GEOLOGY OF SAN LORENZO CANYON: FAQ

How old is the canyon?
The canyon is less than 1 million years old. The upper Rio Grande flowed into a large lake in northern Mexico about 3 million years ago. About 0.8 million years ago, the lower Rio Grande (in Texas) became linked to the upper Rio Grande, which then allowed through going flow from Colorado to the Gulf of Mexico. In response to a new base level, the New Mexico section of the Rio Grande, and its tributaries (i.e. San Lorenzo Canyon), have been cutting down through older river deposits and older rock layers for about 800,000 years. The 200-foot-high cliffs along middle San Lorenzo Canyon were cut by stream erosion during the last 200,000 years.

What controls the location of springs in San Lorenzo Canyon?
Rain and snow melt soaks into the ground and the shallow groundwater then generally flows down slope through the loose sand and gravel that fills the bottom of San Lorenzo Canyon (Arroyo) along most of its course. Where dense (relatively impermeable) volcanic rock forms the floor of upper San Lorenzo Canyon, the shallow water flow is forced to the surface to make springs. Some groundwater also flows very slowly toward the river through cracks in the volcanic rocks; this deeper flow is locally forced to the surface, where impermeable mudstones are faulted down against the volcanic rocks (as at “Query Spring”—see below). The sandy floor of lower and middle San Lorenzo Canyon is normally a dry arroyo bed. During unusually wet periods the water table can rise rapidly and a shallow clear water stream can reach the 200-foot high cliffs in middle San Lorenzo Canyon. The headland of San Lorenzo Canyon is a relatively small catchment area (6 $mi.^2$) and at low elevation (5600 ft). Flash floods in San Lorenzo Canyon can only occur in response to intense rainstorms centered immediately west and southwest of San Lorenzo Spring or directly over the canyon.

What types of rock layers are present in the canyon and how old are they?
Volcanic strata and sedimentary beds are the main types of rock layers. Near the end of the “road”, on the north side of the canyon, is a light brown, cliff-forming rock layer above “Query Spring”. This graffiti marked layer (white “?”) is part of a large volume (260 $mi.^3$), sheet-like, pyroclastic-flow deposit (now named the Vicks Peak Tuff) that was erupted from a super-volcano (caldera) in the southern San Mateo Mountains 28.6 million years ago. Basaltic lava flows (malpais-type lavas), stacked one on another, form a thick dark gray layer above the brown ash-flow tuff layer and a thin dark gray layer below the brown tuff. Volcanic strata adjacent to upper San Lorenzo Canyon range in age from 32 to 27 million years old. Sedimentary beds include red, gray, and brown conglomerates and light yellowish brown sandstones deposited by streams from about 18 to 7 million years ago. Abundant volcanic cobbles in the conglomerates (cemented stream gravels) were eroded from upthrown sides of fault blocks that offset and "stretched" the older volcanic strata within the Rio Grande rift. Sedimentary formations at San Lorenzo contain several thin, light-gray, ash beds ranging from 18-14 million years old.

What is a fault? What does a fault look like?
A *fault* is a slip surface (dislocation surface) that offsets strata (rock layers). In a mine tunnel, the fault surface over your head is called the "hanging wall" and the fault surface under your feet is called the "foot wall". Where the hanging wall has moved down with respect to the footwall, it is called a *normal fault*. All the faults (fault traces—see below) that cross San Lorenzo are normal faults of the Rio Grande rift; these normal faults extend (*stretch*) the brittle rocks of the upper crust. When well exposed, a fault looks like a planar surface that truncates or offsets strata. Large displacement faults may be obvious where the offset strata display different colors. The largest displacement fault in the area (~ 1mile stratigraphic offset) meets San Lorenzo Canyon at Query Spring. The intersection of a fault plane with the earth’s surface forms a line, called a *fault trace*.

What is the Rio Grande rift?
The *Rio Grande rift* is a north-trending zone of west-directed crustal extension marked by deep asymmetrical basins (tilted blocks) called *half grabens* that are filled by 1-3 miles of relatively young sediments. The Albuquerque Basin and adjacent Sandia-Monzano mountain ranges represent large east-tilted blocks. The Rio Grande follows the axis of these actively subsiding basins. A satellite image on the *New Mexico Highway Geologic Map* (NMGS, 2005), shows the vegetated banks of the Rio Grande as a narrow green ribbon along the axis of the otherwise poorly vegetated sedimentary basins of the Rio Grande rift. The fault-bound basins have subsided in response to westward extension of the crust over the last 30 million years, which has been caused by differential motion of *tectonic plates*. The Pacific plate is being pulled westward faster than the North American plate is being pushed to the west (by spreading of the Atlantic Ocean).

How can moving tectonic plates "stretch" solid rocks?
As plates move apart the deeper hot rocks stretch like taffy and the cold brittle rocks near the surface break into numerous *fault blocks*. The fault blocks commonly slip and tilt, much like books on a shelf (or fallen dominoes), which allows the solid upper crust to stretch. Extensional fault block depressions (basins) are called *grabens* (German for trough). In New Mexico, the Colorado Plateau *microplate* (small tectonic plate) has been drifting away from the Great Plains for the past 30 million years. The rift axis follows a pre-existing zone of crustal shortening (older mountain belt), which was squeezed up between the more rigid (colder and stronger) Colorado Plateau and Great Plains microplates, as if in the jaws of a giant vise. The “vise” is now opening.

Why do we find volcanoes in rifts?
As the crust and underlying upper mantle stretch (thin by necking), hotter mantle rocks, already near their melting temperature (asthenospheric mantle), well up into the space created by the necking process. The decrease in pressure during upwelling allows the asthenospheric mantle to partially melt and form basaltic magmas; these magmas are then forced up tensile fractures (dikes) to feed volcanoes or shallower magma chambers in the crust (e.g. Socorro magma body).

How do geologists determine the relative ages of different rock layers?
In layered sequences, the younger layers are always deposited on top of older layers (Law of Superposition). Also, a geologic feature that cuts across another feature is the younger of the two. The angular unconformity in eastern San Lorenzo Canyon illustrates several cross cutting relationships, originally horizontal beds, and older tilted beds that must be deformed.

How do geologists determine the numerical (absolute) age of different rock layers?
Potassium is a radioactive element found in most igneous rocks. Potassium decays to argon (a noble gas) at a constant rate. At New Mexico Tech, the Argon Geochronology lab very precisely measures a nuclear-reactor-generated proxy for potassium (^{40}Ar) and the radiogenic argon (^{39}Ar) trapped in a potassium-bearing mineral (e.g. potassium feldspar), which allows them to determine the cooling age of an igneous or volcanic rock (analytical error ± 0.5 %). The argon forms slowly, so the argon method works best for igneous rocks more than 1 million years old. In contrast, very young lava flows on Hawaii and volcanic deposits at Mt. St. Helens are dated from historic records. Slightly older prehistoric flows (less than 50,000 years old) can sometimes be dated using radioactive carbon (^{14}C) found in charcoal (cooked vegetation) under the flows. Unique fossils in sedimentary rocks can help determine the approximate numerical age of sedimentation, if the same fossils were previously found in conjunction with dated volcanic strata.

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