Geology of the Tucson Mountains

General Setting of the Tucson Mountains

The Tucson Mountains are one of many relatively small ranges that dot the southwestern United States belonging to the Basin and Range Province. These ranges are the result of block faulting, which occurred about 10-15 million years ago (MYA), and today are separated by basins filled with thousands of feet of alluvial sediment derived from the erosion of these mountains. The Tucson Mountain block is about 20 miles long and up to 7 miles wide at present, although valley fill covers much of the lower slopes of the mountain block. The highest peak in the Tucson Mountains is Wasson Peak at 4,687 feet, the terminus of many popular hiking trails in the park.

The Geologic History of the Tucson Mountains: General

Before we begin to look at the origin of the Tucson Mountains, it is important to look briefly at the rocks which make up the mountains and the theory of plate tectonics, which holds the key to understanding the origin of the rocks and structures which make up the Earth's crust.

The Building Blocks

Rocks of the three major classes - ingenous, sedimentary and metamorphic - are found in the park. The ingneous rocks include coarse grained intrusive rocks such as granite, which cooled deeply within the Earth, and fine grained rocks including extrusive lava flows and intrusive basalt dikes which cooled much more rapidly. Sedimentary rocks are formed from the consolidation of sediment derived from weathering and erosion of preexisting rocks and deposited in layers by streams, wind or in the shallow waters of the ocean. The most common of these rocks include sandstone, shale and limestone. Metamorphic rocks form deep within the Earth when heat, pressure and chemical fluids alter preexisting rocks. These include slate, marble, gneiss and schist. Specific examples of these major rock types will be discussed in the following sections as they help to explain the geologic history of the Tucson Mountain District.

The theory of plate tectonics states that the crust is made up of many plates, some of which are thousands of miles in diameter and up to sixty miles thick. These plates are in constant motion, breaking apart along the mid-ocean ridges, as molten material (magma) wells up beneath them, and coming together along the margins of certain continents. Where these plates meet, one of three things may happen. If one plate, usually the oceanic plate, is denser than the other, it will descend (subduct) under the other plate and a trench will form at that point. As the oceanic plate continues to descend deeper, the rocks become plastic and then molten, leading to the formation of a chain of volcanoes as the less dense magma rises to the surface. Such is the case today as the Pacific Plate subducts under the North American Plate or Asian Plate. On the other hand, if the two colliding plates are of similar densities, neither can descend very far beneath the other. As a result, the plates will rise (obduct) high above the surface. Such is the case with the Himalaya Moutains in Asia. Finally, if the two plates are moving in the same general direction but at different rates, the plates will separate along a horizontal or strike-slip fault. Such is the case today with the San Andreas Fault along the Pacific coast of North America. This very brief description of the theory of plate tectonics will hopefully suffice in our discussion of the origin of the Tucson Mountains.

How it Came to Be

The oldest rocks found in the area, although not directly in the park, are granites and metamorphic rocks which represent the original crust of Southern Arizona. These rocks are approximately 1.7 billion years old and belong to an era of geologic time known as the Precambian. The metamorphic rocks are mostly schist

How it Came to Be Con't

resulting from a plate collision at that time, altering preexisting sediments and volcanic rocks.

There is little evidence of what happened over the next billion plus years, as the region was subjected to extensive erosion. Approximately 600 million years ago (MYA), at the beginning of the Paleozoic Era, gentle rise and fall of the crust, as the Pacific Plate approached the North American Plate, led to deposition of sedimentary rocks, mostly limestones, sandstones and shales separated by extensive periods of erosion. A few scattered outcrops of these rocks can still be seen in the park including around the Sus Picnic Area.

During the early part of the Mesozoic Era, approximately 150 MYA, continued uplift of the region led to erosion of the exposed rocks by streams. The sediments were deposited as floodplains in the shallow water of an inland sea. Today these sediments make up the Red Hills to the south of the visitor center. The red color is from the iron oxide, hematite, which formed in the oxygen-rich shallow seas of this area. Further evidence of the shallow nature of these waters can be seen in the fossils of petrified wood, clams and even dinosaur leg bones found in the area.

As the Red Beds were being formed, the ancient Pacific Plate continued to descend under the North American Plate leading to much volcanic activity and mountain building in the west. This event is known as the Laramide Orogeny, which occurred over a 30 million year interval during the latter part of the Mesozoic Era and beginning of the Cenozoic Era. At this time the Tucson area was subject to extensive volcanic activity, resulting in extensive emission of rhyolite (a light tan fine grained rock) lavas and fiery ash-steam clouds, or nuee ardentes, which were so dense they rolled down the sides of the volcanoes consuming everything in their path. So much material was pumped out from below the surface that eventually the area collapsed producing a huge depression or caldera at least fifteen miles in diameter! Over time this caldera was filled with rhyolite, ash deposits (tuff) and brechia, a rock formed from the consolidation of blocks broken from the collapse of the sides of volcanoes. This complex mass of rocks collectively is known as the Tucson Mountain Chaos, and forms the bulk of the rocks which make up the present Tucson Mountains. All can be seen in the proximity of the scenic overlook at Gates Pass. At the same time, nearby areas were intruded by masses of pink granite and quartz veins which bear many of the minerals, mostly copper, silver an gold, which led to the rapid development of southern Arizona during the late 1800's. One of these intrusions is exposed today at Amole Peak located northeast of the visitor center. No major ore deposits were found in the Tucson Mountains, but the area is dotted with prospector pits and abandoned mines.

After another long period of erosion, renewed activity began with the intrusion of the Wilderness Granite as well as renewed volcanic activity in parts of southeastern Arizona. (What follows is the most commonly accepted theory, but it is still controversial.) The Wilderness Granite was emplaced about six to eight miles below the surface approximately fifteen to twenty miles east of Tucson. This intrusion bowed up this region and at the same time altered the surrounding rocks to a highly mobile state. As arching continued, a huge slab of rocks broke loose and slid west and to its present position along a special type of fault known as a detachment fault. This movement took place slowly over thousands of years. Eventually the rocks upon which the upper plate rocks slid, solidified and today comprise the Catalina Gneiss which can be seen as strikingly banded rocks along the Catalina Highway. The actual detachment fault and the lower plate rocks can be seen along the loop road at the Rincon Mountain District of Saguaro National Park.

This detachment of the upper plate rocks brought the rocks of the Tucson Mountains to their present site, but this is not the end of our story. This event, however, did end the compressional stage of the Laramide Orogeny. As these stresses relaxed, the entire southwestern portion of the United States became stretched as the Pacific Plate began to pull away from the North American Plate, beginning approximately 20 MYA. The extension of this area produced block faulting, where many blocks separated from other blocks along steep normal faults producing the basins which today surround the Tucson Mountains and other similar mountain ranges in the southwest. At one time valley floors may have been as much as eight to ten thousand feet below the mountain crests, but today relief is much reduced, as alluvial (stream) deposits of gravel, sand and mud have filled the basins to their present levels.

What does the future hold for the region? Erosion will continue to reduce the relief of the mountains, which may lead to renewed uplift of the mountain fault block and potential future earthquakes. A major earthquake has not occurred in the Tucson region since the 1880's, but could happen at any time. However, such events will most likely be few and far between over the next few thousand years!