Appendix 9: California – An Analogue to Queen Charlotte Basin?[7]

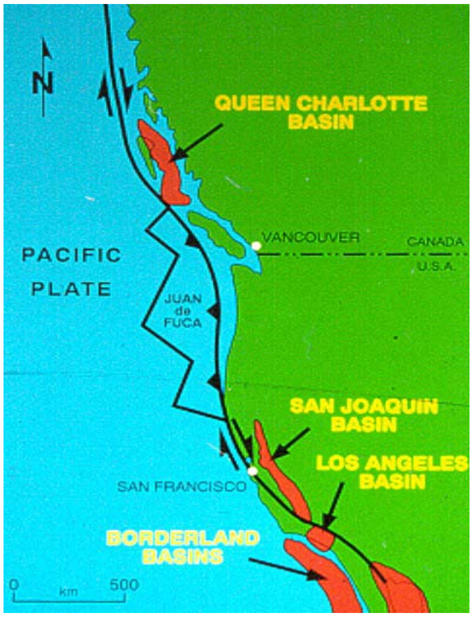


Figure 1. Cartoon of Pacific and North American plate boundaries.

Tectonically both the Queen Charlotte region and California are dominated by a transform plate boundary between the Pacific and North American plates (Fig. 1). In California the plates are moving at a relative rate of 40 km/Ma which is mainly carried by the San Andreas Fault, but also by a number of secondary faults (Fig. 2). Off British Columbia the rate is 48 km/Ma and is almost entirely carried by the Queen Charlotte Fault west of the Islands.

Geometry of the plate boundary in California has changed dramatically as two triple junctions migrated along the coast; the main transform fault has progressively moved inland over the years. The geometry of the Queen Charlotte Fault seems to have been fairly stable over tens of millions of years; triple junction complications have mostly been accommodated in oceanic crust to the south.

Both regions experienced extension in the Miocene followed by basin inversion and compression in the Pliocene. Small changes in the relative plate motion can explain the Pliocene compression but not the Miocene extension.

Hundreds of scientists have been detailing California's geology and tectonics since the 1800's. Many current studies are aimed at understanding seismicity including measuring the strain partitioning along the different faults in California in order to delineate potential hazards (Fig. 3). Over 700 hundred seismometers monitor every temblor; in some areas events can be mapped with accuracy of meters resulting in new insights into how faults behave. In contrast the Queen Charlotte region has only 9 permanent seismograph stations; the depth distribution of earthquakes on the Queen Charlotte Fault is entirely unknown. Stations lie east of the Fault and do not provide a good geometry to determine depth. Earthquakes on the shelf occur to depths of 15-20 km (Bird, 1997).

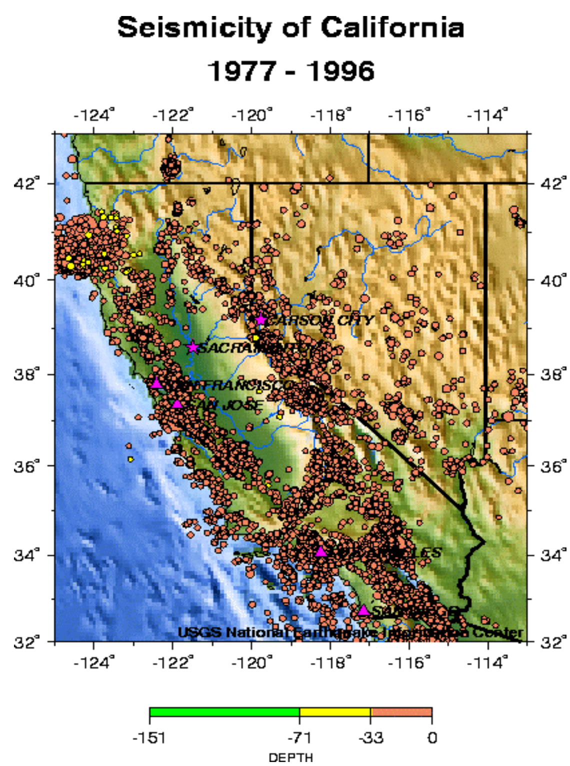
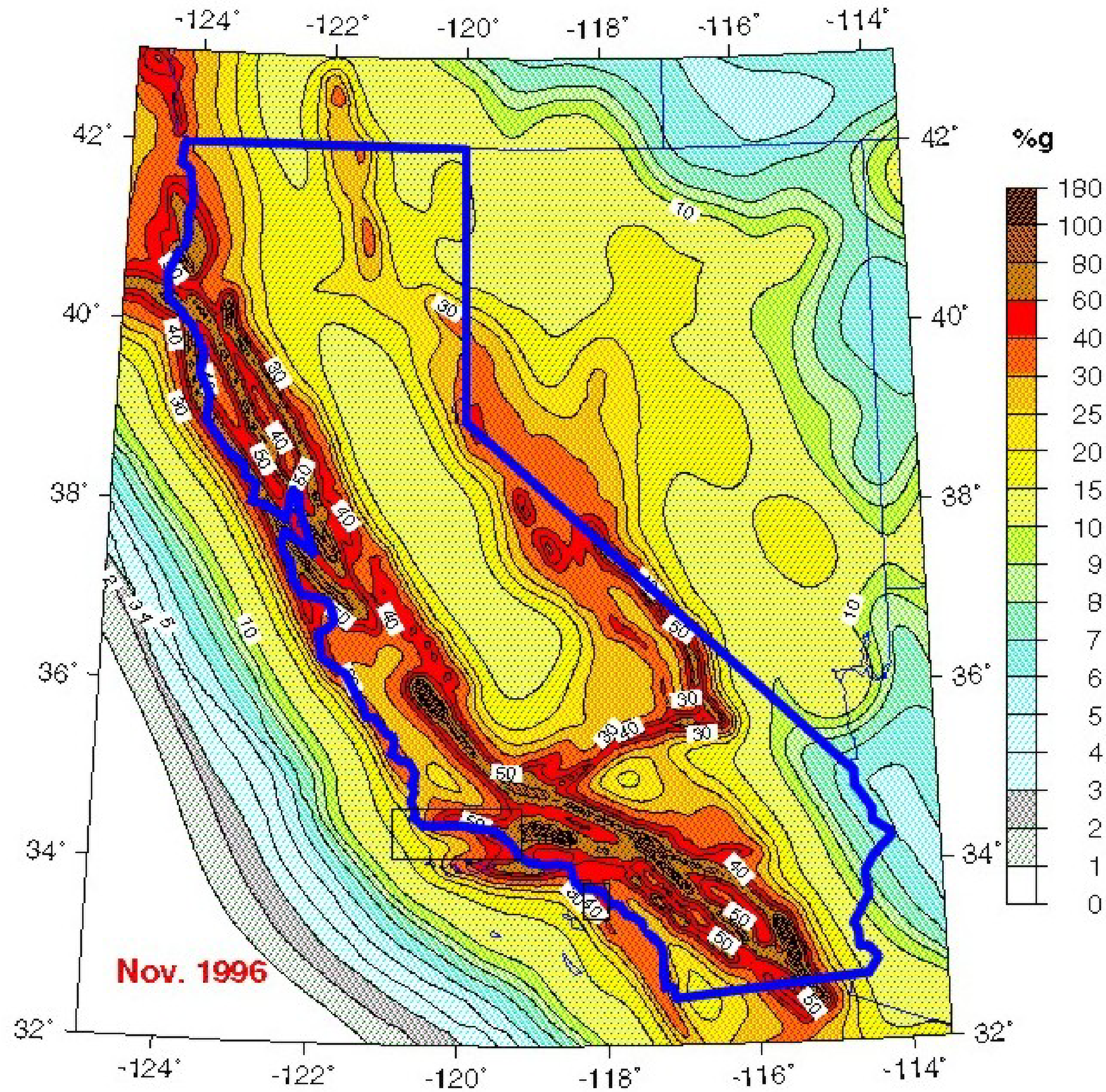


Figure 2. Seismicity is distributed along many faults in California.

[7] Submission to Dr. D. S. Strong, Chair, Scientific Review Panel, BC Offshore Hydrocarbon Development prepared by Kristin M. M. Rohr. December 2001.

Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years

site: NEHRP B-C boundary



For California portion: U.S. Geological Survey - California Divison of Mines and Geology

For Nevada and surrounding states: USGS

Figure 4. Oil, gas and geothermal fields in California, 2001, from California Division of Oil. Gas. and Geothermal Resources.

Seismicity and Oil and Gas Production in CA

California has a long and rich history of utilizing and producing oil and gas. In the 1500's natives were using asphaltum from ground seeps to seal containers; Europeans learned to caulk boats with it. The first commercial well began production in 1876; production has varied since then, but reached a peak in 1985 at 423.9 barrels of oil. Oil wells tend to be in southern California and purely gas wells in northern California (Fig. 4). In 2000 46,799 oil wells and 1,169 gas wells were producing hydrocarbons from 288 fields (Fig. 4); total production was 307.4 million barrels of oil and 379.1 billion cubic feet of gas. 1,412 offshore wells accounted for 17.6% of the total oil production and are largely found off southern California in a seismically active region. Areas within 3 miles offshore are regulated by the state and the rest by the federal government.

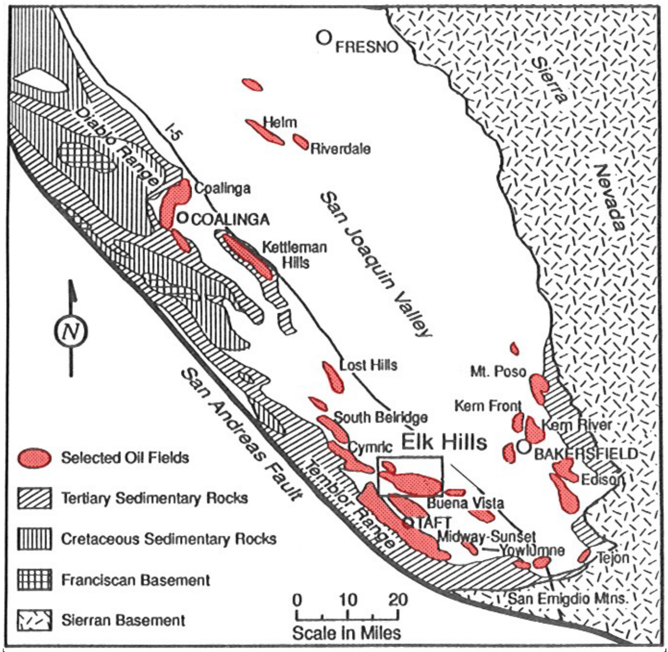


Figure 5. Cartoon of San Joaquin sedimentary basin highlighting selected oil fields (from Reid and Wilson, 1990). Note that many are within 20 miles of the San Andreas Fault. 38,733 wells within this entire region produced 217.3 million barrels of oil or 71% of California's oil in 2000.

Damaging earthquakes have also been a part of California's history killing hundreds of people and causing hundreds of millions of dollars of damage over time. In available accounts of damage caused by major earthquakes, damage to wells and ensuing oil spills is not mentioned (e.g. Dept. of Conservation; von Hake, 1971). An official from California's Division of Oil, Gas and Geothermal Resources which regulates drilling and production of wells could recall no instance of damage done to offshore production facilities by an earthquake. An earthquake near Coalinga (Fig. 5) (M=6.7, 1983) on a blind thrust caused minor damage to storage tanks which were stressed by sloshing fluids. In any event these tanks are surrounded by berms to protect against the more imminent danger of leakage from corrosion. However, nearby houses and commercial buildings of unreinforced adobe and concrete were heavily damaged leaving 1,000 people homeless.

Spills from blow-outs were not unusual in early days of drilling, but engineers learned to control the spontaneous flow of oil out of most pressured zones. The last major blow-out offshore occurred in 1969 off Santa Barbara in federally regulated land. The state placed a temporary moratorium on drilling offshore until stricter regulations were in place to prevent another such occurrence. The blow-out was not caused by an earthquake but rather the simple effect of drilling into a highly pressured zone. Since that time exploration and production have been highly regulated but active at a modest level. Eleven development wells were drilled in Federal lands in 2000. In 1995 ARCO and a subsidiary spent US$ 2.8 million on a 3D survey covering a 10 square mile area off Long Beach to develop a drilling program.

Seismic activity creates some risk but geologically has created structures favorable to trapping hydrocarbons. Slight compression across the plate boundary has folded and faulted the adjacent basins into structures which trap hydrocarbons; the same kind of structures are observed in Hecate Strait.

References

1995 Annual Report of the State Oil and Gas Supervisor, Division of Oil, Gas and Geothermal Resources, California Department of Conservation, 279 pp.

2000 Annual Report of the State Oil and Gas Supervisor, Division of Oil, Gas and Geothermal Resources, California Department of Conservation, 257 pp.

71st Annual Report of the State Oil and Gas Supervisor, 1985, Division of Oil, Gas and Geothermal Resources, California Department of Conservation, 158 pp.

Bird, A., 1997, Earthquakes in the Queen Charlotte region: 1982-1996, M. Sc. Thesis, Univ. of Victoria, B.C. Canada.

California of Oil Gas and Geothermal Resources, An Introduction, Division of Oil Gas and Geothermal Resources, California Department of Conservation, 85 pp.

Malone, S., 1998, Network Information Summaries from CNSS and other Networks, Report for Council of the National Seismic System.

Reid, S. A. and M. L. Wilson, 1990, Field trip stops at the Elk Hills oil field, Kern County, California; in J.G. Kuesport and S. A. Reid (ed.s) Structure, Stratigraphy and Hydrocarbon Occurrences of the San Joaquin Basin, California, 1990, Pacific Section, Society of Economic and Petroleum Mineralogists and American Association of Petroleum Geologists, Bakersfield, CA, p.277-286.

von Hake, C. A.,1971, Earthquake History of California, Earthquake Information Bulletin, v. 3, No. 2.