2008 Torrey Pines State Natural Reserve Geology Walk

1. EAST OVERLOOK BESIDE THE LODGE, N32° 55.274' W117° 15.155'

The ocean wasn't always 300 feet below this spot. About 140 million years ago, the mountains to the east were a chain of volcanic islands. There was a shallow sea to their east and open ocean to their west, including here. A plate of the Earth's crust from the west was pushing under the islands, melting and sending up the molten rock to the volcanoes, and carrying the whole chain to a collision with North America. The nearer mountains you see now are made of volcanic rocks.

One hundred million years ago, blobs of molten rock stopped miles below the surface. They cooled over thousands of years into the granitic rocks that now form most of the mountains to our east. At the same time, large mountains were pushed up so our coast looked like the present Andes.

By 50 million years ago, the mountains had worn down to a plain. Large rivers were carrying sand and gravel from mountains over 100 miles to our east. You would have been standing in the middle of a bay about the size of the present Monterey Bay. The white Torrey Sandstone you see a mile across the valley was being deposited as an offshore sand bar or barrier island.

Only a million years ago, the red Lindavista formation on top of the Torrey Sandstone was laid down as the ocean retreated from the nearly flat terrace it had cut. The red rock on top of the white one is seen in the cliffs just in front of you as well as across the valley. At the bottom of the red rock there is a layer of cobbles that the ocean used as tools to cut the terrace on top of the Torrey Sandstone. You will see the cobbles at our next stop.

The cobble layer is about 30 feet lower than in the nearest ridge to the north. A fault must lie along the steep canyon just in front of you. A fault is a crack in the rocks with movement of rocks across the crack. Many of the canyons that cross San Diego are cut by running water along faults.

Borings show that the mud in the estuary in front of you is about 300 feet deep. The ocean level must have been lower while the valley was being cut for the valley to be so deep. We know that during the great ice ages, the ocean level was indeed several hundred feet lower.

2. ON THE ROAD BELOW PARRY GROVE TRAIL, N32° 55.300' W117° 15.334'

Walk down the steps behind the Lodge and turn right to the road cut. In the road cut, we have a closer look at the layer of cobbles at the bottom of the Lindavista. If you go to the beach later, you will see cobbles much like these. Many of them are not like any rocks in our mountains. The 155 million year old cobbles were washed down from mountains in Sonora, Mexico about 45 million years ago while our area was further south. Our mountains had been worn flat, and there was no Gulf of California. About 25 million years ago, the Pacific Plate ripped us off the North American Plate and has carried us over 100 mile northwest, along with these Mexican cobbles. Rivers and ocean waves erode the old rocks and these hard, tough cobbles begin their cutting action again.

At the sharp right curve, lower in the road, we see parallel lines, tilted about 30 degrees, in the white Torrey Sandstone. These are cross bedding, typical of a sandstone laid down by wave action.

3. START OF PARRY GROVE TRAIL, N32° 55.285'N W117° 15.311'

Go back up the hill and turn off to the right at the sign for Parry Grove. The trail through the

Whitaker Garden near the road is edged with cobbles from the base of the Lindavista formation, You can get a close look here without being hit by a car. Past the steps to the Parry Grove, toward the Canyon of the Swifts, you step down about two feet from the Lindavista formation across the layer of cobbles onto the Torrey Sandstone, N32° 55.233' W117° 15.334'. At the end of the trail is a bench that is my favorite place to rest in the Reserve. You get a great view of the canyon, the western Reserve, and the Pacific.

4. RED BUTTE, N32° 55.145' W117° 15.289'

Go back to the road and continue south to the West parking lot. Go down the trail to Red Butte and climb the stairs. You are standing on the same red rock you were on behind the lodge. A million years ago, fish would have been swimming in front of your nose. The land here has been rising over the last million years to its present 300+ feet. As the land rose out of the ocean, it became marshy. Heavy vegetation and wet conditions made a laterite soil, full of iron. The red color of the rock is from iron oxide (rust). The rust cements the red Lindavista more strongly than the Torrey Sandstone is cemented, so the Lindavista acts as a cap rock. Look toward the Lodge to see how it protects the softer sandstone from erosion.

Leave Red Butte toward the steep canyon you see to the northwest.

What makes sand into sandstone? The Torrey Sandstone across the canyon was loose sand on an offshore bar 45 million years ago. As sea level rose, the sands were buried. Water running through them carried minerals that deposited as cement to glue the sand into a weak rock. The cement wasn't very uniform so the rock is weaker in some places.

5. CANYON OF THE SWIFTS, EAST OVERLOOK, N32° 55.148' W117° 15.302'

The "wind caves" you see were not mainly caused by wind. These holes are started by running water dissolving the cement from an already weak spot. Then either water or wind may carry the loose grains away. Once a hole gets started, the area inside is shaded so it stays damp, more cement is dissolved and the hole gets deeper. Some of the holes started when spherical concretions (lumps of better cemented sandstone) dropped out of the rock.

The "cannonball" concretions in the sandstone are caused by minerals being deposited from water inside the rock. The water dissolves the minerals from the sandstone or from rocks above it, then when the water source is reduced, precipitates them back out. Precipitation starts at some nucleus, perhaps a fossil, then grows on the crystals already there. The concretion of cemented sand then is a sphere if the process started at a point. If the start was along a line like a fossil plant, the concretion is a cylinder. You can see many spheres and a few cylinders in the cliff. The cementing minerals are either calcite from the Torrey Sandstone or iron oxide from the Lindavista.

6. CANYON OF THE SWIFTS, WEST OVERLOOK, N32° 55.144' W117° 15.390'

Continue down the trail next to the canyon. The canyon in front of you was eroded by running water, carrying sand. The weak sandstone wears away at the bottom of the canyon and also along the sides where small streams run during storms. The sides cave in when they get too steep and the debris is carried away in the next storm. The canyon probably started along a weaker zone in the rock, perhaps a fault although we do not see rock layers at different levels on the two sides of the canyon.

Plants, lichens and animals also help erosion. You can see plant roots prying the rock apart. The lichens produce acids the help dissolve cement. The animals dig holes the allow water into the rock.

The nearly horizontal gray rock layers in the canyon wall are old mud layers made into rock. At some time, conditions in the old sand bar changed. Mud was laid down for a while, then sand took over again.

7. BIG BASIN, N32° 55.089' W117° 15.443'

Take the trail south, past the entrance to Razor Point. You soon arrive at a level terrace below you toward the Pacific. During the last million years, the land here has risen at an average rate of about five inches per thousand years. The sea has risen and fallen several times. At several times, the level of the sea on the land stayed the same long enough for the sea to cut a beach terrace. A layer of cobbles like those we saw at the base of the Lindavista marks the base of each terrace. These big steps are hard to see because debris has washed down over them. The Nestor Terrace, 120 thousand years old, fills the end of the canyon just above the sea cliffs where a new terrace is being cut. You can also see the Guy Fleming and Parry Grove terraces from Big Basin.

The "rock" in these terraces is so soft that you can dig it with a spade. It has eroded into gullies to make the "badlands" topography that looks so good in your pictures.

When you come to the intersection with the Beach Trail, turn right toward the ocean.

8. BEACH TRAIL, "CREEK CROSSING", N32° 54.984' WI17° 15.426'

Here are some more of the hard, rounded cobbles so common in the Reserve. Many of them are not from local rock or even from rock in the mountains to our east. Most of the cobbles are volcanic. They came up as lava and solidified near the surface. They cooled too fast for large crystals to grow. The white crystals in many of them are feldspar that solidified at a high temperature and grew while the molten rock was still deep. Then they came up like plums in a pudding and the rest of the minerals solidified quickly into much smaller crystals.

These cobbles are part of the gravel that came into San Diego from the east about 45 million years ago. Geologists looking for their source had to remember that we are on the Pacific Plate of the Earth. This area has moved northwest along the North American Plate by about 200 miles since the cobbles arrived. The cobbles came from mountains in Sonora, Mexico.

We are still moving northwest an average of about two inches per year. Our velocity is not constant. We may not move for a hundred years, then make it up in an earthquake lasting only a few seconds.

9. LOWER BEACH TRAIL, N32° 54.907' W117º 15.494

Near the bottom of the beach trail, see the foot-thick layer of fresh looking shells in the soil on your right. These shells are only about 120 thousand years old so most of them are from species still living. The clear layer shows that these are fossils. If these shells wash out (as they have just beside the path) they are hard to tell from the modern shells from the Kumeyaay middens common in the Reserve.

Keep going down to the stairs to the beach.

10. ON THE BEACH, N32° 54.882' W117° 15.514'

The gray-green rock at the bottom of the cliff is the Delmar formation. It was laid down in a lagoon about 45 million years ago during the Eocene. The formation contains shale, siltstone, and sandstone that were deposited during different weather conditions. The harder rock ledges right at the bottom have so many fossil oyster shells in them that they are almost limestone. Shells, tracks, and burrows of other marine animals can be seen in other layers. Only about 3% of the shells are from species still living.

Flat Rock (or Bathtub Rock) is just to your south. It is part of the Delmar formation that was hard enough to become a point, then get cut off by the surf. You can see the "bathtub" in the rock from the cliff path that leads past it to the south.

Just beside the cliff path, tilted layers of rock are cut off by a horizontal layer. The feature is called a "angular unconformity". The tilted layers were deposited along to edge of an old river channel, then cut off as the layer above washed in.

The hard volcanic pebbles on the beach are thrown against the soft cliff by storm waves to erode the bottom of the cliff. The upper layers then fall to the beach. Don't linger too long near these unstable cliffs.

You can get back to the lodge by returning up the beach trail or by walking north to the entrance road, then walking up the road. Along the beach, you can see many more of the features we have described. The tide level may decide your route.

Don Grine, 2008