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U.S. Geological Survey

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The U.S. Bureau of Land Management

Geologic Map of Gunnison Gorge National Conservation Area, Delta and Montrose Counties, Colorado

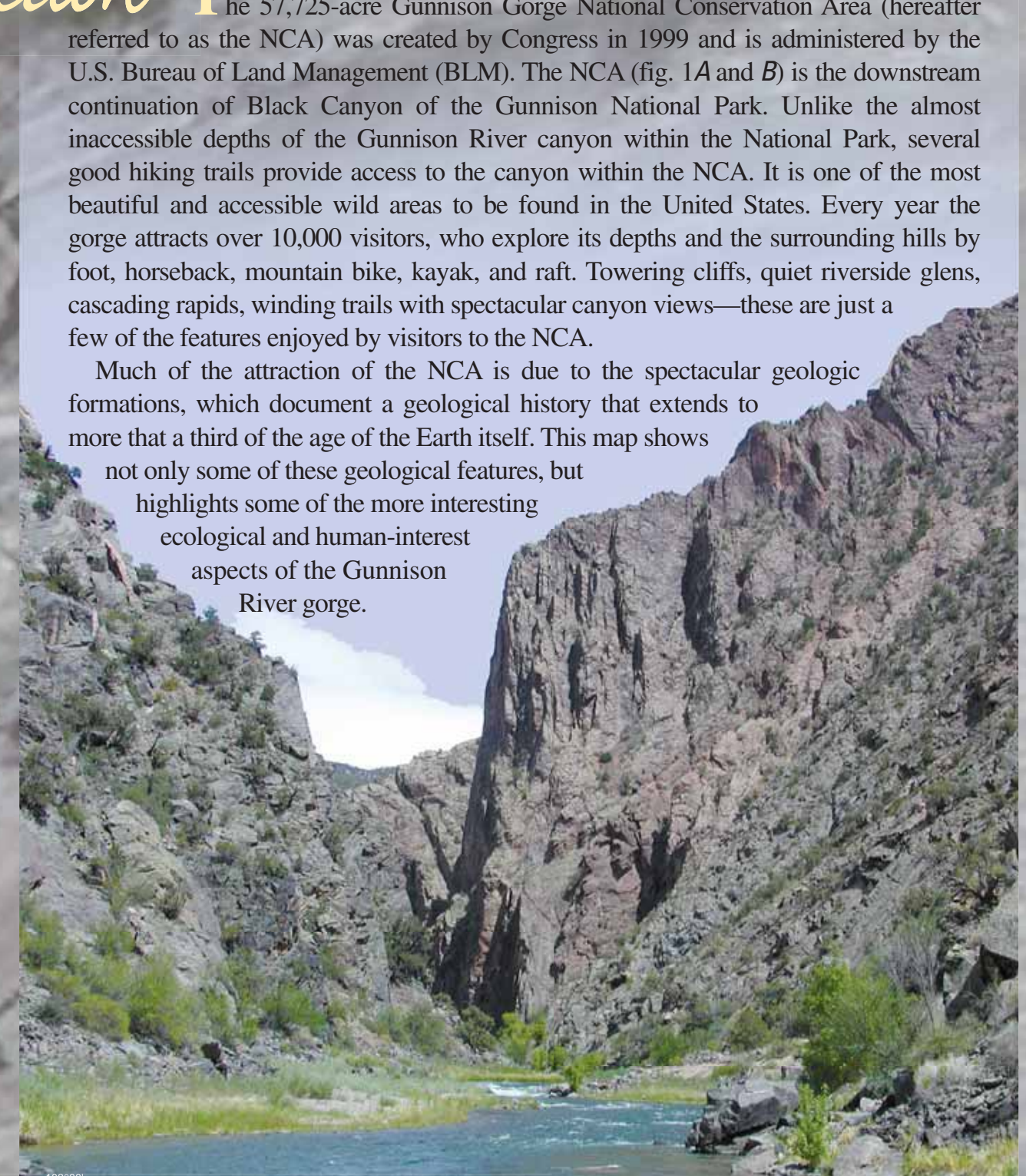
By Karl S. Kellogg,[1] Wallace R. Hansen,[1] Karen S. Tucker,[2] and D. Paco VanSistine[1]

2004

Introduction

The 57,725-acre Gunnison Gorge National Conservation Area (hereafter referred to as the NCA) was created by Congress in 1999 and is administered by the U.S. Bureau of Land Management (BLM). The NCA (fig. 1*A* and *B*) is the downstream continuation of Black Canyon of the Gunnison National Park. Unlike the almost inaccessible depths of the Gunnison River canyon within the National Park, several good hiking trails provide access to the canyon within the NCA. It is one of the most beautiful and accessible wild areas to be found in the United States. Every year the gorge attracts over 10,000 visitors, who explore its depths and the surrounding hills by foot, horseback, mountain bike, kayak, and raft. Towering cliffs, quiet riverside glens, cascading rapids, winding trails with spectacular canyon views—these are just a few of the features enjoyed by visitors to the NCA.

Much of the attraction of the NCA is due to the spectacular geologic formations, which document a geological history that extends to more that a third of the age of the Earth itself. This map shows not only some of these geological features, but highlights some of the more interesting ecological and human-interest aspects of the Gunnison River gorge.



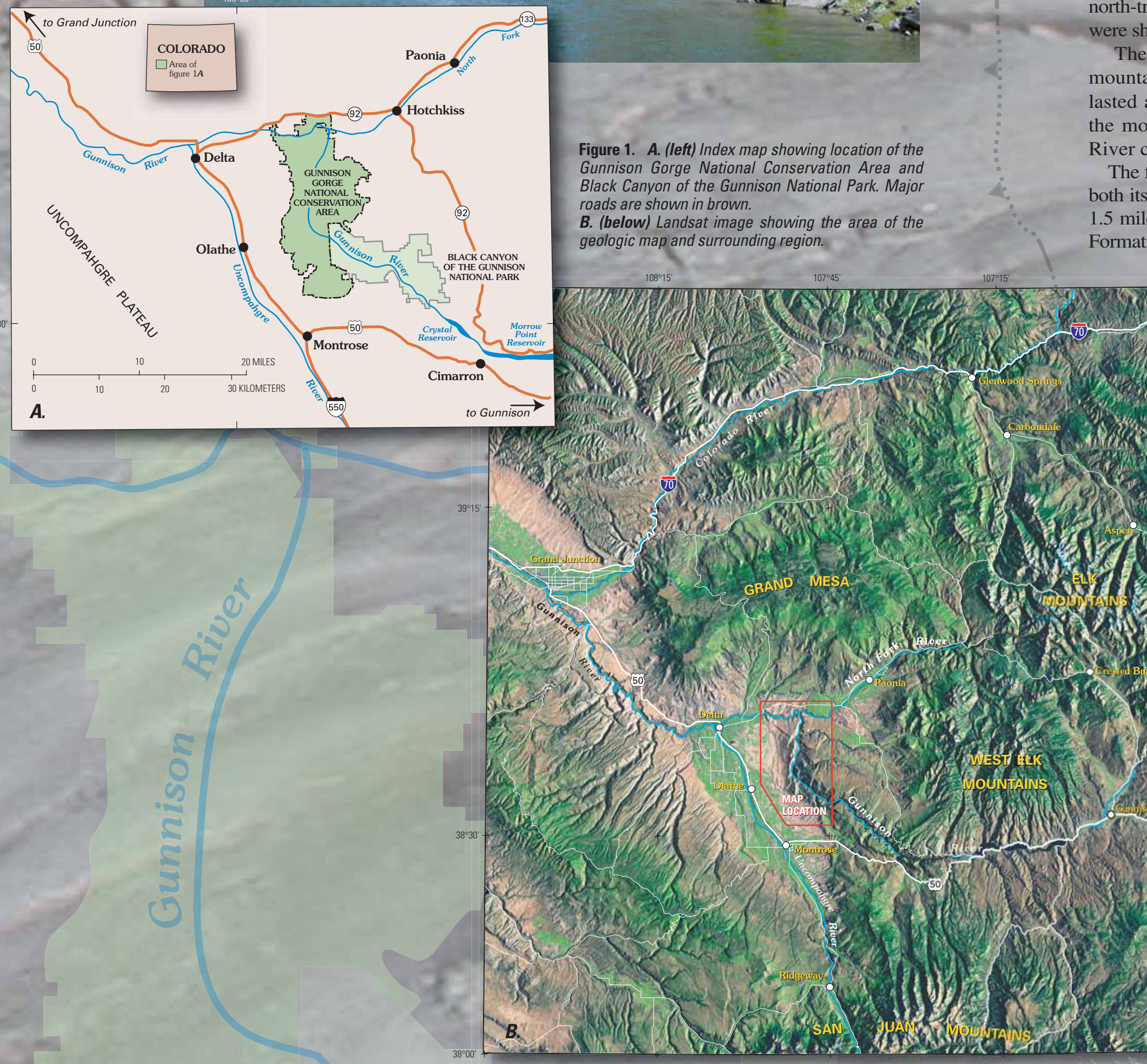


Figure 1. ***A. (left)*** *Index map showing location of the Gunnison Gorge National Conservation Area and Black Canyon of the Gunnison National Park. Major roads are shown in brown.* ***B. (below)*** *Landsat image showing the area of the geologic map and surrounding region.*

Geology

The fascinating geologic story of the Gunnison River gorge is too complicated to describe in detail on this map. However, this story is told in a separate, companion publication, "The Geologic Story of Gunnison Gorge National Conservation Area, Colorado" (Kellogg, in press). For the purposes of this map, the geology is briefly described here.

The Rocks of the Gorge Record Geologic History

The oldest rocks in the gorge are the ancient basement rocks that make up the mostly steep, dark-colored walls beneath horizontal layers of sedimentary rock. These basement rocks were formed by igneous and metamorphic processes deep in the Earth's crust during the Proterozoic Eon, approximately 1.7–1.4 billion years ago. Examples of metamorphic rocks in the gorge are quartzitic gneiss, mica schist, amphibolite, and migmatite (figs. 2, 3, and 4). Within the NCA, coarse-grained Pitts Meadow Granodiorite (figs. 3 and 5) intruded these ancient metamorphic rocks. In addition, many light-colored dikes and irregular masses of coarse-grained pegmatite form a conspicuous network of igneous intrusions throughout the canyon.

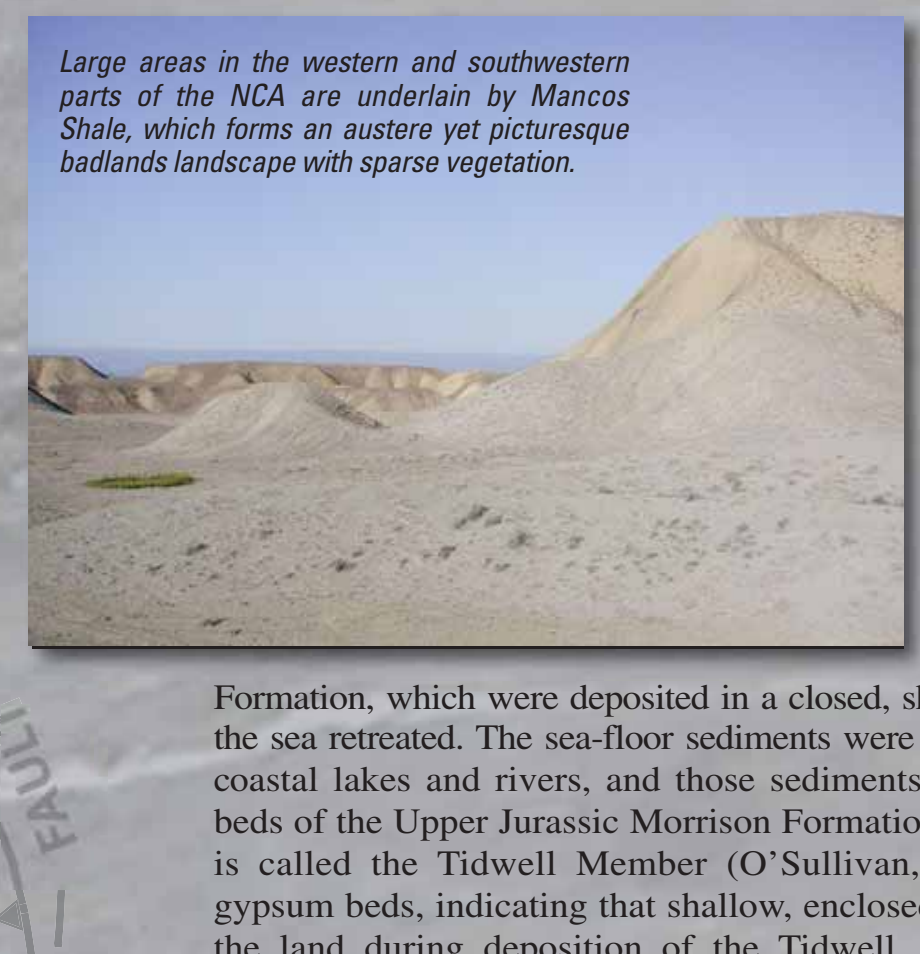
A tremendous period of time—over 1.5 billion years—transpired between the formation of the basement rocks and the deposition of the oldest sedimentary rocks that rest on them. We know that several periods of uplift and erosion took place during this long intervening period. A relatively good geologic record exists for the period of uplift that resulted in the ancestral Uncompahgre uplift, one of several mountainous areas in the Rocky Mountain region that rose about 300 million years ago. Erosion that followed the uplift denuded the region of the 550–300-million-year-old Paleozoic rocks that had been deposited before uplift. The oldest sedimentary rocks that remain on the ancient eroded basement surface are 190 million years old. A younger period of uplift and major mountain building, called the Laramide orogeny, occurred about 70–50 million years ago and formed the pattern of ranges of the present Rocky Mountains.

The oldest sedimentary rocks in the NCA form the Middle Jurassic Entrada Sandstone (fig. 6), which is composed of pink to yellowish-orange, cross-bedded sandstone that accumulated as ancient sand dunes. Overlying the Entrada are mudstone, sandstone, and gypsum of the Middle Jurassic Wanakah Formation, which were deposited in a closed, shallow inland sea. With time, the land was slowly uplifted and the sea retreated. The sea-floor sediments were then buried by sandy and muddy sediments deposited in coastal lakes and rivers, and those sediments now form the multicolored sandstone and shale beds of the Upper Jurassic Morrison Formation. The basal part of the Morrison Formation is called the Tidwell Member (O'Sullivan, 1992), which contains some gypsum beds, indicating that shallow, enclosed seas periodically covered the land during deposition of the Tidwell. The Tidwell Member closely resembles the underlying Wanakah Formation, and on older maps (for example, Hansen, 1968, 1971) it was included with the Wanakah. The Tidwell Member of the Morrison Formation and the Wanakah Formation are combined on this geologic map because they are so similar in this area; however, they are differentiated in figure 7.

Overlying the Tidwell Member is the Salt Wash Member of the Morrison Formation, which contains cross-bedded, red-stained (from the overlying reddish shale), fluvial (deposited in rivers) sandstone beds and interbedded shale. Overlying the Salt Wash Member are colorful red, green, and gray shales and thin sandstone beds of the upper Brushy Basin Member of the Morrison, which are host to some world-famous dinosaur-bone localities outside the NCA.

A period of no deposition, or deposition followed by erosion, followed emplacement of the Morrison Formation. Such a break in the geologic record is called an unconformity. The rocks above the unconformity are fluvial deposits of the Lower Cretaceous Burro Canyon Formation, which form thick beds of cliff-forming, light-brown, quartz sandstone with interbedded shale and chert-pebble conglomerate. Above the Burro Canyon Formation, thin beds of quartz sandstone, shale, and coal in the Lower to Upper Cretaceous Dakota Formation record a time when rivers and swamps deposited sand, mud, and decaying plant material along a tropical marine shoreline.

Once again, the seas gradually covered the land, and deposits of sand of the Dakota Formation were buried by thick deposits of marine mud of the Upper Cretaceous Mancos Shale, which now form a gray badlands landscape of weathered shale and mudstone in the southwestern and western parts of the NCA. The Mancos Shale is the youngest consolidated bedrock formation exposed in the NCA. Much younger, mostly uncemented Quaternary surface deposits, such as alluvium, terrace gravels, landslide deposits, and talus, cover large areas of the NCA.



Large areas in the western and southwestern parts of the NCA are underlain by Mancos Shale, which forms an austere yet picturesque badlands landscape with sparse vegetation.

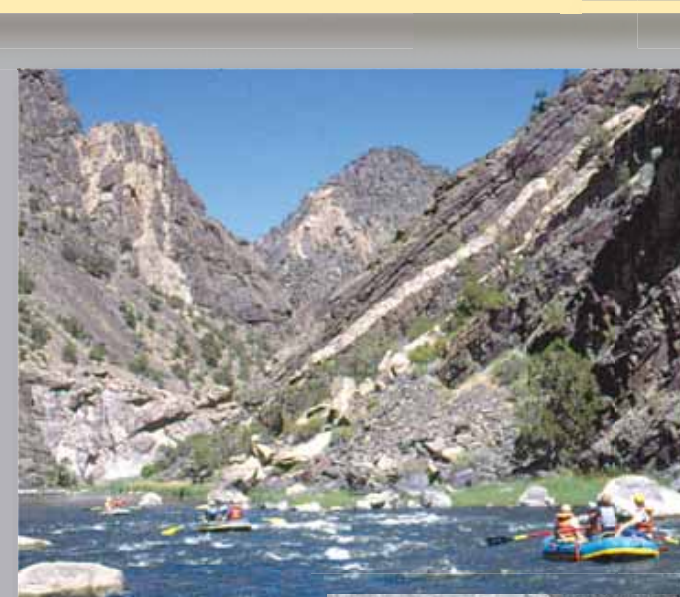


Figure 2 (left). *Running the river, just below the Chukar Canyon launch site. The light-colored rocks are dikes of coarse-grained pegmatite* (YXp) *cutting layered quartzitic gneiss* (Xlq)*. View is toward the northwest.*

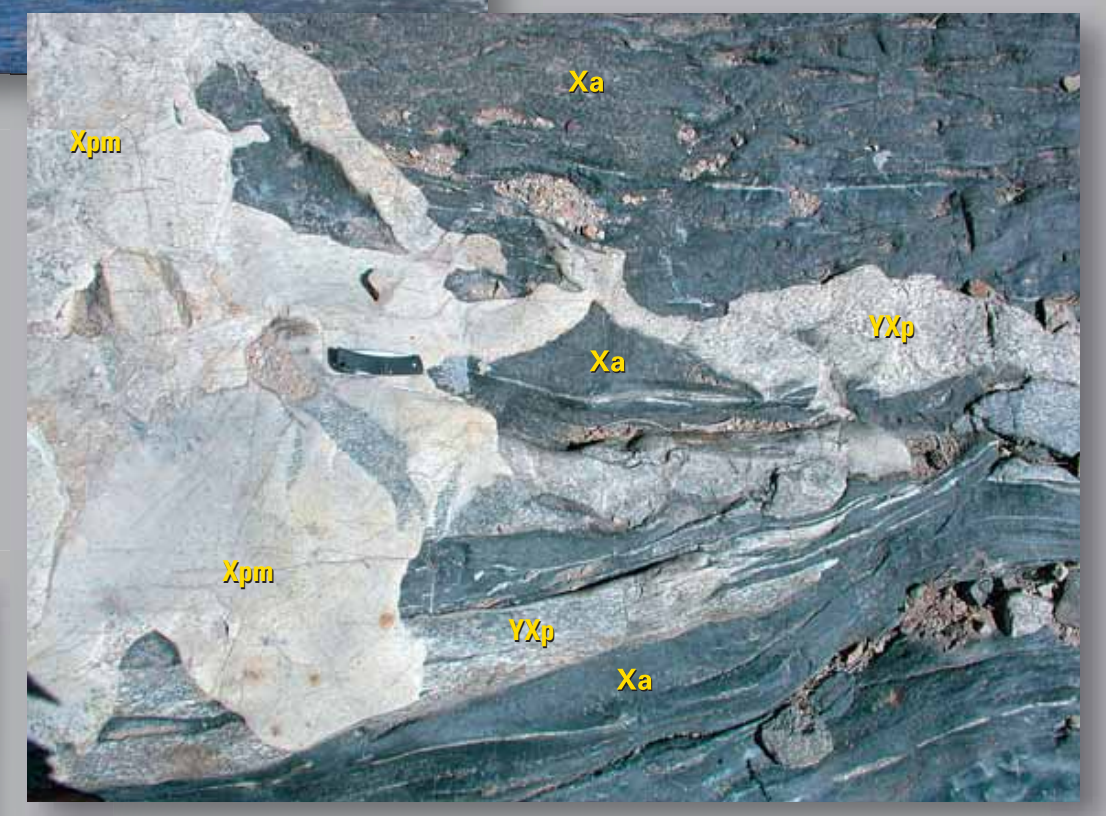


Figure 3 (above). *Outcrop along the Gunnison River, about 0.6 mile (1 km) upstream from Smith Fork, of dark, layered amphibolite* (Xa)*, intruded by Pitts Meadow Granodiorite* (Xpm)*, in turn intruded by light-colored, coarse-grained pegmatite* (YXp) *and fine-grained aplite (not shown separately on map). Knife is about 3.5 inches (9 cm) long.*

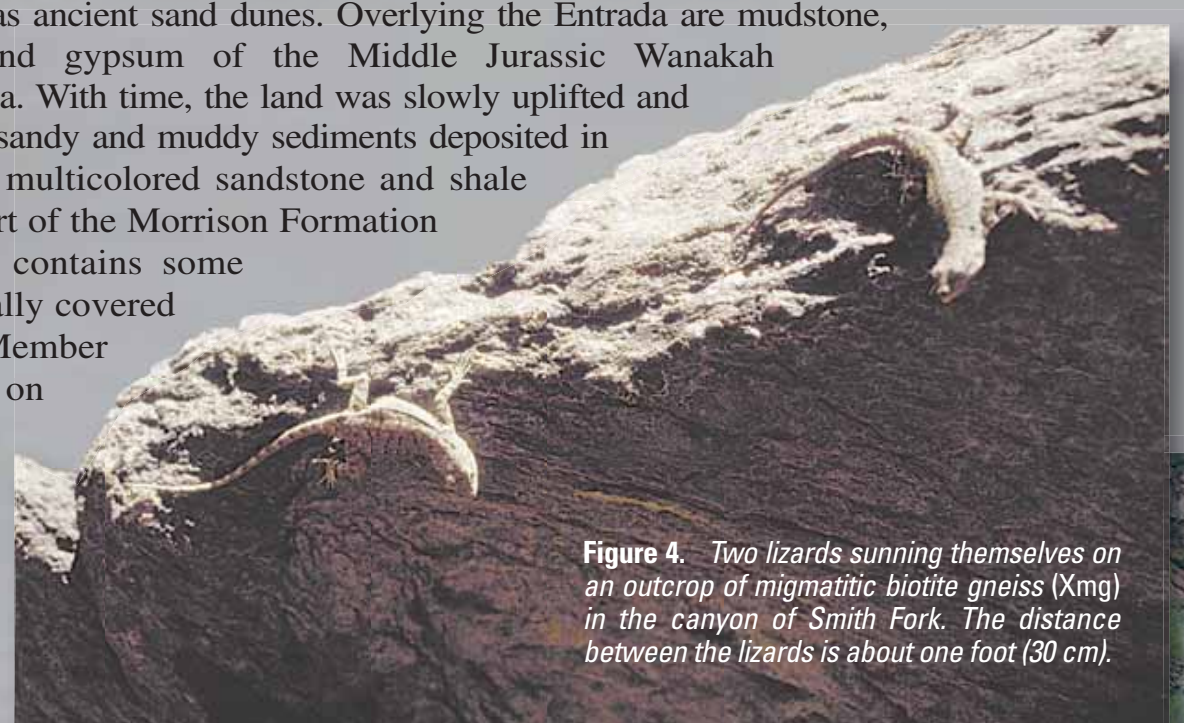


Figure 4. *Two lizards sunning themselves on an outcrop of migmatitic biotite gneiss* (Xmg) *in the canyon of Smith Fork. The distance between the lizards is about one foot (30 cm).*

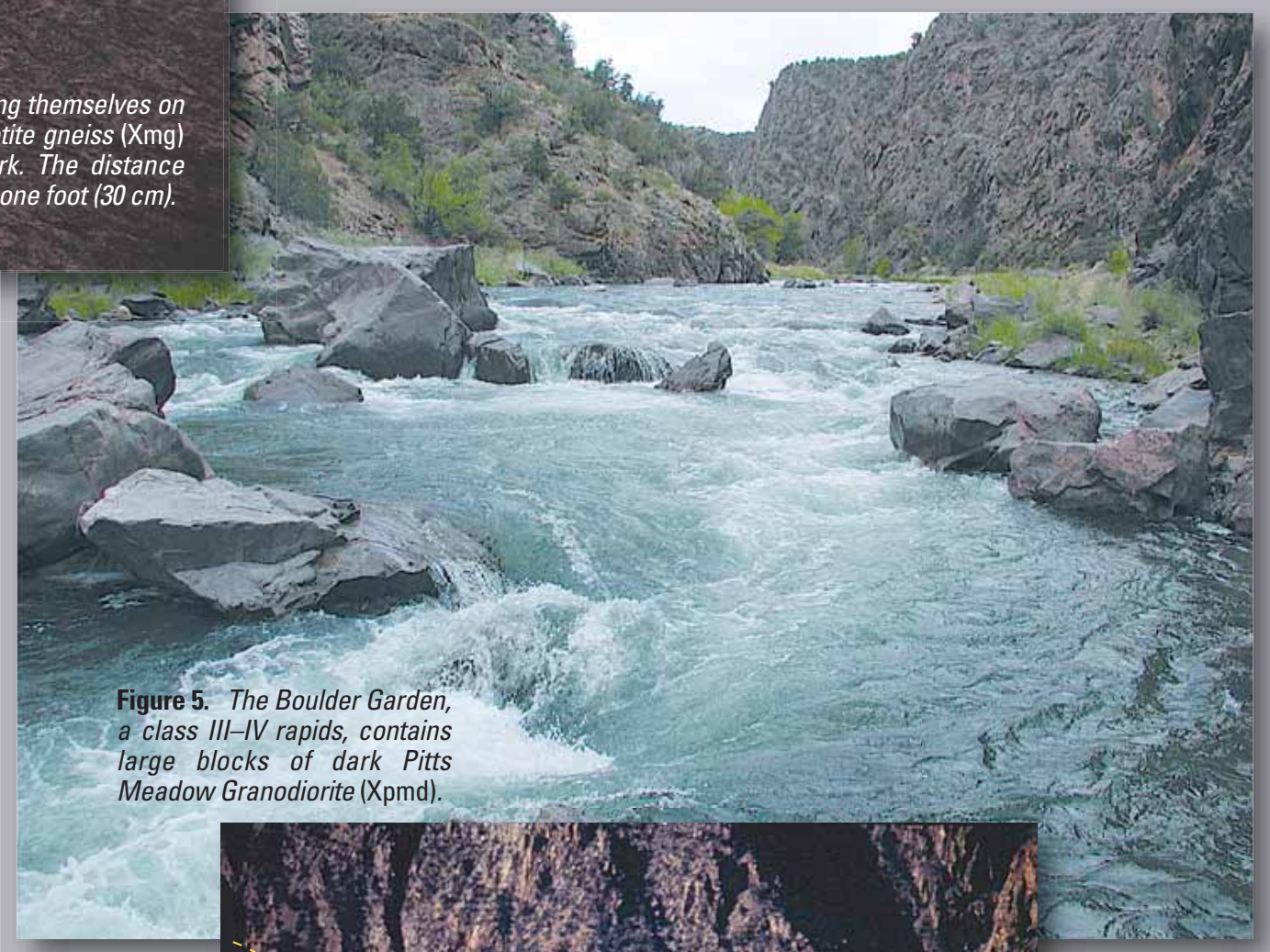


Figure 5. *The Boulder Garden, a class III–IV rapids, contains large blocks of dark Pitts Meadow Granodiorite* (Xpmd)*.*

Ute Indian fault: a Spectacular Laramide Feature

The Gunnison River gorge contains one of the most spectacularly exposed faults in Colorado—the Ute Indian fault. It is a north-trending, east-directed thrust fault that dips (is inclined) about 40º to the west. During the Laramide orogeny, Proterozoic basement rocks were shoved up and to the east along the fault by as much as 1,150 feet (350 meters) vertically above Jurassic sedimentary rocks.

The fault is magnificently displayed along part of the gorge (figs. 6 and 7). The Ute Indian fault formed during a period of great mountain building called the Laramide orogeny, which began near the end of the Cretaceous Period (about 70 million years ago) and lasted about 20 million years into early Tertiary time. During the Laramide orogeny, the present Rocky Mountains formed, although the mountains have subsequently been greatly modified by erosion, volcanic activity, faulting, and additional uplift. The Gunnison River cuts through the middle of the Gunnison uplift, one of a number of highlands that rose during the Laramide orogeny.

The fault is clearly exposed in Chukar Canyon and generally follows the gorge northward, crossing the Gunnison River at several places. At both its south and north ends, displacement on the fault dies out. On the geologic map there is a gap in the trace of the fault, beginning about 1.5 miles (2.4 km) north of Chukar Canyon. There, displacement on the fault is dispersed into the easily deformed gypsum of the Wanakah Formation and the lower Morrison Formation, so the fault does not appear at the sufrace.

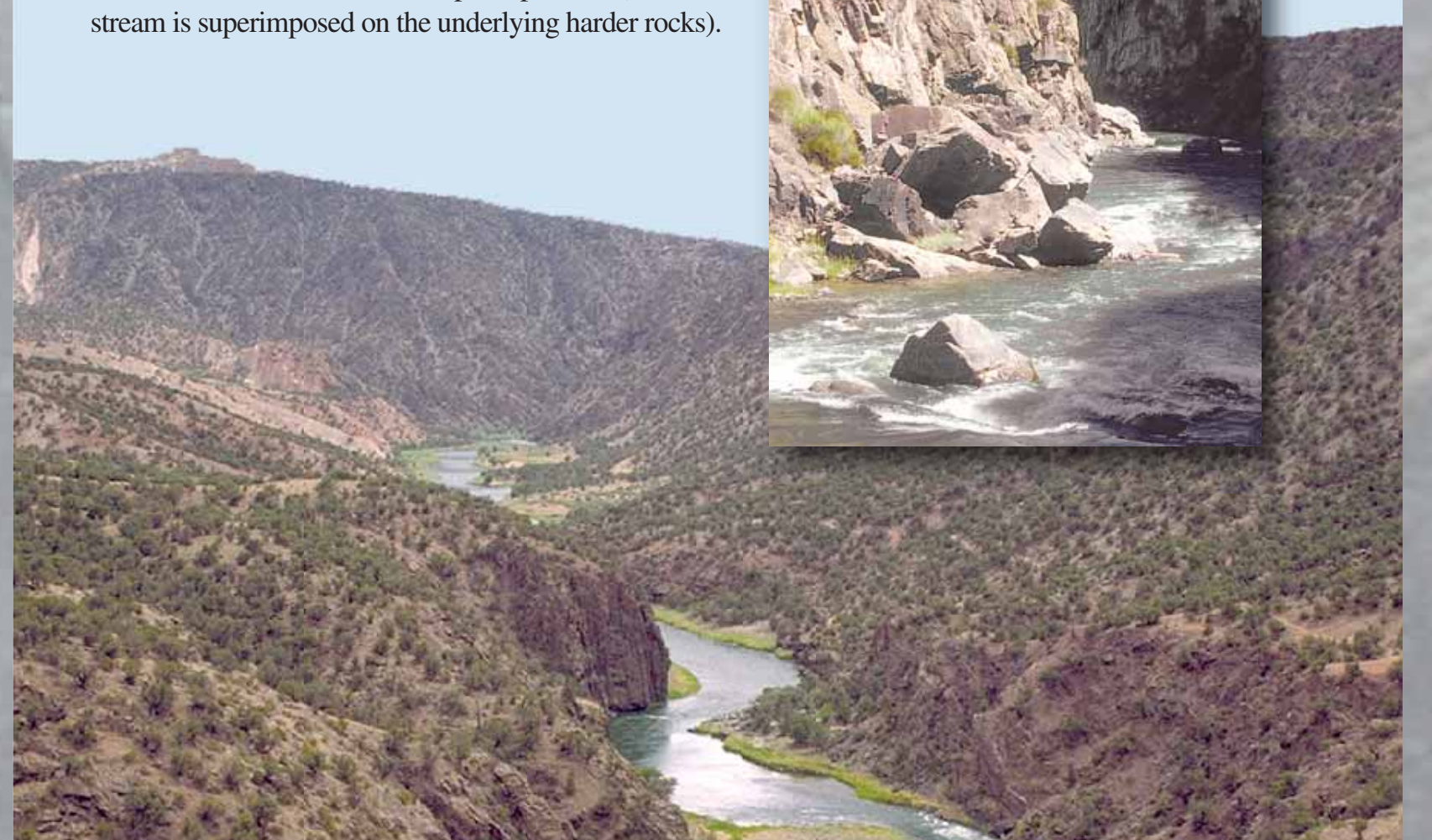
Figure 6 (above). *View to the south (upriver), about 0.6 mile (1 km) south of Ute Park. The hikers are standing on a large outcrop of Entrada Sandstone* (Je)*. The light-colored rocks in the distance, on the left side of the picture, are slabs of Entrada Sandstone that are upturned along the Ute Indian fault (shown in yellow).*

Figure 7. *View to the north showing the Ute Indian fault.* Je, *Entrada Sandstone;* Jw, *Wanakah Formation;* Jmt, *Tidwell Member of the Morrison Formation;* Jms, *Salt Wash Member of the Morrison Formation;* Jmb, *Brushy Basin Member of the Morrison Formation;* Kdb, *Dakota Formation, and Burro Canyon Formation. Note how the down-to-the-east displacement across the fault dies out to the north, such that the beds of unit* Jmt *are folded but not broken by the fault. Where formation and member contact lines are dashed, and where the Ute Indian fault is dashed, indicates that these features are approximately located or concealed. On the geologic map, the Wanakah Formation and the Tidwell Member of the Morrison Formation are combined as one map unit (labeled* Jmtw*), and the Salt Wash and Brushy Basin Members of the Morrison Formation are combined as one unit (labeled* Jmu*). They are combined because at the scale (size) of the geologic map these units would be too thin to show separately.*

The Gunnison River Paradox

Why does the Gunnison River cut through the center of the Gunnison uplift and not around it? Two interesting geologic relationships have been proposed to explain this paradox. First, the Gunnison uplift was mostly buried by enormous outpourings of ash-flow tuff and volcanic breccia during huge Oligocene and Miocene volcanic eruptions that originated from two nearby volcanic centers in the San Juan and West Elk Mountains. These eruptions, as well as a broad, late Tertiary downwarp or syncline (Hansen, 1987), confined the Gunnison River to a course across the buried Gunnison uplift.

Second, rapid lowering of base level (the lowest level to which a stream can erode) during Pliocene and Quaternary time (refer to Kellogg, in press, for how this occurred) caused the Gunnison River to cut rapidly into the thick accumulation of volcanic rocks (as well as the soft Mancos Shale), exhuming the buried Gunnison uplift. The Gunnison River was confined to the established channel within the volcanic rocks, so it continued to erode downward where it was—right into the hard rocks of the Gunnison uplift. This process, whereby a river crossing one type of rock descends over time by erosion into entirely different, commonly much harder rocks, is called stream superimposition (that is, the stream is superimposed on the underlying harder rocks).

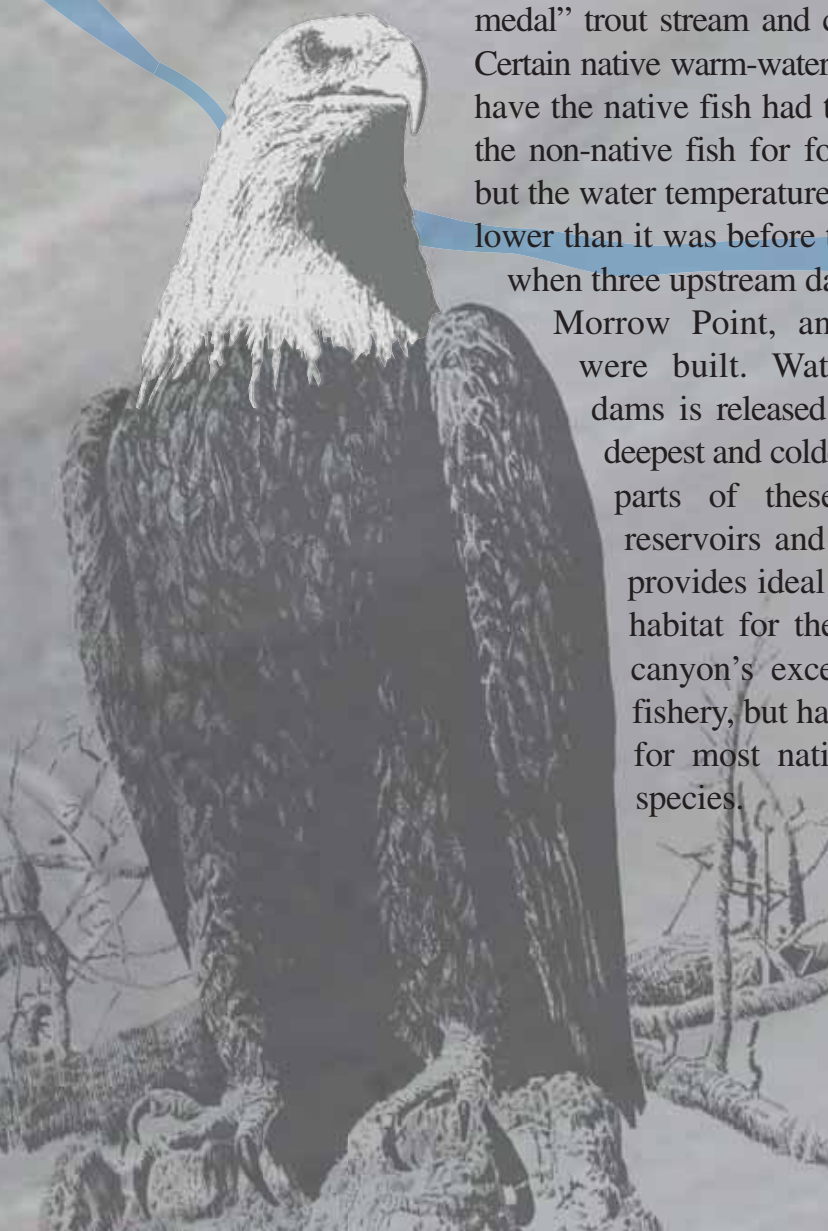


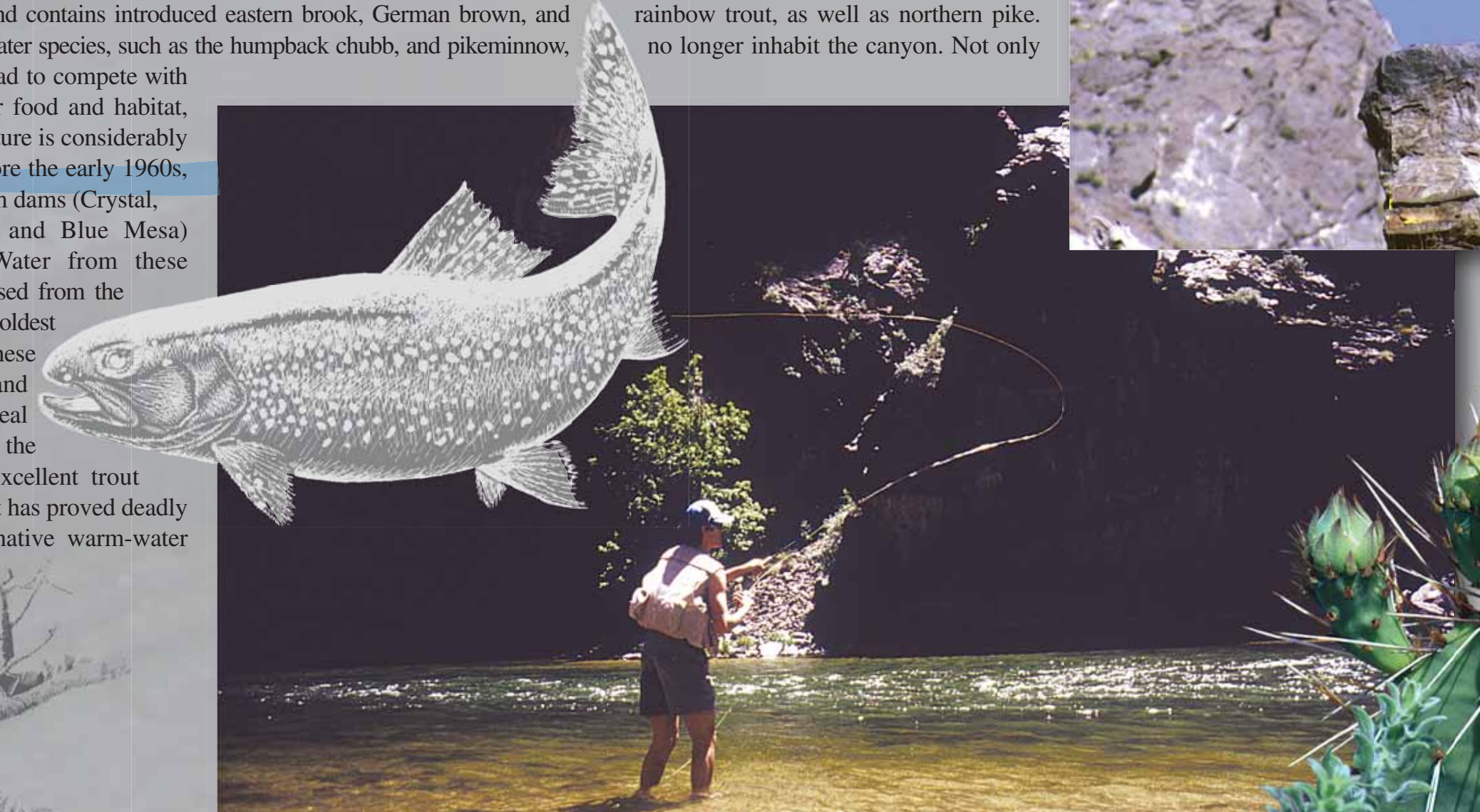
Ecology of the Canyon

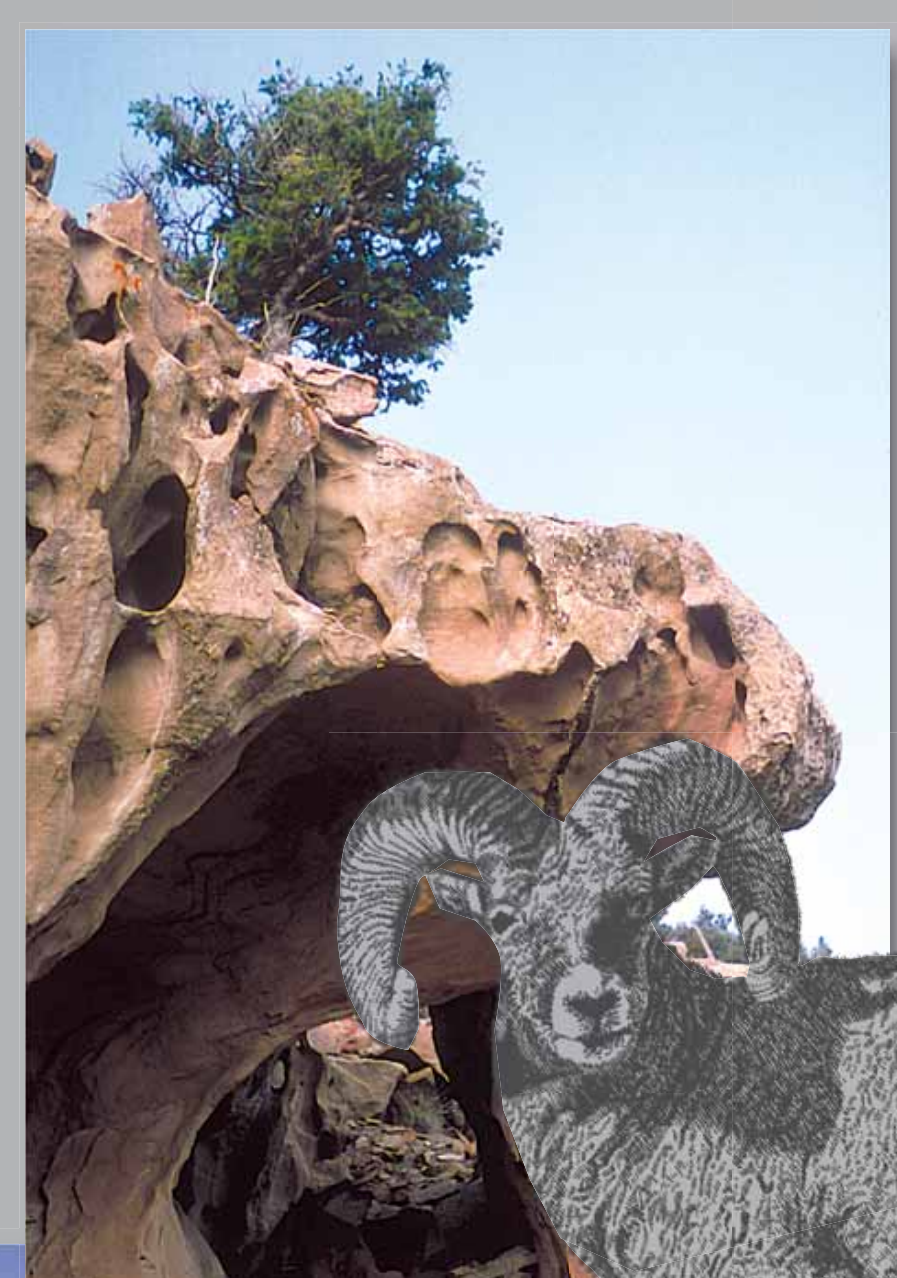
The canyon has a variety of ecological environments. Riparian habitats along the river corridor are host to cottonwoods, box elder, willows, and patches of poison ivy and other plants. In addition to these native plants, tamarisk (salt cedar), an introduced water-loving species, is making inroads along the riverbank. The BLM has launched an aggressive tamarisk-control program to rid the NCA of this threat to native plant communities.

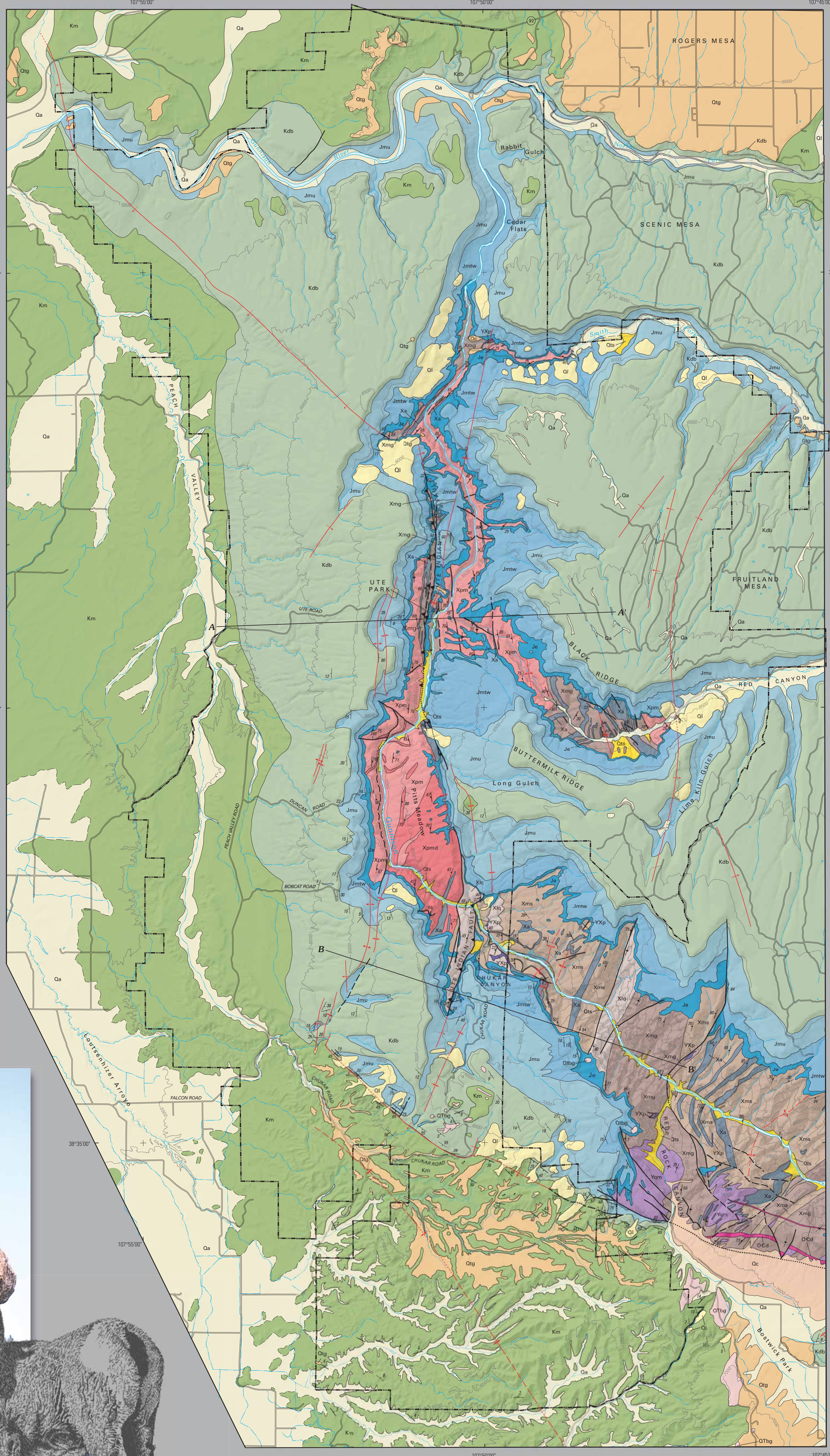
Farther back from the river is a semi-arid environment containing juniper, scrub oak, mountain mahogany, grasses, Mormon tea, occasional cactus, and other plants. Pinon-juniper forests and open sagebrush parks mark the higher regions of the NCA. The western and southern regions of the NCA are underlain by nutrient-poor Mancos Shale, which forms a barren landscape with sparse vegetation. Some of the plants found here, such as a clay-loving species of buckwheat (*Eriogonum pelinophilum*), are endangered and are found only in Mancos Shale soils.

The NCA is the home of a wide variety of wildlife, including mule deer, elk, Rocky Mountain bighorn sheep (reintroduced in 1986), mountain lions, bobcats, black bears, coyotes, foxes (both red fox and the diminutive kit fox), river otters (also reintroduced in 1986), and a variety of snakes and lizards. Birds of prey include peregrine and prairie falcons, kestrels, golden eagles, ospreys, red-tailed hawks, and occasional bald eagles. A small population of turkey vultures also inhabits the area. Many other bird species are either residents of the canyon or are seasonal visitors. The Gunnison River is considered a "gold-medal" trout stream and contains introduced eastern brook, German brown, and rainbow trout, as well as northern pike. Certain native warm-water species, such as the humpback chubb, and pikeminnow, no longer inhabit the canyon. Not only have the native fish had to compete with the non-native fish for food and habitat, but the water temperature is considerably lower than it was before the early 1960s, when three upstream dams (Crystal, Morrow Point, and Blue Mesa) were built. Water from these dams is released from the deepest and coldest parts of these reservoirs and provides ideal habitat for the canyon's excellent trout fishery, but has proved deadly for most native warm-water species.







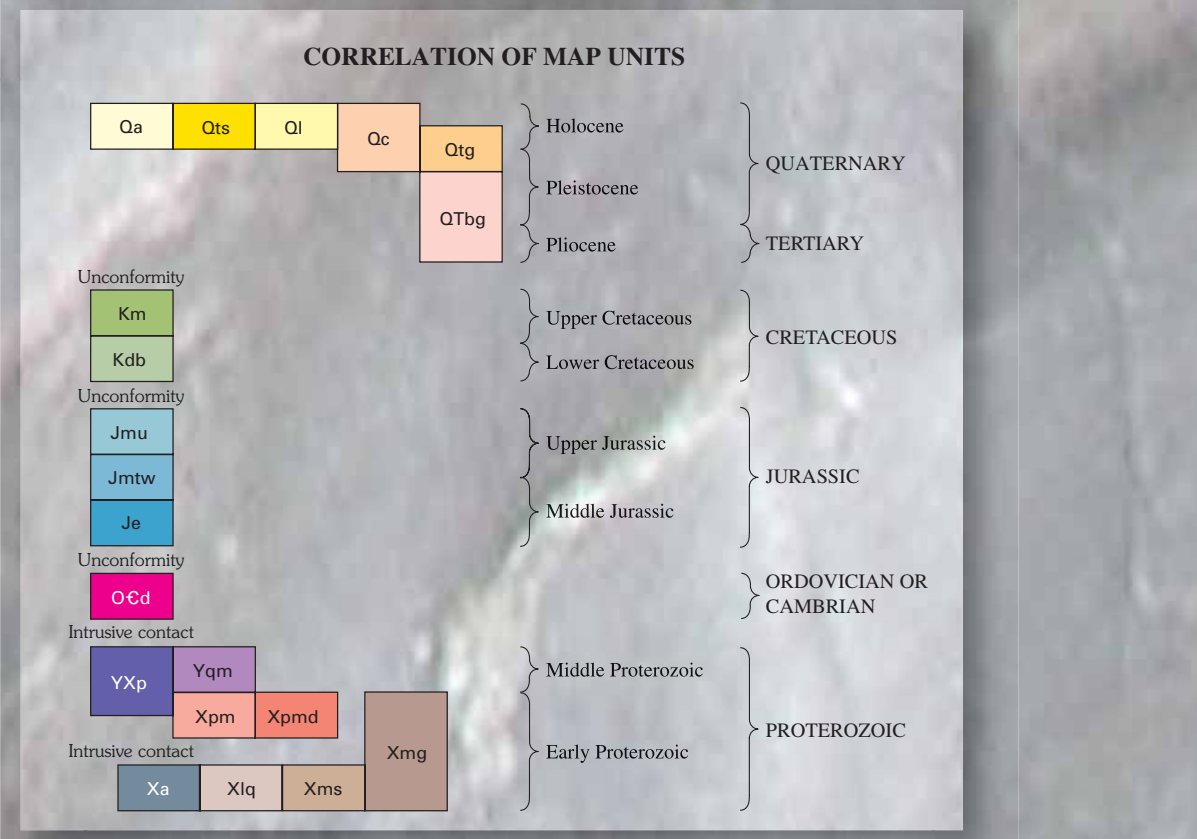


Base created and modified from U.S. Geological Survey 7.5-minute (1:24,000-scale)
DEM and DLG files as follows: Black Ridge, Lazear, Olathe, Olathe NW, and Red Rock Canyon.
DEMs created 1998–2002 from 1950–79 source material.
DLGs created 2000–02 from 1950–55 source material.
Universal Transverse Mercator projection, zone 13, Clark Spheroid of 1866,
North American Datum of 1927

SCALE 1: 45 000
1 1/2 0 1 2 3 MILES
1 .5 0 1 2 3 4 KILOMETERS
CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
2004 MAGNETIC DECLINATION IS APPROXIMATELY 11.5° EAST

Geology compiled and modified by K.S. Kellogg from Hansen (1968, 1971) and Ellis and others (1987).
GIS database and shaded-relief base created by D. Paco VanSistine in 2003

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qa	**Valley alluvium (Holocene)**—Boulders, cobbles, sand, silt, and clay along stream channels
Qts	**Talus (Holocene)**—Angular blocks accumulated by rockfall from cliff directly above deposit
Ql	**Landslide deposit (Holocene)**—Chiefly rock debris accumulated by downslope movement; younger deposits have hummocky topography
Qc	**Colluvium (Holocene and Pleistocene)**—Loose, unsorted soil and (or) rock fragments deposited by rainwash, or slow, continuous downslope creep; includes landslide deposits and talus
Qtg	**Terrace gravel (Holocene and Pleistocene)**—Alluvial gravel on benches at several levels above river
QTbg	**Boulder gravel (Pleistocene and (or) Pliocene)**—Gravel at a high level above streams. Contains large boulders of black volcanic breccia and tuff
Km	**Mancos Shale (Upper Cretaceous)**—Dark-gray, silty clay shale; forms light-gray badland topography
Kdb	**Dakota Formation and Burro Canyon Formation (Upper and Lower Cretaceous)**—Dakota Formation contains thin beds of fine-grained quartz sandstone, carbonaceous shale, and coal. Burro Canyon Formation consists of thick-bedded, medium-grained quartz sandstone, interbedded shale, and chert-pebble conglomerate
Jmu	**Morrison Formation, upper part** —Consists of Brushy Basin Member (red, yellow, gray, and green shale and light-yellow sandstone beds) and underlying Salt Wash Member (thick, cross-bedded sandstone beds and interbedded red, silty shale)
Jmtw	**Tidwell Member of Morrison Formation (Upper Jurassic) and Wanakah Formation (Middle Jurassic)**—Tidwell Member contains some thick sandstone beds, gypsiferous shale and sandstone, and thin, cherty limestone beds. Wanakah Formation consists of mostly gray and pale pink mudstone and friable sandstone, gypsum beds, and gypsiferous sandstone; includes basal Pony Express Limestone Member
Je	**Entrada Sandstone (Middle Jurassic)**—Pink to yellowish-orange, fine-grained, thick-bedded to massive, cross-bedded, eolian sandstone; weathers in rounded forms; conglomerate at base
O€d	**Diabase dike (Ordovician or Cambrian)**—Dark, fine- to medium-grained igneous rock in dikes as thick as about 330 feet (100 meters), composed mostly of feldspar and augite
YXp	**Pegmatite (Middle or Early Proterozoic)**—Pink to white, very coarse grained igneous rock containing mostly quartz, microcline feldspar, and muscovite; forms abundant dikes in basement rocks
Yqm	**Vernal Mesa Quartz Monzonite (and similar rocks) (Middle Proterozoic)**—Mostly dark-gray, coarse-grained, porphyritic, massive rock containing quartz, feldspar, and biotite
Xpm	**Pitts Meadow Granodiorite (Early Proterozoic)**—Gray to dark-gray, massive to foliated, coarse-grained, equigranular granodiorite or quartz diorite; contains numerous mafic inclusions
Xpmd	**Pitts Meadow Granodiorite, dark-colored variant (Early Proterozoic)**—Contains higher percentage of mafic minerals (hornblende and biotite)
Xa	**Amphibolite (Early Proterozoic)**—Dark-gray to black, medium- to coarse-grained, foliated rock containing mostly hornblende and plagioclase
Xlq	**Layered quartzitic gneiss (Early Proterozoic)**—Gray, fine- to medium-grained, well-foliated quartz-rich metasedimentary gneiss and metaquartzite; foliation commonly contorted
Xms	**Mica schist (Early Proterozoic)**—Gray, fine- to medium-grained, strongly foliated and lineated quartz-mica schist. Muscovite predominates over biotite
Xmg	**Migmatite (Early Proterozoic)**—Light- to medium-gray quartz-feldspar-mica metasedimentary gneiss containing numerous, thin granitic layers parallel to foliation. Locally contains sillimanite and garnet

Contact—Between geologic map units; dashed where approximately located

80
Fault—Dashed where approximately located, dotted where concealed by surficial deposits; dip (inclination) of fault plane shown on some faults

Ute Indian thrust fault—Dashed where approximately located, dotted where concealed; teeth are on upthrown side

Syncline—Trough-shaped fold, showing trace of axial plane; dashed where approximately located; dotted where concealed

Anticline—Arch-shaped fold, showing trace of axial plane; dashed where approximately located; dotted where concealed

Monocline—A fold defined by local steepening of otherwise nearly horizontal beds, showing trace of inflection plane of fold; dotted where concealed; arrow points in down-dip direction

25
Strike and dip of bedding—Long line (strike) is horizontal in bedding plane; short line and number is direction of dip of bedding

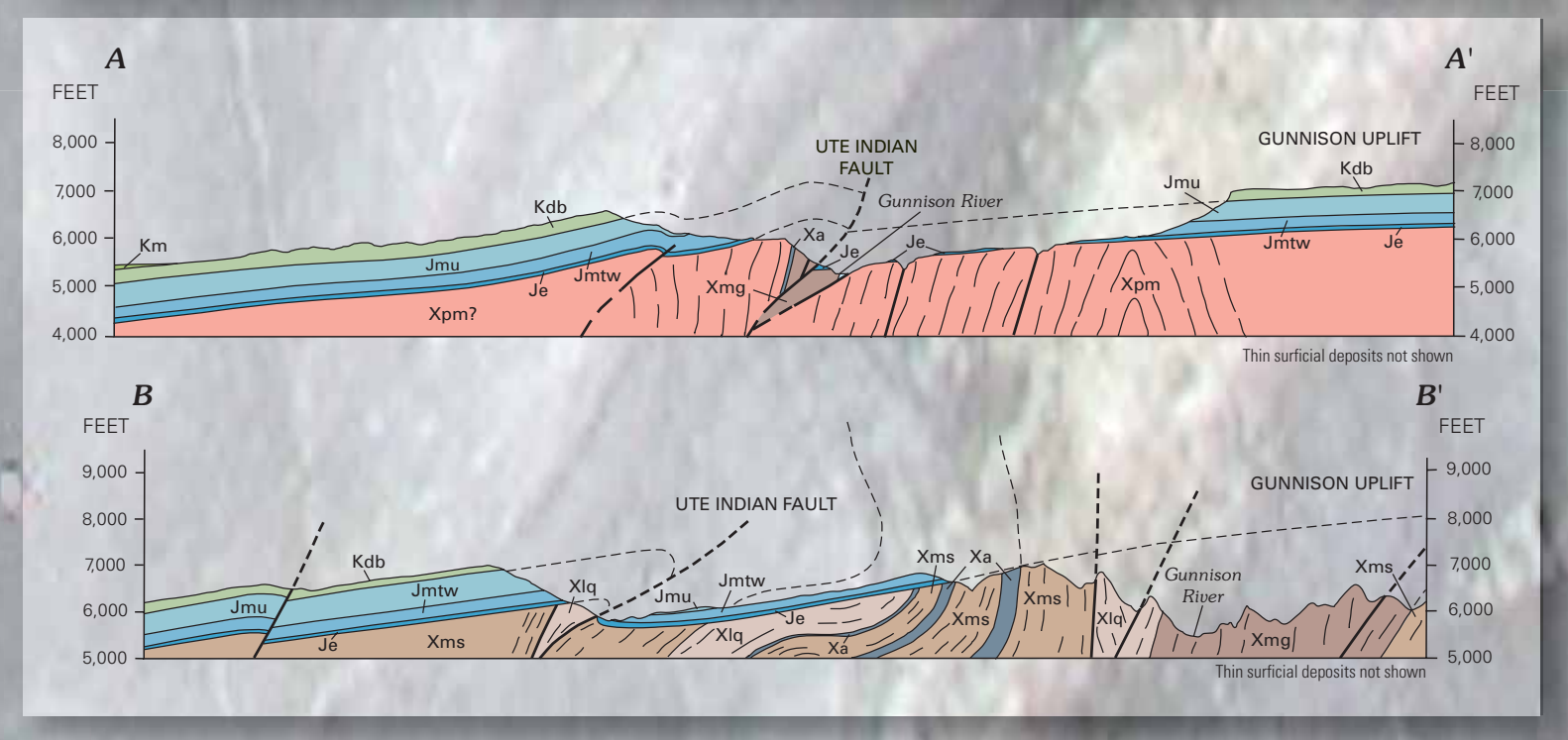
75
Strike and dip of overturned bedding

40
Strike and dip of foliation—Long line (strike) is horizontal in foliation plane; short line and number is direction and angle of dip of foliation

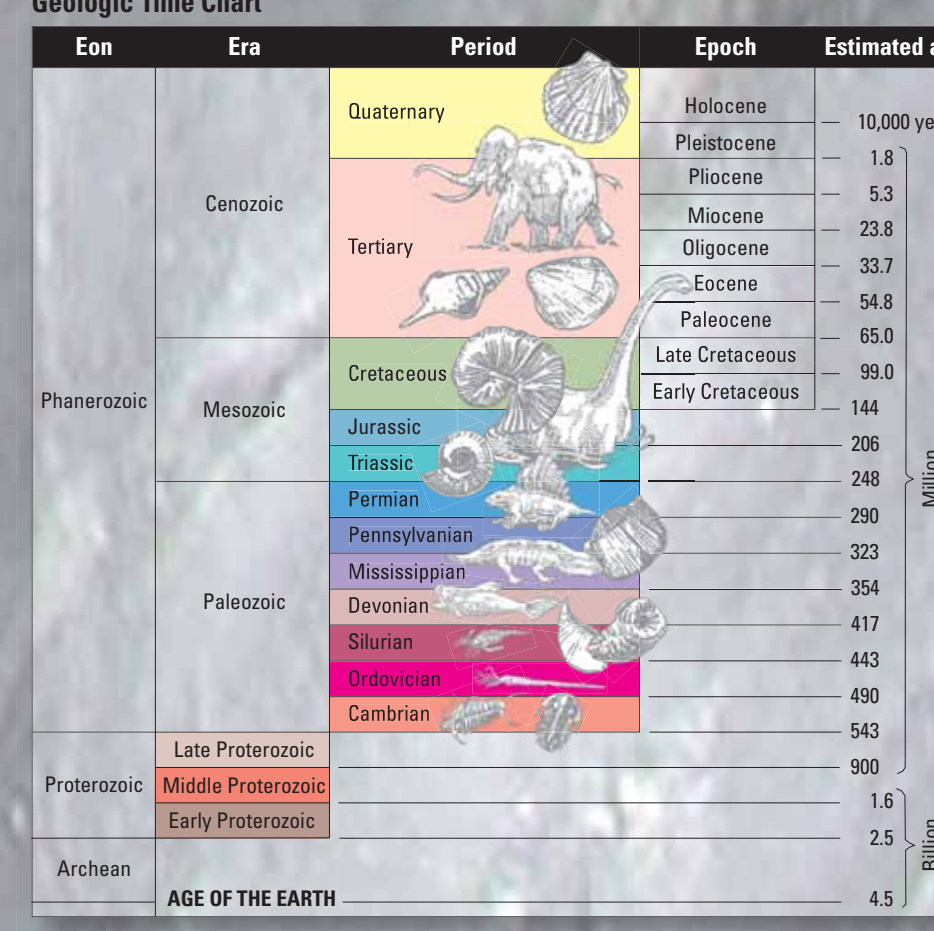
Strike of vertical foliation

Approximate boundary of Gunnison Gorge National Conservation Area

6500
Topographic contour—Numbers indicate altitude above mean sea level. Contour interval 500 feet (150 meters)



Geologic Time Chart



Humans and the Canyon

The earliest known inhabitants or visitors to the canyon were prehistoric Native Americans who camped and hunted in the area. Petroglyphs and rock structures that were constructed without mortar are scattered throughout the canyon; however, the exact origin of these relicts remains unknown. Clovis and Folsom spear points have been found in the Uncompahgre River valley, indicating that the region has been inhabited for at least 10,000–11,000 years. More recently, until historic times, mountain-dwelling Utes traversed the canyon's depths.

The Gunnison River is named after John William Gunnison, who led an expedition through the region in 1854 to survey a railroad route from the Mississippi River to the Pacific Ocean. The Black Canyon of the Gunnison understandably caused the expedition to make a large detour and led Gunnison to conclude that a railroad could be constructed through the region only "at an enormous expense."

Few people have lived permanently in the canyon. During the Depression years, John Howell from Olathe built several cabins at "Howell Village" (fig. 8) and eked out a living prospecting for gold and mining mica from pegmatite deposits in the Ute Park area. The Duncan brothers also prospected in the canyon at about the same time; the ruins of their stone cabin and a prospect tunnel are at the base of the Duncan Trail.

Figure 8. *"Howell Village," the remains of John Howell's cabins built during the 1930s just north of Ute Park. Howell was a prospector who lived in the canyon during the Great Depression.*

Photographs are by Karl Kellogg (U.S. Geological Survey) and personnel of the U.S. Bureau of Land Management; cactus photograph by Craig Brunstein

Acknowledgments

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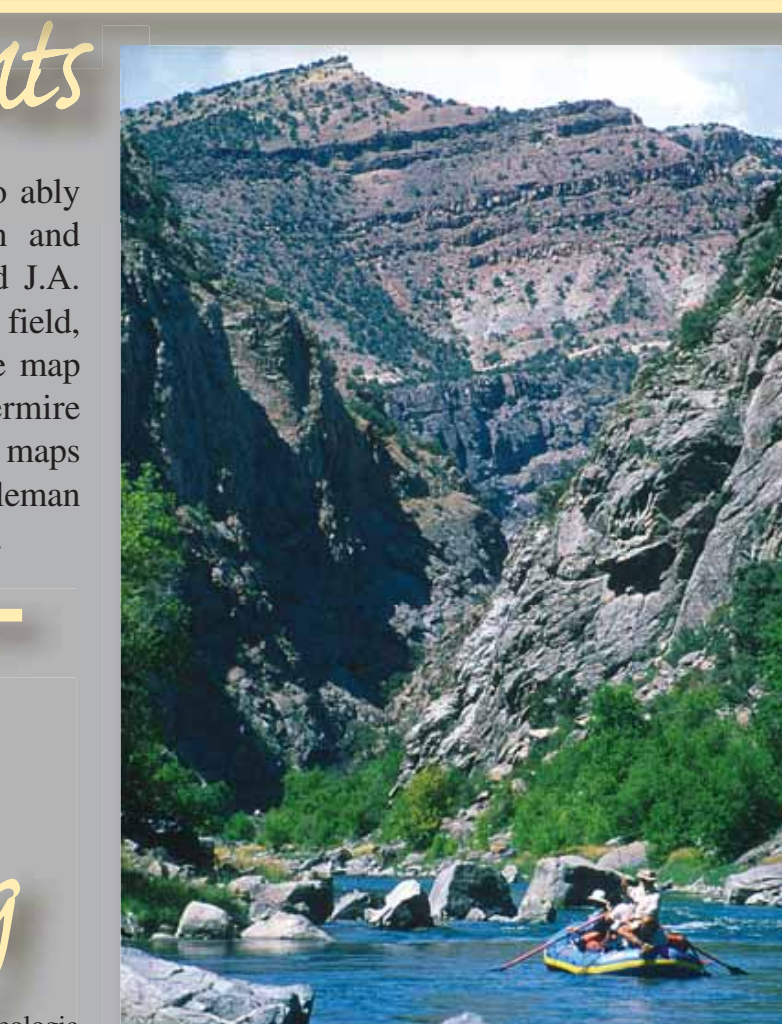

References and Further Reading

Ellis, M.S., Gaskill, D.L., and Dunrud, C.R., 1987, Geologic map of the Paonia and Gunnison area, Delta and Gunnison Counties, Colorado: U.S. Geological Survey Coal Investigations Map C–109, scale 1:100,000.

Hansen, W.R., 1968, Geologic map of the Black Ridge quadrangle, Delta and Montrose Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–747, scale: 1:24,000.

Hansen, W.R., 1971, Geologic map of the Black Canyon of the Gunnison River and vicinity, western Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I–584, scale 1:31,680.

Hansen, W.R., 1987, The Black Canyon of the Gunnison—in depth: Tucson, Arizona, Southwest Parks and Monuments Association, 58 p.

Kellogg, K.S., in press, The geologic story of Gunnison Gorge National Conservation Area: U.S. Geological Survey Professional Paper 1699.

Kellogg, K.S., Hansen, W.R., Tucker, K.S., and VanSistine, D. Paco, 2004, Geology of Gunnison Gorge National Conservation Area, Delta and Montrose Counties, Colorado: U.S. Geological Survey Fact Sheet 2004–3050, 6 p.

O'Sullivan, R.B., 1992, The Jurassic Wanakah and Morrison Formations in the Telluride-Ouray-western Black Canyon area of southwestern Colorado: U.S. Geological Survey Bulletin 1927, 24 p.

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