Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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Submarine canyons–going deeper

Point Lobos State Reserve contains spectacular exposures of ancient turbidity current deposits, or turbidites

While the early marine geologists who believed that submarine canyons might have been eroded by rivers and then were later submerged had to reconsider their ideas, there was an alternative view gaining support, that underwater processes had cut the canyons, or that they had a *submarine* origin. The major shortcoming with this new idea was that there wasn't any mechanism that had been observed 50 or 60 years ago that seemed capable of cutting canyons thousands of feet deep on the seafloor, and in the case of portions of Monterey and Carmel canyons, apparently through solid granite! Several subsequent discoveries, however, began to help

answer the question of how these Grand Canyons of the seafloor could have formed underwater.

Layers of sand were discovered in the first sediment cores that were recovered from the floors of these underwater canyons. Marine geologists for years have dropped corers, long steel pipes with heavy weights attached, into the seafloor from ships to extract cores of sediment. The sediment layers provided a history book or record of what processes had taken place over time at that particular location in the ocean. When the sand layers from submarine canyons were first recovered, we recognized that the layers were graded, or the sediment was coarsest at the bottom and finest at the top. This *graded bedding* can be created in a jar of mixed sediment (gravel, sand, silt and clay, for example) and water if we shake it up and let the sediments settle out. The gravel settles fastest and ends up at the bottom of the jar, followed by the coarsest sand, then finer sand, and finally silt, and hours later, the clay. So the graded sediments recovered from the floors of submarine canyons indicated that these sediments had settled out of suspension.

Additionally, even though many of these sediment cores were recovered from depths of hundreds or thousands of feet below sea level, they contained shallow water fossils, indicating that the sediments originated in shallow water. The concept that emerged from these observations was that underwater flows of muddy and sandy sediments, which were given the name *turbidity currents*, could be generated in shallow water at the heads of these submarine canyons, perhaps from earthquakes, large storm waves, or river floods. These underwater avalanches would flow down slope along the seafloor, driven by gravity because the muddy sediments were denser than seawater. Sand is abrasive, which is why we use sandpaper to smooth wood, and would enable these turbidity currents to progressively cut canyons across the continental shelf and slope over hundreds and thousands of years. Geologists working on land have recognized preserved turbidity current deposits, called *turbidites*, exposed in outcrops of old sea floor deposits in mountain ranges all over the world. In fact, take a drive down to Point Lobos State Reserve some weekend, just south of Carmel, and you can walk through a spectacular coastal exposure of 60 million year turbidites exposed along the entire south coast of the reserve. All evidence suggests that these thick graded layers of gravel and sand were deposited in an ancient submarine canyon by turbidity currents in an environment much like Monterey Submarine Canyon. There is more to this story.