Excerpt from

Geologic Trips
San Francisco and the Bay Area

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GEOLOGIC TIME SCALE				
Era	Period	Epoch	MY*	Event
Cenozoic	Quaternary	Holocene	0.01	Bluff formed, Fort Funston
		Pleistocene	2	Ice ages, early man (2 MY) San Francisco Bay formed Modern Coast Ranges formed Merced fm. deposited
	Tertiary	Pliocene	5	Drakes Bay fm. deposited Continued uplift of Coast Ranges
		Miocene	22	Monterey Shale deposited
		Oligocene	37	San Andreas fault formed (25 MY) Continued movement to present
		Eocene	58	Uplift and erosion of ancient Coast Ranges begins
		Paleocene	65	Pt. Reyes Conglomerate deposited
Mesozoic	Cretaceous	Upper	100	Last dinosaur (65 MY) Youngest Franciscan (65 MY) Franciscan subduction ends
		Lower	145	Granite intruded in Sierras
	Jurassic		208	Smartville docked Oldest Franciscan (175 MY)
	Triassic		245	Sonomia docked and North America extended to Sierras (225 MY) First dinosaur (275 MY)
Paleozoic			570	First fish (340 MY) First trilobite (570 MY)
Pre-Cambrian			4600	Bacteria (2100 MY) Formation of earth (4600 MY)

*MY - Millions of years to beginning of time period

GEOLOGIC HISTORY OF THE SAN FRANCISCO AREA

If you had visited San Francisco during early Jurassic time, 200 million years ago, you would not have seen much. You would have been in a deep ocean, an ancient version of the Pacific, and you would have been far from shore. The western edge of the North American plate was 100 miles to the east, near the present-day Sierra foothills. There was a subduction zone along the western boundary of the North American plate, near the present-day mother lode, and the oceanic plate under the ancient Pacific was moving east into that subduction zone.

If you had been patient and had stuck around until mid-Jurassic time, another 25 million years or so, you would have seen the Smartville terrane passing you by and headed toward this old subduction zone. Smartville was being carried toward the subduction zone on an ancient version of the Farallon plate. When the Smartville terrane reached the subduction zone, it plugged it up and became part of the North American plate. North America was thus extended to the present-day Coast Ranges. Since the old subduction zone was plugged up, a new subduction zone was formed along the new western margin of North America. The Farallon plate continued to move into this new *Franciscan* subduction zone, and the Franciscan rocks began to be formed.

For the next 110 million years, during late Jurassic and most of Cretaceous time, the ocean floor of the Farallon plate continued to move eastward into the Franciscan subduction zone. The lower part of the Farallon plate slid below the North American plate and was largely consumed in the earth's mantle. Much of the upper part of the plate was scraped off in the subduction zone to form the Franciscan rocks. Most of the new rock units that were added to the subduction zone were inserted below the rocks that were already in the subduction zone. Tens of thousands of feet of Franciscan rocks accumulated in the subduction zone in this manner, including the Angel Island terrane, the Alcatraz terrane, the Marin Headlands terrane, and the San Bruno Mountain terrane, as well as the melanges that separate these terranes.

Some of the Franciscan rocks were carried to depths of over 30 miles in the subduction zone. Other rocks were not buried very deeply, but were crumpled and rose above the surface of the ocean to form a chain of islands, an ancient version of the Coast Ranges.

While the Franciscan rocks accumulated in the subduction zone, magma was being generated at depth. This magma forced its way upward along the western edge of the North American plate. The magma cooled at depths of a few miles below the surface of the earth to form the granitic rocks of the Sierras. By late Cretaceous time many parts of the ancient Sierras were being uplifted and exposed to erosion. Some of the quartz and feldspar grains from the weathered granite were carried back into the subduction zone and became part of the younger Franciscan rocks, such as the San Bruno Mountain terrane.

By Oligocene time, the Farallon plate had been almost entirely consumed in the Franciscan subduction zone and the East Pacific Rise and Pacific plate began to enter the subduction zone. As the Pacific plate entered the subduction zone it was still moving northwest away from the East Pacific Rise spreading center. Since the Farallon plate was no longer pushing against the North American plate, subduction suddenly stopped. Instead, the Pacific plate captured the westernmost edge of the North American plate and began to carry it northwest with the rest of the Pacific plate. The San Andreas fault formed along this new boundary between the North American and Pacific plates, and the future Los Angeles began to slowly move north toward the future San Francisco.

Part of the large granite batholith that formed the southern Sierras was on the piece of the North American plate that was captured by the Pacific plate. This piece of granitic crust, now called the Salinian block, was carried several hundred miles to the north by the San Andreas fault. Parts of this block now form Montara Mountain and the basement rocks of the Point Reyes Peninsula.

During Tertiary time, the rocks along the old subduction zone began to be uplifted since they were no longer being pulled into the subduction zone. Eventually, they were uplifted high enough to form a range of mountains, an early form of the Coast Ranges. At times this range of mountains was separated from the Sierras by a shallow embayment of the ocean, an early form of the Great Valley. As uplift of the Coast Ranges continued, Franciscan rocks that had once been buried at depths of over 30 miles were eventually exposed at the surface of the earth.

Continuing movement along the San Andreas fault system broke the Coast Ranges into many large blocks. Some of these blocks continued to be uplifted whereas other subsided. Still others went up and then changed their minds and went down. The high blocks became mountain ranges. Sedimentary rocks were deposited in the low *basin* areas between the high blocks. Sedimentary rocks that accumulated in this manner include the Point Reyes Conglomerate during Paleocene time, the Monterey Shale during Miocene time, the Drakes Bay Formation during Pliocene time, and the Merced Formation during Pleistocene time. As the Coast Ranges continued to be jostled by the San Andreas fault, many of the sedimentary rocks in the basins were folded, faulted, and uplifted.

During Pliocene time, much of the Coast Ranges were eroded to a low, rolling topographic surface that was near sea level. In late Pliocene time, this nearly flat Pliocene topographic surface was broadly uplifted and began to be carved by rivers and the ocean. Most of the major topographic elements of the present Coast Ranges have been formed by erosion of this late Pliocene topographic surface. Remnants of this flattish erosional surface now form the tops of some of the mountains in the Coast Ranges, at elevations of several hundreds of feet to several thousands of feet. You are standing on this surface when you are at the top of Mt. Tamalpais, ten miles northwest of San Francisco.

Although most of the Coast Ranges continued to be uplifted during Pleistocene time, the area around San Francisco Bay subsided, and the Pacific Ocean reached eastward through the Golden Gate and flooded out to form San Francisco Bay. The hills near the Golden Gate were submerged to form the San Francisco peninsula, the Marin Headlands, and the Tiburon Peninsula. The tops of some of the hills became islands in the bay, such as Alcatraz Island and Angel Island.

During Pleistocene time, San Francisco Bay alternately emptied and filled as sea level fell and rose with the advances and retreats of the Pleistocene glaciers. When sea level was low, the Sacramento River flowed through the Golden Gate and deposited sand along the Pacific shoreline tens of miles west of the present shore. Much of this sand was blown inland to form the sand dunes that covered much of northern San Francisco. During interglacial times, as at present, sea level was high, the bay was full of water, and the Sacramento River dumped its load of sediments before reaching the bay.