OPEN-FILE REPORT 05-5

Geologic Map of the Almont Quadrangle, Gunnison County, Colorado

Bill Owens, Governor,
State of Colorado

COLORADO
DEPARTMENT OF
NATURAL
RESOURCES

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Department of Natural Resources
Denver, Colorado
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Geologic Map of the Almont Quadrangle, Gunnison County, Colorado

Description of Map Units, Structural Geology, Mineral Resources, Water Resources, and Geologic Hazards

by

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FORWARD

The purpose of Colorado Geological Survey Open File Report 05-5, *Geologic Map of the Almont Quadrangle, Gunnison County, Colorado* is to describe the geologic setting and mineral resource potential of this 7.5-minute quadrangle located in western Colorado. Consulting geologists Jim C. Coogan, Allen Stork and Robert Fillmore, and field assistants Cody Allen and Dylan Tullius completed the field work on this project during the summer of 2004.

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INTRODUCTION

The Almont 7.5' quadrangle is centered near the junction of the East, Taylor, and Gunnison Rivers in central Gunnison County, Colorado. The quadrangle lies on the southeastern margin of the Piceance basin between the Elk and West Elk Mountains (fig. 1). The geology of the Almont 7.5' quadrangle is generally known through unpublished field studies by Western State College and regional-scale mapping by Tweto and others (1976), Ellis and others (1987), and DeWitt and others (2002) (fig. 2). More detailed studies of Precambrian rocks of the Almont area and lower Taylor Canyon were conducted by Hetherington (1991) (fig. 2), Urbani and Blackburn (1974), and Navarro and Blackburn (1974).

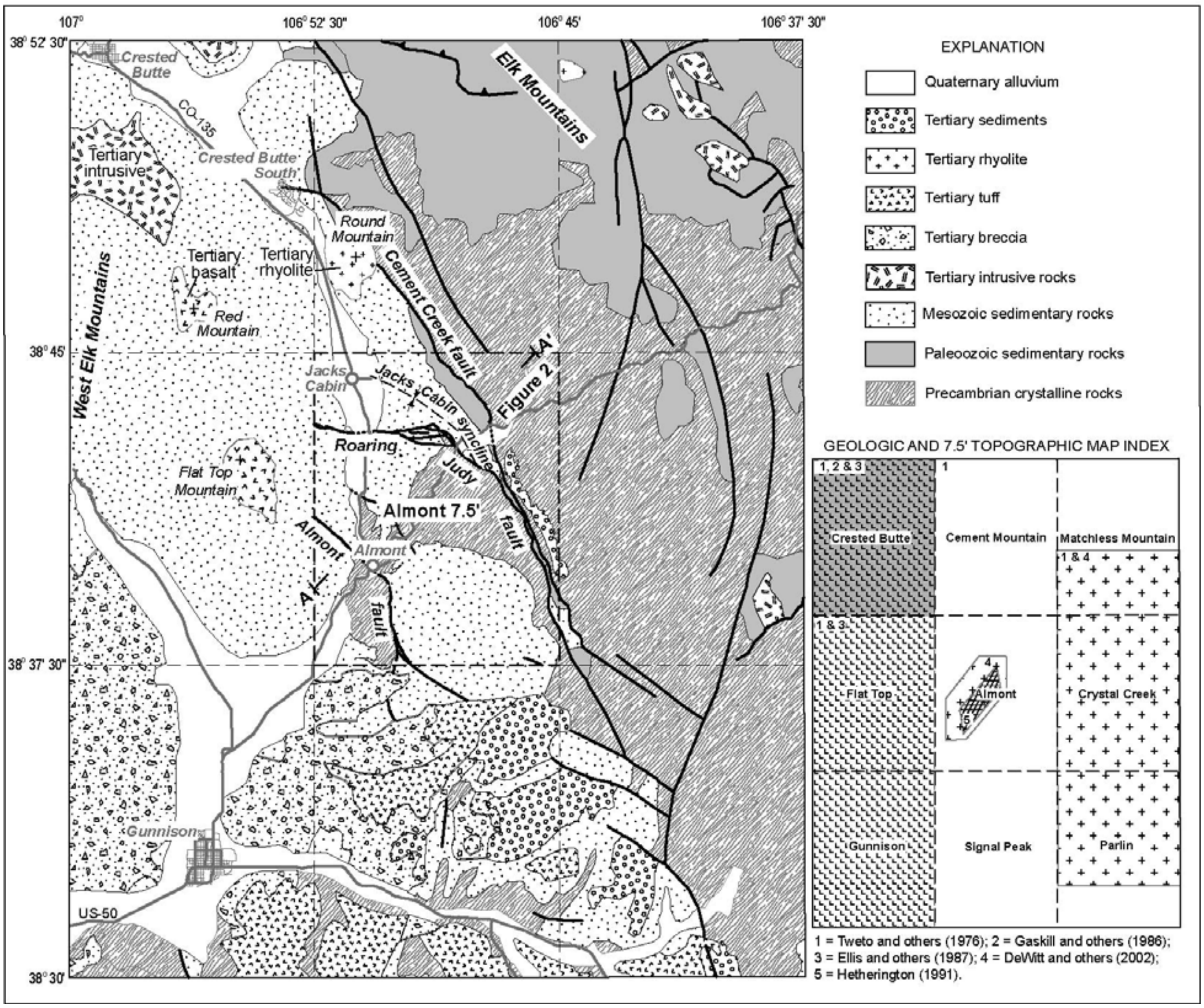

Figure 1. Generalized bedrock geologic map and topographic index map for the area surrounding the Almont 7.5' quadrangle. Modified from Tweto (1979).

ACKNOWLEDGMENTS

Field assistance was provided by Cody Allen and Dylan Tullius of Western State College. Field and office discussions of Paleozoic and Mesozoic stratigraphy with Bruce Bartleson helped to improve the stratigraphic resolution of the map. Field review comments by Vince Matthews and Bruce Bartleson were incorporated into this report. Field review by John Stamm greatly improved the mapping of Quaternary deposits.

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

ALLUVIAL DEPOSITS

Qa **Stream and flood-plain alluvium (Holocene)** -- Sand, silt, clay, and gravel in channels and flood-plains; composition depends on source area; 0 to 20 feet thick.

$Qt_{1,2,3}$ **Stream terrace alluvium (upper Pleistocene)** -- Sand, silt, clay, and gravel in terraces above flood-plains. Suffixes apply only to local drainages with multiple terrace levels; the lowest terraces are labeled 1; 0-45 feet thick. Two charcoal samples taken from the Wilson Pit gravel quarry (Section 4 T.50 N. R.1. E.) have yielded C14 ages of 47.7 ± 1.2 Ka before present and 49.1 ± 1.5 Ka before present (WSC unpublished data) for sediments preserved in the Qt_1 terrace. Depth of the samples is hard to determine because of the quarrying operation; however, the first sample was from the base of the reddish B horizon (?) 10 cm below the disturbed surface. The second sample was found 15 m west of the first sample, 1.5 m below the base of the B horizon.

Qf **Alluvial-fan deposits (Holocene and upper Pleistocene)** -- Mostly poorly stratified and poorly sorted sand, silt, and gravel deposited mainly by a combination of debris flow and alluvial processes at the mouths of drainages; generally less than 40 feet thick. Holocene alluvial-fan deposits are not incised and are graded to modern floodplains, whereas upper Pleistocene alluvial-fan deposits are incised and are graded to upper Pleistocene alluvial terraces.

Qdf **Debris-fan deposits (Holocene and upper Pleistocene)** -- Mostly poorly stratified and poorly sorted sand and gravel that is commonly angular; deposited mainly by rockfall and sheetwash at the base of steep slopes; generally less than 40 feet thick. Holocene debris-fan deposits are not incised and are graded to modern floodplains, whereas upper Pleistocene debris-fan deposits are incised and are graded to upper Pleistocene alluvial terraces.

Qah **High-level alluvium (Quaternary)** -- Sand, silt, clay, and gravel in channels and surfaces that are not obviously graded to modern flood-plains; composition depends on source area; 0 to 20 feet thick.

MASS-WASTING DEPOSITS

Qta **Talus deposits (Holocene)** -- Non-stratified deposits of angular boulder- to pebble-size debris derived from, and deposited at the base of, steep slopes of resistant bedrock; composition depends on local bedrock; 0 to 30 feet thick.

Qc **Colluvium (Quaternary) --** Poorly sorted and poorly stratified sand, silt, and gravel that caps hilltops and gentle to moderate slopes; deposited by a variety of processes, including slopewash and soil creep; composition depends on local bedrock; generally less than 20 feet thick.

Qco **Older colluvium (Pleistocene(?)) --** Poorly sorted and poorly stratified sand, silt, and gravel that caps hilltops and gentle to moderate slopes west of the East and Gunnison rivers; mantled by boulder- to cobble-size clasts of Tertiary basalt of Flat Top Mountain; probably initially deposited by a variety of mass movement processes, but extensively modified by slopewash and soil creep; as much as 30 feet thick.

Qlsy **Younger mass-movement deposits, undivided (Holocene)** -- Slide, slump, and flow material; composed primarily of clay matrix derived from the Mancos Shale with boulder- to cobble-size clasts of local bedrock units; characterized by hummocky topography and head and internal scarps with fresh morphology; thickness is highly variable from 0 to 40 feet thick.

Qls **Mass-movement deposits, undivided (Quaternary)** -- Includes slides, slumps, and flows, as well as colluvium and talus mapped on and adjacent to steep slopes where several mass-movement processes contribute to the deposit; composition varies from poorly sorted clay to boulder-sized material depending on local source terrain; generally characterized by hummocky topography, head and internal scarps, and chaotic bedding in displaced bedrock; morphology is subdued with age; thicknesses are highly variable from 0 to 40 feet thick.

Qef **Earthflow deposits (Holocene (?) - Pleistocene(?))** -- Large scale earthflows exhibiting hummocky internal morphology and distinct hummocky margins; originate in clay-rich bedrock of the Cretaceous Mancos Shale and Jurassic Brushy Basin Member of the Morrison Formation; up to 200 feet thick.

ALLUVIAL AND MASS-WASTING DEPOSITS

Qac **Alluvium and colluvium (Quaternary)** -- Includes stream and fan alluvium and colluvium; generally less than 20 feet thick.

Qp **Pediment deposits (Pleistocene)** -- Mostly poorly stratified and poorly sorted sand, silt, and gravel on gently graded slopes in east and southeast of Jacks Cabin; locally mantled with angular cobble- to boulder-sized clasts derived from older formations; less than 20 feet thick. These gravels are graded to a level above upper Pleistocene terraces along the East River.

TERTIARY SEDIMENTARY DEPOSITS

Ts **Gravel and alluvial deposits (Pliocene(?))** -- Well-rounded, unconsolidated gravels are found above the Gunnison River, Taylor River and Beaver Creek. Gravel deposits above the Taylor River contain sediment from sand to boulder (up to 1-2 m) size. Boulders include Precambrian granites and metamorphic rocks, Paleozoic sandstones, and Tertiary volcanics. Volcanic rocks included in this deposit are quartz porphyries that correlate with Oligocene volcanics and shallow intrusives from the Tin Cup area (Rosenlund, 1984), which were dated by DeWitt and others (2002) at 34.5 ± 3.0 Ma. The base of these gravels lies ~ 650 feet above the current level of the Taylor River. Gravel deposits above Beaver Creek contain sediment from sand to boulder (up to 1 m) size. Boulders are rounded to sub-rounded and predominantly of locally derived Taylor River and Henry Mountain granites. The base of these gravels lies from 240-600 feet above the current level of Beaver Creek. The Tertiary gravel and alluvial deposits were deposited on a surface that is intermediate in elevation between Miocene and Pleistocene age geomorphic surfaces within and surrounding the Almont quadrangle. The base of the gravel and alluvial deposits lies 1,000 to 1,200 feet beneath the base of the basalt of Flat Top Mountain (fig. 1, Gaskill and others, 1986, Tweto and others, 1976), which marks the axis of the ancestral Gunnison River drainage in Miocene time. The base of the deposits also lie between 300 to 500 feet above upper Pleistocene alluvial terraces in Spring Creek. The Tertiary gravel and alluvial deposits are therefore assigned a Pliocene(?) age as a result of the presence of Oligocene rhyolite clasts within the gravels and the intermediate elevation of the gravel surface between Miocene and Pleistocene geomorphic surfaces.

Tsg **Grus deposits (Pliocene(?))** -- Angular, unconsolidated pebble-sized grus gravel along the western slope of Beaver Creek. Grus lies as a continuous layer above the Proterozoic Taylor River and Henry Mountain granites and below post-Oligocene gravel and alluvial deposits (Ts). The base of the grus lies from 200 to 420 feet above the current level of Beaver Creek. The grus varies from 0 to approximately100 feet thick. The grus deposits are assigned a Pliocene(?) age as a result of their apparent depositional continuity with overlying gravel and alluvial deposits (Ts).

BEDROCK

TERTIARY INTRUSIVE ROCKS

Ti **Trachyte of Roaring Judy (Miocene)** -- The trachyte of Roaring Judy is porphyritic with fine-grained biotite phenocrysts in a trachytic groundmass. Biotite phenocrysts are ~1 mm and make up 1-2% of the rock. Plagioclase, clinopyroxene and magnetite phenocrysts are sparse. The groundmass consists of trachytic plagioclase and biotite microlites with a small amount of interstitial quartz. Vesicles make up less than one percent of the rock. The unit occurs as a roughly circular pipe intruded near the Roaring Judy fault. Age is assigned by association with the nearby Round Mountain rhyolite porphyry (12 ± 1 Ma, Cunningham and others, 1977) and the shoshonitic flows on Red Mountain and Flat Top (10 ± 1 Ma; Chad Robinson, unpub. data, 1979).

MESOZOIC SEDIMENTARY ROCKS

Mancos Shale (Upper Cretaceous) – The Mancos Shale is mainly dark-gray to gray fissile shale with subordinate mudrock, limestone, sandstone, and calcareous sandstone. Map unit designations are based on correlation with formal members of the Mancos Shale from the northern San Juan Basin (Leckie and others, 1997) and the Niobrara Formation and Carlile Shale of the southern Front Range (Scott and Cobban, 1964), combined with recognition of local informal units. The eight map units include the upper shale, the calcareous shale of the Smoky Hill Member, the lower shale of the Smoky Hill Member, the Fort Hays Limestone Member, an unnamed shale member and Juana Lopez Member, the Codell Sandstone Member, the lower shale, and the lower member.

Kmu **Upper shale –** Dark-gray to gray fissile shale in the upper part and massive but poorly exposed mudrock in the lower part. Approximately 550 feet thick along the northwestern border of the quadrangle. The top of the upper shale is not exposed in the Almont quadrangle.

Kmsc **Calcareous shale of the Smoky Hill Member –** Dark gray to very dark gray fissile calcareous shale that weathers with a distinctive white calcite coating. 60 feet thick west of the Roaring Judy Fish Hatchery.

Kmsl **Lower shale of the Smoky Hill Member –** Dark-gray to gray fissile shale in the upper part, with increasing amounts of more massive but poorly exposed mudrock in lower part. 150 feet thick west of the Roaring Judy Fish Hatchery.

Kmf **Fort Hays Limestone Member –** Light-gray massively bedded micrite that weathers as very light-gray, highly fractured scree. The best exposures are along the Alkali Creek Road in the northwestern corner of the quadrangle. 30 feet thick west of the Roaring Judy Fish Hatchery.

Kmsj **Unnamed shale member and Juana Lopez Member –** Mainly dark-gray fissile shale alternating with three medium-bedded ledges of fossiliferous limestone in the lower 15 feet. The limestones are dark-brownish-gray to black packstone to grainstone consisting mainly of *Inoceramus* fragments. The lowest limestone is a 1-foot-thick bed of distinctive dark-gray to black, brown-weathering, petroliferous grainstone with *Inoceramus* and *Lopha lugubris* fragments. *Lopha lugubris* is diagnostic of an upper Turonian age (Leckie and others, 1997). The aggregate map unit thickness is 70 feet west of the Roaring Judy Fish Hatchery.

Kc Codell Sandstone Member – Gray, tan-weathering, fine-grained, thick- to medium-bedded calcareous sandstone. 12 feet thick west of the Roaring Judy Fish Hatchery.

Kmls Lower shale – Dark-gray to gray fissile shale. 165 feet thick west of the Roaring Judy Fish Hatchery. The intertonguing lower contact is placed above the highest discontinuous sandstone of the lower member.

Kml Lower member – Dark-gray to gray fissile shale, light-gray massive sandstone, and light-gray silty shale and siltstone. The upper 100 feet of the unit is mainly poorly exposed shale with discontinuous lenses of light-gray, medium- to coarse-grained, massively bedded quartz sandstone that contains euhedral biotite and sanidine grains. The sandstone weathers to light-gray and red-orange flaggy float that covers intervening shale slopes. The sandstone bodies are generally less than 3 feet thick and locally display convoluted bedding, abrupt lateral margins, and scoured bases. They are interpreted as having been deposited as hyperconcentrated flows or storm lags in a deep marine setting. The presence of biotite and sanidine grains and zeolite(?) cement indicates that the sandstone was derived from a volcanic-rich clastic source area. The lower 25 feet of the lower member consists of thin-bedded to laminated light-gray to very light-gray siliceous silty shale and siltstone containing rare fish scales. Siltstone beds increase downward to a gradational lower contact with medium-bedded silty sandstones of the uppermost Dakota Sandstone. The aggregate unit thickness is 125 feet (38 m) thick west of the Roaring Judy Fish Hatchery.

Kd Dakota Sandstone (Upper Cretaceous) -- The Dakota Sandstone is dominated by yellow-brown to gray sandstone with interbedded conglomerate and mudstone. Sandstone is quartz arenite with a minor component of chert grains. Chert and quartz pebble conglomerate marks the base, but conglomerate locally is absent where there are no scours. Three distinct parts are recognized in the map area. The lower third consists of interbedded fine- to coarse-grained sandstone and pebble conglomerate that fill scours up to 10 feet deep into underlying strata. This part is dominated by trough and low-angle cross-stratification with minor horizontal stratification. The middle part of the Dakota consists of thinly bedded, brown and gray, carbonaceous, laminated, fine- to medium-grained sandstone, siltstone, and thin, silty coal horizons. Black carbonaceous clots and plant stem impressions are abundant. The upper third of the Dakota consists of fine- to medium-grained sandstone characterized by ripple laminations, planar tabular and herringbone cross-stratification, and bioturbation. This passes upwards to interbedded gray to black silty shale and thin fine-grained sandstone with horizontal and ripple laminations. Bioturbation throughout the upper third of the formation commonly masks original sedimentary structures. *Diplocraterion* and *Skolithus* trace fossils are abundant. Overall the Dakota Sandstone records a transgression of the sea. The basal third was deposited in braided streams. The middle part represents a swampy shoreline environment and the uppermost Dakota was deposited in a sandy, tide-influenced shallow marine environment. The Dakota Sandstone is 65 feet thick in the Gunnison River canyon in the southwest corner of the map area. Thickness varies with the depth of basal scours into underlying strata and most variations are attributed to the lower fluvial part of the formation. The lower third of the formation weathers to steep cliffs and is of variable thickness, depending on the presence and depth of basal scours; locally this part is absent. The middle part of the formation is poorly exposed and weathers to vegetated slopes littered with sandstone blocks from the upper part. The upper part forms cliffs and, along the west side of the Gunnison River canyon south of Almont, forms a continuous cliff band. The Dakota lies in sharp contact unconformably on the Upper Jurassic Brushy Basin Member of the Morrison Formation or the Lower Cretaceous Burro Canyon Formation. The contact is erosional. The upper contact with the overlying Upper Cretaceous Mancos Shale is gradational and records a continued sea level rise into a deep marine environment.

KJbb **Burro Canyon Formation (Lower Cretaceous) and Brushy Basin Member of the Morrison Formation (Upper Jurassic) –** The Burro Canyon Formation consists of basal cliff-forming conglomeratic sandstone and slope-forming varicolored claystone and mudstone. Basal conglomeratic sandstone ranges 0 to 13 feet (3 m) thick and consists of crossbedded chert pebble conglomerate that grades upwards into coarse- to fine-grained sandstone. Where present this unit scours deeply into the underlying Brushy Basin Member of the Morrison Formation. Where these basal strata are absent the Burro Canyon is indistinguishable from the Brushy Basin. Sandstone is overlain by 50 feet (15 m) of olive-green claystone and maroon mudstone. The Burro Canyon in the map area is grouped with the underlying Brushy Basin Member due to lithologic similarities and abundant cover, which makes it difficult to differentiate between the two. Only one exposure of unequivocal Burro Canyon Formation was recognized in the map area; the preceding description comes from this locality, which is on the west side of the Gunnison River canyon south of the town of Almont in the NW ¼, SE ¼ section 28, T. 15 N, R. 1 E. The Burro Canyon to the west of the study area rests unconformably on the Brushy Basin, although evidence for this is lacking in the Gunnison area (Thomas, 1981). The formation is unconformably overlain by the Upper Cretaceous Dakota Sandstone. The Brushy Basin Member is a heterogeneous assemblage of lithologies and consists of irregular alternations of green siliceous claystone, red silty shale, gray limestone, and sparse lenses of sandstone and conglomeratic sandstone. Beds of all lithologies are less than 4 feet thick. Green claystone is the dominant rock type and mostly is structureless, although laminations are locally evident. Red silty shale is laminated. Gray limestone is micritic and contains evidence of plant rootlets. Clasts in conglomeratic sandstone lenses are composed predominantly of intraclasts of limestone, green claystone, and red shale. The Brushy Basin Member is the product of a broad low-relief fluvial flood-plain. Claystone and shale are flood plain deposits. Lenticular sandstone and conglomerate bodies were deposited in the low energy river channels that cut across the flood plain. Limestone was deposited in shallow ponds that formed in depressions on the plain, between the river channels. The Brushy Basin Member reaches up to 230 feet (70 m) thick. This thickness includes the overlying Lower Cretaceous Burro Canyon Formation, which is impossible to differentiate from the Brushy Basin across most of the map area due to poor exposure and similarities in lithology. The Brushy Basin forms sagebrush-covered slopes and mostly is concealed beneath a thick mantle of colluvium. Where it cannot be recognized by stratigraphic position, it typically is identified by chips of green and red shale in small drainages and gullies. Its recognition is further complicated by its tendency to collapse into landslides, slumps, and debris flows.

Jms **Salt Wash Member of the Morrison Formation (Upper Jurassic) --** The Salt Wash Member consists of tan and red-brown, fine- to medium-grained sandstone and less common pebble conglomerate. Pebbles range 2 to 3 cm and are green and red clay intraclasts. Sandstone is trough cross-stratified with minor horizontal bedding and low-angle cross-stratification. Intraclasts are confined to the base of troughs and individual beds. The Salt Wash Member was deposited in the channels of braided rivers. The Salt Wash attains a maximum thickness of 20 feet in the west part of the map area but thins and locally is absent to the east. At the west edge of the quadrangle, along the East and Gunnison Rivers, the member forms a resistant overhanging caprock above the Junction Creek Sandstone. Where it thins to the east, it forms an indistinct bench. The basal contact with the Junction Creek is sharp with low relief scours. Intertonguing relations between the Junction Creek and the Morrison west of Gunnison suggest this contact is conformable.

Jj **Junction Creek Sandstone (Upper Jurassic) --** The Junction Creek Sandstone consists of well-sorted, fine- to medium grained, yellow-white quartz sandstone. It is mostly crossbedded on a large scale with single sets up to 15 feet thick. The basal 10 to 15 feet of the formation consists of medium-grained horizontal and wavy-bedded sandstone with locally abundant quartz granules and pebbles; symmetrical ripples of aqueous origin occur rarely on bedding surfaces. The bulk of the formation was deposited in an eolian dune setting. Basal strata were deposited on a long-lived erosion surface in a marginal shallow marine setting. The Junction Creek Sandstone ranges 90 to 125 feet thick in the map area. The base is poorly exposed and typically covered by an apron of sand. The upper part forms prominent yellow-white to tan cliffs and slickrock benches. The formation nonconformably overlies Precambrian igneous and metamorphic rocks in the west half of the map area. On the east side it overlies the Maroon or Gothic Formations and the contact is an angular unconformity. The upper contact with the Salt Wash Member of the Morrison Formation is believed to be conformable on the basis of intertonguing relations between the Junction Creek and the Morrison Formation east of the town of Gunnison (Bartleson and Jensen, 1988). These relationships preclude correlation of the Junction Creek Sandstone to the Entrada Sandstone mapped by Ellis and others (1987) in the Crested Butte area north of the Almont quadrangle. The Junction Creek Sandstone is correlative with the Bluff Sandstone in southeast Utah, which also intertongues with the lower Morrison Formation (O'Sullivan, 1980).

PALEOZOIC SEDIMENTARY ROCKS

Pℙm **Maroon Formation (Pennsylvanian-Permian)** -- The Maroon Formation is an assortment of clastic rocks that includes orange and red arkosic sandstone, red and white conglomerate, and dark-red to purple siltstone and mudstone. These lithologies are intimately interbedded and range from thin to thick bedded. All units are discontinuous laterally. Conglomeratic sandstone contains trough, planar tabular, and low-angle cross-stratification, and horizontal stratification. Conglomerate units are clast supported; pebbles and cobbles are composed of gray limestone, quartzite, and various metamorphic and plutonic rock types from the Precambrian basement complex. Sandstone is feldspar rich and commonly contains granitic rock fragments. Siltstone and mudstone is micaceous and typically contains horizontal laminations. The Maroon was deposited in a high-energy fluvial system adjacent to its source highlands. The Maroon Formation in the map area ranges from a maximum thickness of 500 feet to zero thickness where it gradually wedges out. It is present only on the east side of the quadrangle where its thickest exposure is immediately north of the Taylor River in the NW ¼ section 28, T.15 N, R.84 W. North of this area it thins rapidly due to an erosional pinchout. This is attributed to post-Maroon, pre-Late Jurassic deformation and erosion as evidenced by the angular unconformity between the Maroon and the overlying Upper Jurassic Junction Creek Sandstone. In the Elk Mountains north of the quadrangle the Maroon reaches an estimated maximum thickness of 9,500 to 10,000 feet (Bryant, 1969; Mutschler, 1970). Its thinner nature in the map area is attributed to a combination of post-depositional erosion and proximity to the bounding fault of the sediment source highlands immediately to the west, on the west side of the quadrangle. The basal contact with the underlying Gothic Formation is gradational and in the Almont quadrangle is defined as the top of the last gray fossiliferous limestone bed in the Gothic. In the Elk Mountains to the north, this contact has been placed at the color change from the brown and gray clastic and carbonate rocks of the Gothic to the reddish strata of the Maroon (Bryant, 1969; Mutschler, 1970). This color change was used because in this area the lower Maroon contains several tongues of gray fossiliferous limestone. The intertonguing relationship between the red clastic rocks, gray limestone beds, and brown clastic rocks make all these definitions somewhat arbitrary. The limestone marker bed used here is recognizable throughout the map area.

ℙg **Gothic Formation, undivided (Pennsylvanian) -** The Gothic Formation consists of cyclic alternations of gray limestone and brown calcareous conglomerate, sandstone, siltstone, and mudstone. Clastic units near the top of the formation may be pink to red. Limestone composition varies vertically and laterally, and units are thin to thick bedded; limestone commonly contains arkosic sand. These units typically are fossiliferous with components of phylloid algae, blue-green algae in the form of domal stromatolites, wavy laminations, and oncoids, various brachiopods, rugose corals, *Chaetetes*, fusulinids, and other foraminifera. Other common components include intraclasts, ooids, and peloids. Pebble to cobble conglomerate units range up to three feet thick and are interbedded with arkosic sandstone. Conglomerate ranges from clast to sand-matrix supported; clasts are rounded and mostly composed of gray limestone. Clasts of quartz, quartzite, metamorphic, and plutonic rock are less common. Brown arkosic sandstone is poorly sorted and conglomeratic. Grain size ranges from fine to very coarse with a composition of quartz, feldspar, and granitic rock fragments. Sedimentary structures include trough and low-angle cross stratification and horizontal stratification. Sandstone and conglomerate commonly scour into underlying strata. Brown sandy siltstone and mudstone is micaceous with horizontal laminations and rare low-angle and ripple cross laminations. The Gothic Formation was deposited in a variety of shallow marine and fluvial environments along the margin of a seaway that was bounded immediately to the west by a highland source for clastic sediment. The cyclic alternations and wide variety of rock types in the Gothic is attributed dominantly to sea-level fluctuations. Sporadic uplift in adjacent highlands and a resulting influx of clastic sediment also exerted a control on lithology. Cyclic alternations of lithology due to sea-level fluctuations are recognized in Pennsylvanian strata around the world. Three limestone members as defined by Bartleson (1972) can be recognized in the map area. The lowest is the Taylor River Limestone, a dark-gray fossiliferous limestone that ranges up to 210 feet thick. This is separated from the limestone of the overlying Brush Creek Member by up to 500 feet of brown coarse-grained clastic rocks. The Brush Creek Member consists of ~275 feet of interbedded fine-grained clastic rock and thin limestone beds. Overlying the Brush Creek Member is the Hot Springs Conglomerate, a tongue of red conglomerate that can be recognized throughout the region. It is ~150 feet thick just north of Taylor River. This is overlain by the Jack's Cabin Limestone. The Gothic reaches a maximum thickness of 2,375 feet in the map area immediately north of Taylor River (Bartleson, 1972). The base is not exposed and throughout the quadrangle the Gothic is in fault contact with Precambrian basement rock. Its original full thickness is unknown but Bartleson (1972) suggests that up to 700 feet of basal Gothic may be missing in the area. Following Bartleson's redefinition of the Gothic, the top in the map area is defined as the top of the limestone of the Jack's Cabin Member. This is a persistent, dark-gray fossiliferous limestone bounded above and below by red sandstone and conglomerate. This designation is preferable to earlier boundaries based on color changes from the brown strata of the Gothic to the red strata of the overlying Maroon Formation (Langenheim, 1952). These different color strata intertongue and are gradational, and the boundary shifts considerably with location. For instance, the color change in the map area occurs more than 150 feet below the Jack's Cabin limestone, but to the north in the Elk Mountains it may be up to 100 feet above the limestone (Bartleson, 1972). The undivided Gothic is mapped only near the northern edge of the quadrangle (N. ½ section 13, T. 15 S., R. 85 W.), where a shattered mound of the formation is exposed. This exposure is likely a landslide or rock avalanche deposit. Because the limestone members defined by Bartleson are too thin to show on the map, they are used as marker beds to informally divide the Gothic in the map area. Instead the Gothic in the Almont quadrangle is subdivided into upper, middle, and lower members as described below.

IPgu **Upper member** – The top of the upper member of the Gothic Formation is defined as the top of the Jack's Cabin Limestone. The base is marked by the top of the Brush Creek Member. Between these two limestone marker beds the unit is mainly brown and red sandstone, siltstone, and conglomerate. The unit is 600 feet thick on the north side of the Taylor River.

PPgm Middle member – The middle member of the Gothic Formation is mapped from the top of the Brush Creek Member to the top of the Taylor River Limestone. The middle Gothic Formation is 920 feet thick on the north side of the Taylor River.

PPgl Lower member – The top of the lower member of the Gothic Formation is defined by the top of the Taylor River Limestone. The lower member consists of interbedded siltstone, sandstone, conglomerate, and thin discontinuous limestone beds. The base of the Gothic contains a white quartz arenite that reaches several hundred feet thick in the Treasure Mountain area north of the map area (Bartleson, 1972). The base of the Gothic Formation is not exposed in the quadrangle. Approximately 850 feet of the lower Gothic Formation is exposed on the north side of the Taylor River.

PROTEROZOIC IGNEOUS ROCKS

Ytd Taylor River dikes (Middle Proterozoic) – Fine- and medium-grained muscovite granite and muscovite-quartz-microcline pegmatite dikes are common along the southwestern margin of the Taylor River Granite between Beaver Creek and the Taylor River. The fine-grained dikes have mineralogy similar to the leucocratic phases of the granite of Taylor River with muscovite as the predominant varietal phase and only trace amounts of green biotite. The pegmatites have the same mineralogy and are often zoned with quartz-microcline margins, with graphic textures that grade into more muscovite-rich zones and quartz-rich cores. Microcline crystals up to 30 cm and muscovite crystals up to 10 cm can be found. Pegmatite dikes range in width from less than a meter to up to four meters. The dikes represent the youngest phase of the granite of Taylor River and intrude the granite of Taylor River, the Henry Mountain Granite and the metamorphic wall rocks. These dikes make the southern contact of the Taylor River Granite with the Henry Mountain Granite very complicated with both vertical and sub-horizontal dikes common on the contacts.

Yt Granite of Taylor River (Middle Proterozoic) - The granite of Taylor River is a light-gray to light-tan, medium-grained muscovite-biotite granite. This granite contains subequal amounts of unaltered microcline perthite, plagioclase (oligoclase that is variably altered to sericite), and quartz. Brown to green biotite and muscovite each make up about 5% of the granite. Zircon, apatite, garnet and ilmenite (?) are present in trace amounts. More detail on the petrography and geochemistry of the granite of Taylor River can be found in DeWitt and others (2002).The unit is well exposed along the Taylor River and Spring Creek in the northeast part of the map and crops out extensively to the north and east (DeWitt and others, 2002). The granite is generally undeformed, although weakly foliated northwest-trending zones occur rarely. The unit is sometimes well foliated on its southwest margin near the Cement Creek Fault zone. Geochronologic data for the granite of Taylor River are summarized by DeWitt and others (2002). They report $^{207}Pb/^{208}Pb$ date of 1,406 Ma (DeWitt and Zartman, unpub. data, 1990) and Rb/Sr whole-rock, potassium feldspar-plagioclase-muscovite isochron 1,380 ± 19 Ma (Dewitt and others, 2002, recalculated from Wetherill and Bickford, 1965).

Xat **Tonalite of Almont (Early Proterozoic) -** These rocks form a group of biotite granitoids that range from tonalite to granite. The most abundant rock is a gray medium-grained biotite tonalite. The tonalite is equigranular with about 50% subhedral zoned plagioclase (andesine) crystals that are partially sericitized and roughly equal amounts of subhedral biotite with interstitial quartz. Trace minerals include epidote, magnetite partially replaced by hematite, zircon, apatite, and chlorite after biotite. Trondhjemites and granites also occur within the intrusive complex and have the same mineralogy with the addition of interstitial microcline. The most silicic rocks are light-gray biotite granites with about 10% biotite and roughly equal amounts of subhedral plagioclase and quartz surrounded by interstitial microcline. Porphyritic tonalites with medium-grained plagioclase and biotite phenocrysts in a fine-grained groundmass also occur as dikes. Further mineralogical and geochemical information can be found in Urbani and Blackburn (1974) and DeWitt and others (2002). This unit occurs as isolated stocks and as vertical and subhorizontal dikes intruded into the biotite quartzite around the town of Almont. The unit is assumed to be early Proterozoic because it cut biotite quartzites with zircons as young as 1,733 Ma (Hill and Bickford, 2001) and because of petrologic similarity to other early Proterozoic plutons in the Gunnison Basin.

Xag **Quartz gabbro of Almont (Early Proterozoic) -** The quartz gabbro of Almont is a black medium-grained biotite-hornblende quartz diorite to quartz gabbro. The unit is texturally variable from equigranular to porphyritic with either biotite (5mm) or hornblende (up to 15mm long) phenocrysts. The rock contains euhedral hornblende and subhedral biotite that is partially replaced by chlorite, with interstitial plagioclase that is partially sericitized, and quartz. Trace minerals include apatite and magnetite partially replaced by hematite. The unit was originally described by Urbani and Blackburn (1974) and further mineralogical and geochemical information can be found there and in DeWitt and others (2002). The quartz gabbro is older than other rocks in the Almont intrusive complex because it is intruded by more silicic Almont granitoids and there are potential contact chill margins in silicic granitoids against the gabbro.

Xh **Henry Mountain Granite (Early Proterozoic) -** The Henry Mountain Granite is a pinkish-tan and black muscovite-biotite granite. The granite is porphyritic with coarse-grained microcline (2-4 cm) phenocrysts that have myrmekitic margins and subhedral to anhedral quartz phenocrysts (~1 cm) in a matrix of medium-grained quartz, brown biotite, muscovite, and plagioclase (originally oligoclase that is variably altered to sericite and epidote). Trace minerals include zircon, apatite and magnetite (?). The unit was defined by DeWitt and others (2002) and details on the petrography and geochemistry of the Henry Mountain Granite can be found there. The Henry Mountain Granite is only exposed in a small area on the western part of the map area, but is part of a much larger batholith (~60 x 30 km) exposed to the east. The granite is undeformed in this area. Large blocks of Henry Mountain Granite, cut by dikes of the granite of Taylor River and pegmatite, are included in the granite of Taylor River in Section 27, T. 15 S, R. 84 W., east of One Mile Creek. Geochronologic data for the Henry Mountain Granite are summarized by DeWitt and others (2002). They report $^{207}Pb/^{208}Pb$ dates of 1,693 Ma

(DeWitt and Zartman, unpub. data, 1990) and 1,701 ± 10 Ma (Bickford and others, 1989) from an equivalent granite.

Xq **Biotite quartzite (Early Proterozoic)** - This unit is a light- to dark-gray muscovite-biotite quartzite. Quartzite may be massive to well foliated, is very fine-grained, and is commonly finely laminated with dark biotite bands visible in hand specimen. Granoblastic quartz (65-80%) and feldspar (1-2%) make up most of the rock. Very fine-grained muscovite and biotite are either disseminated throughout the rock or occur in fine layers with biotite more abundant than muscovite. Muscovite porphyroblasts are found in some specimens as isolated crystals or in discontinuous schistose layers. These rocks grade locally into thin layers of coarser grained muscovite-biotite schist. These rocks were first described by Navarro and Blackburn (1974). Hill and Bickford (2001) report $^{207}Pb/^{208}Pb$ ages on eight euheral to rounded zircons that are between 1,733 ± 12 Ma and 1,867 ± 7 Ma, indicating deposition after 1,733 Ma.

Xp **Chlorite phyllite (Early Proterozoic)** - This unit is a light-tan to dark-gray chlorite-muscovite phyllite and fine-grained schist. Chlorite (5-10 mm) and magnetite (1 mm) porphyroblasts are present in a very fine-grained muscovite and quartz matrix. The rock is well foliated and exhibits two deformation stages with chlorite porphyroblasts and a crenulation crossing the dominant muscovite foliation. The dominant muscovite foliation has a consistent northwest strike and steep dip throughout the mapped extent of the chlorite phyllite unit and is the foliation represented on the geologic map. The muscovite foliation corresponds to the S_2 foliation of Hetherington (1991) in his detailed map of Taylor Canyon. Field checked S_2 foliation attitudes from Hetherington (1991) were incorporated into the geologic map on the steepest walls of Taylor Canyon. In addition to chlorite and muscovite, fine-grained biotite or garnet is found in some places. Green tourmaline and zircon are common trace minerals. Unmapped medium-grained quartzites with recognizable fine sand-sized grains in a chlorite-muscovite-quartz matrix also occur within this unit. These quartzites form resistant ridges that make up about 10% of the unit. Medium-grained epidote-biotite amphibolites are also found in this unit. The amphibolites occur as poorly defined lenses surrounded by phyllite and are most abundant in the northeast near the Roaring Judy Fault near Taylor Canyon.

STRUCTURAL GEOLOGY

The Almont area contains a record of the four principal phases of mountain building in Colorado. Precambrian metamorphic and igneous rocks in Almont and Taylor Canyons record the early assembly of North America between 1.7 and 1.4 billion years ago (Bickford and others, 1989). The Roaring Judy and Cement Creek faults formed the northeastern margin of the Ancestral Uncompahgre uplift in Pennsylvanian and Permian time. The Roaring Judy and Cement Creek fault zones were reactivated during the Late Cretaceous-early Tertiary Laramide Orogeny and, together with the Almont fault and intervening synclines, controlled the present distribution of uplifts and basins through the area (fig. 1). Finally, the trachyte of Roaring Judy intruded along the Roaring Judy fault plane during late Tertiary regional extension.

PRINCIPAL FAULTS

The present geometry of the Roaring Judy and Cement Creek faults is the result of both Ancestral Rockies and Laramide deformation. The records of these two deformation periods are separated by an unconformity at the base of the Jurassic Junction Creek Sandstone. Ancestral Rockies faulting, folding, and uplift are evident from offset and folding of Paleozoic strata beneath the unconformity. Laramide faulting, folding, and uplift are constrained across all three fault zones by offset and folding of the Junction Creek Sandstone above the unconformity. Figure 2 includes a reconstruction of cross section A-A’ (plate 1) at the end of Ancestral Rockies deformation.

Roaring Judy Fault Zone and Fault

The Roaring Judy fault zone and fault are named for their location beneath the Roaring Judy fish hatchery. The Roaring Judy fault is a steeply west-dipping (65-75^{o}) reverse fault that places Proterozoic metasediments over Paleozoic and Mesozoic sedimentary rocks along the southeastern two-thirds of the quadrangle. The single fault trace divides into multiple splays with smaller offsets north of the Taylor River where the fault zone changes to an east-west trend. The fault zone projects beneath alluvium of the East River valley immediately north of the Roaring Judy fish hatchery and is represented by a single west-northwest trending fault trace on the west side of the valley.

The Roaring Judy fault marked the northeastern margin of Precambrian rocks that were exposed along the uplifted crest of the Ancestral Uncompahgre uplift in Permian-Pennsylvanian time. The Ancestral Rockies structural geometry is constrained by contrasting unconformity levels beneath the Jurassic Junction Creek Sandstone east and west of the fault (fig. 2). The Junction Creek Sandstone overlies Precambrian metamorphic and igneous rocks with nonconformity west of the Roaring Judy fault and lies with a 20-35^{o} angular unconformity above the lower part of the Permian-Pennsylvanian Maroon Formation east of the fault. The amount of Permian-Pennsylvanian displacement cannot be precisely determined because no Paleozoic reference horizons are preserved in the hanging wall.

The Laramide dip-slip displacement on the Roaring Judy fault is estimated at 780 feet (240 m) along cross section A-A’ adjacent to Taylor Canyon. A similar magnitude of dip-slip displacement is inferred south of Taylor Canyon where preserved hanging-wall and footwall outcrops of Junction Creek Sandstone maintain a consistent vertical throw near 525 feet (160 m) across the fault.

The transition from a north-northwest to an east-west trend of the Roaring Judy fault zone is marked by a branching of the fault zone into multiple smaller offset splays. The east-west fault segments are assumed to have accommodated a large strike-slip component because they lie at acute angles to the Laramide slip direction (~245^{o}) inferred from the consistent orientation of slickenlines in Jurassic and Cretaceous sandstones adjacent to all Laramide faults in the quadrangle. The fault splays merge westward to a single fault trace with approximately 380 feet (180 m) of vertical throw west of the Roaring Judy fish hatchery.

Cement Creek Fault

The Cement Creek fault is named for exposures near the mouth of Cement Creek north of the Almont 7.5’ quadrangle (fig. 1). The Cement Creek fault trends north-northwestward across the northeastern part of the quadrangle. The fault trace dips 65^{o} to 75^{o} eastward in exposures at Taylor Canyon and at the northern border of the map.

The Cement Creek fault is a Laramide reverse fault that cuts the west flank of a Permian-Pennsylvanian age anticline associated with the Ancestral Rockies orogenic event. Early Tertiary dip-slip displacement on the fault during the Laramide Orogeny is estimated to be 2,900 feet (880 m) along cross section A-A’ (plate 1, fig. 2) but decreases to approximately 300 feet near the mouth of Cement Creek north of the Almont quadrangle. The displacement estimate along A-A’ is based on a plunge projection of the Cement Creek hanging wall structure from the Crested Butte and Cement Mountain 7.5’ quadrangles north of the map area (fig.1; Gaskill and others, 1986; Prather, 1964) into the plane of cross section (plate 1). The elevation of projected hanging wall Paleozoic strata above the modern topographic surface is further constrained by the 10,400 foot elevation of the Cambrian Sawatch Quartzite mapped by DeWitt and others (2002) two miles north of the northeastern corner of the Almont quadrangle.

The Ancestral Rockies geometry of the Cement Creek fault trend is constrained by restoration of the structure beneath the basal Jurassic angular unconformity as shown in figure 2. The west limb of the Ancestral Rockies anticline is recognized within the Almont quadrangle by the 20-35^{o} westward dip of Paleozoic strata beneath the flattened unconformity in the footwall of the Cement Creek fault (plate 1; fig. 2). The crest and east flank of the Ancestral Rockies anticline are restored from the angular unconformity relationships that are projected up-plunge into the line of cross section (fig. 2). The unconformity becomes sub-parallel to Paleozoic strata near the crest of the anticline, and shows <10^{o} eastward dip along the restored east flank of the anticline (fig. 2).

The restored geometry beneath the unconformity demonstrates that the Cement Creek fault follows the trend of the Ancestral Rockies anticline but does not display unequivocal Ancestral Rockies offset of Paleozoic strata. Instead, the basal Jurassic unconformity appears to overlie approximately the same upper Paleozoic levels in both the hanging wall and footwall of the fault. As a result, any Ancestral Rockies displacement on the fault is too small to measure within the current stratigraphic resolution of the Cement Creek area. The Cement Creek fault appears to have propagated through the western limb of the anticline, parallel to the hinge of the Ancestral Rockies anticline (fig. 2). The anticline was likely a shallow manifestation of Ancestral Rockies faulting at deeper structural levels.

Almont Fault

The Almont fault is named for its location beneath the town of Almont in the southwestern part of the quadrangle. The Almont fault is a high-angle reverse fault that dips 67^{o} westward in Fisher Gulch where it places Proterozoic metasedimentary and igneous rocks over the Jurassic Brushy Basin Member. The fault has a north-south trend southeast of Almont and curves to a northwest trend at the town of Almont. The stratigraphic offset along the fault diminishes west of Almont, where it places the Jurassic Brushy Basin Member over the Lower Cretaceous Dakota Sandstone. Laramide dip-slip displacement across the fault is about 150 feet (45 m) along cross section A-A’, but displacement increases southeast of Almont, where offset of the Junction Creek Sandstone implies ~480 feet (150 m) of vertical throw. Displacement on the fault is partitioned into several fault splays at the south end of the quadrangle. Ancestral Rockies deformation along the Almont fault is not known because Paleozoic strata are absent from both the hanging wall and footwall.

Beaver Creek Fault (Hypothetical)

The distribution of Tertiary sediments along the western slope of the Beaver Creek drainage permits inference of a normal fault along the western contact of these deposits. The Tertiary gravel and alluvial sediments (Ts) and grus deposits (Tsg) lie in the hanging wall of the Cement Creek fault along the contact between chlorite phyllite to the west and the Henry Mountain Granite and granite of Taylor River to the east. No fault is mapped along this contact because the distribution of the Tertiary sediments is adequately interpreted as a paleovalley trend along the contact between resistant granite and nonresistant phyllite.

Slight westward dip of the basal surfaces of units Ts and Tsg, and the steep western map contact with the phyllite, permit an alternative interpretation of a steeply east-dipping normal fault along the western contact into which the Tertiary sediments have rotated. The contact is not exposed in outcrop, and poor exposures along the mapped contact preclude a definitive fault interpretation. A similar geometry between late Tertiary normal faulting in the hanging wall of a Laramide reverse fault is mapped 15 miles southeast of the Almont quadrangle in the Houston Gulch 7.5’ quadrangle (Olson, 1976).

FOLDS

Jacks Cabin Syncline

Jacks Cabin syncline is named for its position parallel to Jacks Cabin cutoff road between Jacks Cabin and Taylor Canyon (fig.1). The syncline occupies the footwall area between the oppositely dipping Roaring Judy and Cement Creek faults. It curves from a northwest to a west-northwest trend between Taylor Canyon and Jacks Cabin, parallel to the trend of the Roaring Judy fault. The syncline is a shallow, upright, symmetrical syncline in Mesozoic strata with 40^{o}-55^{o} maximum dips on both the northeast and southwest limbs. The east limb of the syncline is a composite feature at the upper Paleozoic level. The 70^{o} west to vertical dips in the Maroon and Gothic Formations are the result of the 40-55^{o} of Laramide rotation preserved in the Junction Creek Sandstone combined with 20-35^{o} of west dip associated with Ancestral Rockies folding. The west limb of the syncline is not exposed at the Paleozoic level.

Other Folds

Other map-scale folds within the quadrangle are closely associated with deformation immediately adjacent to Laramide reverse faults. Footwall synclines parallel the Almont fault southeast of Almont, as well as the western continuation of the Roaring Judy fault west of the Roaring Judy Fish hatchery. These footwall synclines are typical of flexures that develop early during fault propagation above the advancing tip of reverse faults. Corresponding hanging-wall anticlines are either deeply eroded to the Proterozoic level or complexly segmented and overprinted by continued faulting along anticlinal hinges.

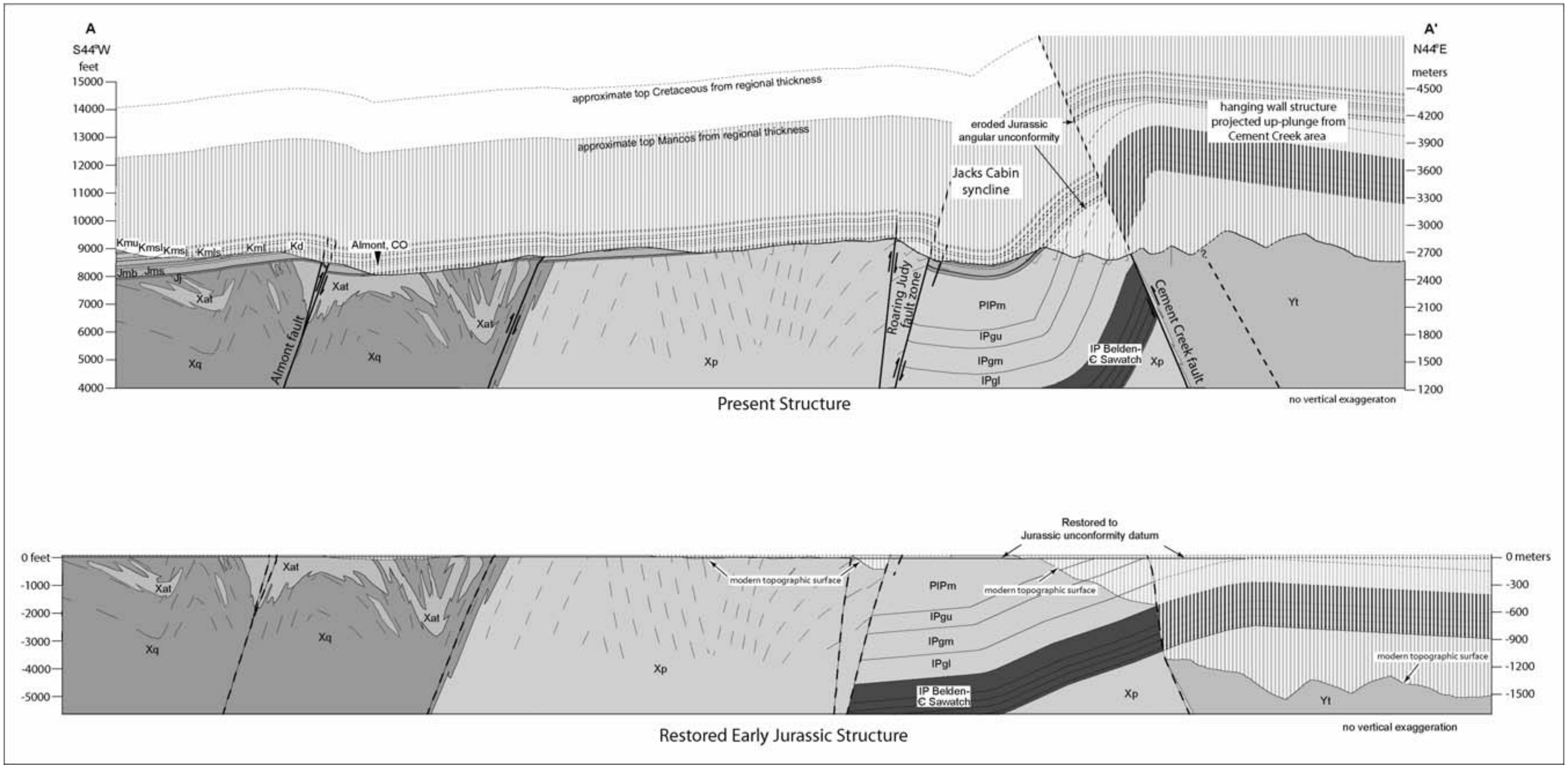

Figure 2. Structural cross section (above) across the Almont 7.5' quadrangle and restoration (below) showing inferred Ancestral Rockies structure determined on the basis of restoration to Jurassic unconformity datum. See description of map units for formational symbols.

MINERAL RESOURCES

Sand, Gravel, and Crushed Aggregate

The most readily available resource in the Almont quadrangle is sand and gravel, which is most easily extracted from alluvial terrace deposits lying above the level of modern floodplains. Large areas of alluvial terrace deposits are found along the Gunnison River and East River valleys and smaller deposits exist along the Taylor River and Spring Creek valleys. Sand and gravel are currently extracted from an upper Pleistocene terrace deposit at the Wilson Pit gravel quarry in the NW1/4 of Section 4, T. 50 N., R. 1 E.. Precambrian granite and quartzite are potential sources for crushed aggregate in Almont Canyon and Taylor River Canyon.

Dimension Stone

The Dakota Sandstone and Junction Creek Sandstone are potential sources of dimension stone, but neither unit has been quarried in the Almont quadrangle. The Dakota Sandstone is highly indurated throughout the quadrangle, which may limit its desirability as dimension stone compared to other occurrences in southwest Colorado. In contrast, the Junction Creek Sandstone is exceedingly friable throughout the Almont quadrangle and would be difficult to quarry as dimension stone.

Clay

Shale deposits of the Cretaceous Mancos Shale may locally contain clay resources suitable for brick making. The clay may also have potential in other industrial applications such as ceramics, fillers, and binders. Clay has been mined in Rio Blanco and Delta Counties but has not been exploited in the vicinity of the Almont quadrangle.

Limestone

The Fort Hays Limestone Member of the Mancos Shale and thin limestone beds within the Gothic Formation are potential sources of limestone for industrial use. Limestone has several potential commercial uses such as a cement ingredient or coal fire dampener and is a potential source of crushed aggregate or dimension stone.

Uranium

Uranium prospects in the Almont quadrangle are limited to a series of pits and one adit along the Cement Creek fault trace that are known as the North Star claims in the southwest quarter of Section 17, T. 15 S., R. 84 W. (Nelson-Moore and others, 1979). Conspicuous mineralization along the Cement Creek fault trace consists of iron oxide mineralization along fractures and minor faults. Visible mineralization is generally restricted to an approximately 50 foot-wide zone of highly sheared Precambrian hanging wall and Pennsylvanian footwall rocks adjacent to the fault. Nelson-Moore and others (1979) report a uranium assay of 0.015% U308 from the North Star claims.

Copper

Malachite and azurite occur as rare, centimeter-scale, discontinuous coatings on fractures and mesoscopic faults in the area of the North Star claims in the southwest quarter of Section 17, T. 15 S., R. 84 W. adjacent to the Cement Creek fault trace. Nelson-Moore and others (1979) report that the North Star uranium claims were originally prospected for copper, but they do not report any copper assays for this area.

Oil and Gas

The Almont quadrangle lies at the southern edge of the Piceance Basin petroleum province and contains a sedimentary sequence that is associated with oil and gas accumulations elsewhere in the state and region (Spencer and Wilson, 1988). The Dakota and Junction Creek Sandstones locally exhibit porosity characteristic of petroleum reservoirs. The Mancos Shale is a known petroleum source rock and low-porosity Mancos sandstone reservoirs produce oil and gas in the northern Piceance Basin (Spencer and Wilson, 1988). However, the deep erosion level in the Almont area precludes large-scale oil and gas accumulation in the quadrangle. All potential reservoirs are in communication with surface waters or shallow alluvial groundwater and are essentially flushed of hydrocarbons.

Water Resources

Alluvium in the Gunnison and East River valleys forms the principal aquifer in the Almont quadrangle. Springs issuing from alluvial terrace deposits are used as a water source that is free from whirling disease for the Roaring Judy fish hatchery. The Dakota and Junction Creek Sandstones are potential confined aquifers, however the lack of significant springs from these strata indicates that these aquifers are not saturated in upland areas.

GEOLOGIC HAZARDS

The Dakota Sandstone poses a rockfall hazard for houses and Highway 135 in the Gunnison River canyon south of Almont. Large blocks of Dakota that litter the slopes and west bank of the Gunnison River in this area indicate such activity in the past. The steep rock walls of Taylor Canyon and Spring Creek also pose significant rockfall hazard. Any steep canyon in the region has the potential for rock mass movements that pose a danger to structures and people.

Steep slopes underlain by Mancos Shale and the Brushy Basin Member of the Morrison Formation have the potential for mass movement. Past movement in these shale-rich units is evident throughout the map area.

Geologic hazard areas have been identified and mapped in detail for Gunnison County by Soule (1976).

REFERENCES CITED

Bartleson, B., 1972, Permo-Pennsylvanian stratigraphy and history of the Crested Butte-Aspen region, *in* De Voto, R.H., ed., Paleozoic stratigraphy and structural evolution of Colorado: Quaterly of the Colorado School of Mines, v. 67, p. 187-248.

Bartleson, B.L., and Jensen, J.A., 1988, The oldest (?) Morrison Formation dinosaur, Gunnison, Colorado: Mountain Geologist, v. 25, p. 129-139.

Bickford, M.E., Schuster, R.D., and Boardman, S.J., 1989, U-Pb geochronology of the Proterozoic volcano-plutonic terrane in the Gunnison and Salida areas, Colorado, *in* Grambling, J.A., and Tewksbury, B.J., eds., Proterozoic geology of the southern Rocky Mountains: Geological Society of America Special Paper 235, p. 33-48.

Bryant, B., 1969, Geologic map of the Maroon Bells quadrangle, Pitkin and Gunnison Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-788, scale 1:24,000.

Cunningham, C.G., Naeser, C.W., and Marvin, R.F., 1977, New ages for intrusive rocks in the Colorado mineral belt: U.S. Geological Survey Open-File Report 77-573.

Dewitt, E., Zech, R.S., Chase, C.G., Zartman, R.E., Kucks, R.P., Bartleson, B., Rosenlund, G.C., and Early, D., 2002, Geologic and aeromagnetic maps of the Fossil Ridge area and vicinity, Gunnison County, Colorado: U.S. Geological Survey Miscellaneous Investigation Series I-2738, scale 1:30,000.

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.

Gaskill, D.L., Colman, S.M., DeLong, J.E., Jr., and Robinson, C.H., 1986, Geologic map of the Crested Butte quadrangle, Gunnison County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1580, scale 1:24,000.

Hetherington, E.D., 1991, Structural analysis of Proterozoic rocks in Gunnison County, Colorado: Minneapolis, University of Minnesota, Ph.D. dissertation, 218 p.

Hill, B.M., and Bickford, M.E., 2001, Paleoproterozoic rocks of central Colorado; Accreted arcs or extended older crust?: Geology, v. 29, p.1015-1018.

Langenheim, R.L., Jr., 1952, Pennsylvanian and Permian stratigraphy in Crested Butte quadrangle, Gunnison County, Colorado: American Association of Petroleum Geologists Bulletin, v. 36, p. 543-574.

Leckie, R.M., Kirkland, J.R., and Elder, W.P., 1997, Stratigraphic correlation of a principal reference section of the Mancos Shale (Upper Cretaceous), Mesa Verde, Colorado, *in*

Anderson, O.J., Kues, B.S., and Lucas, S.G., eds., Mesozoic geology and paleontology of the Four Corners region: New Mexico Geological Society Guidebook 48, p. 163-216.

Mutschler, F.E., 1970, Geologic map of the Snowmass Mountain quadrangle, Pitkin and Gunnison counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-853, scale 1:24,000.

Navarro, E., and Blackburn, W.H., 1974, Investigations in the basement rocks of Gunnison County, Colorado; The metasedimentary rocks: Neues Jahrbuch fur Mineralogie Abhandlungen., v. 122, p. 246-267.

Nelson-Moore, J. L., Collins, D. B., and Hornbaker, A. L., 1978, Radioactive mineral occurrences of Colorado: Colorado Geological Survey Bulletin 40, 1054 p., 12 pl.

Olson, J.C., 1976, Geologic map of the Houston Gulch quadrangle, Gunnison and Saguache Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1287, scale 1:24,000.

O'Sullivan, R.B., 1980, Stratigraphic sections of Middle Jurassic San Rafael Group from Wilson Arch to Bluff in southeastern Utah: U.S. Geological Survey Oil and Gas Investigations Chart OC-12.

Prather, T.L., 1964, Stratigraphy and structural geology of the Elk Mountains Colorado: Boulder, University of Colorado, Ph.D. dissertation, 106 p.

Rosenlund, G.C., 1984, Geology and mineralization of the Cumberland Pass area, Gunnison County, Colorado: Fort Collins, Colorado State University, M.S. Thesis, 113 p.

Scott, G.R., and Cobban, W.A., 1964, Stratigraphy of the Niobrara Formation at Pueblo, Colorado: U.S. Geological Survey Professional Paper 454-L, p.L1-L30.
.
Spencer, C.W., and Wilson, R.J., 1988, Petroleum geology and principal exploration plays in the Uinta-Piceance Eagle basins province, Utah and Colorado: U.S. Geological Survey Open-File Report 88-450-G, 35 p.

Soule, J.M., 1976, Geologic hazards in the Crested Butte-Gunnison area, Gunnison County, Colorado: Colorado Geological Survey Information Series 5, 34 p.

Thomas, M.H., 1981, Stratigraphy of the Dakota and Burro Canyon Formations near Gunnison, Colorado: Golden, Colorado School of Mines, M.S. Thesis, 76 p.

Tweto, O., 1979, Geologic map of Colorado: Reston, U.S. Geological Survey, scale 1:500,000.

Tweto, O., Steven, T.A., Hail, W.J., Jr., and Moench, R.H., 1976, Preliminary geologic map of the Montrose 1° x 2° quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-761, scale 1:250,000.

Urbani, F., and Blackburn, W.H., 1974, Investigations in the basement rocks of Gunnison County, Colorado: The igneous rocks: Neues Jahrbuch fur Mineralogie Abhandlungen, v. 121, p. 273-292.

Wetherill, G.W., and Bickford, M.E., 1965, Primary and metamorphic Rb-Sr chronology in central Colorado: Journal of Geophysical Research, v. 70, p. 4669-4686.