**Channel Islands 1**

1. Channel Islands National Park encompasses 5 of the 8 Southern California Channel Islands - Santa Barbara, and the 4-island complex of San Miguel, Santa Rosa, Santa Cruz and Anacapa …
2. … that once were joined into a single island called Santarosae during the low sea levels of the Pleistocene glacial ages. The origin of all 8 Channel Islands is linked to the evolution of the San Andreas transform plate boundary, but each island has unique geologic characteristics as well. In this lesson we will explore the geology of each island separately, starting with Santa Barbara and working west to San Miguel, while gradually piecing together the large scale geologic story.
3. At only about a mile across, Santa Barbara is the smallest of the 8 Channel Islands. Its tiny size …
4. … combined with the general aridity of Southern California …
5. … explain why there are no rivers on the island. Without rivers, virtually no sediment is carried from the interior of the island to the shore, …
6. … so there are no sandy beaches anywhere on the island. These conditions are somewhat true of all the islands, but they are especially important on tiny Santa Barbara Island.
7. Without beaches, waves crash directly on the rocks – undercutting them until they fall into the sea to create precipitous cliffs.
8. This is a typical Santa Barbara Island “beach” made of boulders that have fallen from the cliffs above. These boulders will eventually be worked into deep water by wave action which will once again undercut the cliff and cause more rock falls. Providing lots of nooks and crannies to shelter sea life as well as heavy anchors for kelp, such boulders contribute to the rich habitat that supports the island’s thriving sea lion colony. Fortunately, for the sea lions, rock falls are relatively infrequent.
9. In fact, the cliffs must be made of a pretty hard rock or else they would just collapse under their own weight like a pile of sand. Judging from the hardness, dark color and subtle layering (look near the base of the cliff here) you may have already pegged these rocks as basalt.
10. If you look closely at the basalt in the upper portion of this photo you can make out several rounded lobes, ….
11. … which you may recognize as pillow lava.
12. Although the sea lions are not resting on the pillows, mere proximity is enough to induce the narcotic effect.
13. A closer look shows that the rocks at the base of the cliff are comprised of angular basalt fragments, ash and marine mud.
14. The rock is called volcanic breccia …
15. …
16. … and the assemblage with pillow basalt implies both effusive and explosive *submarine* volcanism. That’s important because it means that the island was not built above sea level. Like the nearby “Matterhorn” and Osborne Bank, Santa Barbara Island grew from the deep ocean floor as a volcanic seamount. Unlike the Matterhorn and Osborn Bank, however, Santa Barbara Island became exposed above sea level by a combination of volcanic growth and uplift along faults.
17. Faults like these are important not only in the uplift of Santa Barbara Island, but all of the channel islands were uplifted by faulting.
18. Such faults contribute to the differential erosion of Santa Barbara Island by wave action. Here, a sea cave and blow hole have formed along the fault-weakened volcanic rock. Notice that the bulk of the cave is above sea level, …
19. … as is this cave, suggesting uplift of the island …
20. … because sea caves typically form at sea level. This pair of young sea caves on Santa Barbara Island was carved into the relatively soft volcanic breccia. Notice the marine terrace above these caves. Like the elevated sea caves they are yet another indication of emergence.
21. During different periods of the uplifting process, wave erosion caused several marine terraces which are evident today. The broad, flat surfaces promote soil formation on the underlying nutrient-rich volcanic rocks, such that during unusually rainy periods …
22. ... spectacular blooms of native sunflower occur.
23. The origin of Santa Barbara Island is similar to that of all the Channel Islands and begins with the subduction of the Farallon Plate during the Mesozoic Era. Rocks formed in the accretionary wedge and forearc basin here are not exposed on Santa Barbara Island, but play an important role in the formation of other Channel Islands.
24. In the Early Cenozoic, the East Pacific Rise approaches the trench while the erosion of the continent causes sedimentation in the forearc basin to become more terrestrial.
25. Because the East Pacific Rise moved north as well as east, the Pacific and Farallon Plates had a northerly component superimposed on their divergence from the East Pacific Rise. The resultant motion of the Pacific Plate was therefore towards the northwest. Since this was parallel to the orientation of the trench, when the Pacific Plate arrived at the trench, the plate boundary changed from convergent to transform. As more of the Pacific Plate was brought into contact with the North American Plate, the transform plate boundary lengthened into the San Andreas Fault. The conversion to a transform plate boundary removed compressive stress on the western margin of North America, which allowed it to spread laterally while shear stress from the Pacific Plate ripped off great hunks of the North American Plate (like Baja California) and carried them to the northwest.
26. When the East Pacific Rise arrived at the trench production of oceanic crust ended because divergence no longer took place there and the accretionary wedge and forearc basin were thrust over the former spreading center.
27. Because no new oceanic crust replaces the subducting Farallon Plate, mantle wells up to replace the area formerly occupied by the Farallon Plate.
28. Decompression melting takes place in the upwelled mantle, producing basaltic magma that works its way towards the surface. Some is emplaced as small, shallow plutons, but the thin crust allows much basaltic magma to reach the sea floor where it erupts as pillow lavas and volcanic breccias. Notice the numerous faults in the continental borderland. Like the San Andreas, motion along these faults is primarily strike slip, but vertical motion also occurs where bends occur along the fault’s length.
29. Looking down now on a bend along a right lateral strike slip fault, we can see that, depending on which direction the fault bends, localized areas of compression and extension will occur.
30. Compression associated with lateral fault motion is known as transpression and the corresponding extension is called transtension.
31. Crust tends to thicken in areas of transpression, while crustal thinning occurs where there is transtension.
32. Transpressional areas therefore tend to undergo uplift and ridge formation, while transtension causes subsidence and the formation of basins.
33. Because crustal thinning contributes to the decompression of the underlying mantle, basaltic magma tends to form beneath the transtensional basins. Such magma reaches the sea floor as pillow lava and volcanic breccia which fills the basin.
34. Although such volcanism is especially common in the sheared and thinned crust of the Southern and Baja California continental borderland …
35. … Neogene volcanic centers (shown in black here) are found along the entire length of the San Andreas, …
36. … because the formation of the San Andreas was accompanied by mantle upwelling in the wake of the subducted Farallon Plate.
37. So the continental borderland of southern California is comprised of transpressional ridges and transtensional basins filled with volcanic and sedimentary rocks. As lateral motion continues on these faults, ….
38. … stress patterns can reorient such that transpression may be applied to areas that formerly were subject to transtension. If that happens, the volcanic and sedimentary rocks that filled the transtensional basins can be uplifted and potentially exposed as islands. The volcanic rocks on Santa Barbara Island were exposed in this way, as is the case for uplift of most of the Channel Islands.
39. At this point we will examine the four northern channel islands that make up Santarosae, as each add detail to the general tectonic framework outlined for the evolution of the continental borderland here.
40. Because of their alignment, geologists once considered the northern Channel Islands to be simply a westerly continuation of the Santa Monica Mountains. But as the geology of Santarosae became better understood, it became apparent that the geologic connection between the two regions was only valid for their relatively recent and ongoing uplift. Prior to that uplift, however, Santarosae had a strikingly different history, which we will piece together by examining the geology of each northern channel island separately.
41. First let’s have a look at the remarkably long and narrow Anacapa Island. It’s more than five miles long, yet covers barely a square mile of area. Anacapa is so narrow that wave erosion has severed it in a couple places …
42. … such that actually three islands comprise Anacapa – East, Middle and West Anacapa.
43. Looking towards West Anacapa Island in the background from Inspiration Point on East Anacapa Island, you can see the flattened top of Middle Anacapa Island just above this couple.
44. No doubt they recognize that the flat area as a marine terrace and are truly inspired by the implication that Anacapa emerged from the sea floor just like Santa Barbara Island did.
45. …
46. Looking down from Inspiration Point you can see that the channel between East and Middle Anacapa Island …
47. … is actually exposed at low tide. Not long ago a sea arch may have connected the two islands …
48. … much like picturesque Arch Rock, at the east end of East Anacapa.
49. Beneath the recent avian sediment, …
50. … you may recognize this rock as basalt.
51. Just like on Santa Barbara Island, the basalt on Anacapa is strong enough to hold tall cliffs and formed from submarine eruptions in a transtensional basin within the continental borderland.
52. Almost all the rock of Anacapa is basalt and was apparently uplifted by faulting associated with an anticline whose axis lies just south of the island. Such folding is the result of transpression.
53. One small area of sedimentary rock on the south side of West Anacapa Island is noteworthy. It consists of an unusual and tectonically important unit called the San Onofre Breccia.
54. This outcrop of the San Onofre Breccia at Dana Point, CA shows the assorted, large, angular rock fragments that qualify it as a sedimentary breccia. It exerts a seemingly magnetic pull on geologists …
55. …because of the fascinating story it tells.
56. Here’s a close-up of the lower Miocene San Onofre Breccia in the Santa Monica Mountains. Note the variety of rock types contained here which is typical of this unit. Where have you seen this assemblage of rock types before?
57. That’s right, we saw this type of thing in the Franciscan mélange – only here the rock fragments are supported in a matrix that indicates deposition via submarine debris flows. The blue schist fragments are particularly important in that they must have come from a source region that was subjected to high pressure, low temperature metamorphism. Those conditions are characteristic of metamorphism that takes place in sediments that are carried to great depth next to relatively cool subducted oceanic crust. Thus the presence of the blue schist rock fragments in the San Onofre Breccia indicates that the area eroded to produce these fragments must have experienced a great amount of uplift.
58. Although not exposed on Anacapa or anywhere else in Channel Islands National Park, the source of the blue schist rock fragments in the San Onofre Breccia does outcrop in several nearby areas like on Catalina Island and in the Palos Verdes Hills where this photo was taken. Areas like this were the source of the San Onofre Breccia, …
59. … and are interpreted as uplifted portions of the accretionary wedge that formed during the subduction of the Farallon Plate. Uplift and erosion exposed a mélange of rock types which were transported into adjacent basins via submarine debris flows.