**Saguaro National Park**

1. The giant, iconic cactus, for which the park is named, certainly draws most of the attention at Saguaro National Park. Very few park visitors are aware that the park hosts a much larger, albeit more obscure attraction – a world-class example of a geological phenomenon known as a metamorphic core complex.
2. The core complex is located in the eastern of the park’s two parts. The geology of Saguaro National Park West is interesting too, but enigmatically so and not really foundational to our understanding of larger geologic concepts. So our attention will focus on the Rincon Mountains which lie in Saguaro National Park East, …
3. … and their geological big sister - the Santa Catalina Mountains, which lie just north of the park.
4. Core complexes have a general dome-like shape that shows up nicely across Mica Mountain, the park’s highest point.
5. This west to east diagrammatic cross-section through the Rincon Mountains tells most of the story. The rocks in the Rincon's are primarily metamorphic for which the parent rock in most cases was a porphyritic quartz monzonite. What’s *that* you ask?
6. I’ll not keep you in suspense a moment longer! Quartz monzonite is a plutonic igneous rock similar to granite. This one is porphyritic, meaning that it contains a few especially large crystals.
7. Quartz monzonite is not listed in the simple two component, mafic/felsic classification of igneous rocks we used in previous lessons. Real geologists use a more sophisticated classification based on three components – Q for quartz, A for alkali feldspar and P for
plagioclase feldspar. Note that quartz monzonite contains less quartz than granite and a significant amount of plagioclase in addition to alkali feldspar. Don’t worry about memorizing this whole diagram; just remember that our parent rock contains mostly feldspar and some quartz.
8. Looking at Mica Mountain again, we can see a definite grain or fabric in the rocks that was produced by the alignment of rock features during metamorphism. We call this foliation. Foliation may resemble sedimentary layering, but let me remind you that the parent rock here was quartz monzonite, a plutonic *igneous* rock.
9. Fairly near the surface there is a décollement. In this case it is a detachment fault in which the brittle rocks above it slide down, off of the uplifted core complex of ductile rocks below. As we approach the décollement from below, the rocks are subjected to ever greater shear stress which will metamorphose the porphyritic quartz monzonite parent rock into a distinctive, foliated metamorphic rock called mylonite.
10. Mylonite forms from shear stress applied to at least partly ductile materials. To understand how mylonite forms, put a semi-warm Snickers bar between the palms of your hands and then press your palms together to flatten the bar while moving your hands in opposite directions to smear it out. Ignore the disgusting chocolate mess you’ve created and focus on what happened to the caramel and peanuts. The caramel, being ductile, will spread out greatly, while the peanuts, being brittle, will only rotate and possibly fracture a little. Now remember that our quartz mylonite parent contained some quartz and many larger crystals of feldspar. Quartz, having a lower melting point than feldspar will act like the caramel here and become completely sheared-out. Feldspar grains will be fractured and rotated like the peanuts. The black mineral here is biotite mica, which, because of its sheet-like structure, gets completely sheared-out.
11. Although warm and ductile, there is little shear stress at depth so the quartz monzonite is not mylonitized at depth. As we approach the décollement shear stress increases but temperature decreases. These changes produce a series of different rock types starting with a mylonite gneiss where there is a balance between shear stress and ductility. Above that where it’s cooler but the shear stress is greater the mylonite gneiss becomes microbrecciated, which means fragmented on a fine scale.
12. In places, the microbreccia still contains visible rock fragments (up to 1 centimeter), but there is no preferred fabric and the compositional layering is still destroyed. This exposure is in a mine prospect.
13. Very close to the décollement the shear stress is extreme. That combined with the relative brittleness of the crust forms…
14. …ultramylonite. Note that the bar scale is one-half millimeter, so the brecciation is extremely fine. Ductile flow has not happened here like it did where the mylonite gneiss formed, but the intense shear stress has produced a foliation, or oriented grain to the rock that was not present in the microbreccia.
15. Right at the base of the décollement there is a ledge of microbreccia that formed from the grinding action that takes place along the fault surface.
16. The brown microbreccia ledge defines the base of the detachment fault. The brittle deformation has reduced the grain sizes to the point that most grains cannot be seen. Hence, the gneissic compositional layering has been totally destroyed.
17. The brown microbreccia ledge at the base of the detachment fault shows up pretty well here.
18. Near the detachment a glassy material called Pseudotachylite is not uncommon. It forms along sheared surfaces where localized friction-induced melting occurs. Because the amount of melt produced is very small, it cools too quickly to permit crystallization, so glass forms.
19. Now that you have some idea of the rock types comprising a core complex, let’s look at the distribution, structure and origin of core complexes. This map shows in black the location of all known core complexes in North America. You can see that they are fairly common in the eastern part of the Basin and Range province, but they also extend northward into the Canadian Rockies.
20. What makes the one in Saguaro National Park special is how well it exposes the most characteristic elements of a core complex.
21. The basic shape of a core complex is somewhat like this Quonset hut. Notice that superimposed on the elongated arch…
22. … are a series of corrugations aligned perpendicular to the axis of the main arch.
23. The rocks above the detachment fault slid down the main arch parallel to these corrugations.
24. OK, now let’s move from the Quonset hut to the real deal. Can you make out the Quonset hut shape in the diagram?
25. A little color will help. Notice that the detachment corrugations will form a series of ridges perpendicular to the trend of the main ridge.
26. And that’s exactly what we see in the Rincon’s. Pretty cool huh? Take a moment for the epiphany of scale to set in. Three prominent corrugations point west-southwest away from the main north-northwest axis of the Rincon / Santa Catalina Mountain range.
27. The detachment fault lies pretty close to the base of the ranges.
28. Upper plate rocks become normally faulted in typical Basin and Range fashion as they slide away from the core complex along the detachment corrugations.
29. If you climb up Rincon Peak in the park’s southeast corner and look north…
30. … you can clearly spot the upper plate rocks on the Rincon’s eastern slopes.
31. Here’s the same view in Google Earth with the geologic map overlay.
32. Finally, let’s try to understand how core complexes form. The explanation presented here is a hybrid of several models that makes sense to me. If I had more sense, I might very well go with a different model. Check the syllabus for a reference that will give you a more thorough explanation.
33. First note the strong correlation between the distribution of metamorphic core complexes and the areas where the crust has been thickened by orogenies.
34. Compressional thickening due to orogeny created not only higher mountains but deeper mountain roots. In this stage the weight of the mountains was equal to the buoyant forces holding them up. More important to the formation of core complexes, the weight of the mountains is exactly enough to hold *down* the buoyant lower crust.
35. If the mountains erode, their weight is reduced and the forces become unbalanced. This leads to a situation where the ductile lower crust rocks will tend to flow towards the surface.
36. If extension occurs, detachment faulting further reduces the weight of the brittle upper crust - further enhancing uplift of the ductile core complex. There are other mechanisms that have been proposed to explain core complex uplift, like the emplacement of plutons within the lower crust, but all models seem to hinge on this basic principle: Core complexes will form when the buoyant forces on the ductile lower crust exceed the weight of the brittle upper crust.