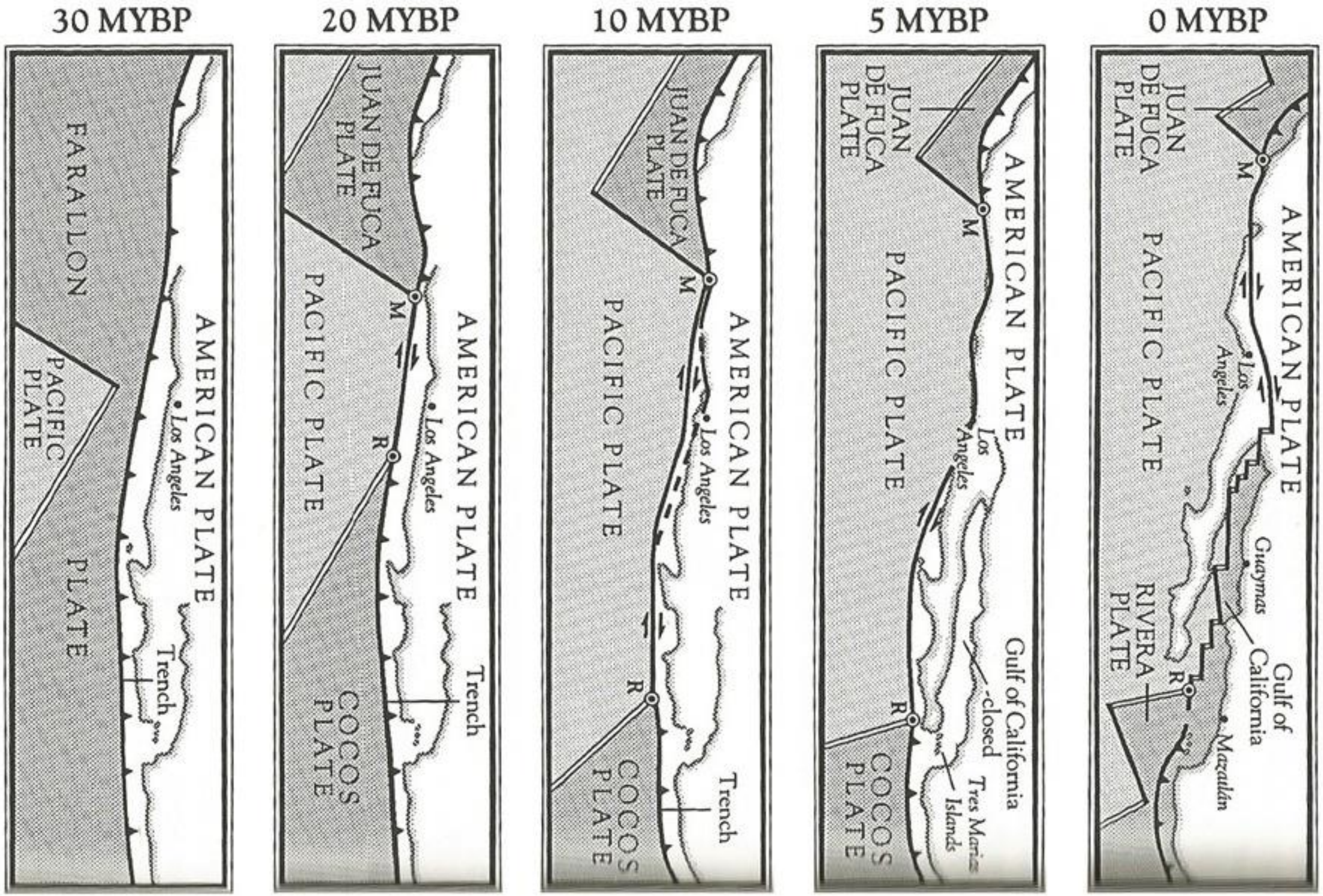
Spreading ridge creating new oceanic crust.

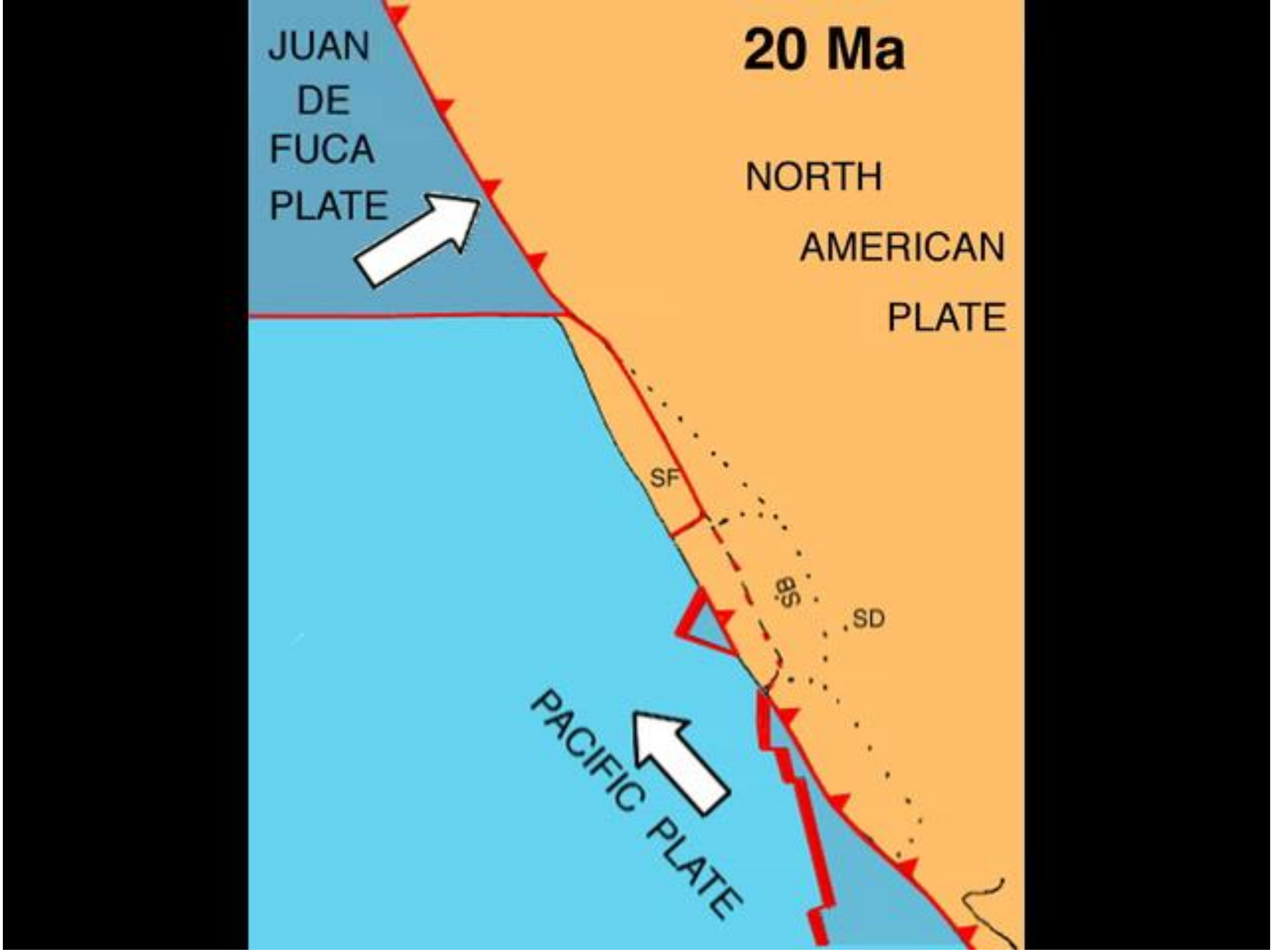
Oceanic crust subducting beneath continental crust.



Tanya Atwater: http://emvc.geol.ucsb.edu/1_DownloadPage/Download_Page.html

Evolution of San Andreas Fault





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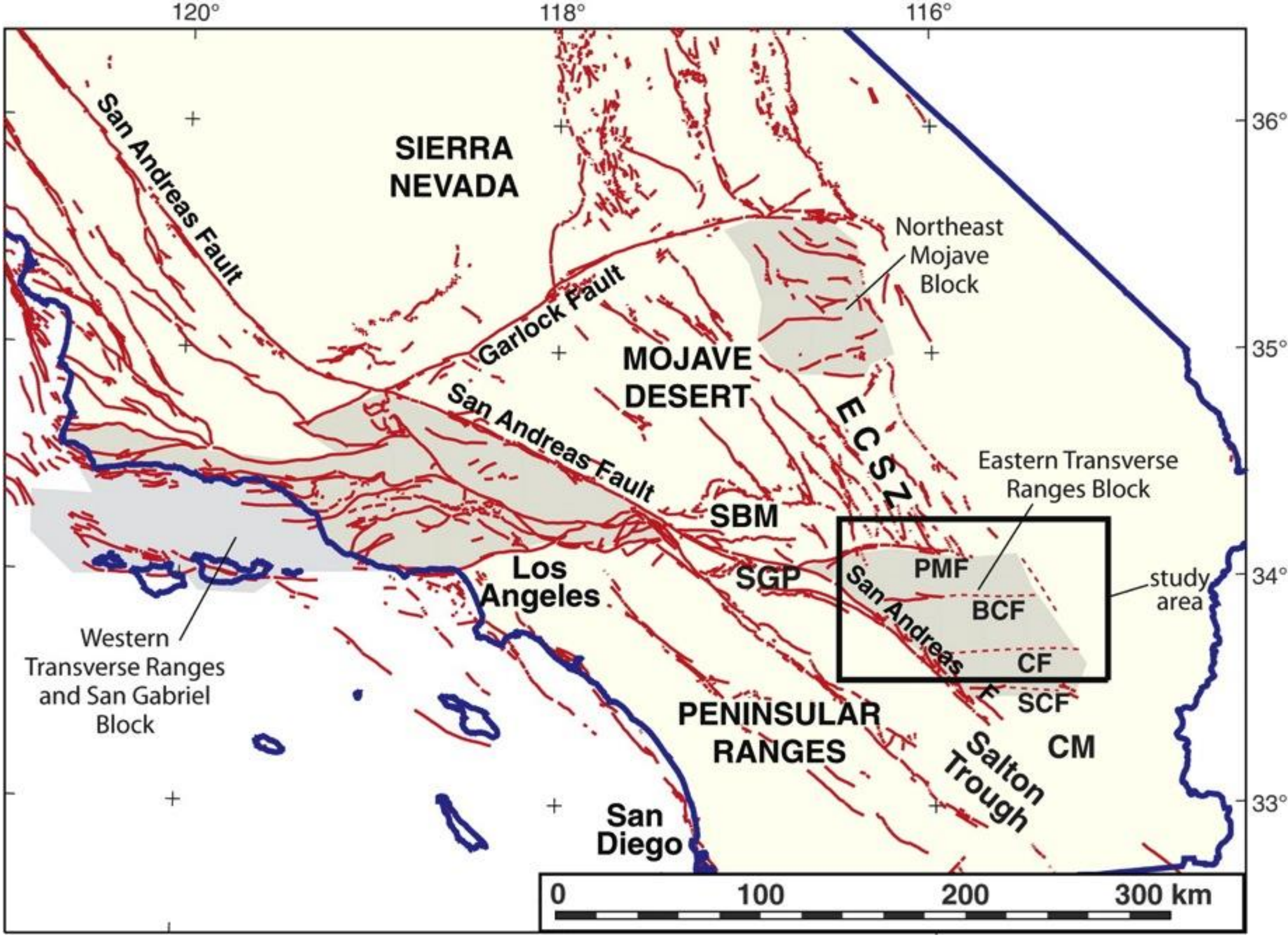


120°
118°
116°
36°
35°
34°
33°
San Andreas Fault
SIERRA NEVADA
Garlock Fault
MOJAVE DESERT
Northeast Mojave Block
ECSZ
San Andreas Fault
Eastern Transverse Ranges Block
SBM
SGP
Los Angeles
PMF
BCF
CF
SCF
San Andreas F
study area
Western Transverse Ranges and San Gabriel Block
PENINSULAR RANGES
Salton Trough
CM
San Diego
0
100
200
300 km

Los Angeles was under water – part of the Pacific Ocean – for millions of years.

Upper Miocene marine rocks in the Los Angeles basin (marine sediment filling the basin about 11.6 million to 5.3 million years before present).

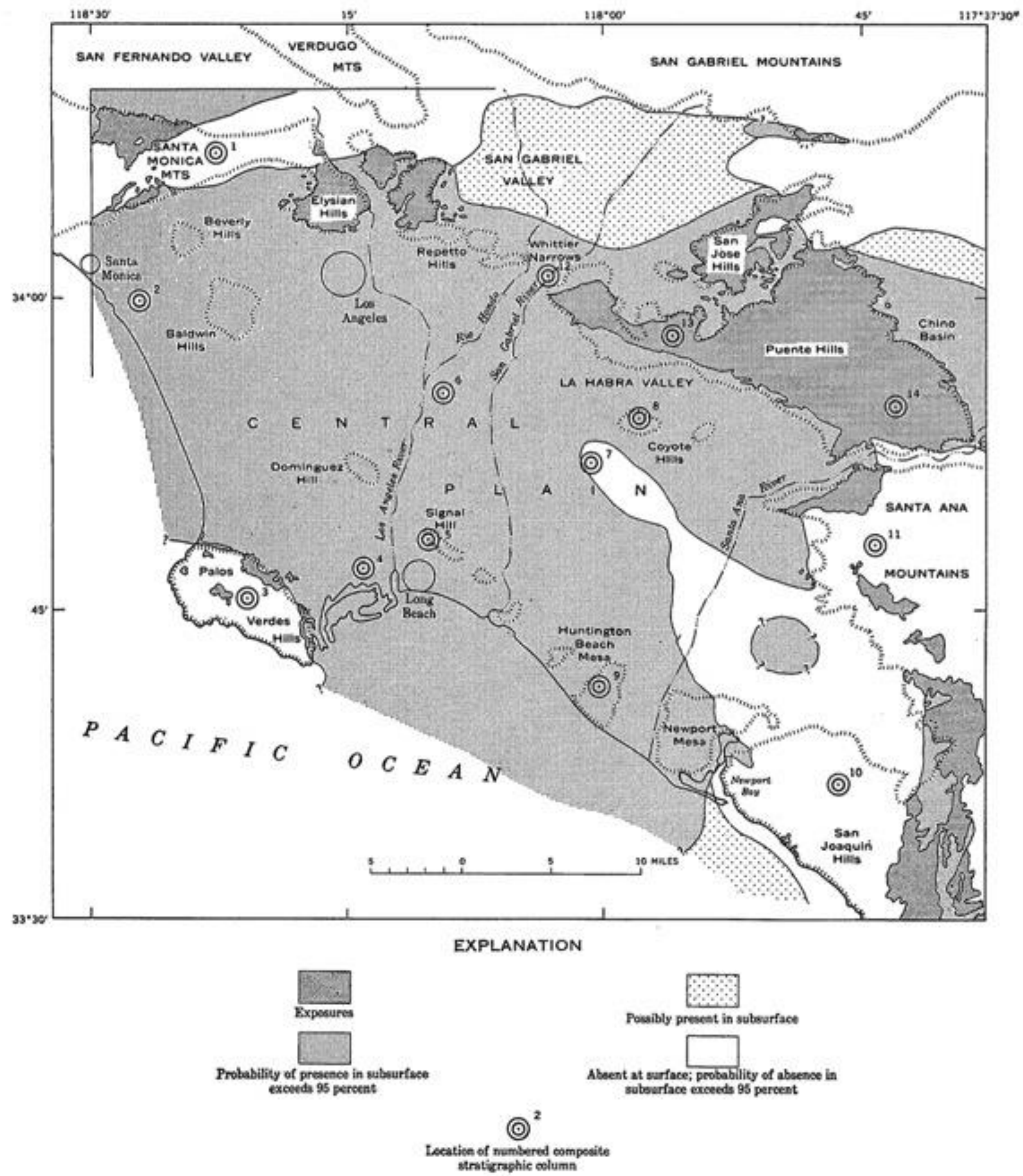
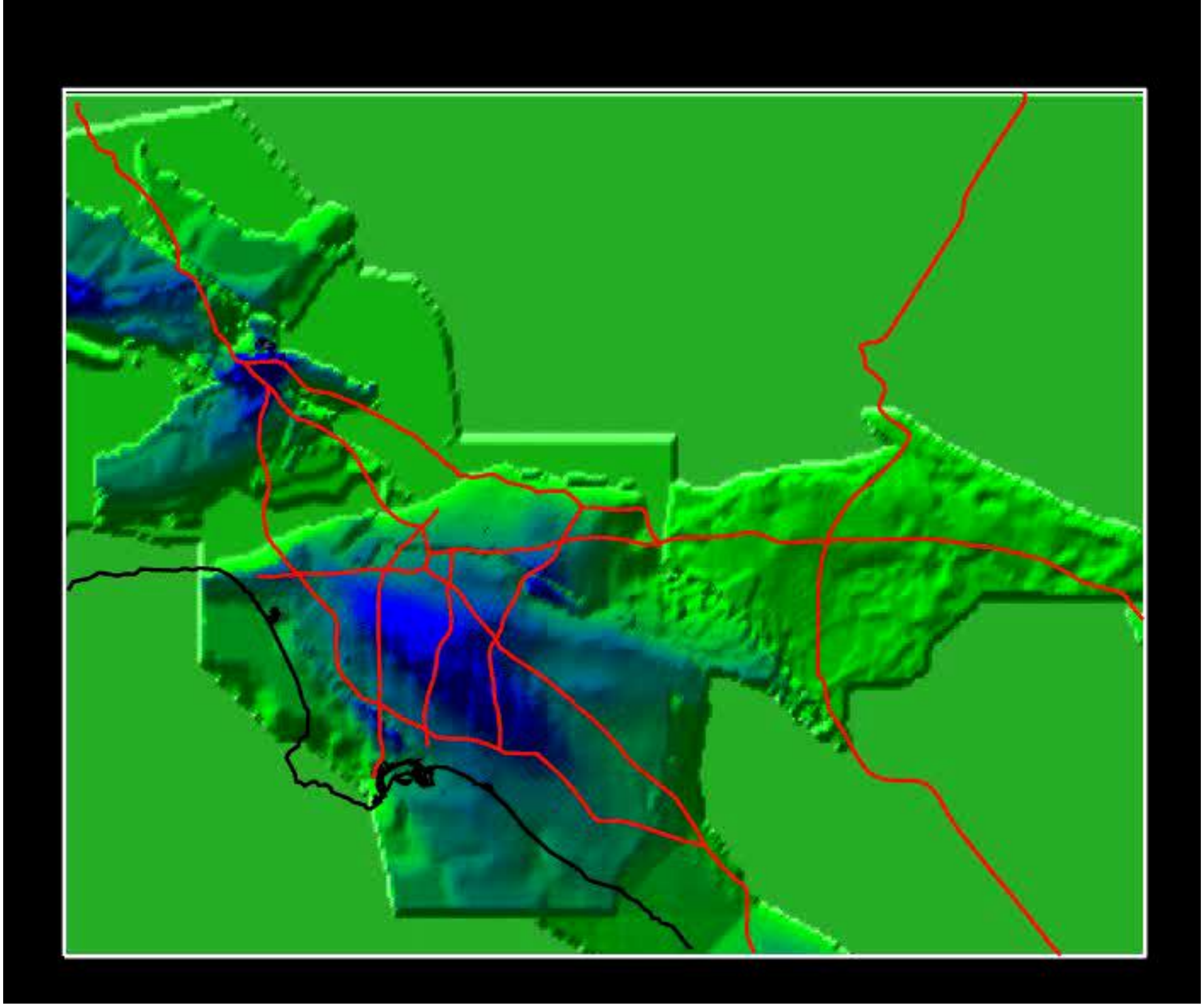
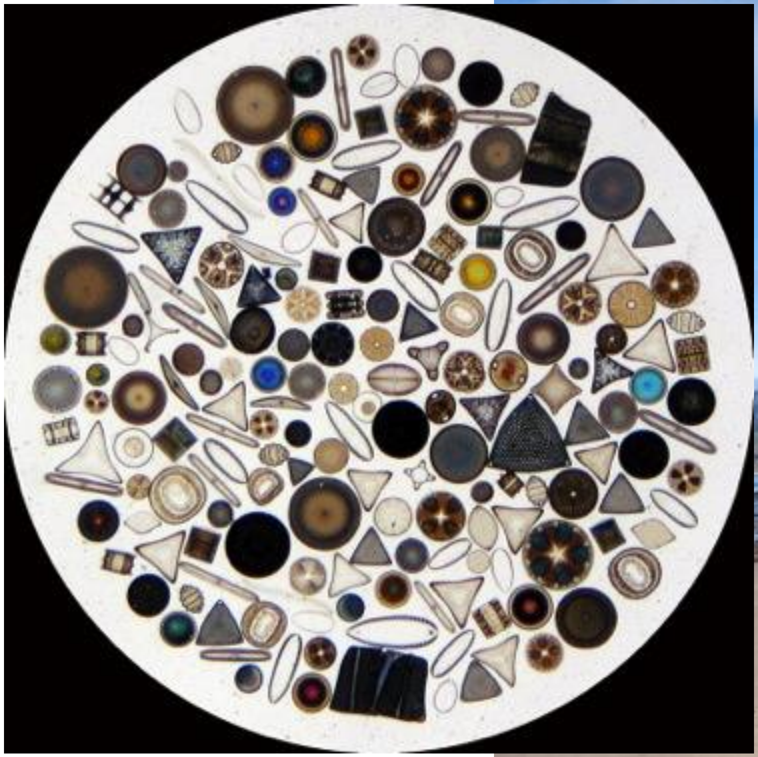


FIGURE 10.—Distribution of upper Miocene rocks in the Los Angeles basin. Location and number of each composite stratigraphic column are the same as in plates 1, 2, and 3.



Southern California Earthquake Center http://www.scec.info/phase3/basinmap.html

Los Angeles structural basin up to 6 miles deep filled with marine sediment

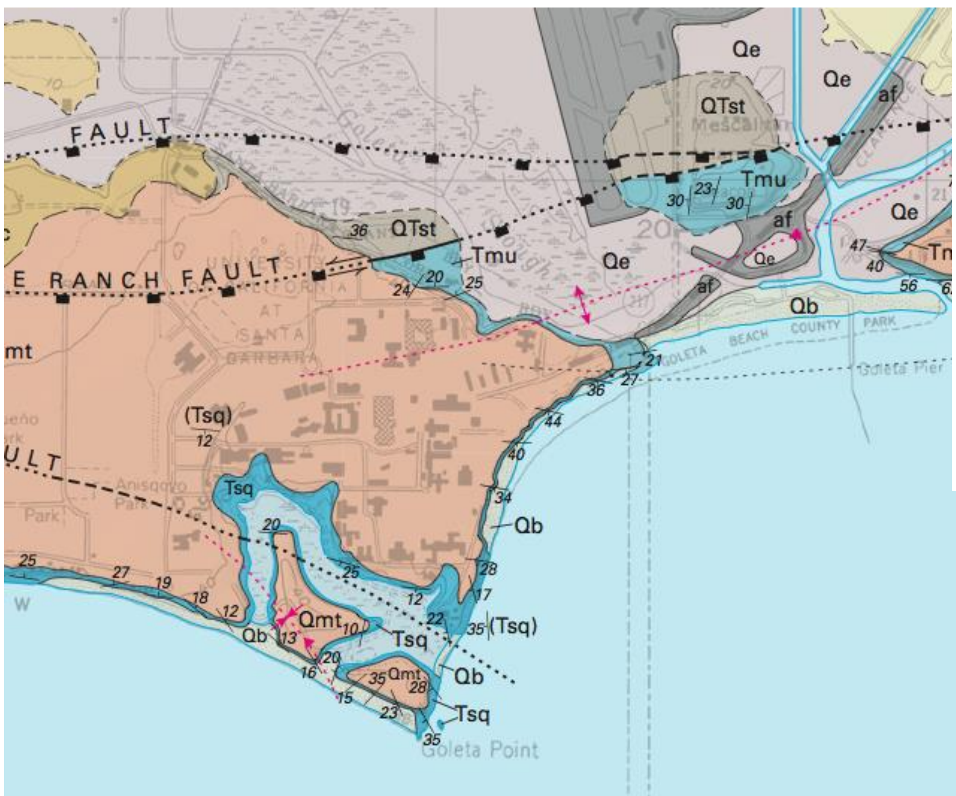



Diatoms – microscopic marine algae – made up much of the organic matter trapped in The sediments of the Miocene Monterey, Modelo, and Puente Formations.

What's a formation?!

A geologic formation is a body of rock that:

1. has a distinctive lithic characteristic (made up of particular types of rock).
2. is mappable on earth's surface or traceable below the surface with a distinct upper and lower boundary.



Tsq — **Sisquoc Formation (lower Pliocene and upper Miocene)**—Marine, tan- to white-weathering, diatomaceous mudstone and shale, conglomerate, and subordinate dolomite. Unit distinguished by thick beds of conglomerate containing angular clasts (commonly up to 1 m across; some blocks as large as 10 m) derived from the Monterey Formation. Both base and top of Sisquoc consist of erosional unconformities. Maximum preserved thickness of 300 m in sea cliffs

Tu — **Unnamed mudstone (upper Miocene)**—Marine mudstone, shale, and porcelanite with subordinate dolomite and phosphatic pebble conglomerate. Exposures of unit are restricted to the coastal area southeast of the mouth of Dos Pueblos Canyon, where it is about 15–20 m thick

Monterey Formation (Miocene)—Marine, predominantly well-bedded, siliceous and calcareous mudstone and shale with subordinate porcelanite and dolomite. Contains abundant microfossils. Unit deposited at water depths ranging from upper to lower bathyal (150–2,000 m). Maximum composite thickness of Monterey estimated to be about 830 m. The Monterey Formation is divided into three subunits that are distinguished from each other by lithology and age:

Tmu — **Upper siliceous unit (upper Miocene)**—East of Eagle Canyon, unit consists mainly of white- to tan-weathering diatomaceous mudstone and shale with subordinate dolomite and porcelanite. West of Eagle Canyon, consists mainly of thin-bedded, light-brown-weathering, siliceous mudstone and shale, porcelanite, and subordinate dolomite. Thickness ranges from about 50 m to 250 m

Tmm — **Middle shale unit (upper and middle Miocene)**—White-weathering shale, mudstone, dolomite, porcelanite, phosphorite, and subordinate tuff. Unit includes a prominent, at least 20- to 30-m-thick, submarine-slump deposit in sea cliff near mouth of Eagle Creek in western part of map area. Thickness estimated to range from 70 to 180 m

Tml — **Lower calcareous unit (middle and lower Miocene)**—Calcareous, siliceous, and phosphatic, white- to tan-weathering mudstone and shale, with subordinate dolomite, porcelanite, breccia, glauconitic sandstone, and tuff. In places, unit exhibits intraformational deformation (including breccia) that may have formed by gravitational slumping shortly after deposition. Thickness about 250 m thick near the mouth of Dos Pueblos Canyon

Tmlb — **Breccia (middle? and lower Miocene)**—Intraformational breccia exposed on the sea cliff near the mouth of Dos Pueblos Canyon. Composed of clasts of calcareous mudstone and dolomite. Unit about 30 m thick

Tr — **Rincon Shale (lower Miocene)**—Marine, primarily massive and thick-bedded, light-brown-weathering mudstone, with subordinate dolomite, siliceous shale, sandstone, and tuff. Mudstone is bioturbated and massive, pervasively hackly fractured, and locally contains abundant microfossils. Single or multiple white-weathering tuff layers limited to upper 10 m of Rincon section. Thickness ranges from about 400 m to 460 m

Geologic formations in the Los Angeles Basin.

Puente Formation in Mustard.

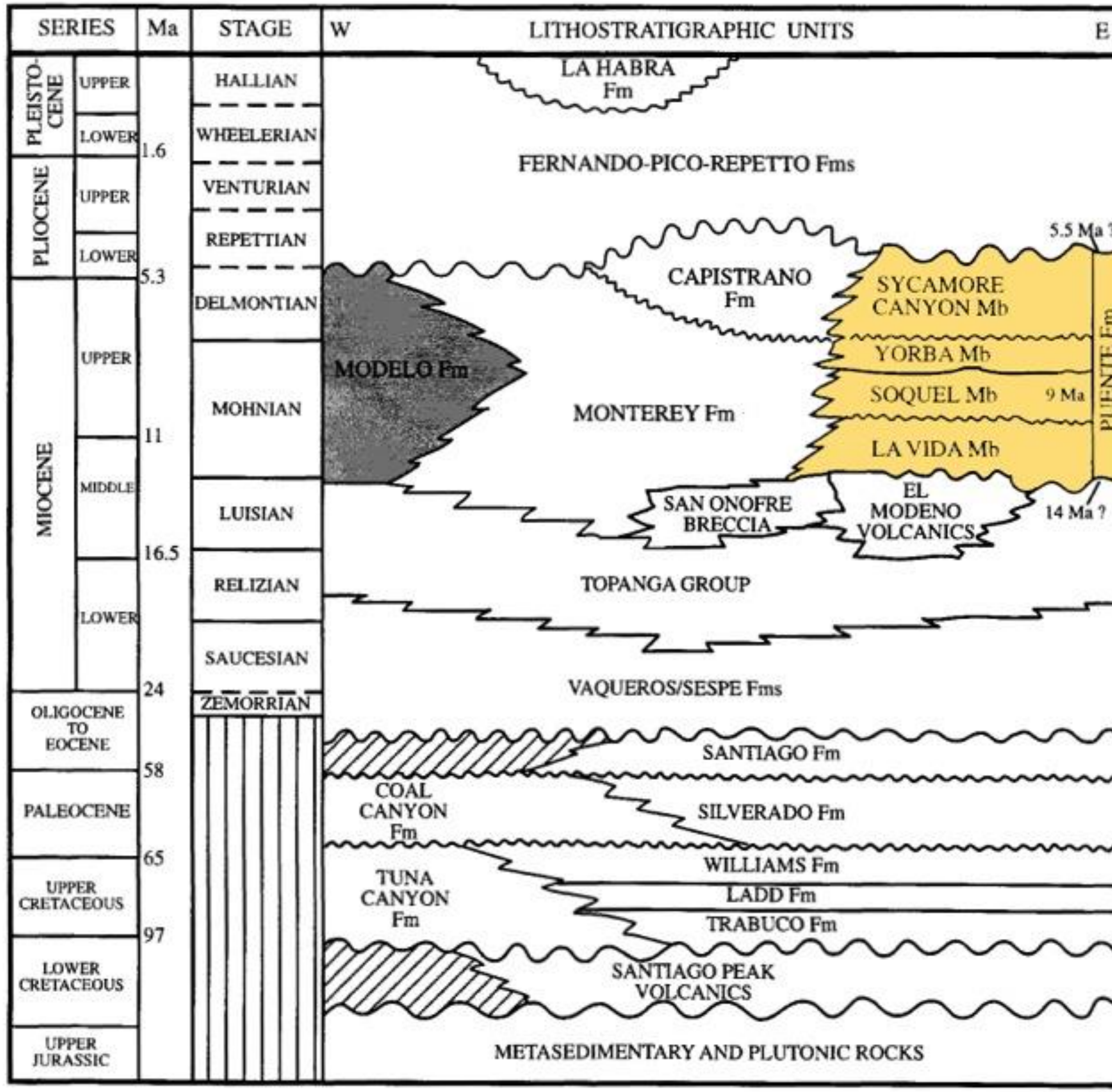
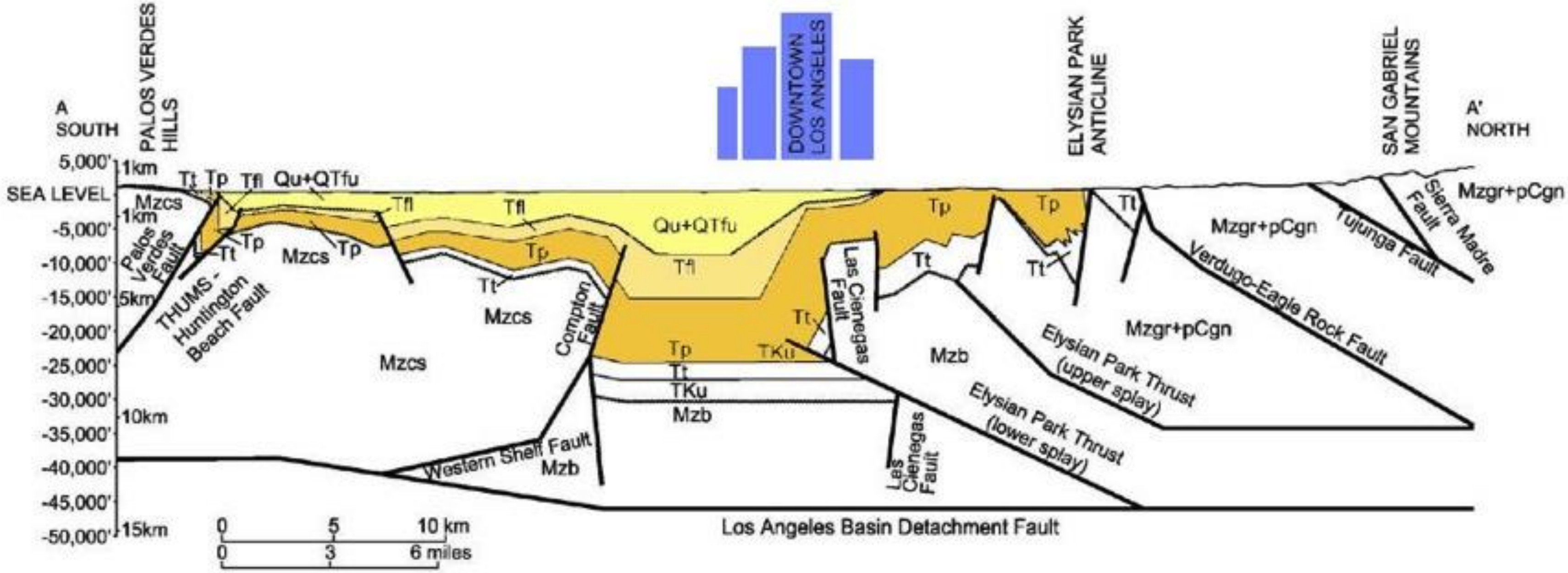


Figure 2. Generalized stratigraphic chart for Los Angeles basin (modified from Blake, 1991). Note nonlinear vertical scale.

Rumelhart & Ingersoll, 1997



Qu	Undifferentiated Quaternary alluvium and shallow marine deposits
QTfu	Upper member of the Fernando Formation ("Pico" equivalent, late Pilocene to early Pleistocene)
Tfl	Lower member of the Fernando Formation ("Repetto" equivalent, early to middle Pliocene)
Tp	Puente Formation (Modello Formation equivalent, late middle Miocene, late Miocene and possibly earliest Pliocene)
Tpss	Puente Formation Sandstone Facies
Tt	Undifferentiated Topanga Group (equivalent to Topanga Formation and lowermost Monterey Formation)
Tku	Undifferentiated Upper Cretaceous to lower Miocene strata
Mzcs	Catalina Schist (Jurassic to early Cretaceous)
Mzb	Undifferentiated crystalline basement including Late Jurassic Santa Monica Slate, Mesozoic age granitic rocks, and various meta'igneous and metasedimentary rocks
Mzgr	Mesozoic age granitic rocks
pCgn	Precambrian gneiss

Figure 5. Basin cross section showing faults and basin detachment fault (after Davis and Namson, 1998). Section line shown on Figure 4.

Cross section of Los Angeles basin. Late Miocene Puente Formation in mustard.

Bilodeau, Bilodeau, Gath, Oborne, and Proctor , 2007

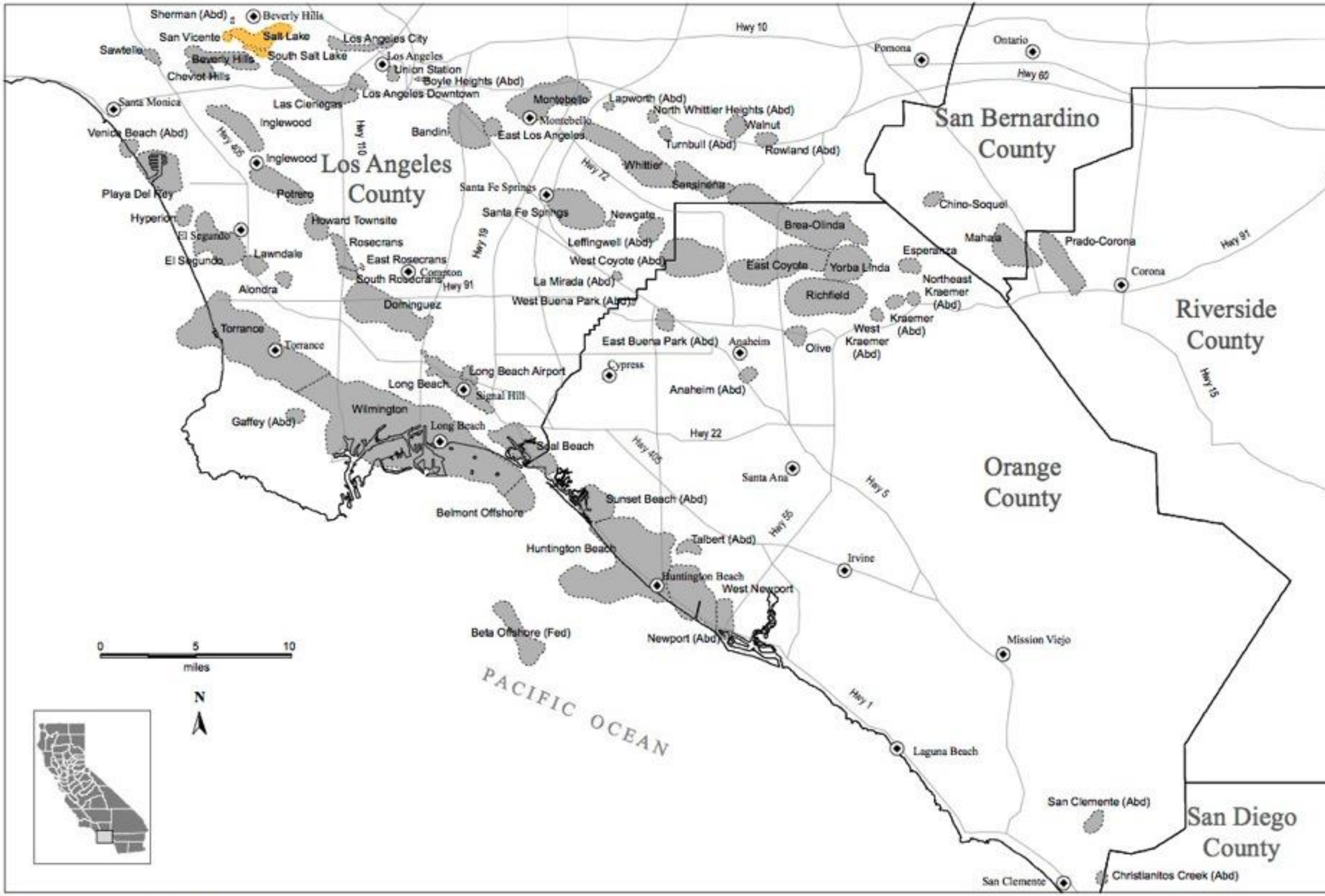
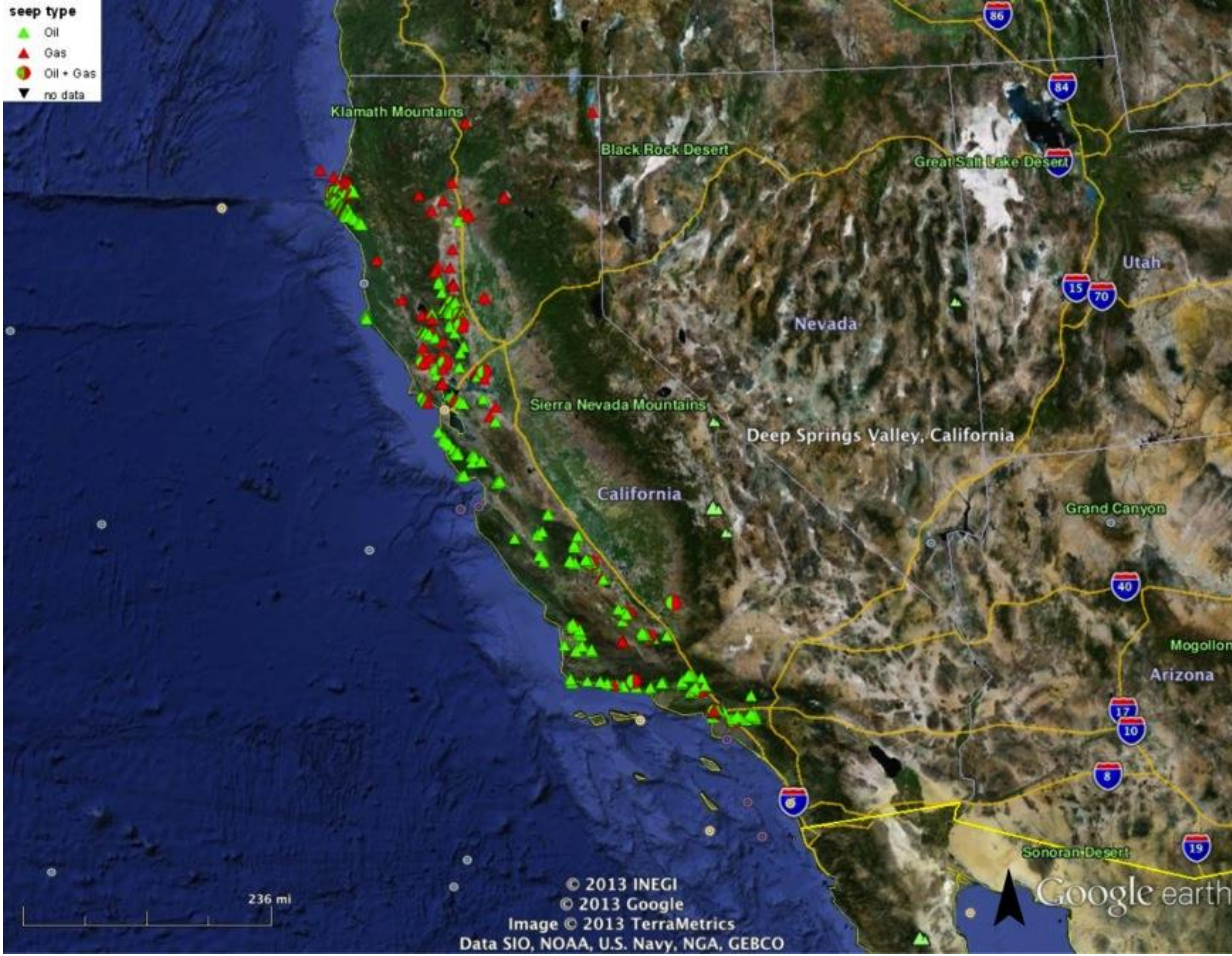


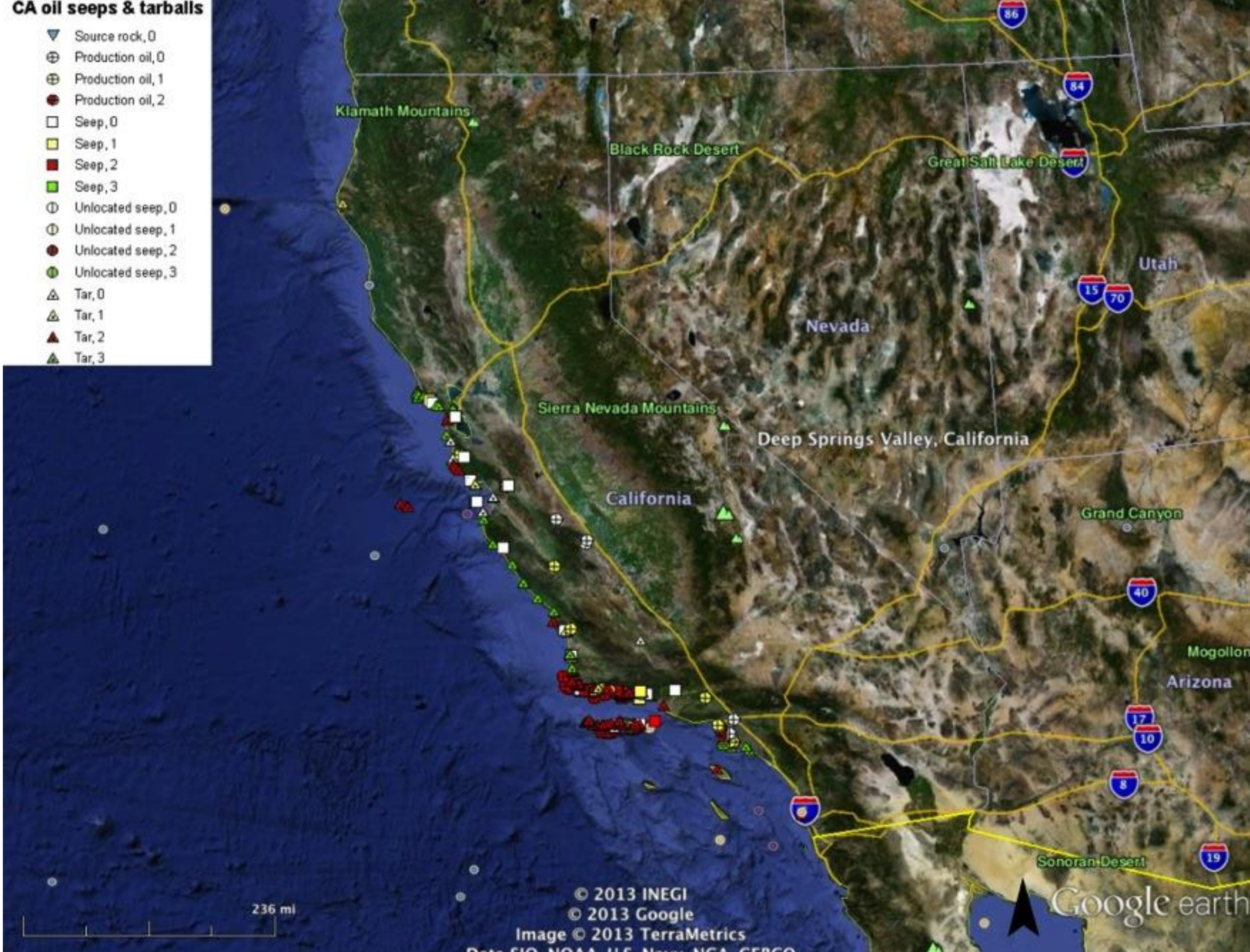
Figure 1. Los Angeles Basin area oil fields.

California Department of Oil, Gas, and Geothermal, TR 52

Seeing the oil in the rocks



Onshore oil and gas seeps in California



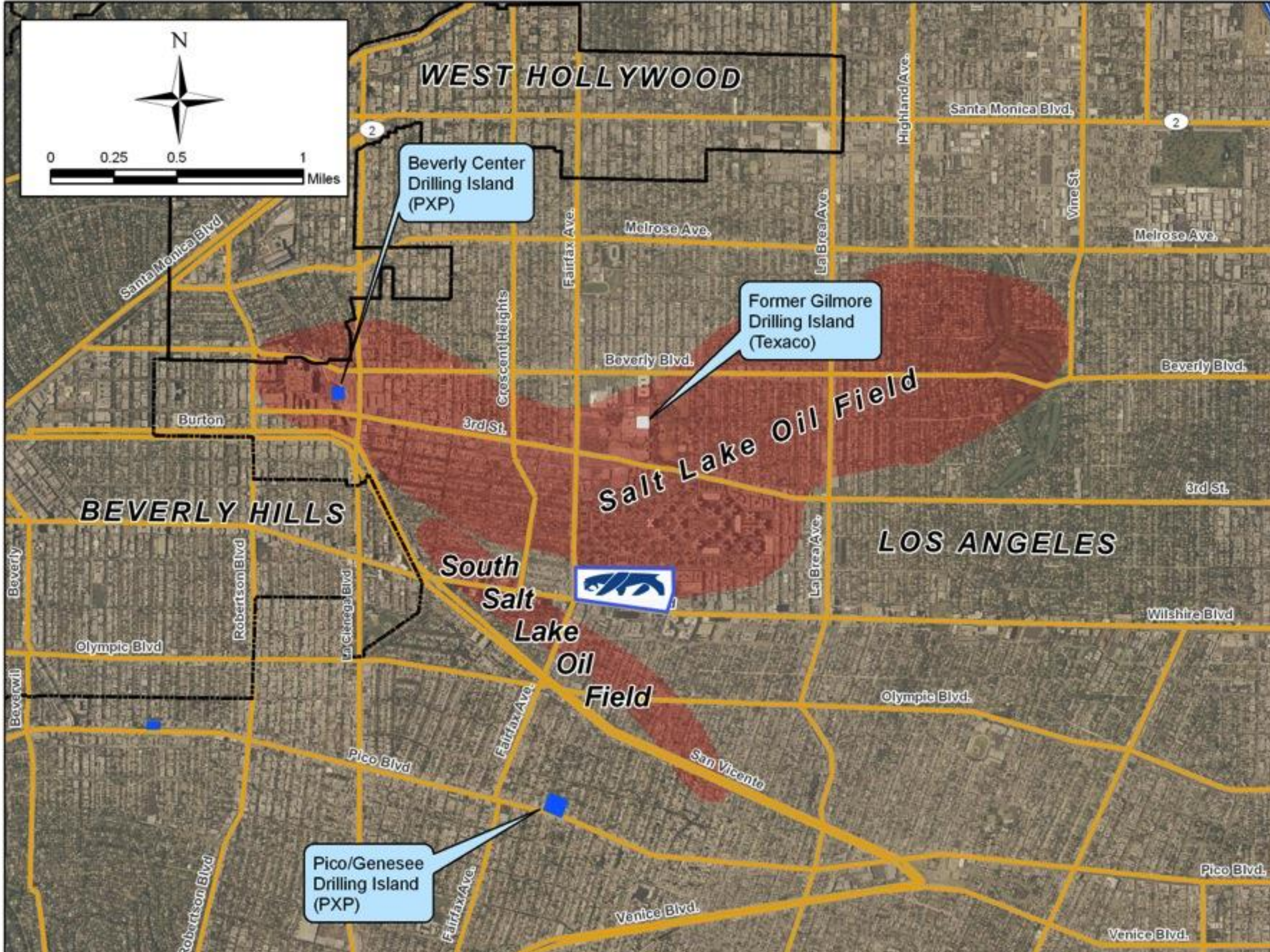
Coastal and offshore seeps in California

Tar Pits Park in Carpinteria

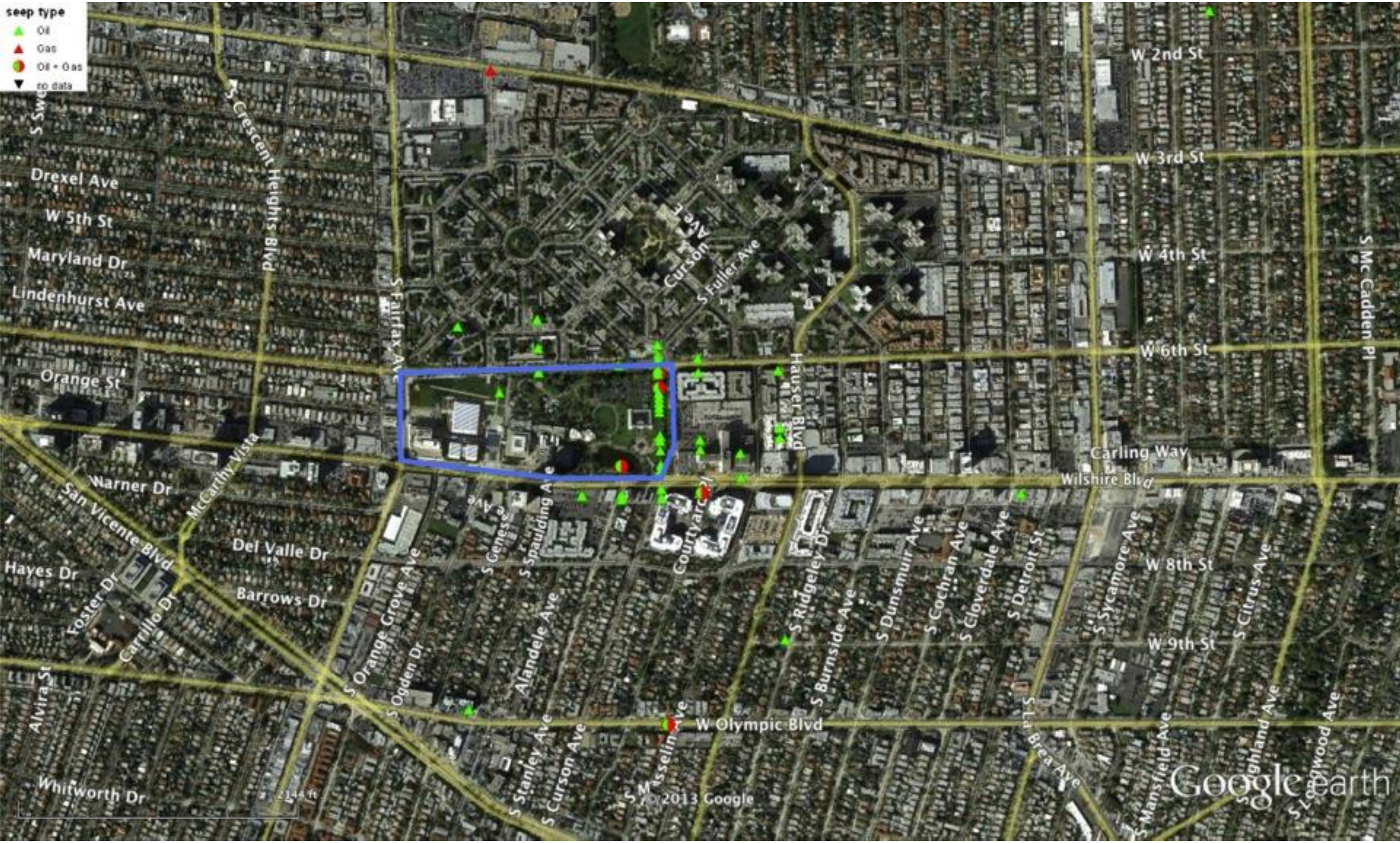
Asphalt seeps flowing onto the beach at Carpinteria

Interface between oil-bearing Monterey Formation and nearshore sands at Carpinteria

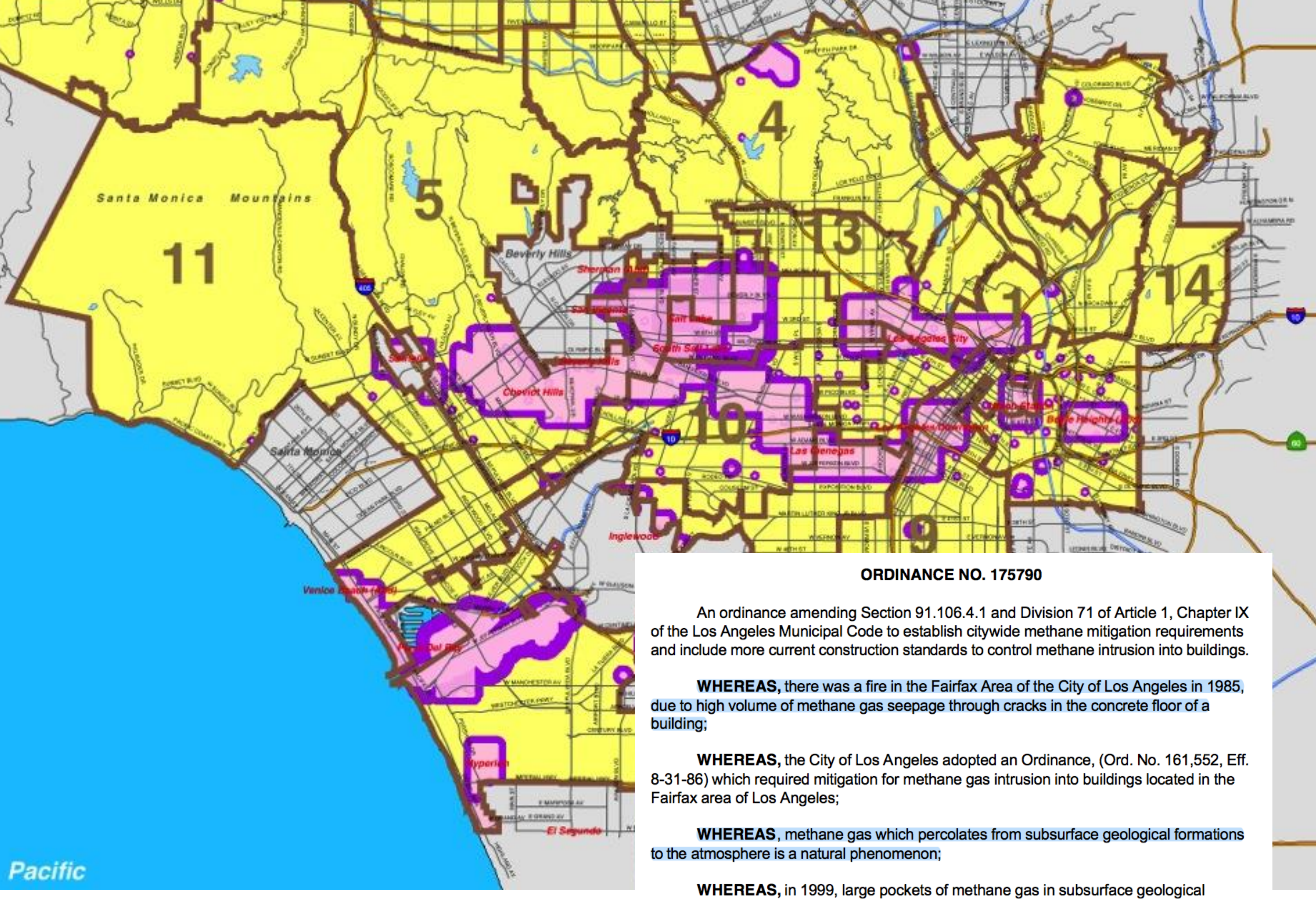
Asphalt seeps up along tilted and nearly vertical Monterey Formation shale beds



Salt Lake and South Salt Lake Oil Fields



Oil and gas seeps around Hancock Park



ORDINANCE NO. 175790

An ordinance amending Section 91.106.4.1 and Division 71 of Article 1, Chapter IX of the Los Angeles Municipal Code to establish citywide methane mitigation requirements and include more current construction standards to control methane intrusion into buildings.

WHEREAS, there was a fire in the Fairfax Area of the City of Los Angeles in 1985, due to high volume of methane gas seepage through cracks in the concrete floor of a building;

WHEREAS, the City of Los Angeles adopted an Ordinance, (Ord. No. 161,552, Eff. 8-31-86) which required mitigation for methane gas intrusion into buildings located in the Fairfax area of Los Angeles;

WHEREAS, methane gas which percolates from subsurface geological formations to the atmosphere is a natural phenomenon;

WHEREAS, in 1999, large pockets of methane gas in subsurface geological formations were discovered at the Playa Vista project area of West Los Angeles;

Los Angeles Methane Zones

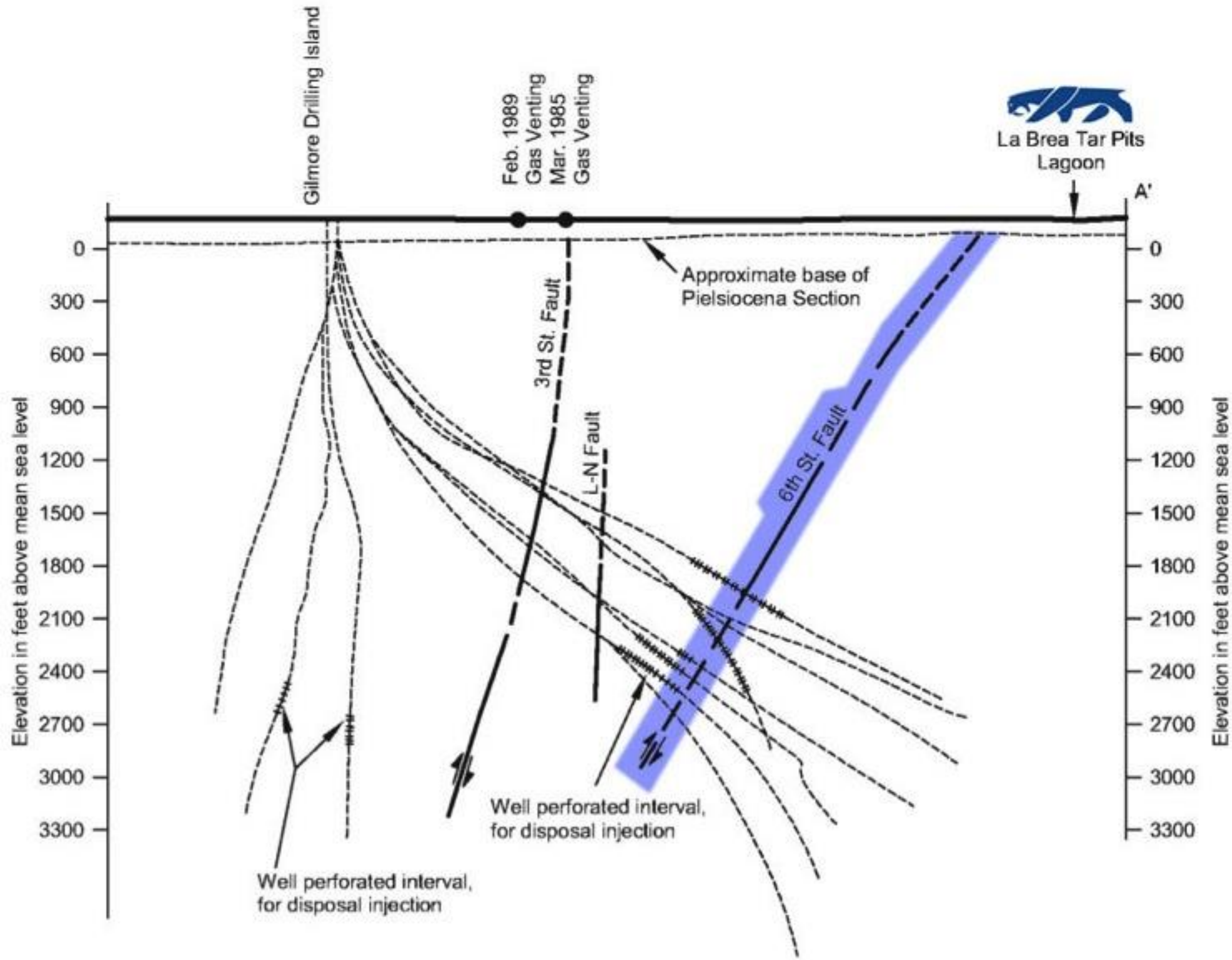
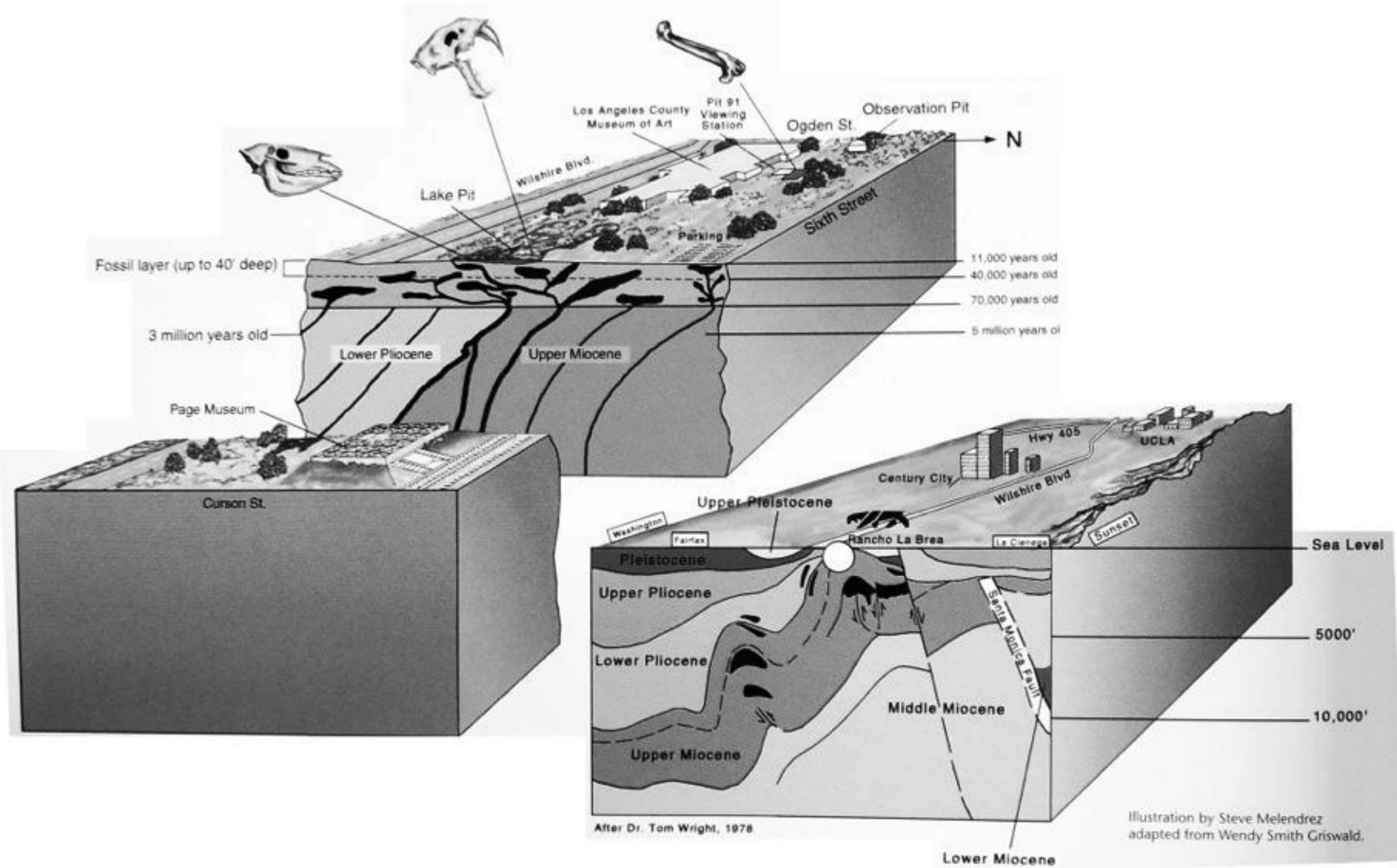


Figure 8. Cross section of directional wells used in Fairfax District to extract oil and gas from the subsurface with minimal disturbance to surface commerce (after Hamilton and Meehan, 1992).

Bilodeau, Bilodeau, Gath, Oborne, and Proctor , 2007

Faulting as pathway to surface



Tilted bedding as pathway to surface

Seeing the water in the rocks

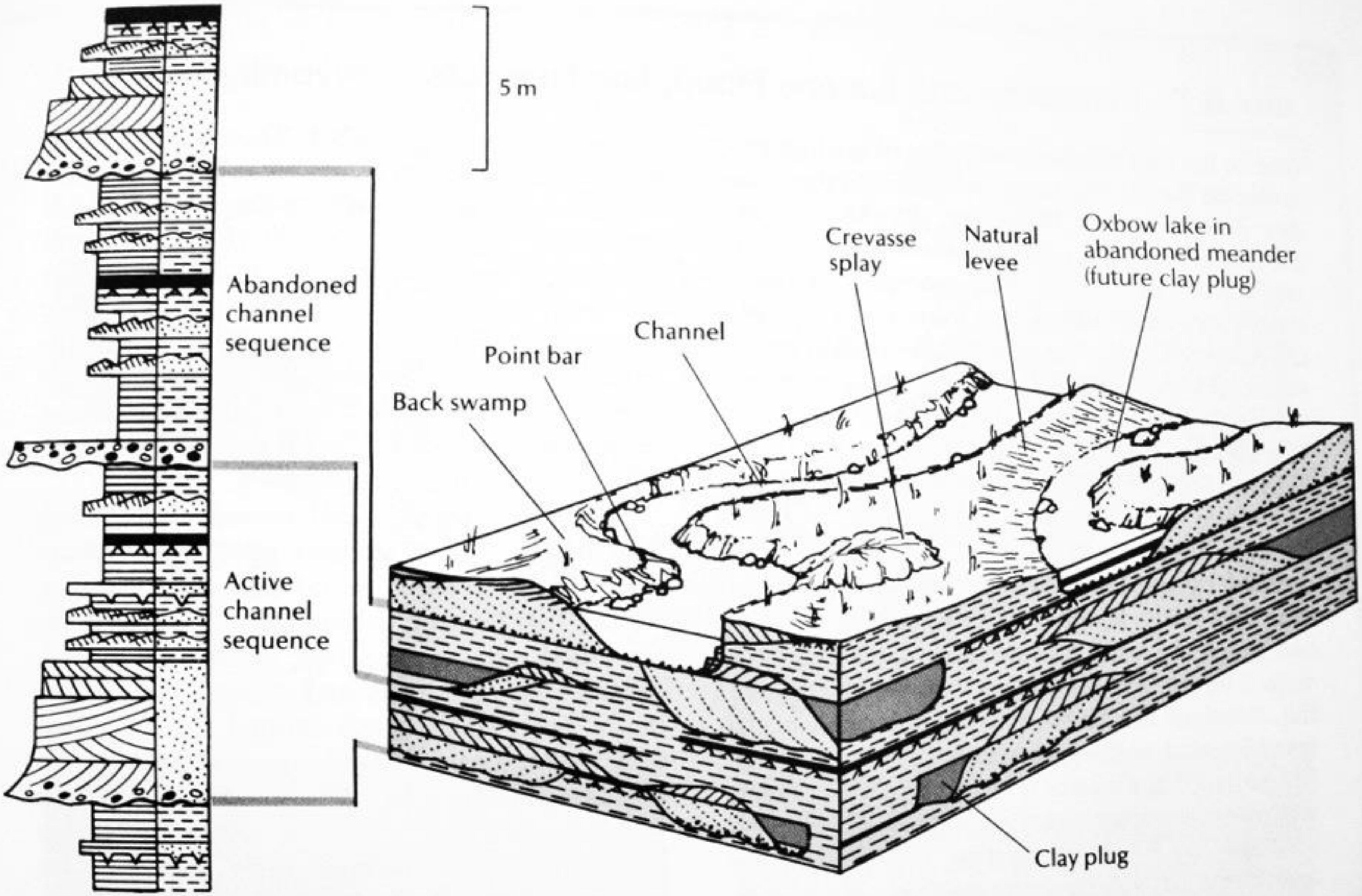
Alluvial river

Westwood with natural drainages , 1922

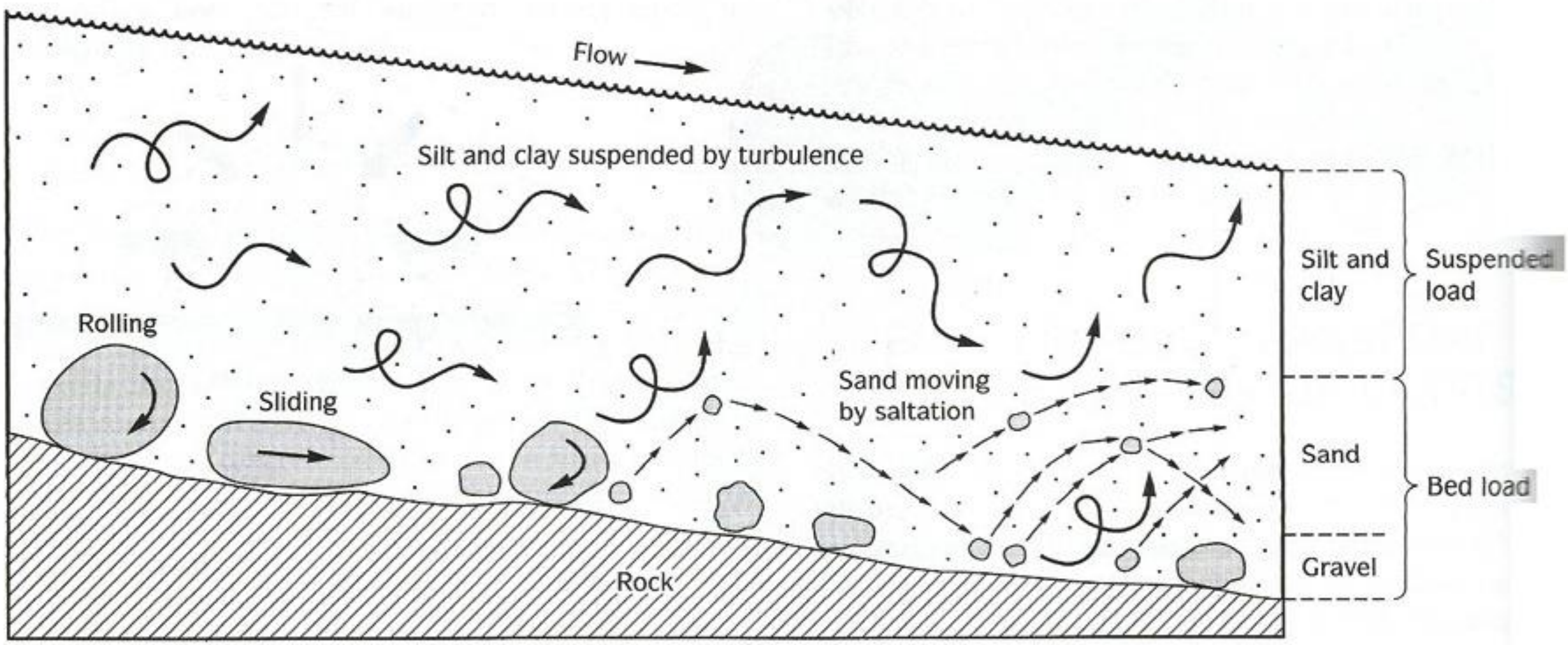
Westwood, 1922

Hancock Park and Salt Lake oilfield, 1922

Los Angeles and unchannelized LA River, 1887



Meandering floodplain



Sediment grains transported along the bottom in bed load or in suspended load

Seeing the geology in the fossils

(It's a very, very, very, very, very, very, very, very lucky organism that gets fossilized)

TAPHONOMY

During each of these years, over the whole world, the land and the water has been peopled by a host of living forms. What an infinite number of generations, which the mind cannot grasp, must have succeeded each other in the long roll of years! Now turn to our richest geological museums, and what a paltry display we behold!

Charles Darwin
"The Origin of Species"

The study of all the processes that occur between the death of an organism and its final state in the rock.

(Benton, 2005, Vertebrate Paleontology)

TAPHONOMY

Possible taphonomic processes acting on fossils can include:

- decay
- scavenging
- disarticulation
- surface weathering
- water transport
- abrasion
- rapid or slow burial
- mineralization and diagenesis
- erosion/exhumation and secondary transport

During each of these years, over the whole world, the land and the water has been peopled by a host of living forms. What an infinite number of generations, which the mind cannot grasp, must have succeeded each other in the long roll of years! Now turn to our richest geological museums, and what a paltry display we behold!

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Charles Darwin
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A few things to keep in mind:

- Geologists tend to see fossils as sedimentary clasts or particles - bioclasts
- Fossils need context to be scientifically valuable
- How and where an organism died may not be related to the accumulation and preservation of its remains

Horse teeth, Pleistocene marine terrace sand, Newport Beach

Bison tooth, San Clemente

Mammoth tooth, San Clemente

Mastodon tooth, San Clemente

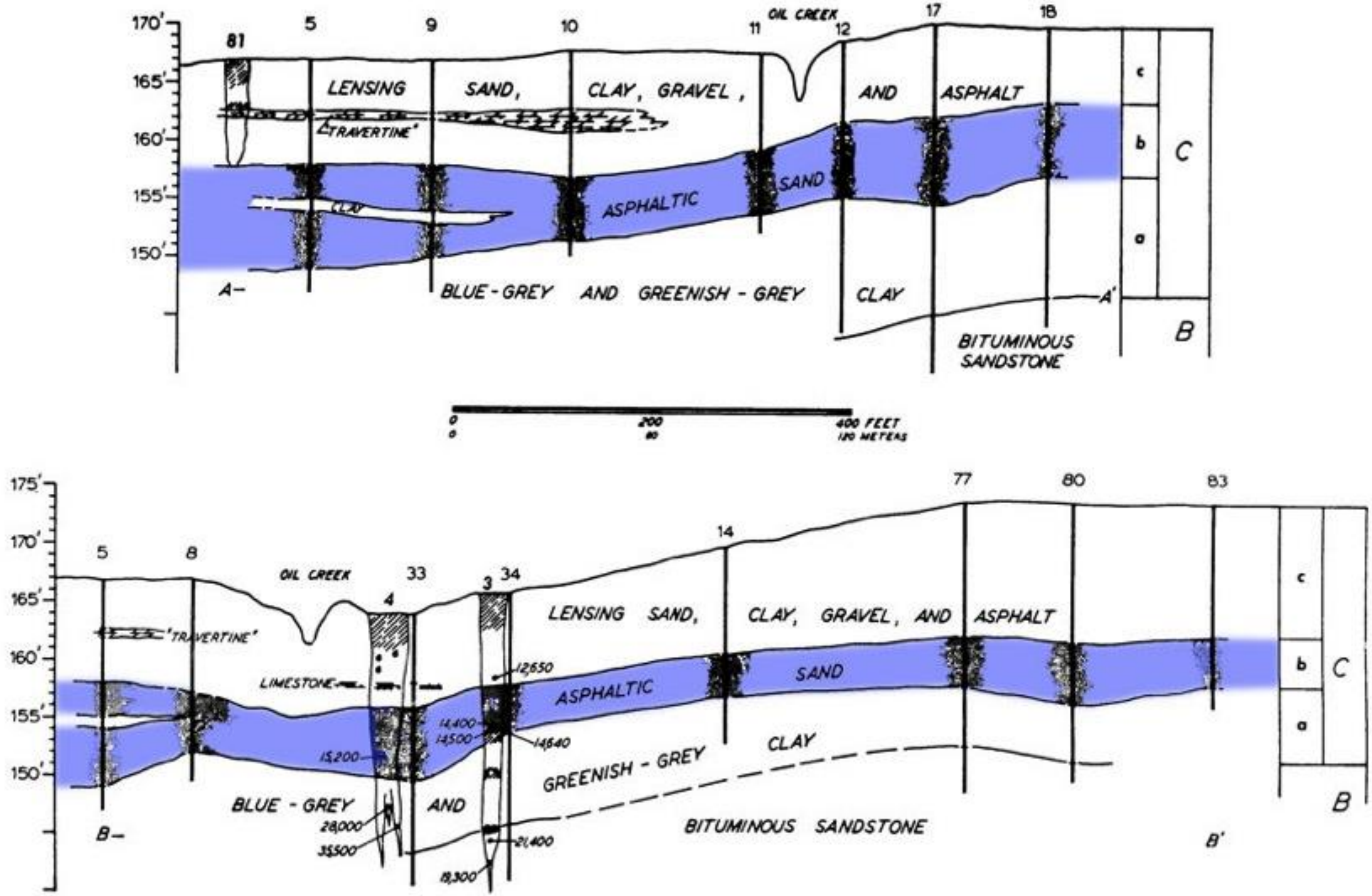
Giant sloth pelvis, San Clemente

Still more Proboscidean bones, San Clemente

Mastodon jaw in Simi Valley

Pit 3/4 Old Faithful gas seep

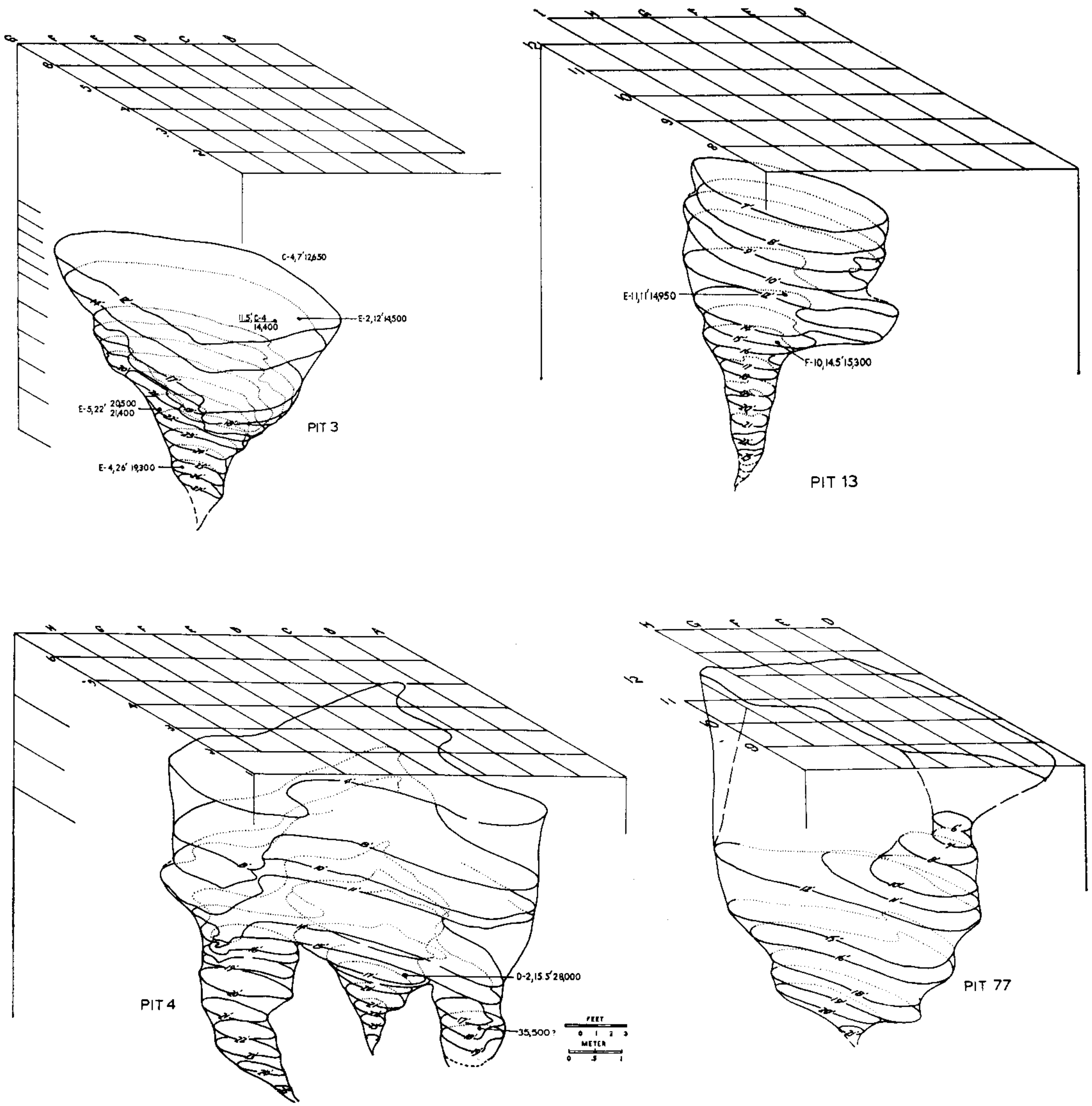
Hancock Park, 1911
Asphalt seep in stream bed



Woodard & Marcus, 1973

TEXT-FIG. 4—Geological cross-sections, Member C, Rancho La Brea.

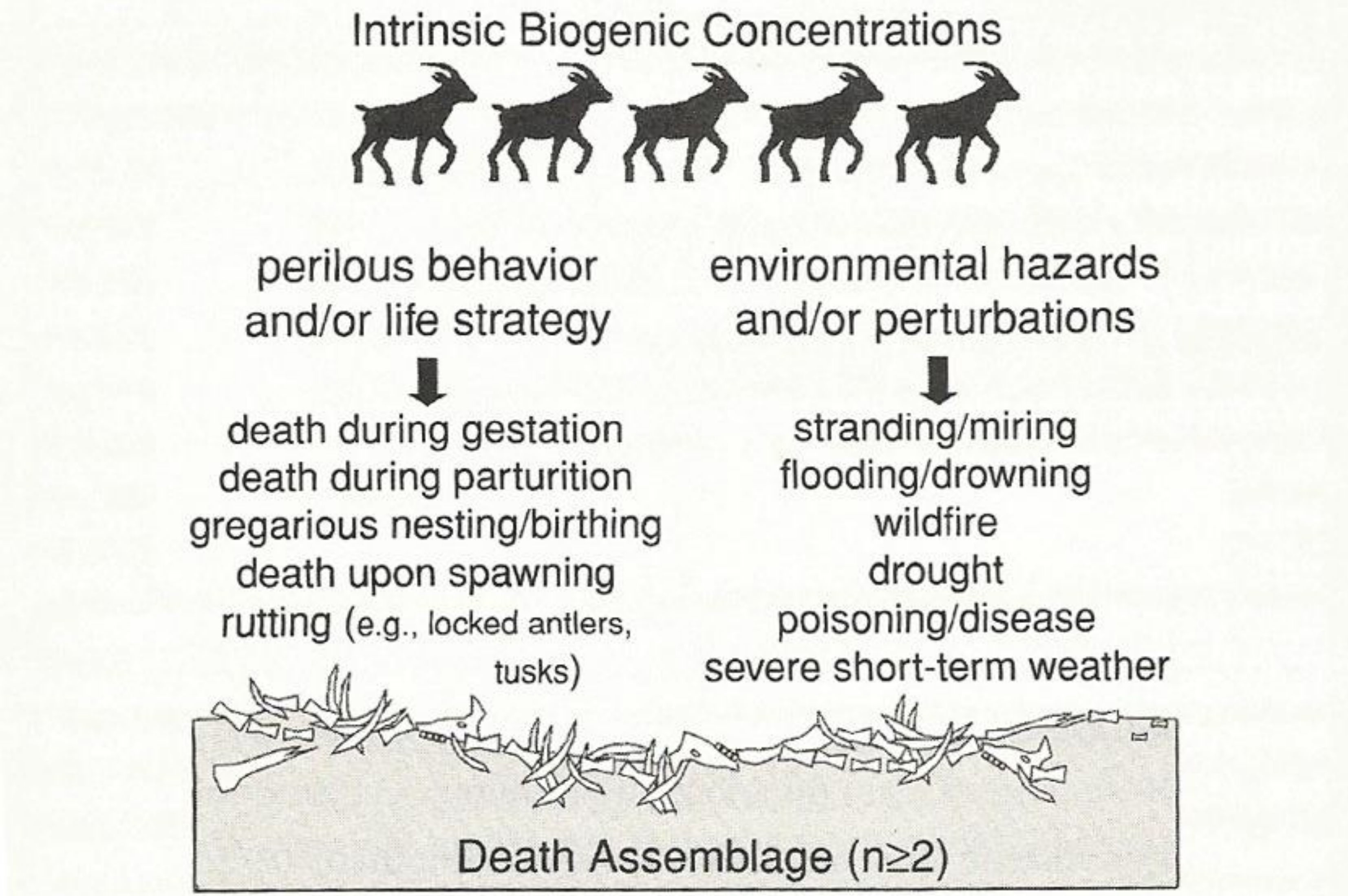
Submember b: The characteristic lithology is highly bituminous, medium-grained quartz sand enclosing pockets of liquid oil, hardened asphaltum lenses, cobble conglomerate and gravel beds, and occasional stringers of dark silty clay.



TEXT-FIG. 5—Isometric reconstructions of Pits 3, 4, 13, and 77, based on data of Wyman (1915). Radiocarbon dates from Los Angeles County Museum specimens analyzed by Berger and Libby (1968).

Woodard & Marcus, 1973

Pit excavation contours. Asphalt-filled pits in the park are artifacts of the old excavations.



Pathways for concentration of bonebeds

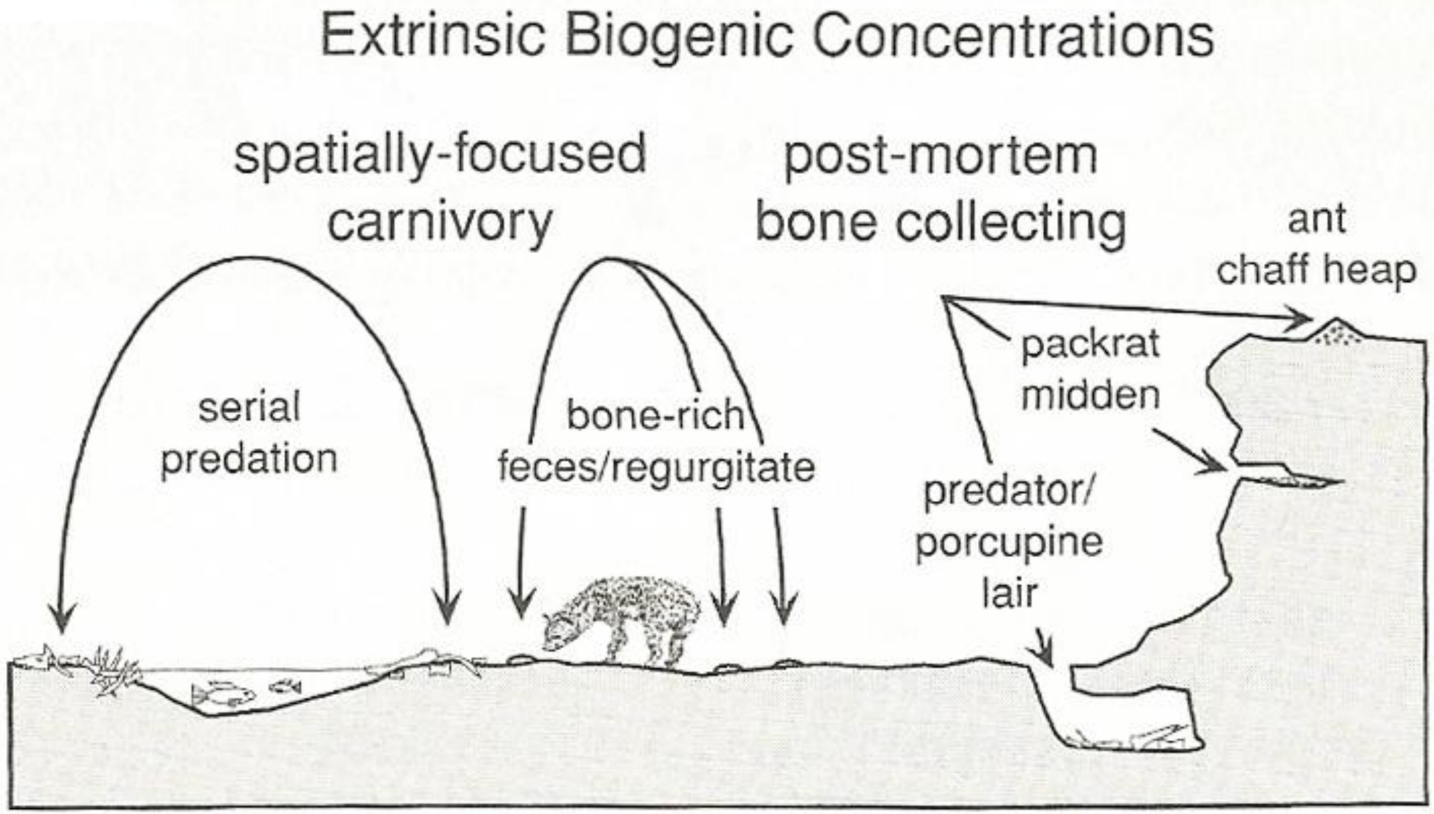
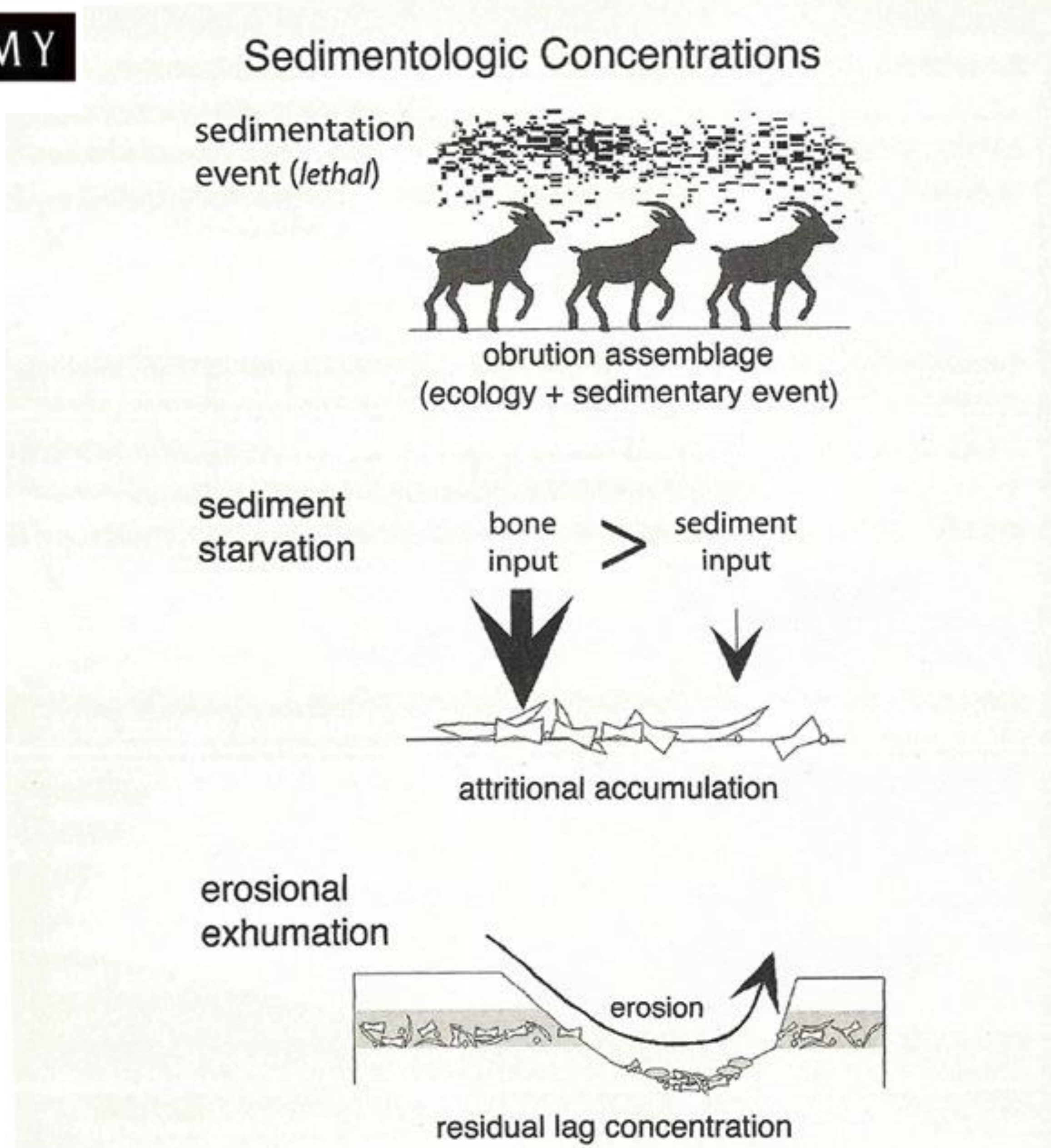


Figure 1.3. Extrinsic biogenic concentrations of vertebrate hardparts are produced by extrinsic biological agents, most notably predators. Nonpredatory animals such as porcupines and packrats also concentrate vertebrate hardparts due to habitual collecting. More rarely, intimate predator-prey associations are preserved, such as instances of fatal ingestion and dead carnivores with osseous gut contents.

Pathways for concentration of bonebeds

TAPHONOMY



Pathways for concentration of bonebeds

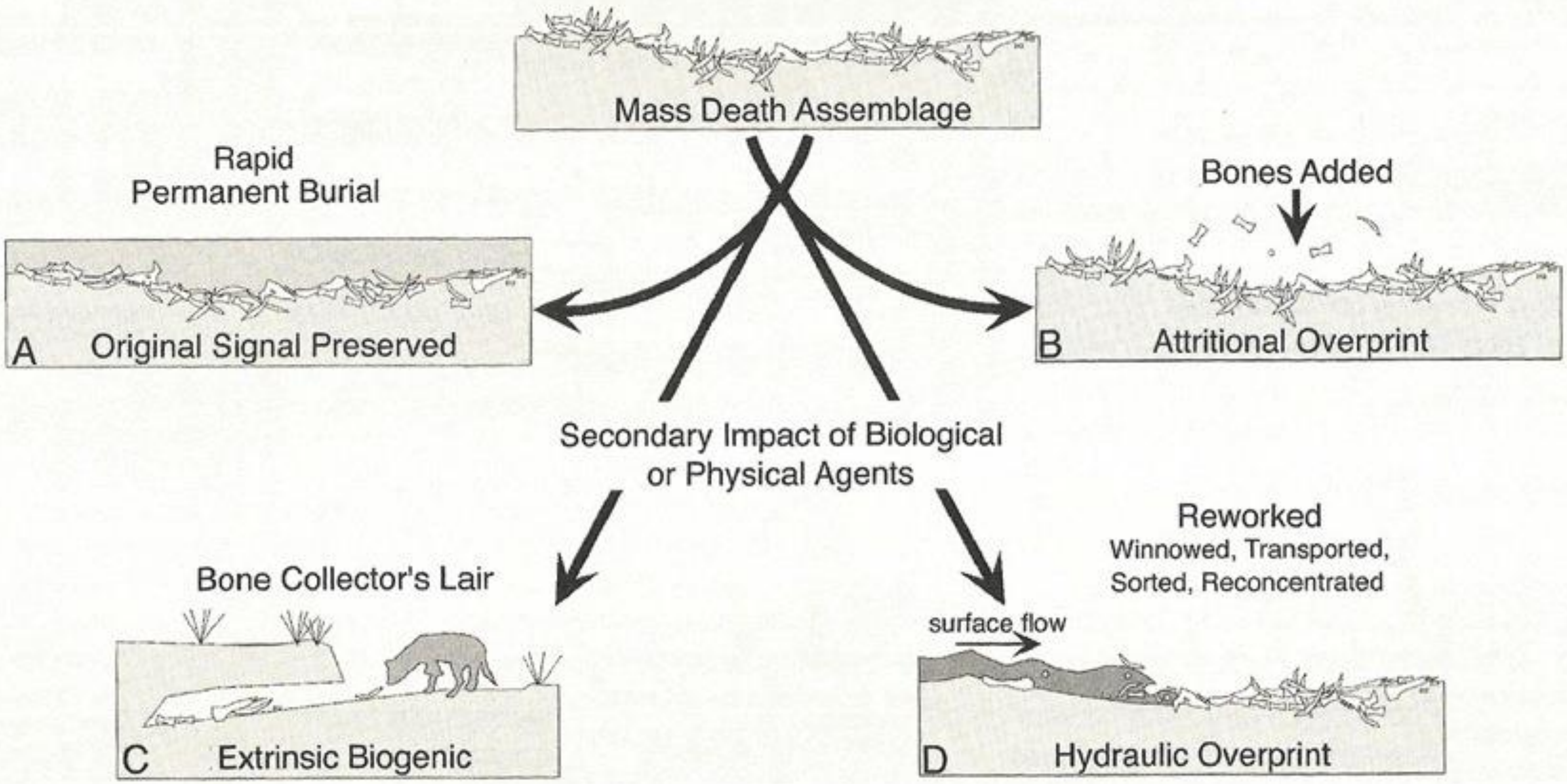


Figure 1.6. Hypothetical pathways that could be followed after a mass-death assemblage is generated. One potential outcome (path A) leads to permanent burial of the unaltered assemblage. A compound concentration (path B) might develop if the mass mortality event transpires under conditions of sediment starvation, and the resulting bone assemblage receives an attritional overprint. A preexisting concentration can also be reworked, transported, sorted, and ultimately reconcentrated by either biological (path C) or physical (path D) agents.

Pathways for concentration of bonebeds

Horse pelvis in very coarse asphaltic sand

Coarse sandy matrix in Box 1 or 14

Box 5B stratification

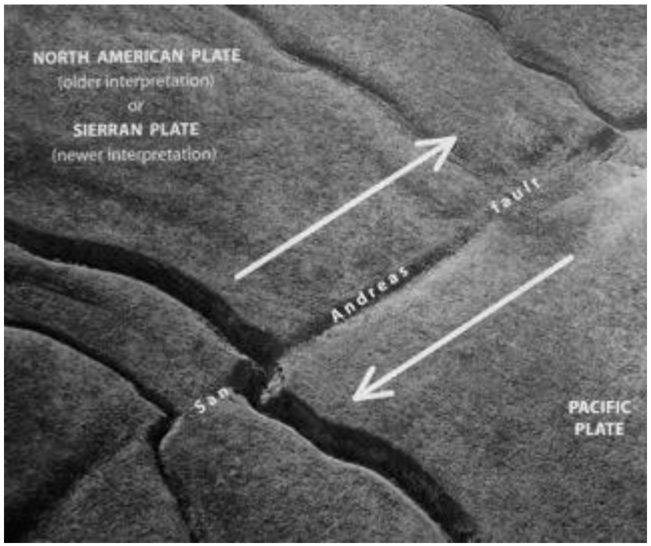
Box 5 stratigraphy

Box 7A cross-bedding in sandy stream deposits

Coarse to gravelly sand with worn and tumbled bones in Box 13

- Fossils are hard to make!
- This site, with its particular geologic history, made lots.
- San Andreas Fault tectonics set the stage, and continues to act on California.
- Marine algae (diatoms) deposited 5 to 15 million years ago reached across those millions of years to trap, kill, and preserve Pleistocene Ice Age animals and plants.
- We can see the water in the rocks – the streams and rivers that flowed across the alluvial plain from the mountains.
- Animals didn’t die in TAR PITS but were entrapped in asphalt seeps.
- We’re not done! We don’t have all the answers. And that’s what keeps us thinking and working every day.

In other words…



Heyer Meldahl, 2011

Tectonics

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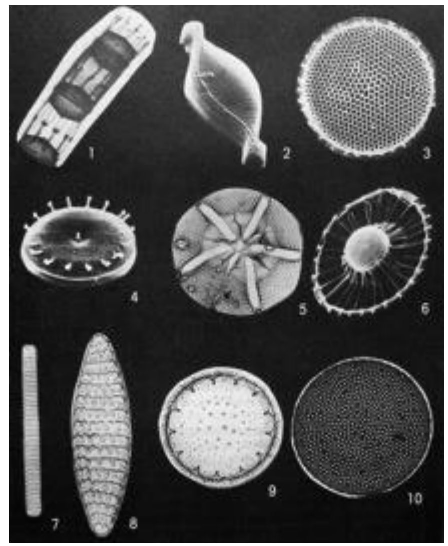


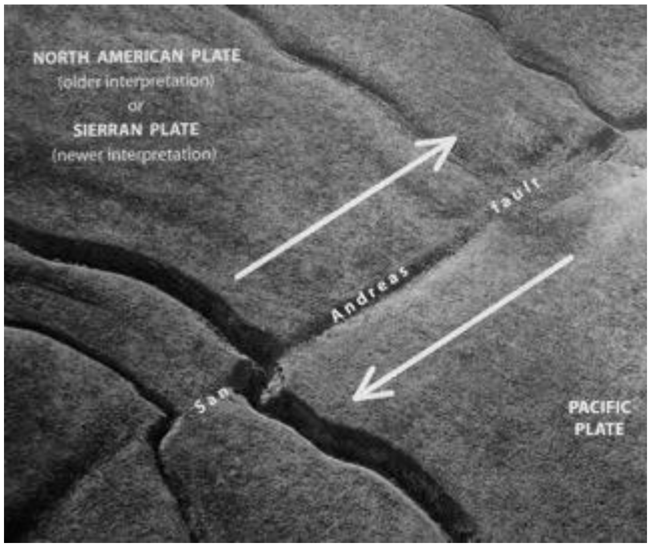
Kennett, 1982

Diatoms

=

La Brea Fossils

In even other words…



Heyer Meldahl, 2011

Oligocene thru Pleistocene Tectonics

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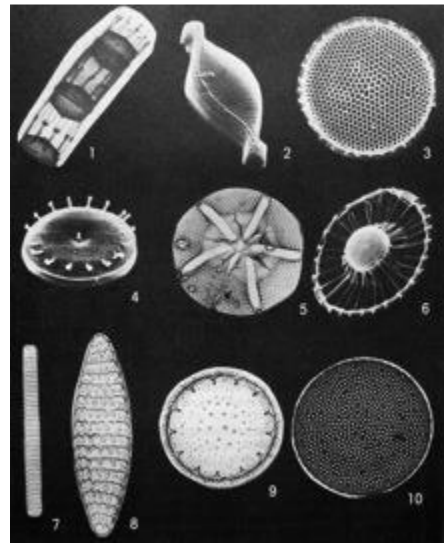

Kennett, 1982

Miocene Diatoms

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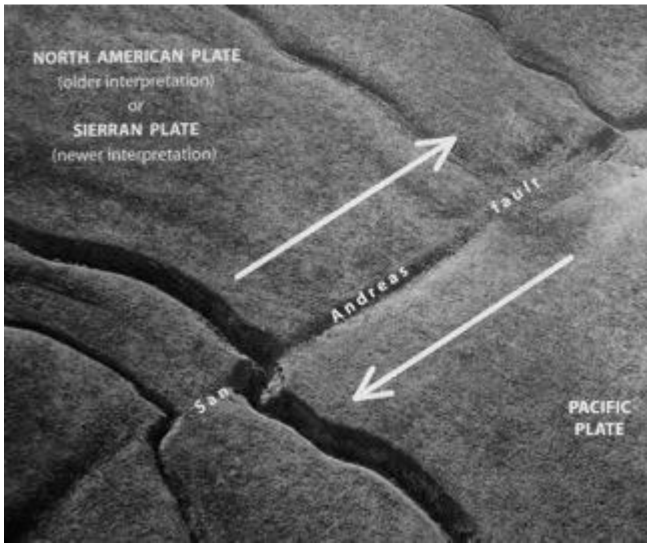
Pleistocene
La Brea Fossils

In still other words…



Heyer Meldahl, 2011

The Mastermind

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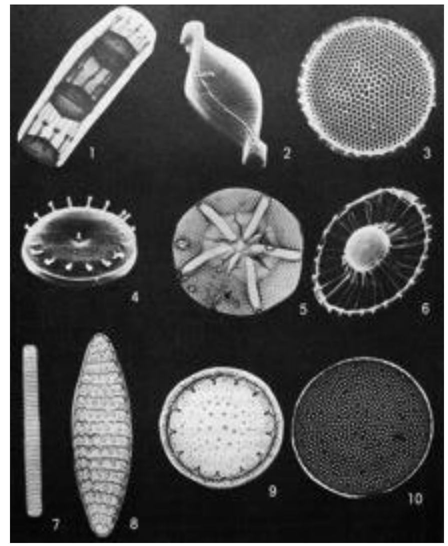

Kennett, 1982

The Zombie Killers

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The Victims

The Miocene killed and preserved the Pleistocene.
And Rancho La Brea is the scene of the crime.