



Geology of Grand Canyon, Bryce Canyon and Zion National Parks

AAPG Field Seminar
May 31-June 6, 2014
Garry Hayes, Organizer

The Colorado Plateau is one of the most scenic landscapes on the planet, exposing some 2 billion years of Earth history in spectacular fashion. The province includes 10 national parks and countless monuments, state parks and recreation areas.



This trip explores three national parks that best expose the history of the plateau in sequential fashion: Grand Canyon, Bryce Canyon, and Zion. These and other localities are part of Grand Staircase, the sequence of sedimentary and metamorphic rocks encompassing 2 billion years of change.



The trip begins and ends in Las Vegas, Nevada, one of the most unlikely urban environments in the world. The city lies within the most arid part of the Basin and Range Province, and must import nearly all the water it consumes (in prodigious amounts).



An optional “pre-trip” excursion will take us to Red Rock Canyon National Conservation Area in the Spring Mountains. In this area, Paleozoic limestone formations have been thrust over the Jurassic Aztec Sandstone (related to the Navajo Sandstone of the Colorado Plateau).



Boulder Dam, which backs up Lake Mead, was constructed in extensively faulted Miocene volcanic tuffs and lava flows. The reservoir has a capacity of nearly 30 million acre feet of water, equivalent to two years of the average flow of the Colorado River. We will stop briefly to observe this stupendous piece of dam engineering.



As we drive south from Lake Mead, we will encounter evidence of geologic violence: ash flows of the Peach Springs Tuff in the vicinity of Kingman, Arizona. The caldera eruption showered ash from the vicinity of Barstow, California to Peach Springs, Arizona. It had an estimated volume of 150 cubic miles.



One of the trip highlights will be a drive down to the bottom of the Grand Canyon at Diamond Creek on the lands of the Hualapai Nation. This is the only place in the canyon accessible by vehicle.



Diamond Creek Road will give us access to spectacular exposures of the Proterozoic and Early Paleozoic rocks of the Grand Canyon, including a close up view of the Great Unconformity that separates 1.7 billion year old metamorphic rocks from the 540 million year old Cambrian Tonto Group.



The 1.7 billion year old metamorphic rock shows the effects of deep burial in the crust. Pegmatite granite dikes cut through the older Vishnu Schist.



Excellent exposures of the Cambrian Tonto Group allow some insight into the earliest complex life on the planet. The Bright Angel Shale often reveals the trackways of worms, trilobites and other animals of the early Cambrian seas.



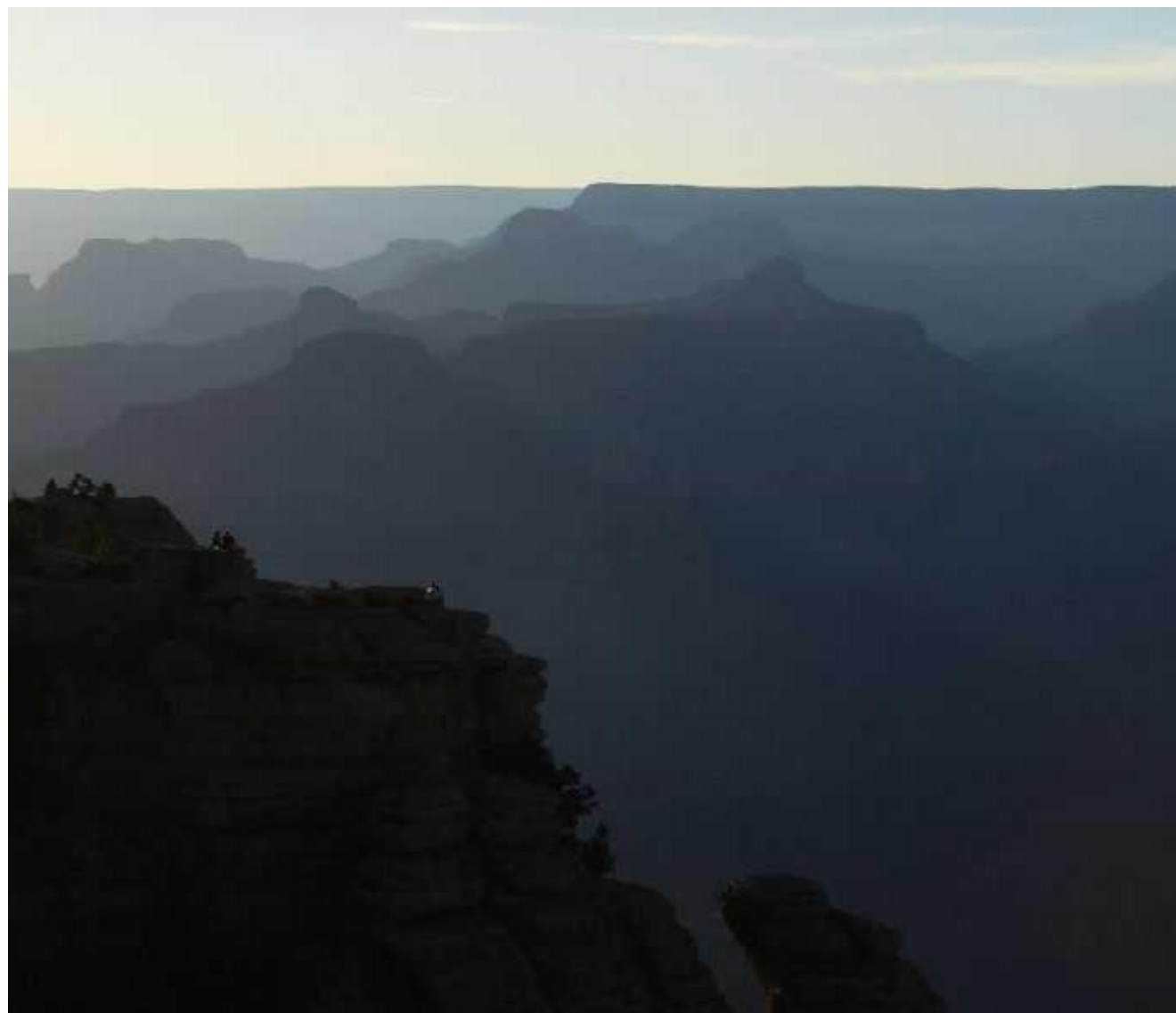
Near Williams, Arizona, we will have a chance to walk around the *inside* of a volcano. A cinder cone has been quarried, exposing the layers of cinders and lapilli, and vertical dikes of basalt. Occasionally small xenoliths of olivine can be found in the basalt.



Peridotite and dunite are ultramafic rocks from the Earth's mantle. The green mineral is olivine.



The Grand Canyon is one of the most stunning spectacles on Earth. The gorge is more than 200 miles long, 10-15 miles wide, and a mile deep. And the origin of the canyon is still somewhat of a mystery: the lower end of the Colorado River has existed for only 4 million years, while some parts of the Grand Canyon are 60 million years old!



There is no way to adequately describe one's first look into the canyon. It is so sweeping, so deep, so...grand. Everyone has seen pictures of this iconic place, but no picture can ever capture the immensity of this gorge. We just take it in and try to understand what our eyes and ears are telling us.



Most people see the canyon for the first time here at Mather Point. If you haven't been to the canyon in a while, you are in for a surprise; there have been a lot of changes at the famous vista point.



Arriving at Mather Point used to be a loud and obnoxious affair. There was a heavily used parking lot, traffic noise, and huge crowds were the norm. A few years ago the park service re-routed the highway and put the parking lot several hundred yards from the rim. Visiting the rim at Mather is quieter and less crowded than it used to be.



As we get past our initial impressions, we start to see the patterns and features of the canyon. We become aware of the history that is exposed by the sedimentary and metamorphic rocks below our feet. The horizontal layers date from the Paleozoic era, and record an encroaching sea, periods of erosion, distant mountain-building events, and the advancement once again of a shallow sea.



The deeper we gaze into the canyon, the more we see. There are other layers, older, and sloping at odd angles. These rocks are more ancient sediments, deposited before life emerged on land, and even before complex multicellular life forms crawled on the ocean floor.



These older rocks, known as the Grand Canyon Supergroup, are best seen from viewpoints along the eastern part of the park. The contact between the horizontal and tilted layers is an angular unconformity. The older rocks are more than 12,000 feet thick, three times the thickness of the overlying Paleozoic sediments. Some of the resistant layers projected as islands in the Cambrian sea.



One of the best ways to appreciate the scale of the canyon is to hike into it. We'll set aside some free time for hiking or strolling at the ability level of our travelers.



As we leave Grand Canyon National Park we will descend the monocline that defines the eastern edge of the Kaibab Plateau, and encounter the canyon of the Little Colorado River. This often dry watercourse plays a major part in our understanding of how the Colorado River could cross the Kaibab Plateau and carve the Grand Canyon.



Oh, have we mentioned the horrific hazards of exploring this wild country?



As we leave the Little Colorado River, we will encounter the Navajo section of the Colorado Plateau, a colorful region of mostly Mesozoic sedimentary rocks. We are on the Navajo Reservation for much of the day.



One of our stops will be at the incised meander of the Colorado River called Horseshoe Bend.



Glen Canyon was a deep gorge carved through the Mesozoic Navajo Sandstone, the petrified dunes of a desert sand sea that covered thousands of square miles. In the 1960's, dam engineers constructed Glen Canyon Reservoir, one of the highest concrete arch dams in the world. It took nearly twenty years to fill, but extreme drought nearly emptied the lake in the 21st century. We will spend a night in Page, near the reservoir.



On the outskirts of Page, Arizona, we will encounter these cross-bedded sandstones. How deep do you think the channel is in the center of this photograph?



Flash floods flowing over the resistant cliff-forming sandstones have carved incredible slot canyons. The narrow cleft in the previous picture is Antelope Canyon, which is more than 100 feet deep in places, but only a few feet wide. We will explore it, assuming the weather is clear!



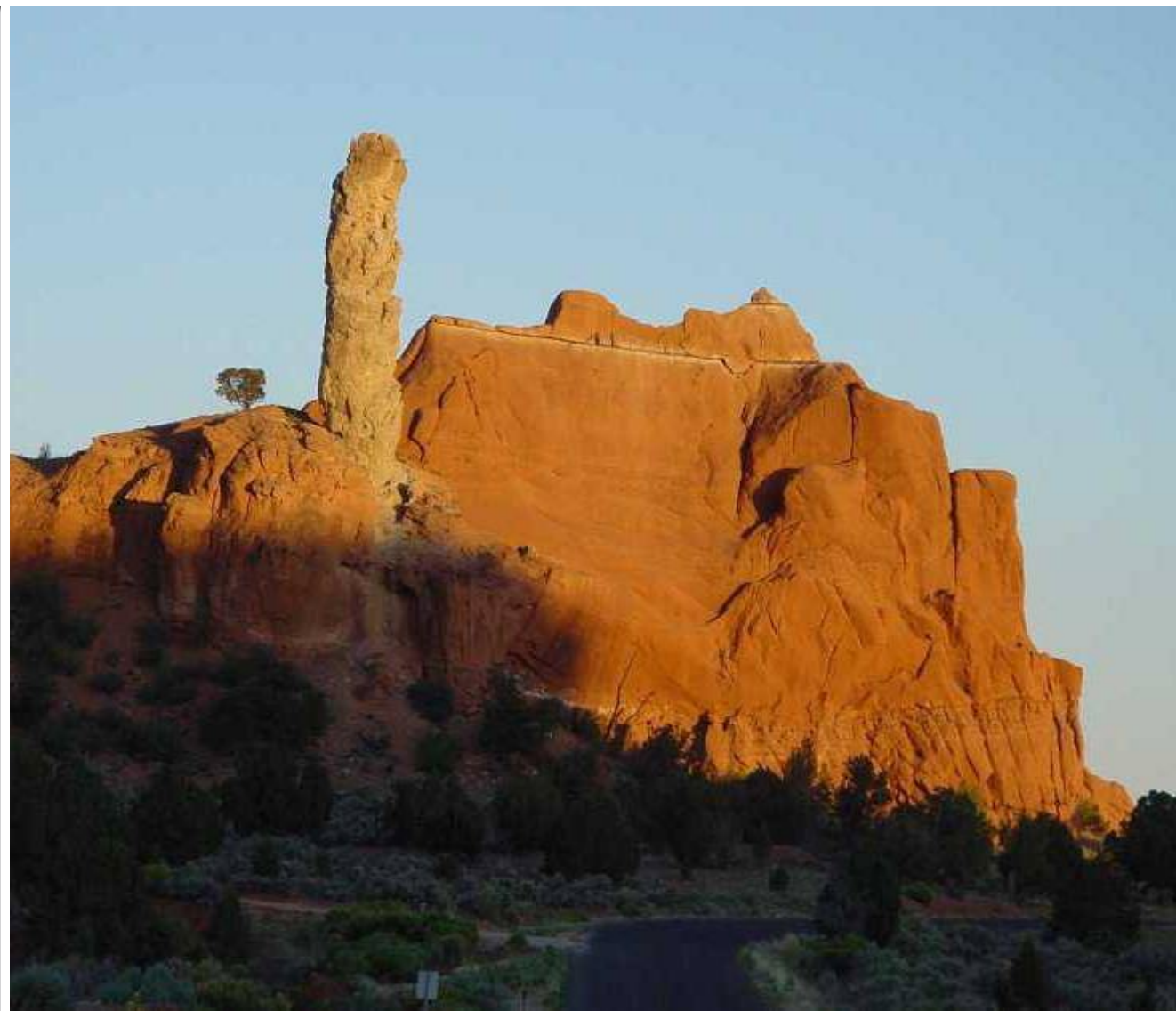
The Cockscomb is a continuation of the East Kaibab monocline that forms the eastern boundary of the Grand Canyon. We will follow the gravel road through Cottonwood Canyon that cuts through the heart of Grand Staircase-Escalante National Monument.



A large natural arch graces the north end of the road through Cottonwood Canyon. Grosvenor Arch is actually two spans, the largest of which is 100 feet across.



Driving beyond Grosvenor Arch, we arrive at Kodachrome Basin State Park, named for the intense colors of the rocks exposed there. Kodachrome is a basin carved out of a member of the Entrada Sandstone. The park is also known for its unusual sedimentary pipes.



In the Kodachrome Basin region, we become more aware of the step-like nature of the Grand Staircase. One brightly colored cliff after another leads off to the horizon. We have been ascending through Mesozoic sediments, and after Kodachrome, we emerge into the rocks of the Cretaceous period.



The Cretaceous sediments of the Colorado Plateau are not so brightly colored as the Jurassic rocks (the bright red Entrada Sandstone contrasts strongly with the Tropic Shale and Mesa Verde Group in the picture). The Tropic Shale records the last transgression of the sea onto the plateau country, while the Mesa Verde Group records the final regression. The coastal swamps and estuaries were the source of the vast amounts of coal found in the region.



We are now in the High Plateaus section of the Colorado Plateau, and some of the youngest rocks are visible: the pink and white sediments of the Claron Formation. The Claron is composed of silt and freshwater limestone deposited in a lake environment in early Cenozoic time.



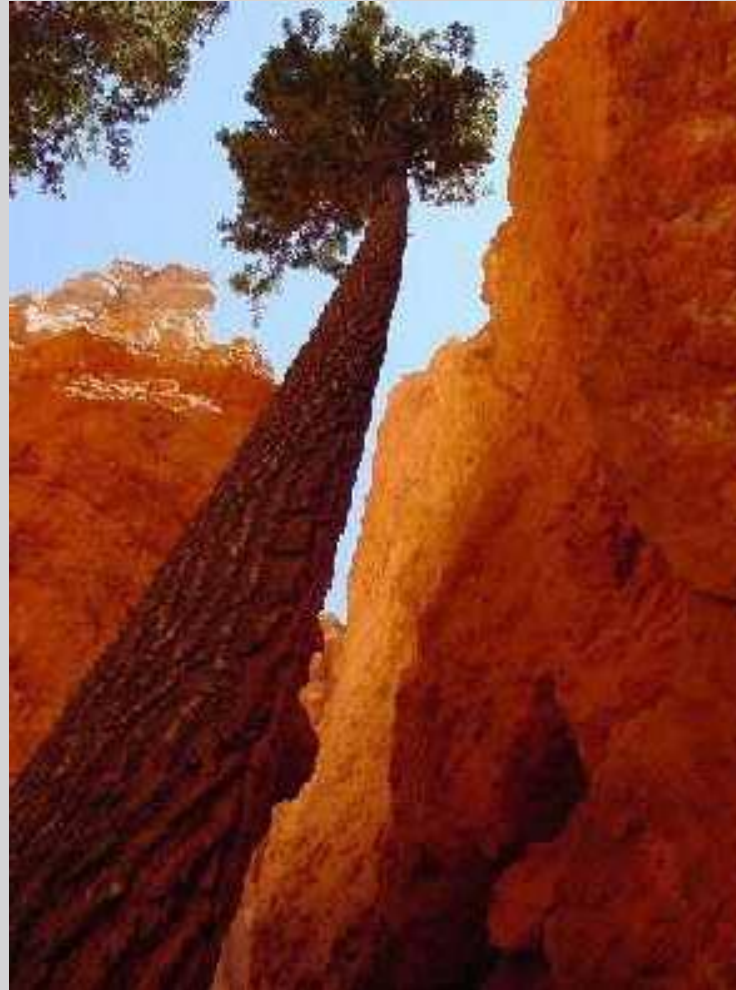
The Claron Formation is jointed and fractured, and when exposed to erosion, it develops into spires called hoodoos. A few hoodoos here and there are interesting to look at...



...thousands of hoodoos is worthy of national park status...this is Bryce Canyon National Park. It is not really a canyon, but a series of amphitheaters that display the hoodoos and wide-ranging views into Grand Staircase-Escalante National Monument region.



We will take part of a day to allow our travelers to hike below the rim, perhaps in Wall Street Canyon.



From the youngest rocks at Bryce Canyon, we start moving back down through the stratigraphic column as we make our way towards Zion National Park. Arriving from the east, we will walk to the Zion Arch viewpoint, and have a first look at an extraordinary canyon carved through the Navajo Sandstone.



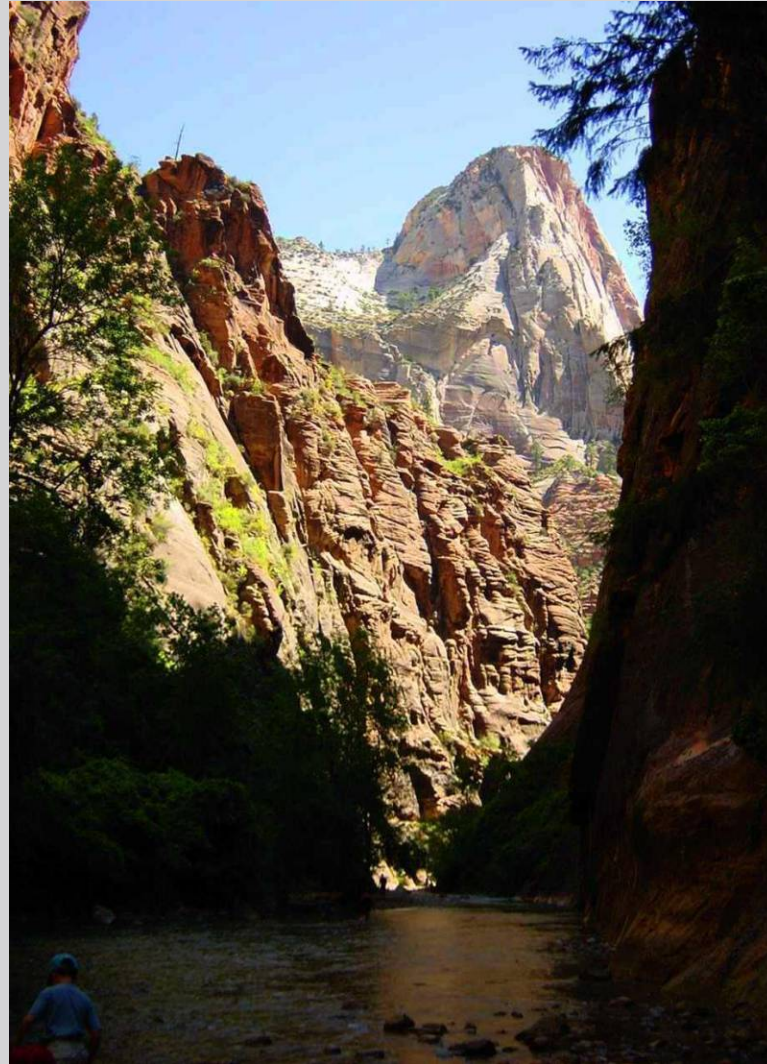
The cliffs of Zion expose some 2,000 feet of Navajo Sandstone, and other Triassic and Jurassic formations. The softer Triassic formations are eroded easily, undercutting the Navajo Sandstone. Rockfalls are common events in the canyon, and cause rapid cliff retreat over geologic time. Where the softer rocks are exposed, the canyon is wider.



When the Virgin River flows over Navajo Sandstone, cliff retreat doesn't take place and the canyon is very narrow.



In some places, the river fills the valley floor. One cannot walk up the Narrows of the Virgin without getting wet. You will be welcome to try during our free time in Zion National Park.



On the other hand, you might choose the climb to Angel's Landing. It is not a trail for anyone with a fear of heights! But the view from the top is stunning...



The park service has thoughtfully provided some chains here and there to give you something to hold onto! As if it would help....



Our final excursion will be into the little-known Lava Point area of Zion National Park, along a road that includes views of recent cinder cones, inverted streams, and a perspective of Zion Canyon from above.



After our day at Zion, we will drive through St. George, back into the Basin and Range Province on our way to Las Vegas and the end of our trip. The Colorado Plateau is one of the most intriguing landscapes on Earth. We hope you will join us on our exploration of this wonderful and mysterious place!



Much of the trip is in isolated parts of the Colorado Plateau, but we have arranged comfortable nightly accommodations, and travel in mid-sized rental Sport Utility Vehicles.

Some roads on our itinerary are gravel-surfaced, but are well maintained. Most stops are accessible and involve easy strolls. Optional hikes may be more challenging.

Meals are not generally provided, but some of the lodging facilities offer free breakfasts. A variety of restaurants and fast food stores are usually available each evening.

For more information, see the AAPG Education website:

<http://www.aapg.org/education/fieldseminars/>

Or contact Garry Hayes:

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Questions?

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Thank You!

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