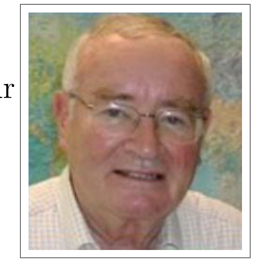
Bob Garrison's Geology Notes for the Big Basin Bus

Here are some comments provided by Bob Garrison, an Emeritus Professor of Ocean Sciences at UCSC, and one of the founding faculty of what was then called (in 1968) the "Board of Studies in Earth Sciences". He knows about our local geology.



Bob Garrison

He recommends having a look at the USGS geological map of Santa Cruz County, which is available on-line at http://pubs.usgs.gov/of/1997/of97-489/scruzmap.pdf.[1] This map contains a substantial amount of information about our local geology, and can be viewed using a good pdf viewer such as Adobe's Acrobat Reader. You will have to zoom it to see various details. There is a key on the map, but a more helpful key that provides meanings for various symbols on the map (such as "Tsm", which stands for Santa Margarita Sandstone) is available here: http://geo-nsdi.er.usgs.gov/metadata/open-file/97-489/metadata.faq.html#what.7. One can easily spend several hours poring over this map, learning what the various colors mean and gradually making the correspondences with familiar features identified more clearly on ordinary maps of Santa Cruz County.

What follows are a few of Bob Garrison's words. (The footnotes are mine.)

The ride to Big Basin

As you leave Santa Cruz driving north on Highway 17, you will see sporadic, small road-cuts in whitish sandstones belonging to the Santa Margarita Sandstone, late Miocene age (about 10 million years old).[2] These are the same crumbly sandstones you will see in road-cuts on the Mt. Hermon road. Studies (by one of my ex-students) showed that these sandstones were deposited in a large channel that connected the paleo-San Joaquin Basin to the east with the open Pacific Ocean to the west. Apparently there were very strong currents in this channel, somewhat analogous to the strong currents that flow back and forth in the Golden Gate channel. The result is winnowed sands and gravels that locally are very rich in fossils, *e.g.*, shark's teeth, marine mammal bones, etc.

Once you reach Highway 9 and the San Lorenzo Valley, the dominant geological feature will be the Ben Lomond Fault, which extends from the deep interior of the Santa Cruz Mtns. to the coast where it enters the ocean very near Woodrow Avenue. (It also runs practically through our backyard!) This fault, supposedly inactive, has uplifted the Ben Lomond mountain block of granitic rocks (which will be on your left as you drive up Highway 9)

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[1] The HTML links in this pdf file are clickable.

[2] It's good to get familiar with a few geologic terms involving time scales, so we know a bit about when we are talking about. We have appended to these notes a chart that summarizes and provides the names for a few of them. This chart, which is not to scale, uses the abbreviation "mya" to mean "million years ago". Some geologists use "BP" to mean "before present". It is not easy to comprehend such long periods of time. One way to get a bit of a handle: A lifetime is about 100 years, so in 1000 years: 10 lifetimes, in 10,000 years: 100 lifetimes, in 100,000 years: 1000 lifetimes, in 1 million years: 10,000 lifetimes, and in 10 million years: 100,000 lifetimes.

> above the Tertiary sedimentary rocks along the San Lorenzo Valley where you will be driving. I do not know of any good exposures of these latter rocks along the highway, but I am also not very familiar with the geology of this area.

Bob also earlier told me about the granitic rocks underlying Ben Lomond Mountain (including the Fall Creek area and parts of the upper UCSC campus), which correlate in both composition and age (Cretaceous—over 100 million years ago, or 1 million lifetimes) with some of the granitic rocks in the Sierra Nevada. The prevalent theory at present is that the local granitic rocks (along with those in the Santa Lucia and Gabilan ranges) were once the southern part of the Sierra Nevada belt, but have been offset several hundred kilometers toward the northwest along the San Andreas and related faults. These granitic rocks were originally magmas that occurred in large magma chambers (plutons) beneath a string of Andesite volcanoes that were subsequently eroded as the Sierra Nevada trend was uplifted.

Bob says he is not very familiar with the geology of the Big Basin Park area and the trails we will be taking, and that perhaps we can figure this out by looking at an ordinary map of the county, in conjunction with the geology map mentioned above. However he says:

> Once you reach the coast, you will be in late Miocene rocks of the Santa Cruz Mudstone ("Tsc" on our geologic map—about 7 to 9 millions years old), This is actually the upper part of the famous Monterey Formation, source of most of California's hydrocarbons. The term "Santa Cruz Mudstone" is only a local nomenclature. As you probably know, there is an extensive road-cut in this formation along Highway 1 just to the north of the mouth of Waddell Creek called the "Waddell Bluffs". These mudstones and siliceous rocks were deposited in a relatively deep-water environment that was beneath a highly productive upwelling zone that produced organic-rich sediments, the eventual source of oil and gas. If you look closely at this road-cut, you can see small but prominent carbonate structures called "concretions" that were formed by escaping or upward seeping gas.

The ride from Waddell Beach back to Santa Cruz

> On the ride back to Santa Cruz along Highway 1, you will be almost entirely in road-cuts of the Santa Cruz Mudstone. These are the light colored rocks whose organic matter has been leached away by weathering, producing the light colors. Where Highway 1 crosses Majors Creek, you will be in the center of an exhumed Miocene oil field, *i.e.*, an oil deposit that formed at great depth but subsequently was uplifted by movements along the San Andreas and other faults so that the oil became weathered at the earth's surface and converted to tar. The oil originally formed in a lower part of the Monterey Formation and migrated upward into the pore spaces of the Santa Margarita Sandstone, which is the so-called "reservoir rock" for this oil field that can be seen in the massive walls of Majors Creek.
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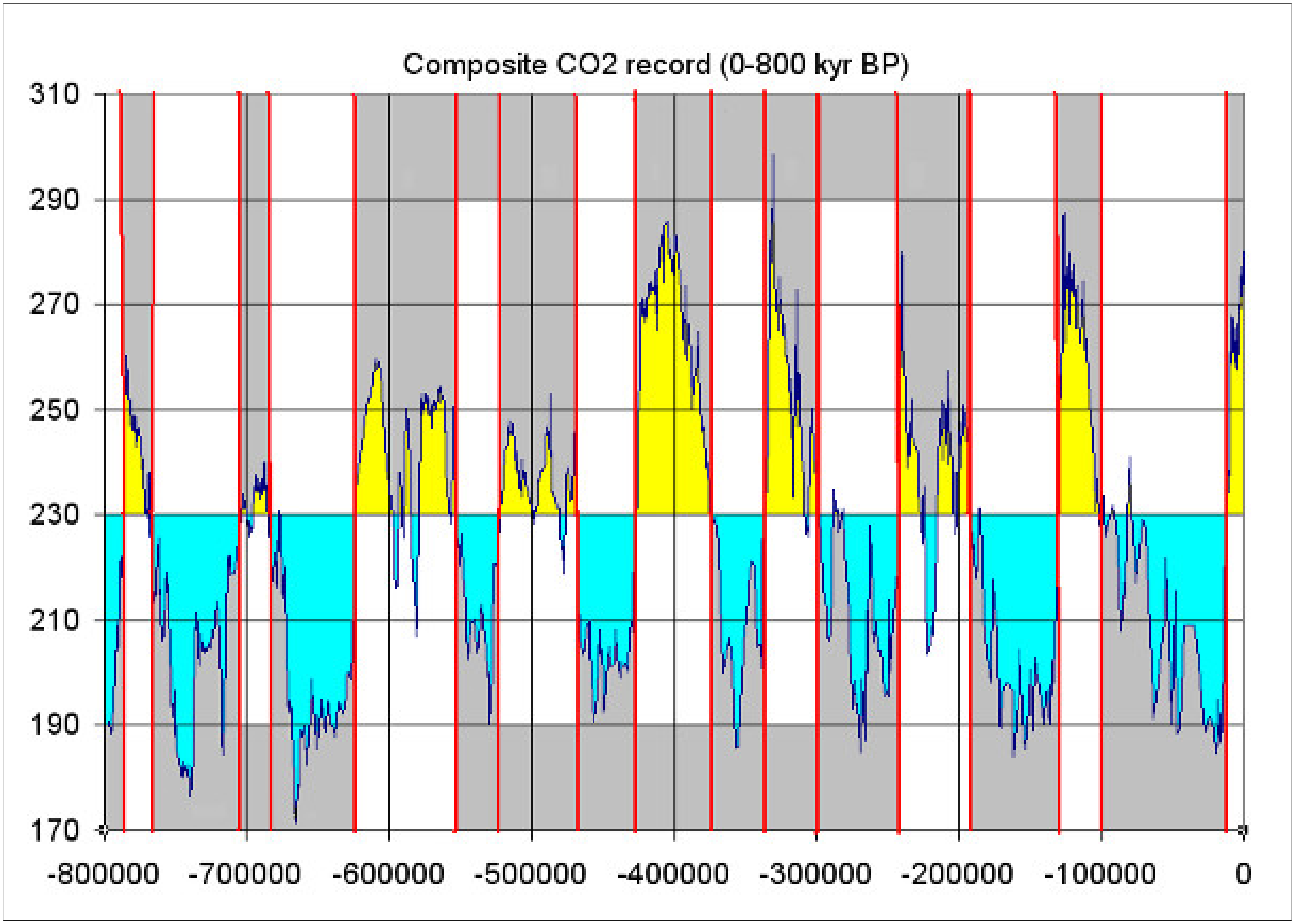
> At two places along Highway 1, you will have good views of uplifted marine terraces: First, between Scott Creek and Davenport, and second, between Majors Creek and the Santa Cruz City line. These are another manifestation of the uplift mentioned above, and further evidence of the geologically active area we live in!

Cenozoic (65.5 mya to present)	Quaternary (2.588 mya to present) Holocene (11,700 yrs to present) Pleistocene (2.588 mya to 11,700 yrs)
	Neogene (23.03 to 2.588 mya) Pliocene (5.332 to 2.588 mya) Miocene (23.03 to 5.332 mya)
	Paleogene (65.5 to 23.03 mya) Oligocene (33.9 to 23.03 mya) Eocene (55.8 to 33.9 mya) Paleocene (65.5 to 55.8 mya)
Mesozoic (251.0 to 65.5 mya)	Cretaceous (145.5 to 65.5 mya) Upper (99.6 to 65.5 mya) Lower (145.5 to 99.6 mya)
	Jurassic (199.6 to 145.5 mya) Upper (161.2 to 145.5 mya) Middle (175.6 to 161.2 mya) Lower (199.6 to 175.6 mya)
	Triassic (251.0 to 199.6 mya) Upper (228.7 to 199.6 mya) Middle (245.9 to 228.7 mya) Lower (251.0 to 245.9 mya)

This chart goes back for only the past 251 million years, to the beginning of the Triassic period. None of what we can see from the bus is older than that. The dinosaurs disappeared at the end of the Cretaceous period, at the last major extinction. The full chart is available from `http://www.ucmp.berkeley.edu/help/timeform.php`.



This chart shows the level of CO_2 in the atmosphere (in parts per million, or ppm) for the past 800,000 years. Glaciation periods occurred during the turquoise-colored times, roughly every 100,000 years, and our marine terraces were formed in similar cycles, as the sea level rose and fell, by several hundred feet. (In general, sea levels fall when glaciers form.) This chart is available from http://commons.wikimedia.org/wiki/File:Co2_glacial_cycles_800k.png.

As of this writing, the concentration of CO_2 in the atmosphere is over 400 ppm, clearly off the chart above. Extensive information regarding CO_2 levels is available at http://en.wikipedia.org/wiki/Carbon_dioxide_in_Earth%27s_atmosphere, and at http://co2now.org/.

– These notes were prepared
by Peter Scott on June 20, 2015.