**Big Bend 2**

1. The Laramide Orogeny did a lot more than fold limestone. When the subduction angle of the Farallon plate flattened, the volcanic arc shifted eastward.
2. Notice the greater distance between the arc and trench during the Laramide Orogeny.
3. Following the Laramide Orogeny the convergence rate slowed between the Farallon Plate (FAR) and North American Plate (NAM), which gave time for the Farallon Plate to sink. Mantle flowed into the widening gap between the North American Plate and the sinking Farallon plate causing magmatism to shift back towards the trench. The result of all this on Big Bend is that arc magmatism shifted into the area during the climax of the Laramide Orogeny in the Eocene and Oligocene epochs, and then retreated from the area before Basin and Range extension began in the Miocene. As we learned from our study of the Basin and Range, extension of the continent causes bimodal volcanism, which in this case will be deposited on top of the Laramide age arc-related volcanic rocks.
4. In Big Bend National Park the Laramide-age volcanic rocks outcrop mostly in the central to southwestern portions of the park.
5. They are particularly noteworthy in the rugged Chisos Mountains – a nearly 8000-foot high jumble of volcanic rocks and shallow igneous intrusions.
6. The Chisos Mountains are the eroded remains of two great volcanoes that once towered above the landscape, but like many great volcanoes, these collapsed into their magma chambers to form calderas.
7. The calderas are visible today, not as depressions, but as elevated, crudely circular areas because resurgent volcanism filled the two calderas with volcanic domes, lava, ash and surge deposits.
8. The structure is further complicated by the intrusion of dikes along the ring fractures that surrounded the calderas.
9. The unusually chaotic topography of the Chisos Mountains mostly results from the intrusion of these ring dikes.
10. Towards the center of the more westerly caldera the softer ash layers have been eroded leaving a depression in the Chisos Mountains simply know as “The Basin”.
11. At almost exactly 1 mile high, The Basin provides welcome relief from the often oppressive west Texas heat. The surrounding intrusions and lava flows that make up the encircling mountains create a picturesque near-360 degree panorama that is the park’s most visited attraction.
12. Every drop of rain that falls on The Basin drains through one canyon, known as The Window because of the spectacular frame it provides to the distant lowland vista.
13. Most visitors to The Basin assume incorrectly that it had to form via some catastrophic event like the explosion or collapse of a volcano.
14. Actually, the feature is only indirectly associated with the caldera here, and is more closely related to the erosion of the lava and ash that covered the caldera and the emplacement of the magmatic intrusion that comprises Ward Mountain. This intrusion pushed the lava-capped ash upwards into a broad dome. The fractured rocks forming the crest of the dome were eroded more rapidly than the lower rocks. Eventually, part of the lava cover was removed, exposing the underlying rocks. Erosion continued, breaching the lava until the underlying softer rocks in the center of the Basin were exposed.
15. Sapping was an important process in forming the Basin. The softer volcanic ash and sandstone beds underlying the massive jointed lava cap were more easily eroded than the lava. The lava was undermined and fell into the valley below, and as the sapping continued, the lava cliffs retreated.
16. Casa Grande is a remnant of the all-but-eroded capping lava flow.
17. Towering above The Basin, it is one of the most obvious and photographed landforms in the park. Beneath it lie the softer ash deposits.
18. Erosion along joints in the ash have resulted whimsical landforms like “Cowboy Boot”. These joints were formed by the forceful intrusion of magma below. Ash that has hardened into rock is known as tuff.
19. Because volcanic ash can deposit far from its volcanic source, tuff blankets broad areas of Big Bend. It is particularly obvious towards the southwestern part of the park where it contrasts nicely next to the darker lava rocks capping it there.
20. It is exposed beautifully along the walls of “Tuff Canyon”, more than 12 miles from the Chisos Mountains in the background.
21. You can see that even this “hardened” form of ash is not really very hard. It quickly erodes under the blade of running water.
22. Sometimes morphing into humanlike entities (even without the ingestion of a certain sacred cactus reported to grow in Big Bend!).
23. Just next door to Tuff Canyon is Cerro Castellan where the tuff is overlain by younger lava flows.
24. At the base of Cerro Castellan there is a hardened “lava neck” through which magma once flowed toward the surface. The remarkably wood-like grain results from flow-induced shear-stress, which was unusually high due to the extreme viscosity of the silica-rich magma combined with the narrow diameter of the neck. The “knot-hole” probably once held a rock that was carried upward by the magma.
25. Magma was more commonly brought to the surface via a system of feeder dikes. Some of these dikes are remarkably continuous relative to their thickness. This one is only about 20 feet thick, yet it can be traced across the surface for more than 12 miles!
26. Others, like the dike that was eroded into the “Mule Ears” …
27. … is several hundred feet thick yet much less laterally continuous.
28. “Elephant Tusk” is yet another Big Bend igneous intrusion. Although almost every imaginable size and shape of igneous intrusion is here, the majority formed from felsic magma that crystallized fairly close to the surface.
29. Of these, laccoliths are particularly common in Big Bend National Park, although they are relatively uncommon intrusions elsewhere.
30. To form the characteristic mushroom-shaped intrusions, viscous, felsic magma must be emplaced between rock layers at a depth shallow enough to allow for the doming of the rocks above the laccolith. Mafic magma cannot form laccoliths because its lower viscosity makes it spread out more thinly between the layers (forming sills). The rise of laccolith-forming magma is driven by the relatively low density of felsic magma. Felsic magma is so buoyant in fact, that in most situations when it gets close enough to the surface to form a laccolith, it is less dense than the surrounding rocks so it just keeps rising to the surface. That’s why laccoliths are rare worldwide.
31. Laccoliths are common in Big Bend, however, because the surface rocks here are limestones and tuffs whose density is low enough to float atop the magma that formed the laccolith. The pairing of limestone and felsic magma is geologically unusual and reflects the great distance to which Laramide magmatism swept into the interior of North America – all the way into an environment rarely affected by arc magmatism, the limestone-filled forearc basin.
32. Laramide folding and magmatism …
33. … gave way to Basin and Range extension in the late Cenozoic, which produced long, conspicuous, linear escarpments along major normal faults.
34. The scarp cut by Santa Elena Canyon is particularly noticeable.
35. At its base lies the Terlingua Fault above which a much thicker pile of sediments had accumulated, but now are mostly eroded.
36. Intense episodes of erosion and deposition accompanied the Basin and Range extension of the Big Bend area as climate and extension rates fluctuated.
37. Remnants of late Cenozoic depositional and erosional surfaces abound in Big Bend. Although not as geologically sexy as laccoliths and Laramide anticlines, they are nonetheless an important component …
38. … in the formation of the gorgeous slot canyons (like Santa Elena) that slice across the normal fault scarps. The Rio Grande River here is a transverse stream – meaning that it flows across the faults and fault blocks. It is also superimposed, …
39. … which means that it was let down from higher levels …
40. … by erosion. During downcutting, the Rio Grande and its tributaries removed sand and gravel that once filled the basins …
41. … and exposed the bedrock of the upfaulted blocks.
42. So the basin in the foreground was once filled to its brim with sediment. Santa Elena Canyon will become even deeper as sediment continues to be removed from the basin. One might ask why this process happens along the Rio Grande but not in other parts of the Basin and Range.
43. Remember that there is no outlet for rivers draining into the Great Basin, so sediment ultimately accumulates there.
44. Areas drained by the Rio Grande River, however, are ultimately eroded, because the Rio Grande exits into the Gulf of Mexico. Note the protruding coastline at Brownsville, where mass quantities of the eroded sediment have deposited.
45. The removal of basin sediment has caused the Rio Grande River to downcut so rapidly in Santa Elena Canyon that there has been little time for widening processes to occur.
46. The result is that some places in Santa Elena Canyon are so narrow that you can touch the walls of Mexico and the United States with outstretched arms.