Geologic Background for the Sierra Foothills

To understand what's going on as we raft through the Sierra foothills on the rivers, we first need to understand the dynamics of the Earth's crust. Figure 1 below shows a cross-section of the Earth, from the core in the middle of the Earth to its' outer "skin" – the crust.

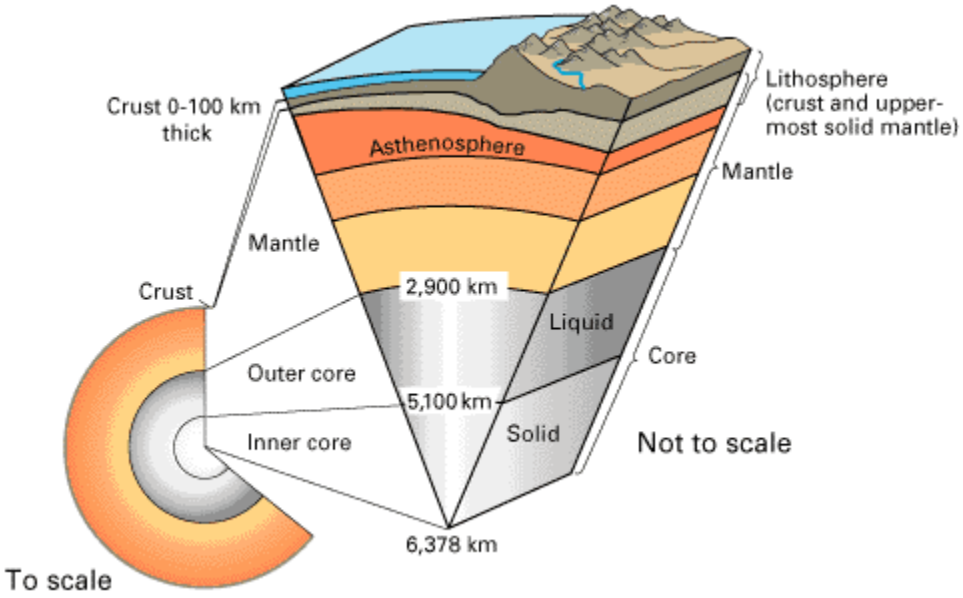

Figure 1. The different geologic pieces of Planet Earth.

Notice how thin the crust is compared to the rest of the planet – the part we live on is really just a very small part of the Earth. Note also that part of the core is liquid – it's still rock down there, but it's so hot that the rock flows like water. This internal heat mostly comes from radioactive decay of elements such as potassium and argon. (For a neat, more detailed discussion of the Earth's core, see http://www.physorg.com/news62952904.html .)

So the rock in the outer core of the Earth flows like liquid, but the rock in the mantle still moves like plastic or Silly Putty. It's not until you get to the crust that rock is cool enough and strong enough to be the solid, hard stuff we see when we are rafting.

This internal structure of the Earth creates something pretty interesting, though – with all the rock flowing and moving at depth, it puts a LOT of stress on the hard, solid crust. In fact, the crust is actually just "floating" on the moving planet underneath our feet. This "floating" movement of the crust is called "plate tectonics" or "continental drift". What happens is shown on Figure 2 below.

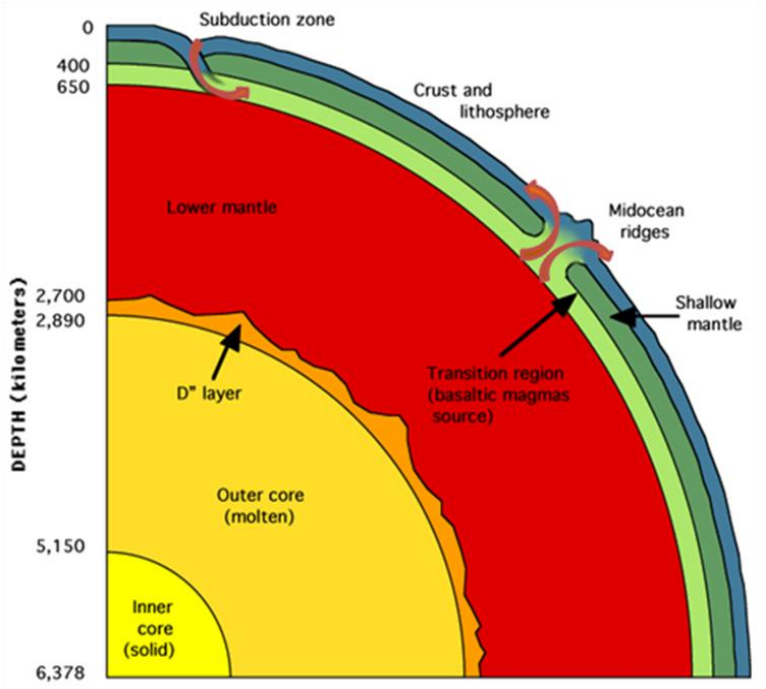

Figure 2. The driving movement of Plate Tectonics.

New crust is actually formed at the mid-ocean ridges. It moves away from these ridges and eventually runs into crust moving in a different direction. When this happens, part of the crust is forced down, melts and is resorbed by the mantle – thus the crust is always being formed and destroyed by Plate Tectonics. We feel this activity most as earthquakes and volcanoes.

For hundreds of millions of years, California has been the location of a subduction zone as seen on Figure 3.

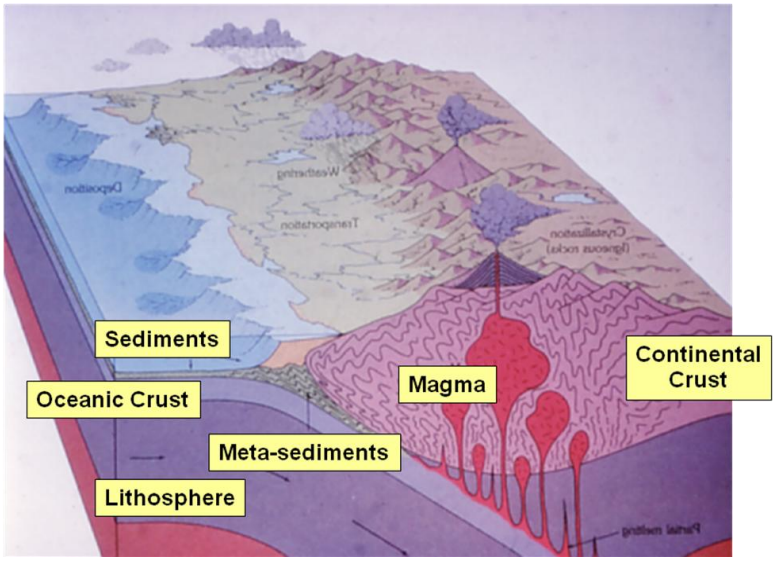

Figure 3. Cross-section through a subduction zone.

If you think of this cross-section as California, then the Sierra foothills is basically located in the area called “meta-sediments” – these are sediments that have been deposited on the edge of the continent but have been metamorphosed (or changed into different rocks) by all the pressure and temperature activity going on at the subduction zone.

Making matters even more complicated is the fact that there isn’t just the remnant of one subduction zone in the foothills, but at least 3 different ones that have collided with the western edge of North America. What follows is a general description of how this all happened.

The oldest subduction zone that smashed into North America and is preserved in the foothills is about 350 million years old. You need to remember that, since Plate Tectonics drives crustal movements, and since the crust moves about as fast as your fingernails grow, then over 350 million years the continents have moved a LONG way- thousands of miles in some cases!

Figure 4 shows a summary of what happened. There is a LOT going on in this Figure!!!

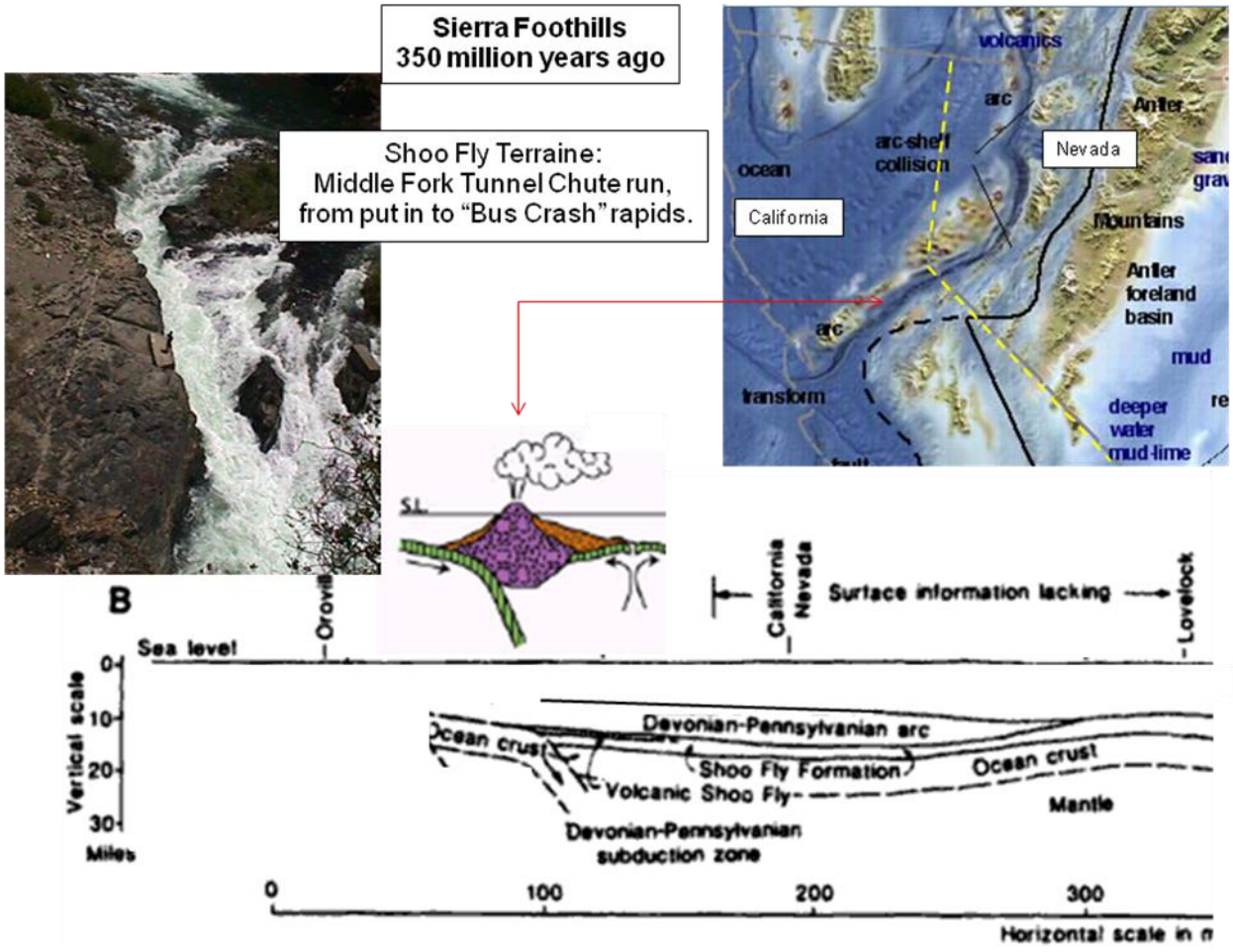

Figure 4. The Devonian in the Sierra Foothills.

Ok – the map in the upper right shows what this part of North America looked like 350 million years ago. You can see that it was mostly open ocean in California, with some islands

scattered around into Nevada and no big continent until you get to Utah! The red arrow shows where the American River is now and the little inset below the red arrow shows what the Devonian subduction zone might have looked like. The cross section below that goes from the Central Valley on the left into Nevada by about ½ way along. Note the name Shoo Fly – this will be talked about on the Tunnel Chute river guide. The picture, upper left, is of some of these rocks that can be seen at the Tunnel Chute. So these rocks were deposited waaaay offshore in the open ocean 350 million years ago.

Now we're going to jump ahead to about 250 million years ago, as seen on Figure 5 below.

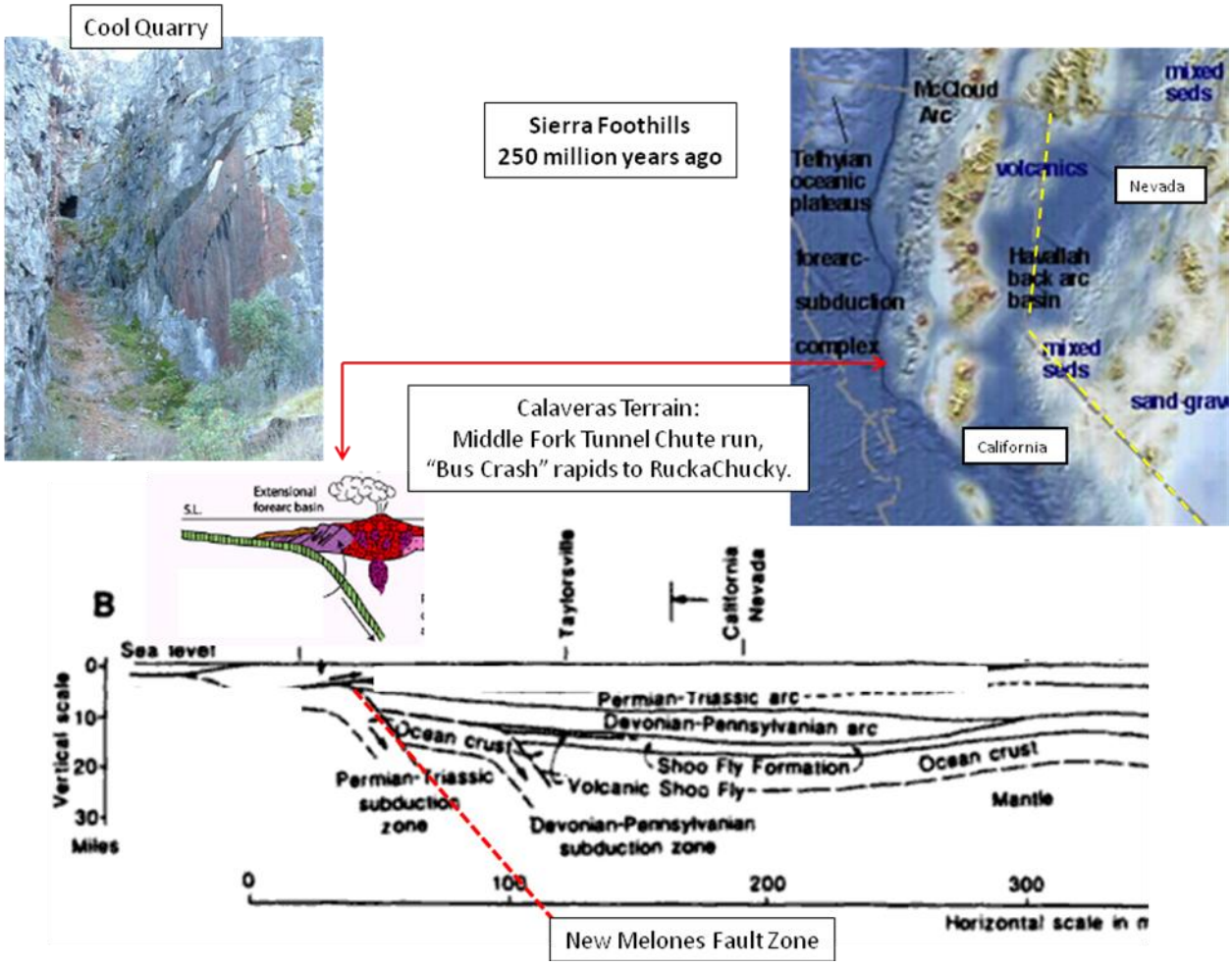

Figure 5. The Permian in the Sierra Foothills.

Yah – another complicated bunch of stuff. Again, the upper right picture is what California and Nevada looked like 250 million years ago. Still lots of open ocean and islands here and there. The subduction zone is again at the tip of the red arrow and shown underneath it and now in the cross section (that is getting more complicated). The New Melones fault zone is the "suture" of these different rocks and can be seen right at the bottom of "bus crash" rapids on the Tunnel Chute run – see that river guide for more details. The limestone in the Cool Quarry area is also Permain in age and has been used for road beds and refining sugar over the years.

Now we jump to “Jurassic Park”, about 150 million years ago – in Figure 6.

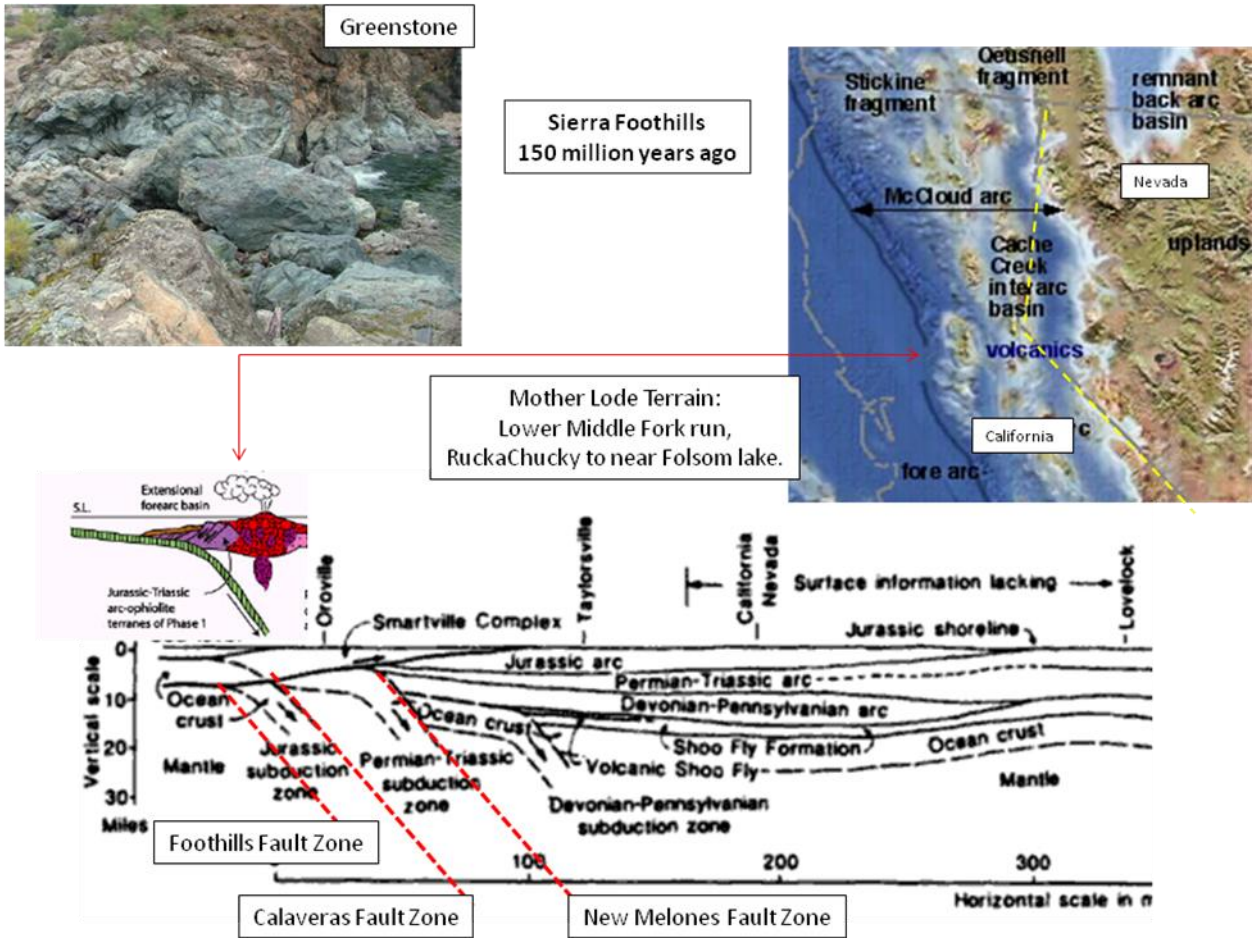

Figure 6. The Jurassic in the Sierra Foothills.

I hope you are getting used to these Figures by now. You can see that the western shoreline of the continent of North America was at about the California-Nevada border, so the rocks deposited in the foothills was still out in the open ocean. These rocks are the common “greenstone” that you see along the rivers (detailed in the individual river guides) – they were open ocean muds that accumulated about 80 miles offshore with 1,000+ feet of water over your head while you are on the river! There are other rocks in here as well, including “pillow basalts” – lava flows on the ocean floor back then, but see the guides for more details.

You can see that the cross section in getting ever more complicated, with new fault zones and lots of “mushed up” rocks (naw, that really isn’t a formal geological term) – but it gets even worse because (a) these different aged rocks are all jumbled up in the foothills, so some 250 million year-old rocks are sitting next to some 150 million year-old rocks with no rhyme or reason, plus (b) there were more rocks that came in from below later (granites and other intrusive) and (c) with all of this we still haven’t gotten to the start of the Sierra Mountain rainge – it has only come up in the past 5 million years!

So, a really complicated bunch of geology by 150 million years ago, but still more to come…

When you think of the high Sierra, you probably think of Half Dome, El Capitan and the other great granite walls of Yosemite and higher. These granites were emplaced about 120 – 90 million years ago and Figure 3 shows how the magma chambers were formed and moved into the "country rock" above them as they melted their way towards the surface of the Earth.

Igneous rock is the term for granites and for volcanic rock as well. If the molten magma cooled and crystallized below the surface, it is called "intrusive igneous" and if it came out as lava and volcanic ash, it's called "extrusive igneous". In the foothills, we have some granites in a couple of places that dominate the river-scape: around Coloma there is a lot of granite (and the original gold discovery) and around Folsom Lake there is a lot more granite. The Folsom granite is about 128 million years old, and the Coloma granite a bit younger. See the South Fork guide to the Gorge section for pictures and more discussion.

The next really interesting geological event in the foothills happened about 50 million years ago with some huge gravel deposits that you can still see up Interstate 80 at the Gold Run area (and below in Figure 7).

Figure 7. Eocene auriferous gravels along Interstate 80

As you drive uphill on I-80 and get to the Gold Run and Dutch Flat area, there is a big wall of gravels on the road-left as you go. These river gravels have gold in them! These are the gravels that the miners used hydraulic mining to extract the gold – an extremely destructive mining technique that washed millions of cubic yards o gravel down into the Central Valley.

Malakoff Diggings - Four Monitors at Work
Nevada County 1890

Figure 8. Hydraulic mining in the Sierra Foothills.

Hydraulic mining was basically outlawed in the 1870s, but the valley to the right of the Gold Run area is there because all of the gravel was mined out of there – over 500' deep!

So we have come up through geologic time from 350 million years ago to about 50 million. The younger section above this has a lot of volcanic rock of about 10 – 15 million years age. If you ever ski at Sugarbowl, you will be skiing on this volcanic rock. You don't really see it along the American Rivers – it is mostly up on top of the near-by hills.

And finally we get to the Sierra Nevada Mountains themselves. The Sierra is a very young range – only about 5 to 8 million years old. With this uplift came lots of earthquakes, more volcanoes and a landscape where the rivers cut down into the growing mountains and foothills. The modern American River canyons are pretty young, are V-shaped and steep and are still the focus of active erosion – with landslides and floods common occurrences each Winter.