The San Andreas Fault System – Paul Withers

Wallace RE, The San Andreas Fault System, California, USGS Professional Paper 1515, 1990 (helpfully pirated at http://www.johnmartin.com/earthquakes/eqsafs/INDEX.HTM)
Schultz SS and Wallace RE, The San Andreas Fault, USGS General Interest Publication, 1989 (http://pubs.usgs.gov/gip/earthq3/index.html) [useful images]

Tectonically speaking, rocky planets are a ductile asthenosphere overlain by a brittle lithosphere. The behaviour of the lithosphere has an immense influence on both the heat budget and surface geology of the planet. Earth's lithosphere currently supports plate tectonics, Venus has stagnant lid convection, the Moon is a one plate planet, and Martian tectonics are a mystery. Europa is covered with faults and evidence of plate motion.

Large, light, rigid caps of lithosphere float around on the convection currents of the mantle/asthenosphere. At their boundaries, they either converge, diverge, or slide past each other. Here in California, the oceanic Pacific plate slides past the continental North American plate. The messiness of the Pacific-North American boundary is primarily due to the subduction of the oceanic Farallon plate beneath continental North America. This plate once underlay part of the Pacific Ocean east of the Juan de Fuca ridge and East Pacific Rise. Only small remnants remain; most has been swallowed to influence Arizona's volcanic history (see fieldtrips passim ad nauseam). The San Andreas fault system was formed 30 My ago when parts of the Pacific plate began subducting as well. "The San Andreas fault system, a complex of faults that display predominantly large-scale strike slip, is part of an even more complex system of faults, isolated segments of the East Pacific Rise, and scraps of plates lying east of the East Pacific Rise that collectively separate the North American plate from the Pacific plate." The bend in the fault north of LA is characterized by significant north-south compression.

"The San Andreas fault system is considered to lie principally within a belt about 100 km wide by 1,300 km long." Current speeds between the North American and Pacific plates are 30 – 40 mm/yr, with a somewhat lower average speed causing 300 – 500 km strike-slip movement in total. "The modern San Andreas fault apparently did not come into being in southern California until the opening of the Gulf of California during Pliocene time, about 4 Ma, since which time Baja California has moved 260 km away from mainland Mexico. The San Andreas fault is commonly referred to as the boundary between the Pacific and North American plates, which is true in the sense that the rocks on the west side of the fault are moving somewhat in concert with the Pacific plate, although those rocks actually are displaced fragments that once were part of the North American plate" "The modern trace of the San Andreas fault in central California probably had only minor slip until about 12.5-10 Ma and probably was not the strand of dominant slip before 7.5-5 Ma."

"Deformation occurring at the times of large strike-slip earthquakes is concentrated within a few tens of kilometers of the surface fault rupture, indicating that earthquake fault slip is largely confined to the upper 10 to 15 km of the crust." The quakes are shallow, unlike those in subduction zones.

Seismicity is not uniformly distributed along the fault system. The central regions creep aseismically, some have lots of small quakes, and some have infrequent but large quakes. This behaviour is correlated with the local geological setting. CO_2 lubrication,

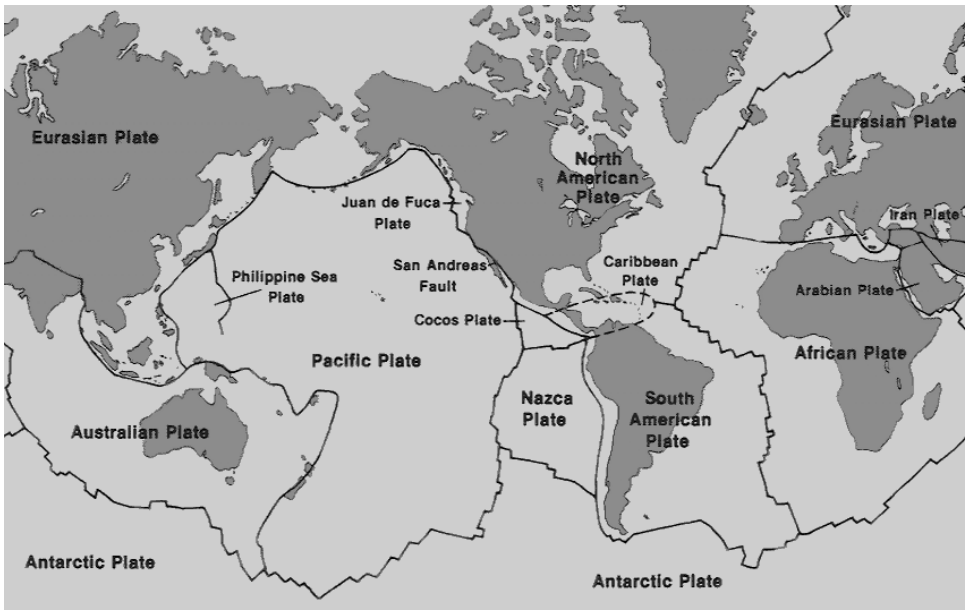
increased pore pressure, and decreased frictional strength may be permitting the gradual creep.

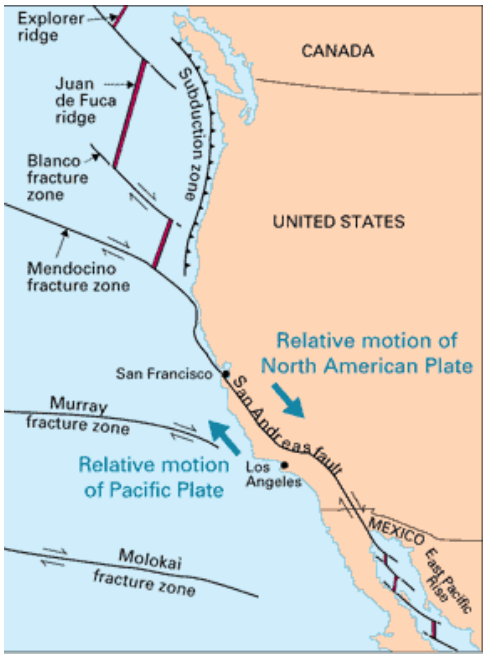
"The crust along the San Andreas fault system thickens from about 16 km at Cape Mendocino, in northern California, to about 30 km in southern California and thus is significantly thinner than the average thickness (36 km) for the conterminous United States. Lithospheric thickness (20-60 km) is also substantially less along most of the San Andreas fault system than is typical for continental areas (60-170 km). The lithosphere is thinnest at both ends of the fault system, at the Mendocino triple junction on the north, where the North American plate is sliding off the edge of the Gorda plate as it moves northward, and in the Salton Trough on the south, where onshore spreading centers of the East Pacific Rise are generating new crust in a rift between the North American and Pacific plates. In contrast, the lithosphere is abnormally thick (250 km) in the Tranverse Ranges, where "subduction" of lithospheric mantle is occurring."

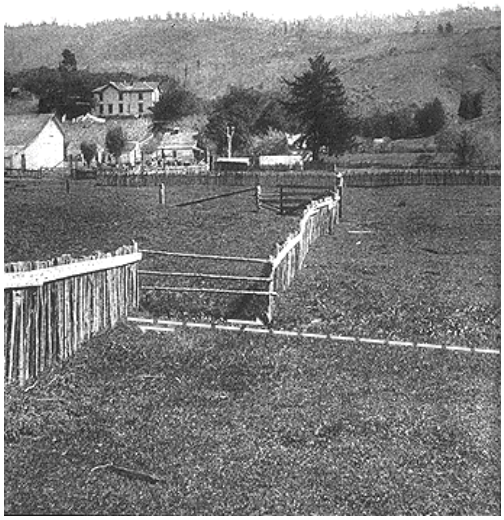
"From what we currently know of crustal stress and heat flow, neither is influenced by proximity to the San Andreas fault, the most conspicuous and best studied plate-boundary fault on the continents." There is a problematical paradox: "(1) inplace and laboratory measurements of rock stress imply average fault stresses of about 50 MPa or more, and (2) the absence of a local heat-flow anomaly and the energy balance of the fault imply an average fault stress of about 15 MPa or less."

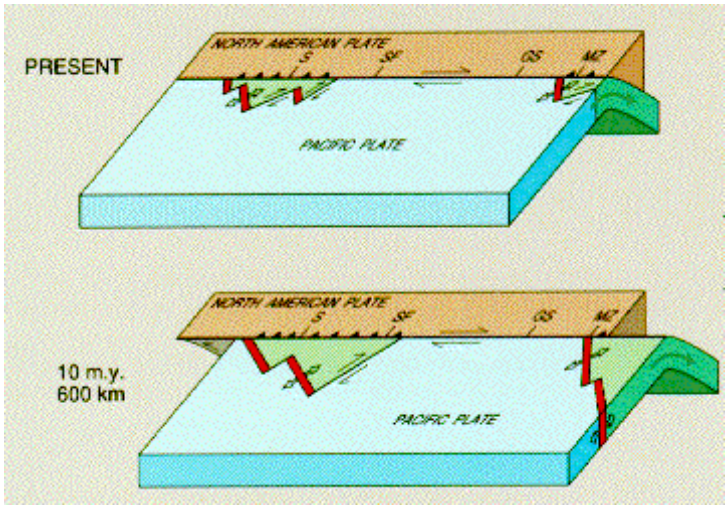
"The San Andreas fault is marked in the landscape by a series of linear valleys and mountain fronts, aligned lakes and bays, elongate ridges, and disrupted or offset stream channels." In the shear zone itself, sheared rocks are easily eroded and cause a valley-like shape. "Along its entire length, the fault zone exhibits peculiar, anomalous drainage patterns." Shifted fences are also cool (9ft offset, Point Reyes, photographed by Gilbert)

Since 1800, there have been about 20 quakes greater than magnitude 7 in the California-Nevada region. Half of these have occurred in the San Andreas fault system, a quarter in the Basin and Range province, and a quarter on the Juan de Fuca plate boundary. "Except for the two largest events, the great 1857 (Fort Tejon, 2 deaths) and 1906 (San Francisco, 2000 deaths) earthquakes that together ruptured two-thirds of the total length of the San Andreas fault, large earthquakes are conspicuously absent along the master fault itself." The 1906 earthquake was felt in LA, Oregon, and Nevada. It spawned Reid's elastic rebound theory. Loma Prieta (1989) and Northridge (1994) both killed 60ish people and cost several $B or more.


Eurasian Plate
North American Plate
Juan de Fuca Plate
Eurasian Plate
Iran Plate
Philippine Sea Plate
San Andreas Fault
Caribbean Plate
Arabian Plate
Cocos Plate
Pacific Plate
African Plate
Nazca Plate
South American Plate
Australian Plate
Antarctic Plate
Antarctic Plate


Explorer ridge
CANADA
Juan de Fuca ridge
Subduction zone
Blanco fracture zone
UNITED STATES
Mendocino fracture zone
Relative motion of North American Plate
San Francisco
San Andreas fault
Murray fracture zone
Relative motion of Pacific Plate
Los Angeles
MEXICO
East Pacific Rise
Molokai fracture zone




PRESENT
NORTH AMERICAN PLATE
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PACIFIC PLATE
10 m.y.
600 km
NORTH AMERICAN PLATE
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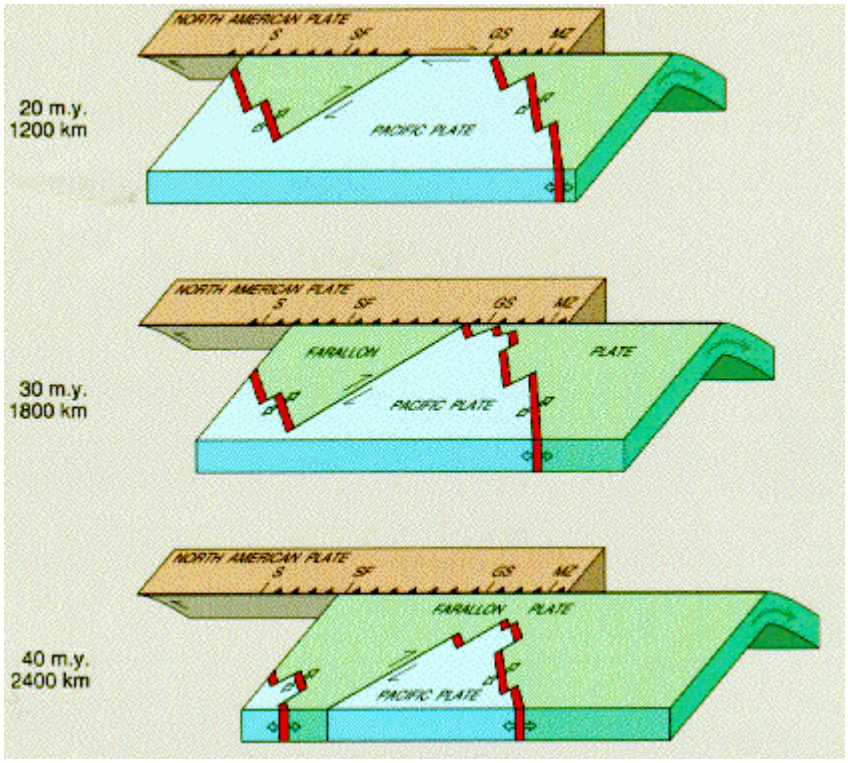
GS
MZ
PACIFIC PLATE


20 m.y.
1200 km
NORTH AMERICAN PLATE
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30 m.y.
1800 km
NORTH AMERICAN PLATE
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PACIFIC PLATE
40 m.y.
2400 km
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PACIFIC PLATE