SAN JUAN AREA HISTORY

Pre-1700: See Archaeology guides.

1700's: Continuing conflict between Comanches, Utes, Navajo, Puebloans, Apaches, and the Spanish invaders. Skirmishes occurred in just about every conceivable combination.

1765: Juan Maria de Rivera apparently enters the area, going perhaps as far north as Moab.

1776: Dominguez-Escalante expedition. First documented map of the area.

1821: The Spanish begin their withdrawal from the Southwest.

1830: President Andrew Jackson signs the Indian Removal Law, the beginning of the reservation system.

1830: Joseph Smith publishes the Book of Mormon and establishes the LDS Church.

1837: Denis Julien was possibly somewhere in the vicinity.

1845: Joseph Smith killed. Brigham would set off for Salt Lake the following year.

1848: US takes control of the Southwest.

1849: Brigham Young asks for a provisional state called Deseret,stretching roughly from San Diego to South Pass, the Gila river to Oregon. Congress reduced the size and renamed the proposed territory Utah.

1852: Mormon polygamy publicly announced. The US Army is promptly sent to war against Utah, but never quite makes it there.

1855: Elk Mountain Mission is established by one of the earliest groups of Mormon homesteaders in the area. The Mission was located at Moab, but quickly failed.

1858: US Soldiers kill 60 of Navajo headman Manuelito's livestock. Furious, he resolves to drive the soldiers from the land.

1859: Macomb Expedition. Captain John N. Macomb of the Army Corps of Engineers tries to determine the course of the San Juan and fix the position of the confluence of the Green and Grand (Colorado) rivers.

1860: Navajos attack Fort Defiance, led by Manuelito and Barboncito, almost completely overrunning it. The army begins a "total war" policy against the Navajo.

1862: Kit Carson arrives to begin the war against the Navajo.

1863-64: War against the Navajo, ending in the Long Walk to Bosque Redondo. More than 8,000 Navajo were marched 350 miles through spring blizzards. Soldiers shot stragglers, women giving birth, and the elderly, and raped women, passing on syphilis. Stories of this period are handed down in the same way Jews hand down stories about the Holocaust. Kit Carson became an American hero.

1868: The cost of Bosque Redondo had become an embarrassment, triggering the settlement of a peace treaty and the creation of the Navajo reservation, an area about $1/10^{th}$ the size of lands previously claimed by the Navajo.

1869: Major John Wesley Powell makes his historic trip down the Green and Colorado.

1871: Powell makes his second expedition.

1875: Hayden Expedition. William Jackson sent to look for ruins in San Juan drainage. He specifically mentions Casa del Eco (16 room ruin).

1878: LDS President John Taylor directs a group of Mormons out of Cedar City and Parowan to settle the San Juan region.

1879: USGS created.

1879: The scouting party for the San Juan mission traverses almost 1,000 miles, going across Lee's Ferry to Montezuma Creek, then up to Moab and back.

1880: Hole-in-the-Rock expedition.

Hole-In-The-Rock Expedition

It's purpose was to help settle Utah in the face of gentile expansion and to minister to the "Lamanites", the Indians who were considered to be a lost tribe of Israel. After disagreement on a route, the group decided to take a shortcut suggested by scouts who had not even made it as far as the Colorado river. The 6 week trip to Montezuma Creek was apparently deemed too long. The 230 person expedition left in October of 1879 and rendezvoused east of Escalante. The leader, Silas Smith, left to get more supplies and Platte Lyman took charge, leading the expedition along the Straight Cliffs to a narrow cleft in the walls above the Colorado river.

It took 6 weeks to widen the passage (Hole-in-the-Rock) and build a road down to the river and up the other side. Once on the other side, the pioneers struggled up Syncline Canyon, then made their way across Grey Mesa. Their search for a way off the mesa seemed in vain until a scout discovered a way by following a "llama" (a bighorn sheep). From there, the party had to cross Clay Hills pass, where it took a week to get through the slimy muck. After this, a 50 mile detour was required to get around Grand Gulch, hacking through a dense juniper forest the whole way.

After coming off Cedar Mesa via the rocky curves of "The Twist", the pioneers were forced to head south along the curving wall of Comb Ridge, until they reached a natural break at the San Juan. Throughout the journey, expedition members had become more and more strung out, so there were few to help in making the ascent up San Juan Hill to the top of Comb Ridge. Pioneers claimed this ascent to be the worst of the trip, saying the road ran with the blood of stumbling animals.

On April 6, 1880, 6 months after beginning the 6 week shortcut, the pioneers reached the site of Bluff. Although they were supposed to settle in Montezuma Creek, a relatively easy journey of 18 more miles, they decided to stay where they were at.

1880: San Juan County officially created.

1881: Cass Hite comes to the canyon country, looking for the fabled Navajo Pish-la-kai silver mine. He strikes up a friendship with Navajo headman Hoskininni. Hoskininni leads Hite down White Canyon to a Colorado river crossing (later called the Dandy crossing) to look for gold in 1883. Hite starts a small gold rush to the area, staking out mining claims and forming mining companies and districts and selling stock, as well as advertising the area. He and his brothers found Hite, just below the Dandy crossing. Cass died in February 1914 and was buried outside his cabin, now under Lake Powell.

1881: A flood washes out Amasa Barton's trading post in Montezuma Creek. He asks Bishop Nielson permission to build a new one at the bend of the San Juan where it cuts through Comb Ridge.

1882: Emery Langdon Goodridge makes the first recorded boat trip on the San Juan, where he notices oil seeps. He stakes a claim at Mexican Hat, but doesn't have the money to exploit it.

1882: President Chester Arthur creates the Hopi reservation, essentially to prevent Mormon settlers from claiming the land under the Homestead Act, since the land was believed to hold valuable mineral deposits. This order forms the legal basis of the Navajo-Hopi land disputes.

1884: President Arthur expands the Navajo reservation border to the San Juan.

1887: Amasa Barton is killed, by whatever means you happen to believe.

1888: After trouble with the Paiutes, the federal government passes a law providing for the abandonment of almost the entire San Juan County area north of the San Juan River to create individual allotments for the Southern Utes and Paiutes.

1890: Grand County officially created.

1891: McLoyd expedition goes to Grand Gulch looking for artifacts. They later tell the Wetherills about their finds.

1892-93: After Hite's praise of the San Juan for flour gold (in order to make money off the believers), floods of prospectors come to the river.

The San Juan Gold Rush

It started in 1892, with Cass Hite printing praises of the San Juan River for its "flour" gold. This was gold that had eroded from the San Juan mountains and been ground down to the consistency of flour. Unfortunately, it was mixed in with one of the heaviest silt loads in the west.

200 men a day were showing up to mine the river. Claims stretched from Bluff down to Glen Canyon. 2,000 men alone worked for the Gabel Co., who had established hundreds of claims around Clay Hills Crossing.

Although many miners claimed to have inventions to save the gold, most of them were actually just using sluice boxes, and within several years, most had given up. The mine at Zahn's camp was the longest to operate, being used into the 1930's.

1893: Walter Mendenhall comes from Lake City CO to hunt for gold. He and Alonzo Savage have little success and leave. Mendenhall returns with his father and brother that October, and after looking for good spots by horse, Mendenhall leaves them at Mendenhall Loop, where they build a cabin.

1893: A collection of Mormons in Bluff form the "Bluff Pool" to buy out a tough bunch of Texans who were in the area grazing cattle.

1893-94: First Wetherill Grand Gulch expeditions in which the Basketmakers were named.

1894: Augustus C. Honaker, a freighter working between Cortez and Bluff, decides to look for gold. In the spring, he starts work on a 1,500 foot trail to the river, with the help of Bert Loper. Eventually the trail was widened for pack animals. The mine didn't amount to much. Hazel Lyman of Blanding, grandaughter of Honaker, wears a ring she says contains the total amount of gold removed from the Honaker mine.

Bert Loper

Bert was born in 1869 and orphaned at an early age. He ran away from his foster home to seek his fortunes in the Colorado mines. In 1893, he left the mines around Rico to live on a ranch near Cortez. There he met Honaker. In 1894, he joined Honaker in mining for gold on the San Juan.

It was here where he first fell in love with the river. He started by running supplies in a boat from Bluff to their claim. Then, as the claim fizzled, he moved up and down the river. Here he got his initiation into pulling a loaded boat upstream, something he became quite good at. On one trip, he went through the upper and lower canyons, then hauled his boat all the way back.

He spent the winter of 1894 in Mendenhall's cabin with a brickmaker named Mulenix who persuaded him to give up mining and come to Bluff to make bricks. While in Bluff, Loper stayed with the Kumen Jones family. Eventually he left for Moab, then on to enlist in the Spanish-American War. Eventually he returned to Colorado, but was run out of the state for labor agitation.

In 1907, he joined Charlie Russell on a doomed Colorado river run that ended for Bert with him rowing and pulling his boat back upriver from Lee's Ferry to Red Canyon in the dead of winter (January-February 1908). There, Cass Hite persuaded him to take up residence in a small cabin.

1895: After receiving permission to leave the flood-prone Bluff area, Mormon pioneers join forces with the gold miners to make Congress rescind the 1888 Ute & Paiute Reservation ruling. They then begin to settle the Blanding and Monticello areas.

1896: Utah becomes a state.

1897: A.L. Raplee files his first gold claim, just above Honaker's. Although it's a failure, He stays on, continuing to look for gold and oil for many years. Because he was such a colorful figure and employed such colorful language, the Navajo called him "Hosteen God-damn".

1898: John Wetherill, while guiding an archaeological expedition in the Red Canyon area, notices some yellowish matter embedded in petrified wood. It looked interesting, so he posts a claim. This would later become the Blue Lizard Mine, one of the richest strikes of radioactive material in Utah.

1898: The Bluff Pool sells the White Canyon range to John Scorup, beginning the Scorup cattle empire. The Scorups were probably the most indefatigable explorers ever in the San Juan country, their cattle range eventually reaching almost 2 million acres.

1906: John and Louisa Wetherill and Clyde Colville establish their Oljeto trading post.

1906: Passing of the Antiquities Act.

1907: Prudden publishes *On the Great American Plateau: Wanderings Among Canyons and Buttes, in the Land of the Cliff-Dweller, and the Indian of Today.* This contained what is really the first accurate map of the Colorado Plateau, showing landforms and river courses in their proper relationship.

1907: E.L. Goodridge begins drilling in Mexican Hat.

Oil

E.L. Goodridge found investors in 1907 to finance his Mexican Hat oil claim. In 1908, they were rewarded with a 70 foot gusher. Goodridge also built a road from Mexican Hat, around John's Canyon, to Slickhorn, where he had seen more oil seeps. After bringing equipment 175 miles, his machinery plunged off the last grade going down to the mouth of Slickhorn where it still lies today.

Goodridge also built the bridge at Mexican Hat, which was washed out several times. Until recently it was called the Goodridge Bridge.

In 1925, the Utah Southern Oil Co. began construction on a road into Soda Basin, where they drilled their San Juan No. 1. In 1928, at 1870 feet, they bottomed in precambrian mica shist.

In 1948, Boundary Butte was discovered as a marginal gas field. It wouldn't be until much later that it could be exploited.

In 1952, Skelly builds a road from present Highway 95 to Nokai Dome, along with an airstrip, but no paying amounts of oil are found.

In 1954, the Desert Creek oil field is discovered by Shell. This serves to keep the major oil companies interested in the area after a series of dry holes had dissuaded them.

In 1956, Texaco begins to drill an expiring federal lease. The feds inaccurately record the resource potential, and in 1958 the land is annexed to the Navajo reservation in exchange for the Glen Canyon Dam area. This annexed land would eventually become the Aneth oil field.

1907-09: Byron Cummings, "the Dean", spends his archaeological field seasons in the area, going to the Natural Bridges area, Grand Gulch, Tsegi canyon, and Rainbow Bridge.

1908: Natural Bridges National Monument created.

1909: Navajo National Monument created, with John Wetherill as the first custodian.

1909: Herbert E. Gregory comes to the area for the first time. Throughout his career, Gregory would produce 66 papers and establish himself as the preeminent field geologist of the Colorado Plateau.

1910: Rainbow Bridge National Monument created, with John Wetherill as custodian.

1915: A skirmish between Paiutes and whites, called the Ute War, took on dramatic proportions and left the whites feeling embarrassed in the following publicity. This sets the scene for Posey's War.

1918-19: Influenza epidemics sweep the Indian reservations, decimating native populations. Little medical assistance is offered by the U.S. government. (life expectency for native americans had dropped to 33 years)

1921: Trimble Expedition.

Trimble Expedition

Kelly Trimble, a topographic engineer, and Hugh Miser, a geologist started out with an expedition to map Glen Canyon and the San Juan. They departed Sand Island on July 18, 1921 and reached the Colorado on October 3. Head boatman for the expedition was Bert Loper.

Their maps extended to the 3900 foot elevation and were obviously prepared with dam sites in mind, but this elevation meant they would survey a great deal of the surrounding country as well as the river. In addition, Miser's curiosity would lead him even further afield, where he could study the geology of the area. His 1924 reports remain among the best sources for accurate information.

1922: The Colorado River Compact is ratified by 6 of the 7 states (Arizona wouldn't join until 1944). This divided the river drainage into 2 basins, with the dividing line at Lee's Ferry. The Lower Basin (AZ, NV, CA) were guaranteed 7.5 million acre feet of water annually, and they began a series of dams almost immediately. The Upper Basin had too few people to begin constructing anything, but this would later change with the Colorado River Storage Project Act of 1956.

1922: Oil discovered on Navajo land.

1923: The Posey War. Really this was more of a white uprising than an Indian one, mainly in response to the bad feelings created in 1915 during the Ute War. The outcome of this conflict was the creation of the White Mesa reservation.

1924: Native Americans made U.S. citizens.

1925: Harry Goulding arrives in Monument Valley and builds his trading post.

1930: U.S. Senate investigation confirms the systematic kidnapping of Navajo children by church denominations. The reason for this was to fill boarding school quotas.

1932-36: The Stock Reduction Policy allows federal agents to kill more than 250,000 Navajo sheep and goats, with the Navajo having no say in the matter. At first, the Navajo were paid, but eventually the agents just shot the animals and left the carcasses to rot.

1933-34: Rainbow Bridge-Monument Valley Expedition. This expedition also included several boat trips down the San Juan. A young member of the mapping crew, Norm Nevills, was introduced to boating. A young Kenny Ross was introduced to the country.

1936: Norm Nevills begins accepting paying clients for river trips.

1939: The first John Wayne movie, "Stagecoach", is filmed in Monument Valley.

1942: More than 400 Navajo recruited to become "code-talkers" for the war in the Pacific.

1943: Reverend H. Baxter Liebler, who had first visited the previous year, begins building St. Christopher's Mission.

1946: The Uranium boom begins.

1946: Creation of the Bureau of Land Management by merging the General Land Office and the Grazing Service.

1953: Senator Arthur Watkins of UT passes legislation making termination the official Indian Policy. Essentially, this would dismantle the reservation system, and the services, programs and management that supported it. The legislation provided for the termination of "certain tribes, bands, and colonies of Indians in the state of Utah".

1956: Dwight D. Eisenhower, on October 15, pushes the little red button, triggering a blast 8 miles below the Utah border. Glen Canyon Dam construction had begun.

1957: C. Gregory Crampton begins his studies of the Glen Canyon area, resulting in 6 books by 1963. The archaeological salvage surveys of Glen Canyon were also begun.

1957: Kenny Ross begins running the San Juan commercially.

1962: Navajo Dam is completed, creating flood-control for the San Juan. New Mexico Indians finally gain the right to vote in state elections.

1962: Goosenecks State Park is created.

1963: The gates close at Glen Canyon Dam. It would take another 17 years for the reservoir to fill, as the bureaucrats realize the Colorado drainage cannot deliver what was promised. A 30 year legal battle is also settled between Arizona and California, giving Arizona a larger share of water and paving the way for the Central Arizona Project.

1964: Canyonlands National Park is created by act of Congress.

1966: The Hopi and Navajo councils sign coal-mining leases with Peabody Coal and Kennecott Copper for stripmining the Hopi-Navajo Joint Use Area. The history of getting these leases signed is pretty sordid and underhanded. The lawyer for the Hopi also represented Peabody Coal Company, but claimed there was no conflict of interest. Unknown to the Indians, a consortium of 23 utility plants had already planned to build 3 massive coal-powered plants – Mohave Generating Station, Navajo Generating Station, and Four Corners Power Plant.

1974: The Navajo Relocation Act displaces 12,000 Navajo living over the coal deposits in the Joint Use Area. This becomes the largest Indian removal since the 1800s. The Secretary of the Interior claimed only 800 families would be affected, then left the Interior department after the decision became final. He left to become vice president of Peabody Coal.

1979: Passing of the Archaeological Resources Protection Act attempts to slow the destruction of archaeological sites on public and Indian lands.

1990: Native American Graves Protection and Repatriation Act passes, requiring institutions receiving federal funds to return Indian bones, human remains, and sacred objects to tribes.

DECADE OF NORTH AMERICAN GEOLOGY
GEOLOGIC TIME SCALE

DNAG

GEOLOGICAL SOCIETY OF AMERICA

CENOZOIC

AGE (Ma)	PERIOD	EPOCH	AGE	PICKS (Ma)
	QUATERNARY	HOLOCENE		0.01
		PLEISTOCENE	CALABRIAN	1.6
	NEOGENE	PLIOCENE L	PIACENZIAN	3.4
		PLIOCENE E	ZANCLEAN	5.3
		MIOCENE L	MESSINIAN	6.5
			TORTONIAN	11.2
		MIOCENE M	SERRAVALLIAN	15.1
			LANGHIAN	16.6
		MIOCENE E	BURDIGALIAN	21.8
			AQUITANIAN	23.7
	PALEOGENE	OLIGOCENE L	CHATTIAN	30.0
		OLIGOCENE E	RUPELIAN	36.6
		EOCENE L	PRIABONIAN	40.0
			BARTONIAN	43.6
		EOCENE M	LUTETIAN	52.0
		EOCENE E	YPRESIAN	57.8
		PALEOCENE L	SELANDIAN: THANETIAN	60.6
			SELANDIAN: UNNAMED	63.6
		PALEOCENE E	DANIAN	66.4

MESOZOIC

AGE (Ma)	PERIOD	EPOCH	AGE	PICKS (Ma)	UNCERT (m.y.)
	CRETACEOUS	LATE	MAASTRICHTIAN	66.4	
			CAMPANIAN	74.5	4
			SANTONIAN	84.0	4.5
			CONIACIAN	87.5	
			TURONIAN	88.5	2.5
			CENOMANIAN	91	
		EARLY	ALBIAN	97.5	2.5
			APTIAN	113	4
		NEOCOMIAN	BARREMIAN	119	9
			HAUTERIVIAN	124	9
			VALANGINIAN	131	8
			BERRIASIAN	138	5
	JURASSIC	LATE	TITHONIAN	144	5
			KIMMERIDGIAN	152	12
			OXFORDIAN	156	6
		MIDDLE	CALLOVIAN	163	15
			BATHONIAN	169	15
			BAJOCIAN	176	34
			AALENIAN	183	34
		EARLY	TOARCIAN	187	34
			PLIENSBACHIAN	193	28
			SINEMURIAN	198	32
			HETTANGIAN	204	18
	TRIASSIC	LATE	NORIAN	208	18
			CARNIAN	225	8
		MIDDLE	LADINIAN	230	22
			ANISIAN	235	10
		EARLY	SCYTHIAN	240	22
				245	20

RAPID POLARITY CHANGES

PALEOZOIC

AGE (Ma)	PERIOD	EPOCH	AGE	PICKS (Ma)	UNCERT (m.y.)
	PERMIAN	LATE	TATARIAN	245	20
			KAZANIAN	253	20
			UFIMIAN	258	24
		EARLY	KUNGURIAN	263	22
			ARTINSKIAN	268	12
			SAKMARIAN		
			ASSELIAN		
	CARBONIFEROUS: PENNSYLVANIAN	LATE	GZELIAN	286	12
			KASIMOVIAN (S.)	296	10
			MOSCOVIAN (W.)		
			BASHKIRIAN	315	20
	CARBONIFEROUS: MISSISSIPPIAN		(N.)	320	
		EARLY	SERPUKHOVIAN	333	22
			VISEAN	352	8
			TOURNAISIAN	360	10
	DEVONIAN	LATE	FAMENNIAN	367	12
			FRASNIAN	374	18
		MIDDLE	GIVETIAN	380	18
			EIFELIAN	387	28
		EARLY	EMSIAN	394	22
			SIEGENIAN	401	18
			GEDINNIAN	408	12
	SILURIAN	LATE	PRIDOLIAN	414	12
			LUDLOVIAN	421	12
		EARLY	WENLOCKIAN	428	8
			LLANDOVERIAN	438	12
	ORDOVICIAN	LATE	ASHGILLIAN	448	12
			CARADOCIAN	458	16
		MIDDLE	LLANDEILAN	468	16
			LLANVIRNIAN	478	16
		EARLY	ARENIGIAN	488	20
			TREMADOCIAN	505	32
	CAMBRIAN	LATE	TREMPEALEAUAN		
			FRANCONIAN		
			DRESBACHIAN	523	36
		MIDDLE		540	28
		EARLY		570	

PRECAMBRIAN

AGE (Ma)	EON	ERA	BDY. AGES (Ma)
	PROTEROZOIC	LATE	570
750			900
		MIDDLE	
1000			
1250			
1500			1600
1750		EARLY	
2000			
2250			
2500			2500
2750	ARCHEAN	LATE	
3000			3000
3250		MIDDLE	
3400			3400
3500		EARLY	
3750			3800?

San Juan Stratigraphy

JURASSIC

Bluff Sandstone
The Bluff Sandstone is named after . . . Bluff! It's what you see in town and on the horizon at Sand Island. The eroded tops expose the natural color of the stone, the red cliff faces are simply **desert varnish**. On the face exposures, you can see large **cross-beds**, indicating that these were once large sand dunes. The formation is about 340 ft. thick near town – the thickest it gets. In all other directions it thins, barely making it to Arizona, Colorado, and the Abajo mountains.

Wanakah Formation
This formation is usually covered in debris from the Bluff Sandstone, but where it is exposed you can see it looking crinkled. This is due to **soft sediment deformation**. At most, it's about 140 ft. thick, and was probably deposited in some kind of lagoon or estuary.

Entrada Formation
Below the talus slope of the Wanakah, you start seeing some thin, ledgy cliffs. This is all that remains (for all those Arches people) of the Entrada. It has shrunk from being 1800 ft. at Arches to only 120 ft. thick here. It probably represents a shallow water margin to the marine deposition further north.

Carmel Formation
This is the slope between the ledgy cliffs and the Navajo cliffs, and is pretty unimportant here.

Navajo Sandstone
From the time you leave Sand Island to the time you get to Comb Ridge, you travel through the massive cliffs of the Navajo Sandstone. This is a classic **eolian** deposit with huge sweeping **cross-beds**. Like the Bluff Sandstone, it is a light buff color, with the red faces being **desert varnish**. It's pretty accurate to say that this area would have looked like the Sahara desert when the Navajo sands were blowing around. There were even oases, meaning that there are occasional lenses of limestone in the sandstone – check out the cliffs above the Moki Steps. The Navajo Sandstone is around 400 ft. thick here and VERY extensive. It also tends to form nice alcoves for any Ancestral Puebloans who happened by. Incidentally, it is such a uniform sandstone that it forms a perfect reservoir to get water from.

Kayenta Formation
This is the ledgy stuff Barton's Trading Post is sitting on – the bench between the cliffs of Navajo and Wingate. You can find **ripples** and **mudcracks** and sometimes dinosaur tracks (near Moab) exposed in it, which implies the presence of water. The uneven ripples imply water *flow* (symmetrical ripples imply oscillating water, like waves at a beach). The mud was probably pretty similar to what comes out of Chinle today – slimy, sticky, mucky stuff that cracks beautifully. The Kayenta is also the main reason why there are such nice alcoves in the overlying Navajo, as well as why it is such a good reservoir. The Kayenta is practically impermeable, forcing water that has trickled down through the Navajo to find a way out. For the residents of Bluff, the way out is through a well. Along the river, the water works its way out along the surface of the Kayenta and forms a spring, like at River House, which allows invading plants to speed the erosion process. Eventually an alcove forms that might even have a water source at its back.

Wingate Formation
The Mule's Ear (along with much of Comb Ridge) is a pretty typical exposure of the Wingate – sheer, red cliffs up to 400 ft. thick. Like the Bluff and Navajo Sandstones, the Wingate shows signs of massive dunes. Unlike the Bluff and Navajo, the Wingate actually IS red, though it can be exaggerated by desert varnish. The Wingate is grouped with the Navajo and Kayenta into the Glen Canyon Group. The reason for grouping them is that fossils are rare, nor were there any volcanoes spewing ash or lava at the time these sediments were being deposited, so no one really knows for sure WHEN one ends and another begins. Together, the three straddle the boundary between the Triassic and Jurassic periods. Other than that, we KNOW that the underlying Chinle is Triassic and we KNOW that the overlying Carmel is Jurassic.

TRIASSIC

Chinle Formation
The Chinle forms most of the valley between Comb Ridge and that fin of rock sticking up near the mouth of Chinle Wash. The most noticeable aspect of the Chinle at both Comb Ridge and Clay Hills is the fact that it is multi-colored: blue, green, red, orange, purple. All of these colors can be attributed to iron (gee, what a surprise). But the Chinle contains interesting stuff. The low-lying floodplain subject to debris flows and ashfalls that characterized the region during the Triassic was IDEAL not only for the preservation of downed trees (petrified wood) and dead critters (fossilized bones and teeth), but for making them dateable. The famous "yellowcake" of the uranium boom also comes from the Chinle. Exposures of the formation along Comb Ridge are almost 1200 ft. thick, and while pretty, can be very very bad to be in during a rainstorm. The Hole-in-the-Rockers found this out while mucking their wagons through Clay Hills Pass.

PERMIAN

Moenkopi Formation
You will hardly ever see this one on the river, except where it lies on top of that big DeChelly fin.

DeChelly Sandstone
Unfortunately for us, we only get a glimpse of the rock that forms Monument Valley and Canyon de Chelly. While it's about 600 ft. thick down there, it thins to nothing by Road Canyon. It DOES form that cool ridge in front of Chinle, however.

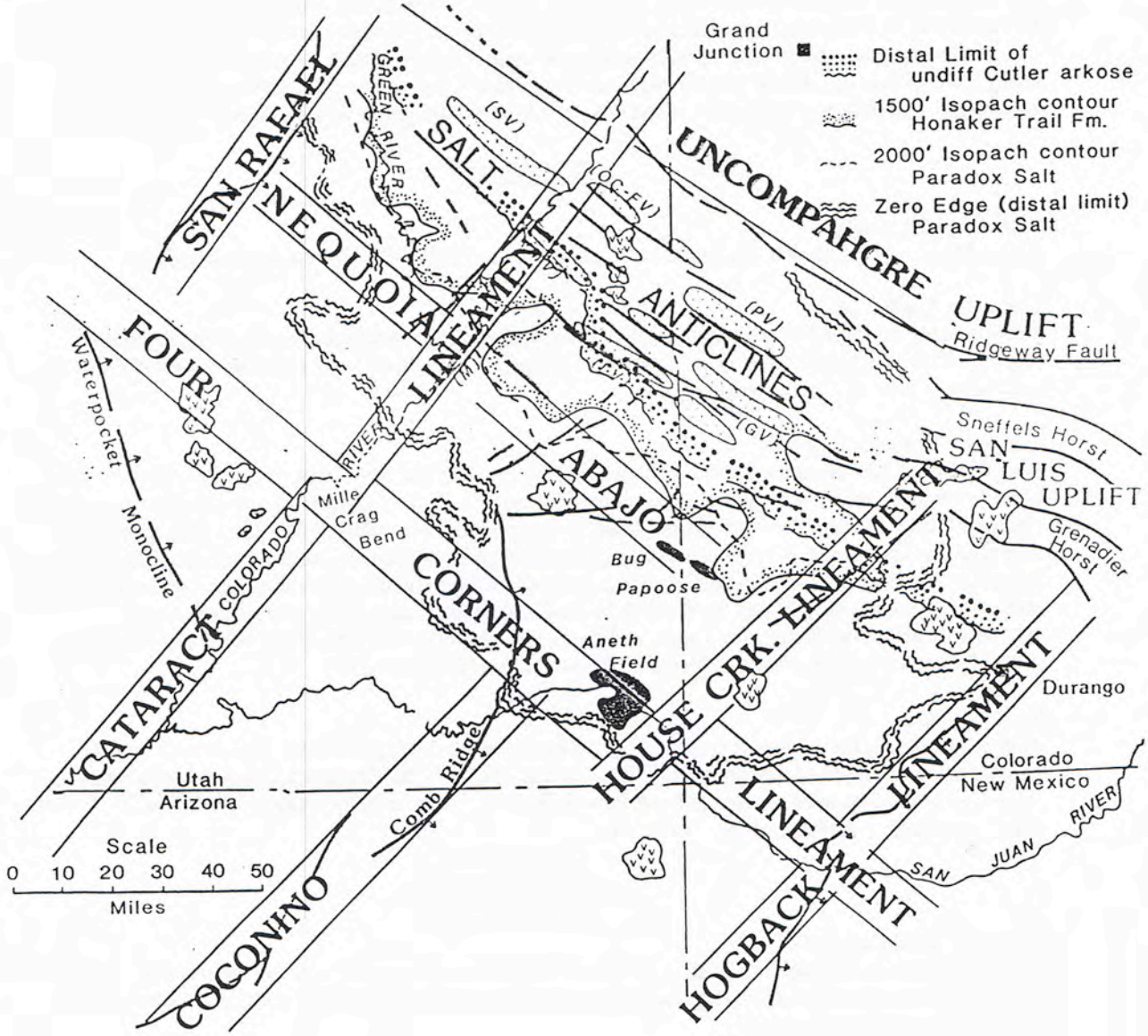
Cedar Mesa Formation
Why does the Cedar Mesa Formation in Comb Wash look more like the Chinle Formation than the Cedar Mesa Formation on Cedar Mesa? Because it has undergone a **facies change**! This is one of those awkward changes that takes a lot of explaining, but basically it represents a changing landscape. The Cedar Mesa is interesting because it has the dune sands and limestone beds of the Navajo and the river channels of the Kayenta. One of the possible explanations for this kind of depositional environment is a "beach and barrier reef" environment – kind of like the coast of South Carolina these days. This creates sand dunes, evaporative basins for the gypsum facies, and rivers and tidal channels. The Cedar Mesa also has more great alcoves for those fun loving Ancestral puebloans, and lots of springs.

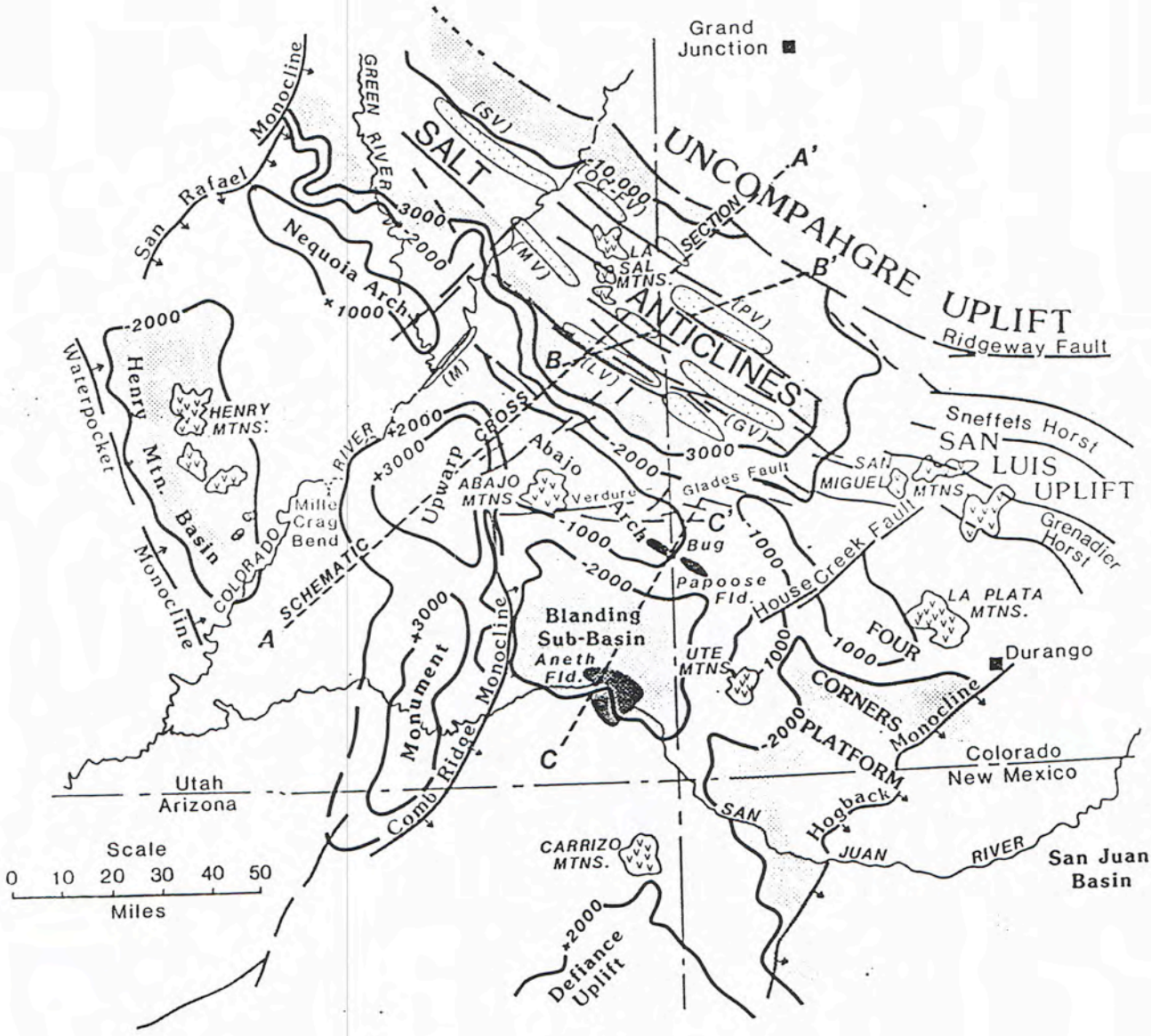
Halgaito Shale
Most noticeable in the long windy stretch right before entering the upper canyon, it's the rock who's angular fractures make all the guests say, "It looks man-made!" The Halgaito has fern and vertebrate fossils, as well as limestone lenses and windblown deposits. Thus, nobody really knows EXACTLY what the depositional environment was. But its red.

PENNSYLVANIAN

Honaker Trail Formation
Gene Stevenson is the authority on this, so I won't even attempt to give a "concise" description. There are some very cool fossils – the Chaetetes coral, crinoids, brachiopods, bryozoans, and the occasional shark tooth (where are their bones?).

Paradox Formation
Topped off by Old Yeller for a good marker, this is the oil producer. The Paradox contains those little humps we call the bioherms or algal mounds, and was a HUGE marine basin that filled with thousands of feet of sediment, and some evaporites (like gypsum) and LOTS of fossils. The Honaker Trail and Paradox give the canyon that classic stairstep appearance because they record the sea levels rising and falling many, many times. The ledgy grey stuff is limestone, which is resistant in the desert; the stuff inbetween is some shales, some sandy shales, some shaley shales, some limey shales, some shaley limes, etc. If you get interested, there's lots of literature about this stuff.


Grand Junction
Distal Limit of undiff Cutler arkose
1500' Isopach contour Honaker Trail Fm.
2000' Isopach contour Paradox Salt
Zero Edge (distal limit) Paradox Salt
SAN RAFAEL
NEQUOIA LINEAMENT
SALT
(SV)
(OC-EV)
UNCOMPAHGRE UPLIFT
Ridgeway Fault
ANTICLINES
(PV)
(IGV)
FOUR
Waterpocket
Monocline
RIVER
Mille Crag Bend
ABAJO
Bug
Papoose
Sneffels Horst
SAN LUIS UPLIFT
Grenadier Horst
CORNERS
Aneth Field
HOUSE CRK. LINEAMENT
CATARACT
COLORADO
Durango
Utah
Arizona
Colorado
New Mexico
Comb Ridge
LINEAMENT
SAN JUAN RIVER
COCONINO
HOGBACK
Scale
0 10 20 30 40 50
Miles


Grand Junction
UNCOMPAHGRE UPLIFT
Ridgeway Fault
A
A'
B
B'
SECTION
SALT
(SV)
(MV)
(PV)
(LV)
(GV)
(M)
10,000
+3000
+2000
+1000
-2000
-1000
3000
LA SAL MTNS.
ANTICLINES
Monocline
San Rafael
GREEN RIVER
Nequoia Arch
Waterpocket
Henry Mtn. Basin
HENRY MTNS.
COLORADO RIVER
Mille Crag Bend
SCHEMATIC
Upwarp
CROSS
Abajo
ABAJO MTNS
Verdure
Arch
Glades Fault
SAN MIGUEL MTNS
Sneffels Horst
SAN LUIS UPLIFT
Grenadier Horst
House Creek Fault
Bug
Papoose Fld.
LA PLATA MTNS.
FOUR CORNERS
Monocline
Durango
Blanding Sub-Basin
Aneth Fld.
UTE MTNS
Monument
Comb Ridge
PLATFORM
Colorado
New Mexico
Utah
Arizona
Hogback
SAN JUAN RIVER
San Juan Basin
CARRIZO MTNS.
Defiance Uplift
Scale
0 10 20 30 40 50
Miles

THE INFAMOUS CROSS-SECTION

FREELY PILFERED FROM THE RIVER GUIDE

A few things of some importance:

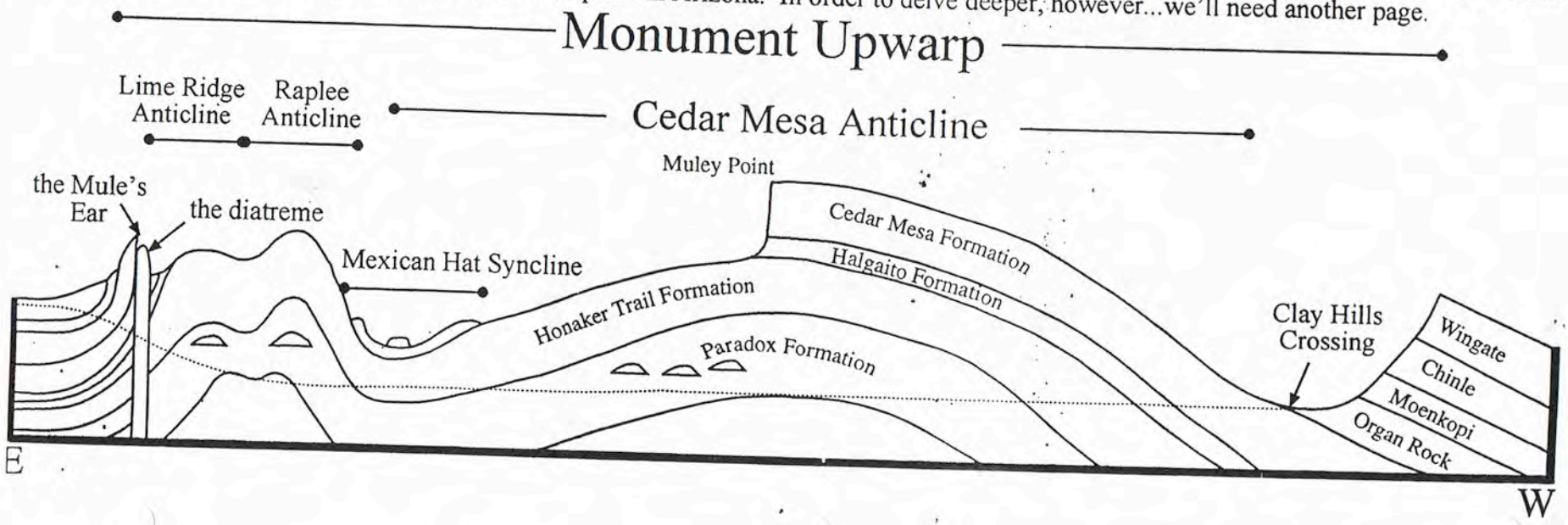
1) The **Monument Upwarp** extends from Comb Ridge to the Clay Hills and from the confluence of Green & Colo ~~Abajos~~ to Kayenta, Arizona. It includes the Lime Ridge, Raplee, and Cedar Mesa anticlines, the Mexican Hat syncline, AND Monument Valley, Valley of the Gods, etc. Monument Valley is kind of the apex of the whole thing, which makes it a topographic high point even though it's a valley.

2) All of the folding is compressional, but even within compressional folds you can get extension at the tops of the folds. Perhaps the best example of this is in Soda Basin, the apex of Raplee anticline, where the walls are highly fractured and falling into the river. Think about folding a sandwich in half, all of the cracks that form on the bread--every little crack makes the rock less resistant to erosion, just like you tend to lose a few crumbs when you fold the bread. A good reason to eat everything out of tortillas.

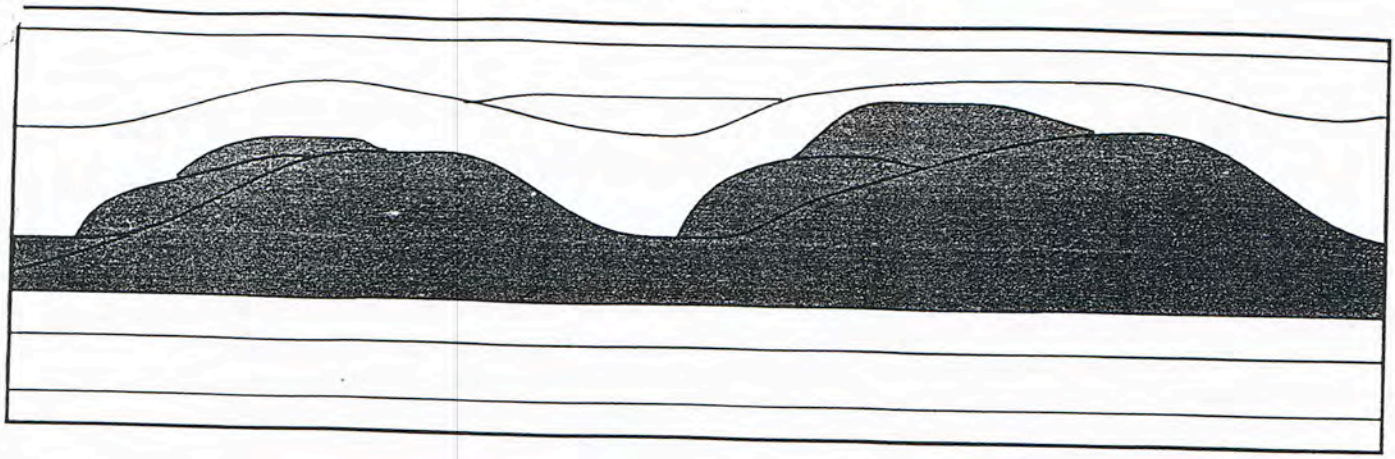
3) The diatreme (and Comb Wash) occur along a fault to the west of Comb Ridge. This is not unexpected, since water and intrusions like to follow existing weaknesses in the crust. More about the diatreme later.

4) Oil is lighter than water. Therefore, in an undulating, porous rock layer, oil will tend to be in the tops of the folds and water in the bottoms of the folds. One of the few exceptions to this rule occurs in Mexican Hat, where toy oil rigs pump oil out of the syncline. This is the case when there IS no water in the porous layer--just oil. The rigs look like toys because they are only going down about 50 ft. As opposed to the Aneth field, where they are drilling down something more like 6000 ft. In Aneth, they are pumping oil out of those little humps on the cross-section below. That means that, between the Aneth field and the upper canyon (about 20 miles), the little humps get uplifted over 6000 ft. That is a lot, and it is rare that an oil-producing layer is exposed so close so where it is being drilled, and that is why we take so many petroleum geologists down the San Juan to camp at Eight Foot for a few days. They usually live in Texas, where they don't have rocks.

5) So what CAUSED the Monument Upwarp? On one level, that's easy to answer--the same kind of compressional forces that caused the San Rafael Swell, Waterpocket Fold, and the numerous uplifts in Arizona. In order to delve deeper, however...we'll need another page.



THE MOUNDS



Bioherms = mounds of life

First of all, the undulating waves of rock exposed just before Syncline Rapid are NOT the bioherms--they are the wavy layers just above the bioherms. The bioherms themselves are best exposed in the corridor above Eight Foot and along the rapid. They look kind of like swiss cheese, because they have lots of holes. They have lots of holes because they are composed of corn flakes.

Actually, they are composed of algae--not the green, slimy blooms of algae that take over the Slickhorn pools by July, but a species of algae (Ivanovia) that secretes a calcareous shell. The shell is shaped and sized about like a cornflake. These algae prefer shallow, near-shore waters with some wave action (which, incidentally, is why they are not deposited in large planes, but in strips). They form mounds because they are photosynthesizing, and it is ever so minutely more advantageous to be one cornflake closer to the sun. When you can see little mounds piling off to the side of mounds, it means that the relative sea level changed just a little bit, moving the ideal habitat one way or the other.

So the key thing about the cornflakes is that, when they compress, they leave lots of space for milk (POROUS) and, more importantly, those holes are connected (PERMEABLE). If the holes aren't connected, you might as well not have any holes, because the stuff (water, oil) can't get into the holes in the first place. So, of course, it's NOT milk, but OIL in among the cornflakes, but we still need to know where it came from and why it stayed, and where it is now.

Where it came from:

• Oil is lighter than water, remember, and stuff underground is under a lot of pressure anyway, so the source for our oil is BELOW the reservoir--an organic-rich layer, which decays and releases its petroleum, which percolates upward until ...

Why it stayed in the mounds:

• Until it reaches something to stop it, like an impermeable layer of Gothic Shale which caps the mounds. But where we see the mounds, of course...

Where it is now:

• The river has, in its erosional process, cut down through the reservoir, releasing all of the oil, and probably creating quite an oil slick at one time. But the lower canyon has some very smelly oil seeps in the Goosenecks and down just above Slickhorn, where the river is just beginning to cut into those rocks. And, of course, it is also coming up through the wells in Aneth and Montezuma Creek.

THE DIATREME
Or the Mega-Geo Fart

What is a diatreme?

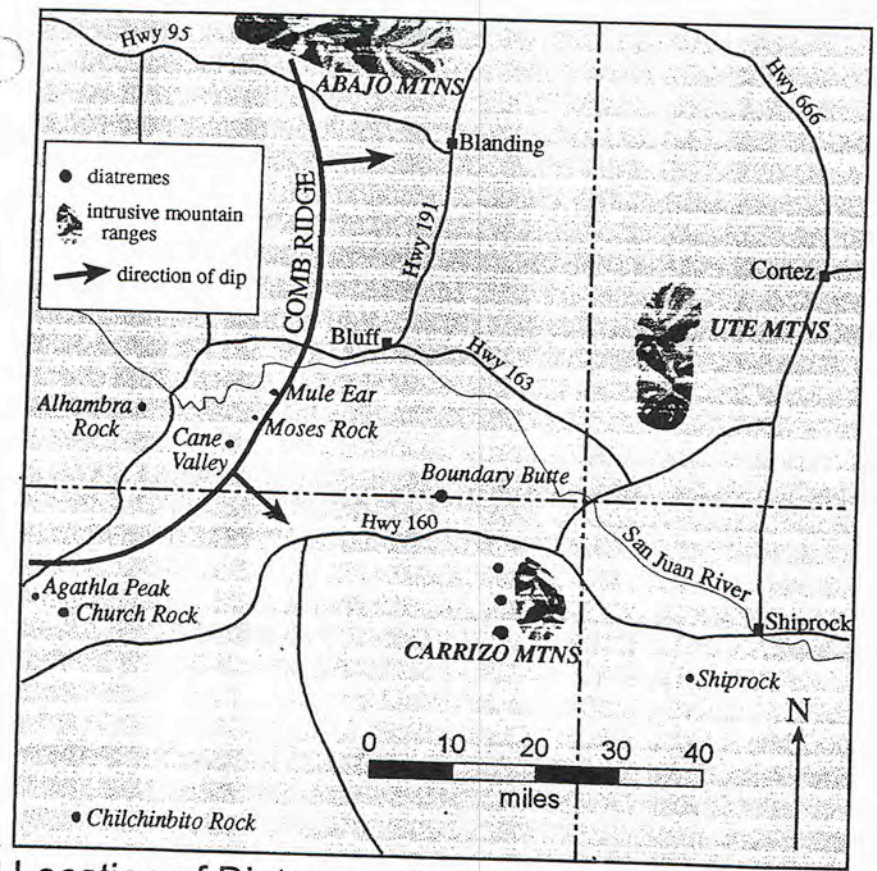
- it is NOT a volcano or a volcanic neck
- it IS, however, caused by the presence of magma in the subsurface, heating gasses that expand and therefor want to escape to the surface
- in our case, the diatreme exploded through an existing weakness in the crust (see "Infamous Cross-Section"), a fault
- technically speaking, it is a mega-geo fart

When Powell showed up down here in the 1870s, he described the diatreme as a terminal moraine of a glacier. This is obviously not the case--whay did he think that?

The problem is that the diatreme not only contains rocks from the deep earth (like gneiss and garnets), but it also contains sedimentary rocks found stratigraphically ABOVE the local rocks--like the Burro Canyon Formation and the Mancos Shale, which TODAY don't show up until we get into Colorado. So it was logical to think that something transported them from Colorado to here.

HOWEVER, the diatreme is about 30-35 million years old. At that time, the Monument Upwarp was young, and another mile of sedimentary rock covered what we can see today. And also remember that the explosion itself didn't actually create any new material (like an erupting volcano does)--it just blew a hole in the crust carrying stuff up from below. That hole subsequently got filled in by the stuff falling back in from the top, like the higher sedimentary rocks.

Think of an avalanche; after the snow seetles, it sets up like cement. The diatreme, which would have been a crater originally, had set the rocks up like cement inside it, which is why it is a positive topographic feature today.



Location of Diatremes in the Four Corners Area

- recognize that the Mule Ear diatreme is not unique--there are many within the Four Corners area, especially Monument Valley
- there are also many within the world--most famously the Kimberley region in South Africa where the diatremes produce DIAMONDS
- also recognize the Mule Ear itself--why is it there? The heat produced by the explosion of gasses could have slightly metamorphosed the sandstone and made it slightly more resistant, allowing it to stand up a bit higher today.
- the ultimate source of the diatremes is still unclear--possibly shallow subduction of Farallon plate, possibly suture zone of North American continent (towards Gulf of Mexico, not California
- for more info, see article.