GEOLOGY OF DINOSAUR NATIONAL MONUMENT

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Introduction

[1] Dinosaur National Monument lies in a high plateau area on the boundary between Colorado and Utah (figure 1). The park was established as an 80 acre monument in 1915 to preserve the outstanding fossil resources. The scenic canyon areas of the Green and Yampa rivers (203,885 acres) were added to the monument in 1938. The monument is best known for its Jurassic dinosaur remains, but it also contains rocks that span 1.1 billion years of geologic history (figure 2). Battles erupted in the mid 1940's and 50's over whether or not dams should be built within the park. Oscar Chapman stated "... unfortunately the same natural processes which have carved out great canyons and created magnificent scenery ... also have produced dam and reservoir sites which are veritable engineer's dreams" (Harvey, 1977). So the battle began and continued until 1956 when president Eisenhower signed a 760 million dollar bill to protect the park.

Dinosaur National Monument is in the heart of a semiarid region of deep canyons, rivers, and high plateaus. Elevations in the park range from 4,730 to 9,005 feet. The area is considered a "cold desert". Temperatures can top 100ºF (38ºC) in the summer, but drop to 40ºF below zero (-40ºC) in the winter. Precipitation ranges from 9-20 inches (23-51 cm.) per year.

Geology

Dinosaur is on the eastern margin of the Uinta Mountains. The Uinta Mountains formed in a manner similar to the Front Range of the Rockies. It is a basement cored, fault bounded uplift that formed by compressional forces during the Laramide orogeny (figure 3). However, unlike other Laramide uplifts which are oriented in a general north-south direction, the Uintas are oriented in an east-west direction.

The Green River slices through the Uinta mountains exposing their underlying structure. There are a number of places in the Southern Rockies where streams cut through Laramide structures. Why did these streams flow across the mountains rather than take the easier path around them? This was a question that was first addressed by John Wesley Powell. He suggested that the streams established their course prior to uplift of the mountains, and like a buzz saw they eroded downwards as the mountains rose upwards. Powell coined the term *antecedent stream* to describe this process. It is now known that uplift of the mountains occurred prior to the establishment of the stream courses.

An alternate hypothesis is that the major drainages are *superposed streams*. Sediments eroded from newly formed Laramide uplifts, filled the adjacent intermontain basins and eventually completely covered the the Laramide structures, resulting in a flat featureless plain. Some of these sediments can still be observed in the Browns Park area. The present day streams established their drainage patters on this relatively flat surface and eroded downward through the buried structures.

A final hypothesis that can be used to explain this type of drainage pattern is that of

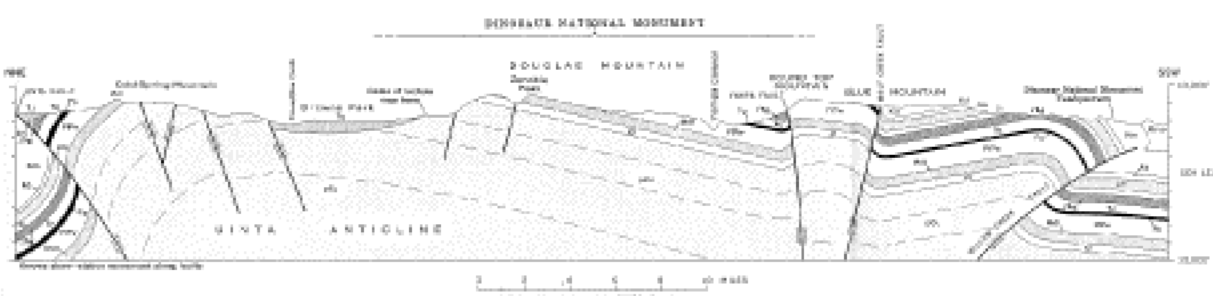


Figure 3. Geologic cross-section across the Uinta Mountains (Hansen, 1971).

Figure 1. Map of Dinosaur National Monument (National Park Service)

Age		Description
Quaternary	**Qal**	**Alluvium**
	QTt	**Terrace gravels**
Tertiary	**Tbp**	**Browns Park Formation** White tuffaceous cross-bedded sandstone with chert and conglomerate.
	Unconformity	
Cretaceous		**Mancos Group**
	Kms	**Mancos Shale** Dark gray to yellowish shale with thin sandstone lenses.
	Kf	**Frontier Sandstone** Limy sandstone with dark shale and Subbituminous coal beds.
	Kmy	**Mowry Shale** Dark gray, marine, siliceous shale containing abundant fish scales.
Cretaceous	**Kd**	**Dakota Sandstone** Conglomerate sandstone with carbonaceous shale.
	Unconformity	
Jurassic	**Jm**	**Morrison Formation** Dinosaur-bearing conglomeratic sandstone and variegated marls.
Jurassic		**San Rafael Group**
	Jc	**Curtis Formation** Greenish gray, sandy at base, with shale and oolitic limestone in the upper part.
	Je	**Entrada Sandstone** Light gray to buff and pink, medium grained sandstone.
	Jca	**Carmel Formation** Red siltstone and shale with gypsum.
	Unconformity	
Jurassic		**Glen Canyon Group**
	Jn	**Navajo Sandstone** Buff to red medium grained, cross-bedded sandstone.
	Unconformity	
Triassic	**Trc**	**Chinle Formation** Red shale, marl and siltstone with sandstone and conglomerate.
Triassic	**Trs**	**Shinarump Conglomerate** Light buff to yellow, coarse sandstone and conglomerate
	Unconformity	
Triassic	**Trm**	**Moenkopi Formation** Red, limy and gypsiferous shale and sandstone with abundant ripple marks.
	Unconformity	
Permian	**Ppc**	**Park City Formation** Light-gray, thin-bedded, fossiliferous limestone, limy sandstone and gray, red and yellowish shale with phosphate nodules.
Pennsylvanian	**Pw**	**Weber Sandstone** White to light-gray or buff cross-bedded sandstone.
Pennsylvanian	**Pmu**	**Morgan Formation** Interbedded gray limestone and white to red sandstone, limy shale and limestone at the base.
	Unconformity	
Mississippian	**Mu**	**Undifferentiated Manning Canyon Shale, Humbug, Desert and Madison Limestones** Limestone, dolomite, and carbonaceous shale.
	Unconformity	
Cambrian	**Cl**	**Lodore Formation** White to red, coarse grained, quartzitic, and arkosic sandstone with silty shale interbeds.
	Unconformity	
Precambrian	**PCu**	**Uinta Mountain Group** Red to white, coarse-grained quartzitic and arkosic sandstone and conglomerate with thin beds of shale.

Figure 2. Stratigraphic units at Dinosaur National Monument (after Untermann and Untermann, 1965).

stream piracy. Initially we had a system of streams that flowed away from the Uinta Mountains. The ancestral Upper Green river flowed east, probably into the Mississippi Basin, and the Lower Green and Yampa Rivers flowed southwest into the Colorado Basin. The Lower Green River eroded northward toward a low point in the crest of the Uinta Mountains. It eventually breached this point and intersected the drainage of the ancestral Upper Green River. Because the base level of the Lower Green was lower than the Upper Green it was able to "capture" it's drainage. Once the two rivers combined the the drainage system was reinvigorated, with more water and erosive power, resulting in rapid down cutting of the canyons.

Green River Raft Trip

Our raft trip will take us down the Green River through Split Mountain. We will put in at Rainbow Park and end our journey at the Split Mountain Campground. Moonshine, SOB, Schoolboy and Inglesby are the names of the rapids we will pass through, hopefully in one piece.

Rainbow Park, where we will start our journey is the approximate location of the Island Park Thrust fault, and we should see highly deformed Entrada sandstone. We will then pass a sequence of Jurassic and Triassic strata that are steeply dipping toward the north. Note that the rock units become progressively older as we travel downstream. This is because we are traveling across the northern limb of the Split Mountain Anticline. Older, more resistant limestones and sandstones make up Split Mountain. We cross the axis of the Split Mountain anticline between the SOB and schoolboy rapids. The oldest rock units are exposed here, the Mississippian Madison Limestone. Note how the dip of the beds change as we continue downstream on the south flank of the anticline. The rock units will begin to dip toward the south and become progressively younger as we travel toward the campground.

Jurassic Paleoenvironments

During the Early Jurassic the area around Dinosaur National Monument was a low-lying desert, as indicated by the large cross-bedded dune sands of the Navajo Sandstone. A shallow sea transgressed over the area from the west during the Middle Jurassic. Marine and marginal marine, sandstone, shale and limestones of the Carmel, Entrada and Curtis Formations were deposited at this time. By Late Jurassic the area from Mexico to Canada and central Utah to the Mississippi River was above sea level. To the west was a mountain chain. Streams flowing from these mountains deposited sediment on the adjacent plains. Several large rivers and many intermittent streams flowed across this low-lying plain which were also dotted with small lakes and swamps. The Jurassic Morrison Formation represents the stream, lake and swamp deposits. Semitropical conditions prevailed at this time with the land covered by forest of ginkos, cycads, clubmosses, tree-ferns and clumps of tall conifers. In addition to dinosaurs, small mammals roamed the land, and crocodiles, turtles and clams lived in the rivers.

Dinosaurs

Dinosaur National Monument has long been one of North America's most spectacular, and easily accessible (providing you have a car), dinosaur localities. It is certainly the best Jurassic park in the United States. Visitors to the monument can see dinosaur bones *in situ*, embedded in a steeply dipping surface. This site supplied a number of dinosaurs to museums in the past. Many of the famed dinosaurs in the collection of the Carnegie Museum of Natural History in Pittsburgh were quarried at this site earlier in this century.

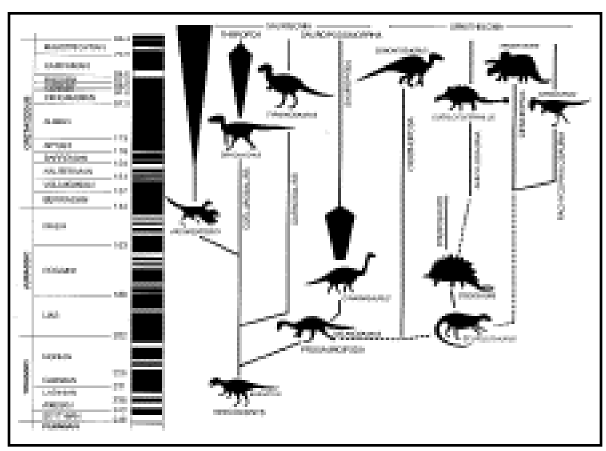


Figure 4. Evolutionary diagram of the dinosaurs (Condie and Sloan, 1998)

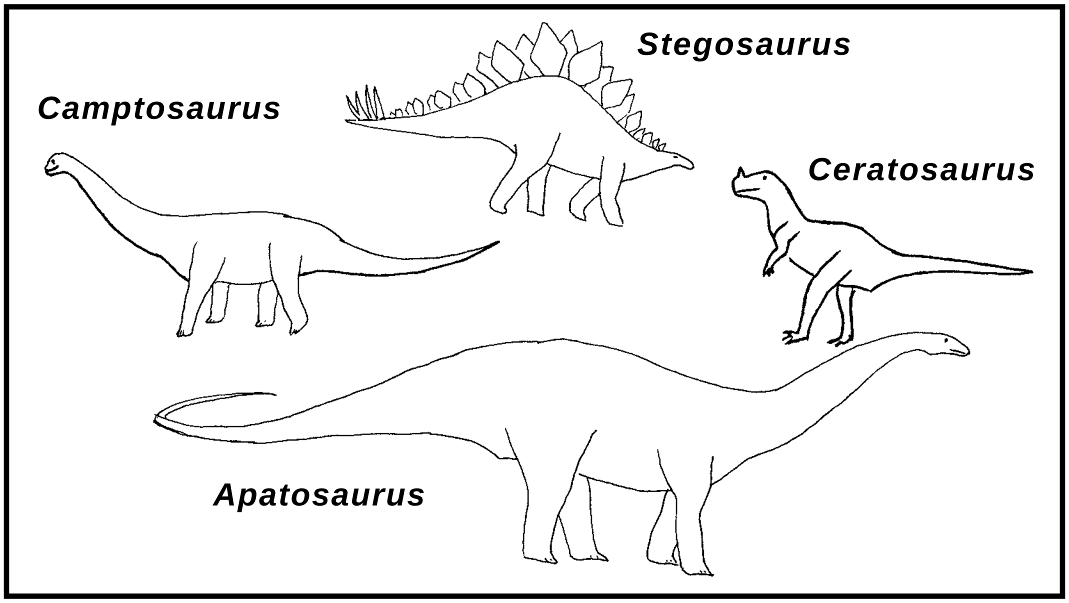


Figure 5. Common dinosaurs at Dinosaur National Monument

The list of dinosaurs found here is a veritable who's who of famous Jurassic forms (figures 4, 5 & 6). Sauropods, the dinosaurs with the long necks, long tails, and stout tree-trunk sized legs, were the most common dinosaurs excavated at the site. These included the genera Apatosaurus (once also known as Brontosaurus), Camarasaurus, Barosaurus, and Diplodocus. The large, carnivorous theropods Allosaurus and Ceratosaurus have also been found here, as well as the vegetarians Camptosaurus and Stegosaurus. These dinosaurs represent the two great groups of dinosaurs, Camptosaurus and Stegosaurus are ornithischians (bird-hipped dinosaurs); the rest are saurischians (reptile-hipped dinosaurs).

Today, emphasis is on exposing additional bones in relief, but leaving them in place in the rock so that visitors can see them in relation to other bones and the enclosing rock (Chure, 1987). We will take advantage of this very special exhibition by using it as a laboratory for analyses of dinosaur death positions and the environment of deposition of these dinosaur remains.

References

Chure, D. J., 1987, Dinosaur National Monument: a window on the past. *in* W. R. Averett (ed.) *Paleontology and Geology of the Dinosaur Triangle: Guidebook for 1987 Field Trip,* Museum of Western Colorado, Grand Junction, p. 75-77.

Condie, K. C., and R. E. Sloan, 1998, *Origin*

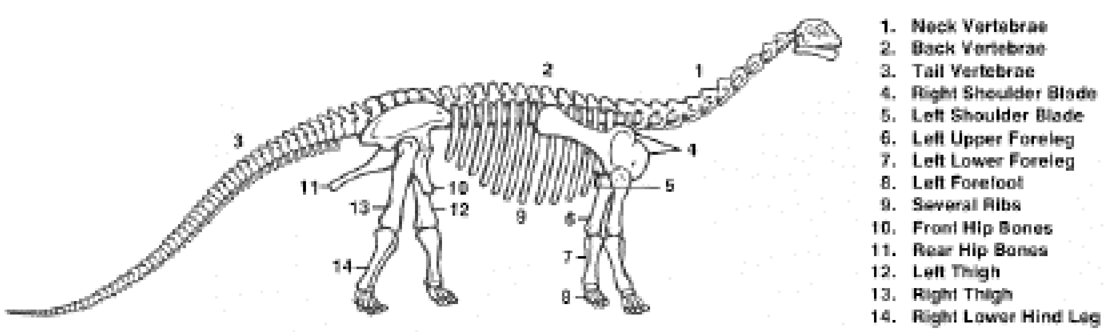


Figure 6. Bones of a *Camarsaurus* (West and Chure, 1984).

and evolution of Earth; Principles of Historical Geology. Prentice Hall, NJ, p.344.

Hagood, A. and L. West, 1994, *Dinosaur, The Story Behind the Scenery*. KC Publ. Inc. Las Vegas NV, 48 p.

Hansen, 1971 Dinosaur National Monument Colorado-Utah, 1:62500 topographic map, U. S. Geological Survey, Washington DC.

Harvey, M. W. T., 1994, *A Symbol of Wilderness.* Univ. of New Mexico Press, Albuquerque.

Untermann, G. E. and B. R. Untermann, 1965, *Geologic map of the Dinosaur National Monument.* Dinosaur Nature Association.

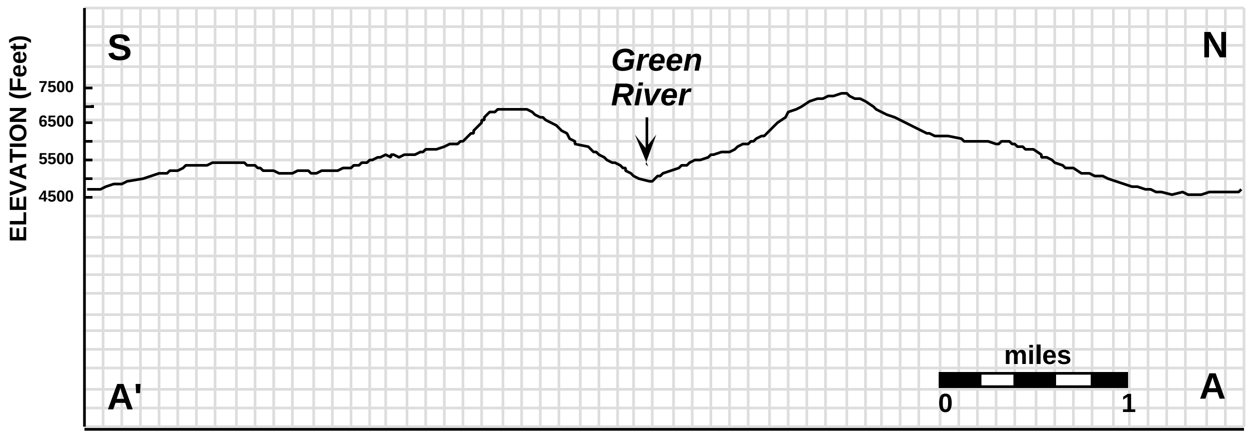
West, L. and D. Chure, 1984, *Dinosaur; The Dinosaur National Monument Quarry,* Dinosaur Nature Association, Salt Lake City Utah.

Wicander, R. and J. S. Monroe, 1993, *Historical Geology, Evolution of the Earth and Life Through Time*. West Publishing Co., Saint Paul MN, p. 425

Exercises

Raft Trip

1. Make a geologic cross section across Split Mountain.



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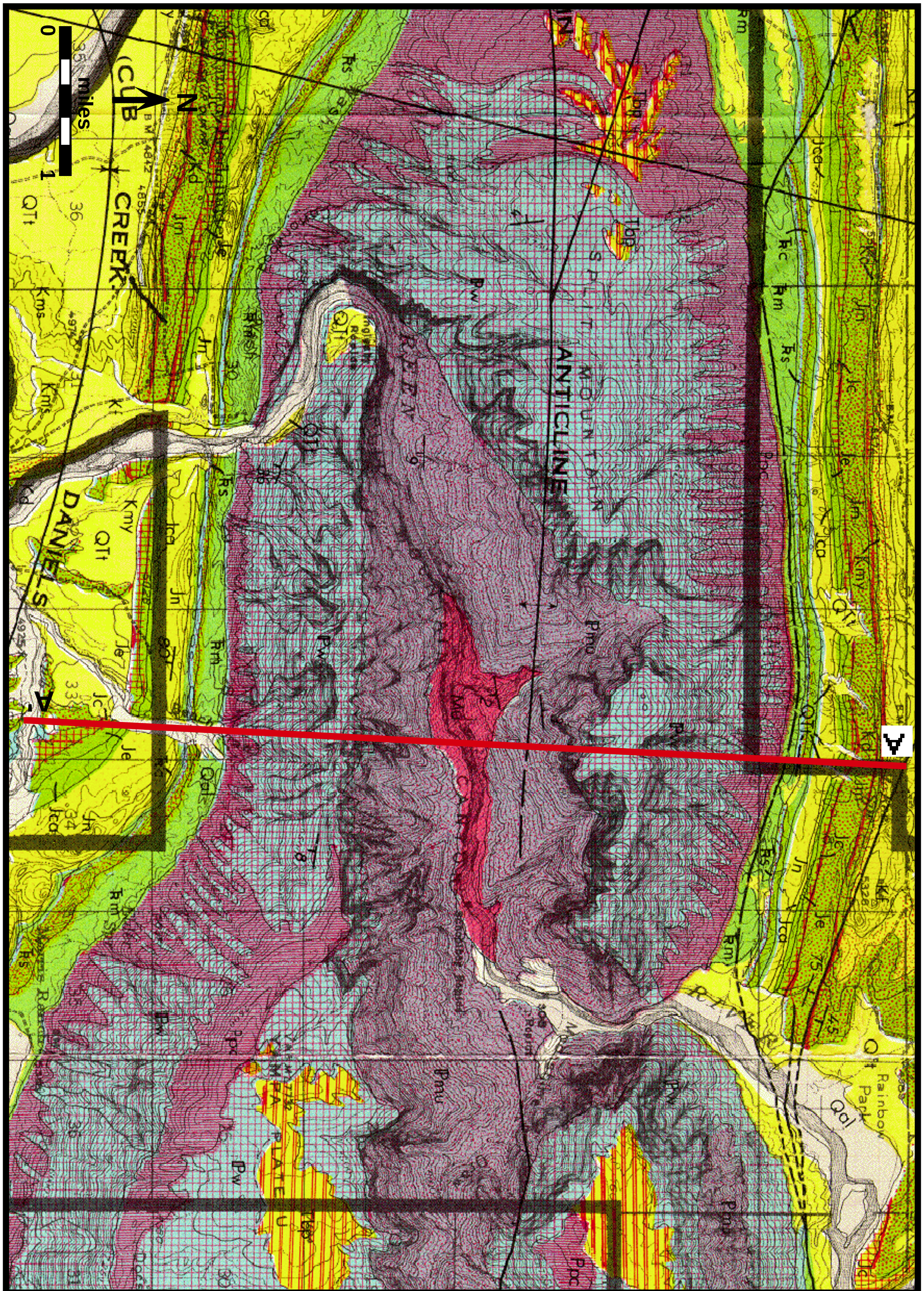

Figure 7. Geologic Map of Split Mountain, Dinosaur National Monument (Untermann and Untermann, 1965)

Morrison Formation

1. Describe the lithology, geometry and orientation of the sand bodies that contain the dinosaurs at this location.

2. Based on the rocks seen here determine a possible environment of deposition for the dinosaur bones.

3. Compare the Morrison Formation at Dinosaur to Golden/Morrison CO area.

Dinosaur Quarry

1. Pick out a dinosaur skeleton, or partial skeleton, in your assigned part of the quarry wall. Sketch the bones of your dinosaur. Label the bones (skull, hip bone, etc.). Add a scale. Then, flesh out this skeleton in order to show your dinosaur in death position.

2.Can you say anything about what happened to the dinosaur after death based on your reconstruction?

3. Note any general trends in bone orientation along the bedding planes exposed. Do these trends help to explain why there are so many dinosaur bones at this location?

4. Can you see any fossils other than dinosaurs in the rocks? Do they give any clues as to the environment in which the dinosaur remains were preserved?

5. Based on your reconstruction and the surrounding skeletal material, reconstruct what the scene looked like just after your dinosaur died.