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 - igneous, sedimentary and metamorphic - are found in the park. The igneous 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 Mountains 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.
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 ex-
posed 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 begin-
ing 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
grayed 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 depres-
sion or caldera at least fifteen miles in
diameter! Over time this caldera was filled
with rhyolite, ash deposits (tuff) and
breccia, a rock formed from the consoli-
dation 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 over-
look at Gates Pass. At the same time,
neighboring 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
northwest 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 re-
newed volcanic activity in parts of south-
eastern 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 thou-
sands 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 Moun-
tains 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 approxi-
nately 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 Moun-
tains 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!