GEOLOGY OF THE NIPOMO MESA REGION

To learn about the geology of the region, we must go much further back in time than when the first humans arrived here. Our history does little to explain how the landscape came to be as we see it today. It only tells how we have affected its character and, perhaps, even altered its direction.

The initial impression one has of the area may come from seeing the mesa bluffs for the first time. They rise up as sheer cliffs from the sandy, willow-lined channel of the Santa Maria River. At their topmost, the fields of human industry come to an abrupt end where hawks watch for prey from the crumbling edge. One does not usually give much thought to how these cliffs came to be this way. Nor do they wonder how such a place as Black Lake Canyon could possibly have water that flows like a small stream within willow thickets and poison oak. These features of the land are simply there and many love to see them. The dune lakes and the dunes, beautiful and unique, tell stories of the Dunites in their hidden glades. While the hills of sand pocketed with dark and murky marshes and dotted with the tracks of unseen creatures are nothing less than mysterious.

A drive up Los Berros Canyon reveals its own impressive characteristics. The canyon walls seem to grow steeper and the road itself hugs the cliff edges. In exceptionally cold winters, the frost never thaws during the day and puddles stay frozen, the sun not reaching this part of the canyon. In the warmth of summer, when the song of birds carries through the trees, the air becomes laden with dust rising and settling all along the road's washboard surface. To understand how the canyon came to be this way, however, one must walk this road and step into its wondrous past.

The roadcuts along the quiet stream tell an ancient story that has many versions, changing always. The rock moves in folds and creases, layers crumbling in-between. The roots of trees and shrubs lay bare and twisted in deep, shadowed clefts of stone. Mosses and ferns carpet the canyon walls with their greenery, seeping the winter's rain in tiny rivulets. The entire ridge, named for a Chumash village once here, called "Temeteti," tells this story, too, and it spills and flows down onto the valley beyond. It is a long and wandering story that geologists, rock hounds, and the like, strive to understand. And, as these stories often go, it begins with a description of the region, defining its boundaries to outline what is not only a biological whole, but what is truly a geological marvel.

Topography & Climate

The Nipomo mesa is a sand-covered terrace bounded by bluffs on the north, south, and northwest. Situated north of the Santa Maria Valley and south of Los Berros Creek and the Arroyo Grande Valley, it is these picturesque bluffs which give rise to this unique region that have inspired the imagination of many a newcomer. One can very easily see this is not just another hill sloping gently downward from the Coast Range to the Pacific Ocean. Still connected to the southwest portion of the mesa, the more recent, stabilized and active coastal dunes spread outward from the ocean between the mouthes of Arroyo Grande and Oso Flaco Creeks. Known by many names, like the Callender

Dunes and the Nipomo Dunes, they are still but a part of an extensive dune system, 18 miles in length and 2-5 miles in width.(1) Within these dunes, are small, freshwater lakes. Nearest the mesa, these are, from south to north, Black Lake, Mud Lake, White Lake, Bolsa Chica Lake, and the Big and Small Twin Lakes, several of what are collectively known as the dune lakes.(2)

Heading east from Black Lake, is a ravine called Black Lake Canyon, which runs in an east-west direction and appears to divide the mesa in half. It is pocketed with several, small, marshy ponds and peat bogs that raise questions as to their source within this closed canyon. Still further inland is Nipomo Creek, which flows southwesterly along the eastern edge of the mesa. It makes its way toward the Santa Maria River, interrupted by man-made obstacles at various points along its course. This drainage separates the sandy Nipomo mesa from the alluvial soils of Nipomo Valley and is fed by smaller tributaries coming in from the east, like Mehlschau and Deleissigues Creeks.(3) Rising above the valley in the east is the southernmost edge of the Santa Lucia mountain range, one of the Coast Ranges that run in a northwesterly direction. Temetate Ridge is the most visible aspect of this rugged coastal mountain range, reaching 1,600 feet in elevation, nearly 1,300 feet above the Nipomo Valley. On the back side of Temetate Ridge, is Los Berros Canyon where Los Berros Creek makes its way from south to north. Where it exits the canyon, the northernmost extent of Nipomo Creek is so near, questions are again raised as to their history.

The Mediterranean, or maritime climate suggests mild winters with an abundance of sunny, warm days in summer. Topography influences this locally to where the winters can receive slightly more rainfall than the Santa Maria Valley to the south and reach lower nighttime temperatures.(4) This can be as much as ten to fifteen degrees lower in Los Berros Canyon, maintaining cooler temperatures there throughout the day. In exceptionally cold winters, frost will remain in shaded areas of the canyon and the surface of the roadbed will freeze.

Spring brings strong, cold winds to the region that run downslope toward the ocean. In summer, this is reversed, as the pattern of onshore wind and coastal fog is begun. This can differ from outlying areas in that the mesa can be engulfed in fog, with clear skies to the south and north. The opposite can also occur. It can be hotter and drier on the mesa, eighty-four degrees and clear, seventy-two degrees along the fogged-in coastline, or high-seventies in the Santa Maria Valley with a stronger onshore influence. Then, autumn arrives and, though the days are still warm and dry and dustier than ever, the nights become much cooler. The shadows once again lengthen as the days grow shorter, with the first precipitation of "the rainy season" arriving in mid to late autumn.

Basic Geology

The geological history of the Nipomo mesa region begins during the Cretaceous Period 65 million years ago. This was long before the California landscape, as we know it today, came into being. The western edge of North America was only about as far as the Sierra Nevada and Mojave Desert, sometimes having a tropical climate and other times forbiddingly cold. Many changes were occurring involving the continuous movement of the earth's crust and its underlying upper mantle, each moving piece, or section, called a "plate."

The North American Plate is east of the San Andreas Fault and the Pacific Plate is west of this fault and moves in a north-northeasterly direction, geological history still in the making. These plates are, themselves, further made up of smaller pieces, called "terranes," which also continue to move and push against one another, causing the land to rise and mountains to be built as a result. Terranes are composed of differing assemblages of rock material geologists refer to as "formations." Over the course of millions of years of this continuous movement, a total of sixty-five terranes gradually became attached, or "accreted" to the continental margin, creating what we know today as California. These terranes continue to alter the shape of the land.(1) Each of the formations has its own geological history, as well, together creating a complex and highly-diversified landscape. There are few places in the world where such diversity exists as in California, particularly in its coastal regions.

Each terrane is bounded by smaller faults where movement occurs. Nearest the Nipomo mesa, the Big Pine/Nacimiento Fault parallels the foothill region, running in the same northwesterly direction. Like the San Andreas, these smaller faults have their own pattern of movement, or slippage, which causes earthquakes. Landslides and earth-flow deposits are visible signs geologists look for in studying and tracking fault activity. Topography also gives clues as to the direction each fault moves during times of slippage. Plate tectonics, as this area of study is called, like the determination of our geological history, is highly-theoretical and controversial. Yet, it is probably the most important aspect to understanding how California and, likewise, the Nipomo mesa region came to be the way we see it today.(2)

Formations are made up of different types of rocks, which aid in determining the age and depth of each formation or when and where they were originally deposited. Some of these rocks contain different types of fossils, which further aids in this determination. The most recently deposited formation in the Nipomo area would be the Paso Robles Formation, which can be readily observed where Highway 101 and North Thompson Avenue meet. It makes up the hills between Los Berros Road and Highway 101. It was formed on land that may have once been the ocean shore and is comprised of various gravels, sand, silt, and clay. The older, Careaga Formation, which outcrops as the beach gravel and limestone in the Nipomo foothills, was formed in a shallow marine environment, close to shore. It is also made up of differing grades of sand and clays, with some containing sea shell fragments. Then, there is the Monterey Formation, which is best represented in the foothill region and Upper Los Berros Canyon. It was once the ocean floor and is composed of basically sandstones of various consistencies, with a predominance of layered rock, known as Monterey Shale. This formation is rich in marine fossils, such as those of whales, sharks, and bony fishes. The Obispo Formation is primarily volcanic rock with siltstone, claystone, and mudstone, suggesting volcanic material erupted through what was once the bottom of the ocean. Also comprised of rocks called Obispo Tuff, this formation is best represented on the west side of Temetate Ridge.

The oldest rocks found in our area are of the Franciscan Assemblage, which is minimally represented east of Highway 101. Once thought to be a formation itself, the rocks found in this group include metamorphic rocks, such as schist, miolite, serpentine, and chert that were once sandstones, claystones, siltstones, conglomerates, and volcanic rocks that were called "trappean" in the 1800's. This assemblage forms the basement upon which the other formations were later deposited.(3) One of the main components of the Franciscan Assemblage is serpentine, or serpentinite. This dark, greenish-blue rock was intruded along faults into the Franciscan Assemblage while it was being deposited. Because of its widespread occurrence in the state and its striking blue-green color, it has been designated the California State Rock.

Another rock that can be found here is limestone, which was developed as a vitally important source of lime in the 1880's. It was mixed with cactus juice to make whitewash for the adobe buildings, without which these houses of clay would have become mud in just one season of rain. Other rocks found here are many that rock collectors look for, such as agates, which are formed in gas pockets and fissures in lava flows. Nipomo is the type location for two types of extremely rare, semi-precious gemstones, generally termed "moss agates," one being marcasite agate and, the other, sagenite agate. Banded agates can additionally be found. A form of jasper is also found here, as is a green-black opalite.

In studying rocks and the formations in which they are found, one may come to learn about or, at the very least, be able to ponder their origin. The various types of rocks, such as sandstones, claystones, etc., would tell a story of where sediment, that created each type of rock, had been deposited. It may have been coarse sand that lay close to shore and was affected by wave action, creating conglomerates or sandstones. Or, it may have once been a finer sand being deposited in calm, shallow water. At the bottom of the ocean, layers of sedimentation might have formed to later become shale, as mud and debris, including what would become fossils, settled there and became buried by further deposits. Pieces of the eroding bedrock of the basaltic ocean floor and any volcanic material that erupted into this submarine environment would add to this mixture. One place to study rocks is on Upper Los Berros Creek Road. Folded and uplifted layers of stone are readily visible in the roadcuts along the canyon wall. The rocky outcrops that dot the foothills of Temetate Ridge is another place. Stream courses, such as Nipomo Creek, are excellent, as well, for studying alluvial deposits, derived from the older deposits that make up the thick soil of Nipomo Valley.

Formation of the Region

At the start of the Miocene Epoch, 24 million years ago, the Pacific Plate began to move north-northeasterly along what was to become the San Andreas Fault. The ocean floor that would become the western half of California was still a couple of hundred miles southwest of its present location.(1) It was part of a deep trench that had formed offshore millions of years prior to this time. As this portion of the earth's crust moved, volcanic eruptions took place and deep cracks, or faults were created in this submarine environment. The earth's crust, now broken into smaller pieces, could move independently of one another along these faults. Some moved toward one another, the convergence causing them to buckle and lift upward or one to slide beneath another, both processes creating mountains. Some moved away from each other and created a different topography. Still others moved from side to side. The layers of sedimentation, fossilized organic material and marine organisms, were then combined with molten lava and crumbling bedrock, all being distorted and pulled apart. New sedimentation was continually added due to erosion. Older rocks from the Jurassic and Cretaceous Periods, such as serpentinite, were also being thrust upwards along faults.(2)

In the Nipomo area, the layers of sedimentation on the ocean floor and the deposits resulting from volcanic activity that became the Monterey and Obispo Formations are now rocks that make up our nearest mountains. They are exposed in some areas, but mostly covered in vegetation. Monterey Shale is found in the foothill region, comprising the top one-third of the rock layers found there. Obispo Tuff and basaltic lavas are now found in part along the foothills and on the western side of Temetate Ridge. On the east side of the ridge, rocks exposed there are again of the Monterey Formation. In Nipomo Valley, small outcrops of serpentinite and Franciscan rocks are found, exposed by erosion of the recent alluvial deposits of the rich valley soil.

The Big Pine/Nacimiento Fault in the foothills runs parallel with Temetate Ridge and it is believed that it was movement along this fault that created the ridge, as well as, mountain ridges south and northward along the fault. It was through a process called subduction, as one side of the fault compressed against the other side of the fault and slid underneath it. The other side buckled and lifted upward, while the subducted material turned to molten lava deep within the earth's crust. It is through this manner of subduction that the ocean floor gradually became the tops of mountains, explaining why fossils of marine mammals, such as whales, and other organisms may also be found there, miles from the sea today.(3)

Between 5 and 3 million years ago, during the Pliocene Epoch, this uplift was occurring all along the San Andreas Fault as the Pacific Plate compressed against the North American Plate. As the land rose, water levels inland fell. By the late Pliocene, 3 to 2 million years ago, the shoreline of the Pacific was at the Nipomo foothills, where the deposition of limestone and beach gravel there would eventually become the Careaga Formation. The Mediterranean climate on the coast had developed and the vegetation, such as the trees, was thus altered to adjust to a more arid and warm climate. Animals, such as ancestors of today's deer, bears, and birds had to adjust, as well. The newly-forming Coast Ranges, such as the Santa Lucian, became lush on the seaward side and more desert-like on the inland side, the rain shadow effect coming into existence.

This climatic change, however, was not completely permanent, as the earth began to experience a period of cooling that was in full swing by 2 million years ago at the start of the Pleistocene Epoch. This Ice Age alternated with warming periods, a cycle that would repeat itself about 48 times until 13,000 years ago, the "dawn of man" in California.(4)

During cooling periods, glaciers grew and the level of the ocean lowered as water was bound up in ice. The coastline was further west as a result.(5) The winters would have been harsh with heavy snows in the mountains and rain in the lowlands, particularly on the coast. The summers may have been dry, though still cold enough to prevent the snow in the mountains from melting, allowing glaciers to form. On the coast, within the fog belt, summers would have been damp. During warming periods, as glaciers melted and receded, the seas would again rise. The coastline would likewise recede. Glaciers would melt and cause torrential flooding. Evidence of this raising and lowering of the ocean level is found in the Paso Robles Formation, which is composed of both marine and terrestrial near-shore deposits, demonstrating an environment existed at the time that alternated between coastal estuary and dry land.

These climatic changes came to support chaparral and oak woodlands in drier areas and trees, such as redwoods, firs, and pines, like the Monterey pine, along the coast as far south as current Los Angeles. Plants occurred in association with one another differently than today, however, due to the continuously altering coastal topography. As the cycles of cooling and warming progressed, the landscape that was slowly becoming what we recognize today, was developing. The redwood's range would shrink toward the north as would the Monterey pine's, and chaparral and oak woodland would become more predominant. The large Ice Age mammals would have had difficulty adjusting to the changing vegetation, as well as, the changing climate. With the coming of humans, their waning presence would be further challenged, their existence fading into extinction.

Beginning approximately 100,000 years ago, the climatic fluctuations that were occurring resulted in the earliest deposition of the Nipomo mesa dune lobe. Yet, it was not until the latest glacial advance 13,000 years ago, at the onset of the Holocene Epoch, that the mesa actually began to be formed. As the sea level lowered, the alluvial marine terrace that would become this mesa, was exposed. Then, a dramatic warming trend began, causing the polar ice caps to rapidly melt, creating catastrophic flooding and raising ocean levels at a very fast rate. Between approximately 11,000 and 7,000 years ago, as the sea level rose, the shoreline dunes, with the aid of strong winds, advanced eastward to eventually cover this terrace. This dune-building process was occurring along 22 miles of coastline between Pt. San Luis and Pt. Sal. Though it reached its furthest inland at 12 1/2 miles in the Nipomo area.(6) The build-up of "blow-sand dunes" in this area may have blocked the channel of Nipomo Creek where it flowed into Los Berros Creek, causing it to change direction and empty instead into the Santa Maria River. It is also theorized that, before that occurred, it flowed across the mesa dune sheet, downcutting the easily-eroded sand to form Black Lake Canyon in its struggle to meet the sea.

To the south flowed the Santa Maria River on its way out to sea where Oso Flaco Lake currently sits. The river flowed within a broad lowland that stretched further and further out during periods when the sea level lowered more and more. The river had to continually cut through the shoreline as the ocean receded, this downcutting and erosive process gouging deeper, as well, into the terrace and dune sheet, continually carving the south bluffs of the mesa.(7) The ocean gradually went as far out as several miles further west than it does today. Arroyo Grande Creek flowed toward the south, carving the north bluffs of the mesa as a tributary of the Santa Maria River. It met the river in a large estuary like an inland bay or lake, similar to the estuary now seen at Morro Bay. Its flow in this direction eventually caused downcutting of the dune sheet on its western edge, creating a bluff along that side, as well.

Where the sand became stabilized on the mesa, vegetation grew, mostly the chaparral and oak woodland that predominated by then on the Central Coast, but also grasslands, all providing habitat for the diverse animal life that was once here, such as the tule elk, pronghorn antelope, jaguar, wolf, and grizzly.(8) Because sand continued to blow onshore, newer dunes were formed. The advancing belt of dunes to the north of the mesa continually blocked the lowering levels of Arroyo Grande and Los Berros Creeks in their attempt to reach the sea. The large estuary was overcome by rising ocean levels, while the remainder of it gradually became covered with the build-up of dunes. Dune swales and the dune lakes are evidence of this dramatic change. It would not be until the 1870's, before the Santa Maria River would change its course to where it presently meets the sea. By that time, the earliest presence of humans and animals on the Central Coast were and would continue to be experienced only through discoveries made of their fossilized or long-buried remains.

Native Vegetation of the Mesa and Adjacent Land Forms

For over one-hundred years, at least since 1892, various systems have been devised as a means of classifying native vegetation. Of these, three systems most often encountered in literature today are the "biome," "plant community," and "life zone" systems. The vegetation of California is far too diverse and complex to fit into such broad categories as those outlined in the biome and life zone concepts. To be most accurate, the plant community system of classification, first published by Phillip Munz and David Keck in 1959, has become the system of choice. It is most widely used and, therefore, best suits our purposes here.

Under the concept, or system, of plant communities, native vegetation on the Nipomo mesa and its immediate surrounding area, can be generally classified as: grassland, coastal-sage scrub, chaparral, oak woodland, and riparian. These can be further modified to more specifically describe our native vegetation and additionally create a clearer picture of Nipomo's natural landscape.

Native grassland is that which grows in open areas of the coastal scrublands and in greater expanses in the foothill region and on upper mountain slopes. It now primarily consists of non-native grass species, though these areas provide for our most spectacular shows of spring wildflowers. Man-made grasslands created through brush clearing for grazing are considered "pastoral," where non-native species have nearly replaced the original landscape. Weedy fields that may appear to be grasslands, as well as, plant species of urban association and other continually disturbed areas have acquired their own classifications. Veldt grass is widely invasive across the mesa and should not be considered grassland. It is an introduced species that has spread like wildfire, displacing the native vegetation of every plant community in its wake.

Coastal-sage scrub is the most common shrubbery seen on our dunes and hillsides. Where California coastal sagebrush is absent on the active dunes, the shrubbery there is called merely "dune scrub." Chaparral consists of the more woody shrubs that grow on the mesa amongst the coastal-sage scrub and oak woodland, and in pure stands in the mountainous backcountry. On the mesa, however, the unique and rare combination of plants found there are known as maritime chaparral. Oak woodland on the mesa is the commonly-seen, acorn-producing trees and associated vegetation under constant threat from increasing housing development, though it also continues up into the mountains. There, it consists of a variety of oak species. Like the chaparral, the oaks on the mesa exhibit growth patterns indicative of a maritime plant region, those adapted to unusual soil types and coastal wind and fog. These trees branch out lower to the ground, with long, sprawling limbs that appear to hug the slopes, and they grow closer together, creating a closed canopy, typical of the maritime configuration.

Lastly, the riparian plant community is that which is found along Nipomo Creek, in Black Lake Canyon, and along Los Berros Creek. The term "riparian," is derived from the Latin word "ripa," which means "a river bank." This lends name to the location, but can be built upon, then, to more specifically classify the vegetation found in each of the given locations. Along Nipomo Creek, there can be found mostly a willow-riparian plant community, with sections of large trees creating a riparian woodland, which is also found along Los Berros Creek. Black Lake Canyon contains remnant willow-riparian and riparian woodland communities.

Riparian areas also exist in moister sections of the dunes and surrounding each of the dune lakes. The dune plant communities consist of their own unique species having evolved under unique geological conditions. "Coastal strand" refers to plants just above the high tide line and it transitions into the foredunes plant community. The natural state of the active dunes has also been severely impacted by plants introduced to stabilize the loose sand. Further classifications can be added in regards to bodies of water. Our dune lakes are termed "shoreline lakes" by some and "freshwater marshes" by others. The term "marsh," comes from an Old English word "merisc," meaning "full of meres," meres being stretches of water. Marsh is usually meant to describe areas of still or slow-moving water inhabited by plants and animals which are suited to this environment. Freshwater marsh, by this definition, would also then be what can be found in sections of Nipomo Creek, such as by the raceway and the southern end of Thompson Avenue, as well as, in Black Lake Canyon, with some of the marshes there having developed into peat bogs. Bogs are a good place to look for rare plants. These and freshwater marshes, like estuaries, are also called "wetlands."

Nipomo and Los Berros Creeks, themselves, are considered "interrupted" or "intermittent streams" in that they flow above ground in some sections and underground in other sections for most of the year. During the rainy season, though, these creeks, like the Santa Maria River, become channels for water run-off.

Studying native vegetation as it correlates to the geological landscape is as theoretical a practice as the study of the earth's history. The origin of our native plants is theorized as having migrated from elsewhere, influenced by the changing land formations, not to mention the changing climate. Soils and weather patterns that were created by these changes came to accommodate differing plant species suitable to each climate and soil type. Because of these influences, certain plant species (and wildlife species) reach their northern or southernmost extent in the Nipomo Mesa Region, such as the coastal encelia, the bush sunflower found as far north as the south mesa bluffs and the Santa Margarita manzanita found as far south as upper Los Berros Canyon. Generally speaking, our rocky, mountainous regions will be best suited to hardy chaparral plants with coastal live oak woodland within the canyons and draws, growing best on north-facing slopes. Coastal-sage scrub can also be found there in areas with the thinnest of soil, but also in sanddunes that have become stabilized by "pioneer plants." Grasses will grow where erosion and weathering has deposited deeper soils in valleys and woodland openings. Where erosion of soil is the most torrential, as in creeks and ravines, shrubs and trees that can withstand the torrent, as well as benefit from the immediate water source, will grow in the gravelly and sandy mixture of alluvial deposition. This is why we see willows and cottonwoods following the course of streams and rivers, holding fast during times of flooding and continuing to grow and thrive during periods of apparent drought. Looking at the various plant communities, furthermore, one may be able to ascertain the type of rock formation that lies beneath the vegetation, with unusual species being found upon serpentine, others in limestone. Pairing the two studies of botany and geology, in this way, can bring a deeper understanding and appreciation of our area's geological and botanical history.