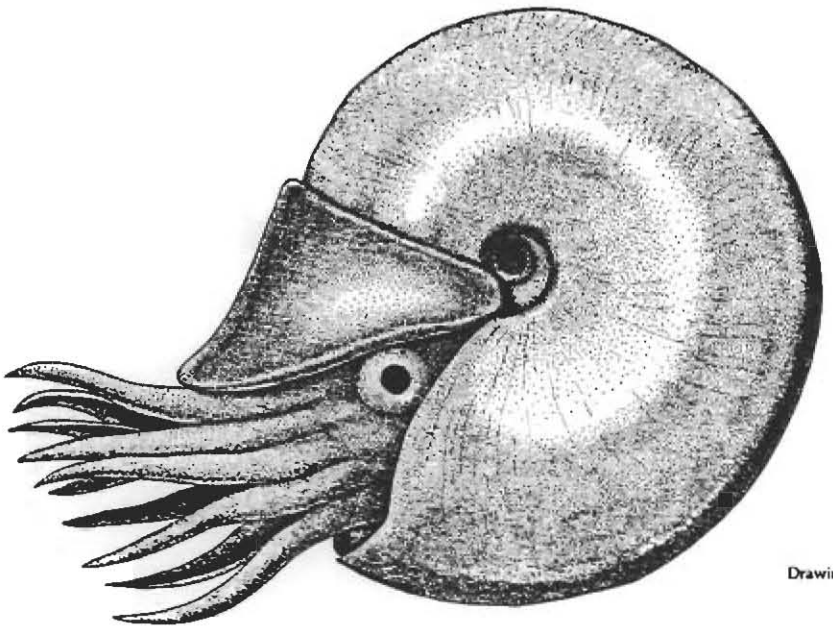
FAULTS, FOSSILS, AND CANYONS

SIGNIFICANT GEOLOGIC FEATURES ON PUBLIC LANDS IN COLORADO

GEOLOGIC ADVISORY GROUP
BUREAU OF LAND MANAGEMENT



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Bureau of Land Management
Colorado State Office

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Denver, Colorado

1989

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FOREWORD

The Geologic Advisory Group (GAG) was formed in 1983 to help identify and evaluate significant geological and paleontological features on the public lands in Colorado. Because the comparison of these sites is important in the development of land use plans and in managing natural resources, the GAG was designed to use the expertise of numerous professionals from federal, state, local, and private sources.

The GAG was operated as a voluntary group of advisors to the Bureau of Land Management, Colorado, utilizing geologists, paleontologists, mining engineers, and others to identify and then rate the significance of known geological or paleontological sites in Colorado. The GAG was solely based on volunteerism; none of the participants were funded by BLM. Only travel expenses were reimbursed. In this way, hundreds of hours of expertise were donated to BLM.

Beginning in 1983, the Colorado Natural Areas Program (CNAP) operated the GAG for BLM. The CNAP handled administative affairs, planned and executed meetings, and held annual field evaluations. In 1986, responsibility for the GAG moved to the Museum of Western Colorado in Grand Junction, Colorado. Again, administration and operation of the GAG were taken care of by the Museum. During 1987-1988, the GAG was operated by the BLM. The GAG last met in 1988, at which time they agreed their mission had been accomplished. A total of 41 sites were identified and evaluated in the years between 1983 and 1988. The GAG was disbanded in 1988, having completely accomplished its goals.

The first Draft GAG report was published in 1986 by the CNAP. The present report represents the final field examinations and recommendations that the GAG has made to BLM. I am pleased to note that many GAG suggested designations have been incorporated into our land use plans. This reinforces the concept that interagency cooperation can lead to positive, long-lasting results.

The GAG represents an outstanding success story in volunteerism and in federal-state-private efforts to improve the management of the public lands. I wish to thank all of the GAG members who contributed their valuable time for excellent products. This is especially true for the on-the-ground field examinations of sites. The GAG was a time-consuming project that could not have occurred but for the volunteers who made it reality.

I am pleased to make this report available to both the public and to the professional community. I hope that the information contained in this final GAG report is of scientific interest and of general value to all public land users.

Neil F. Morck
State Director, Colorado

PREFACE

A cooperative agreement between the Department of Natural Resources, State of Colorado, and the Bureau of Land Management - Colorado State Office (BLM), signed in April 1984, defines the responsibilities of the State of Colorado and the Bureau of Land Management in the identification and evaluation of geologic features on BLM lands in Colorado.

The cooperative agreement between the Colorado Department of Natural Resources and the Bureau of Land Management is based in part on an existing Memorandum of Understanding (MOU) executed in January 1983 between Colorado Department of Natural Resources and the Bureau of Land Management - Colorado . The MOU describes a process for identification, registration, and designation of those areas managed by BLM which qualify as state natural areas and BLM Special Management Areas (e.g., areas which possess unique or exemplary natural features of statewide or national significance).

Results of the work by the BLM's Geologic Advisory Group are summarized in this report. Site-specific information is presented by BLM district: Canon City, Craig, Grand Junction, and Montrose.

INTRODUCTION AND SUMMARY

Purpose of Geologic Advisory Group. The BLM-Geologic Advisory Group, consisting of experts in the fields of geology and paleontology, was established by the Department of Natural Resources and the Bureau of Land Management, Colorado. The Geologic Advisory Group has two principal functions:

1) to identify and evaluate geologic sites on BLM lands in Colorado which may qualify for special management area designation (Research Natural Areas, Outstanding Natural Areas, or Areas of Critical Environmental Concern); and

2) to recommend appropriate management to BLM for the identified significant features.

The Geologic Advisory Group provided a systematic and professional review of existing data on rare or exemplary geologic features which are used for scientific research or education on BLM lands in Colorado and provide additional data on geologic features on BLM lands where necessary. Members of the Geologic Advisory Group include professional geologists from Colorado's academic institutions, research community, industry, and federal and state agencies.

Results of Site Evaluations. Thirty-nine geologic sites were evaluated by the BLM Geologic Advisory Group. Twenty-five of the evaluated sites were recommended by the GAG for Special Management Area (SMA) designation based upon the significance of their geologic features. Eleven of these 25 areas were recommended by the GAG as Research Natural Areas (RNA); eight sites were recommended as Outstanding Natural Areas (ONA) for geologic features; four areas were recommended as Special Management Areas (SMA); and one area was recommended for a recreational (REC) designation.

The initial list of areas considered by the Geologic Advisory Group was weighted with nationally or regionally known sites containing significant geologic features. Recommendations made by GAG emphasize the national importance of these geologic features.

The "SMA" (Special Management Area) designation used by the GAG has no official status within BLM statutes or regulations. The GAG used a "Special Management Area" denotation to highlight the importance of the geologic features of a site without assigning a particular management recommendation defined by statute or regulation to a site. The Special Management Area designation can be used as one element by BLM in the selection of areas for ACEC designation. The GAG did not recommend any areas for Area of Critical Environmental Concern (ACEC) designation. Research Natural Areas (RNA) or Outstanding Natural Areas (ONA) will be designated in conjunction with ACEC designation in accordance with BLM regulations. A recreational designation (REC) was developed by the GAG to specify the interpretive use by the public of geologic sites.

Seven areas were not recommended by the GAG for Special Management Area designation. Recommendations by the GAG for no Special Management Area designations were based on size of site, ownership status, lack of uniqueness or significance of geologic features, and the extent of modification of geologic features by human activities or natural forces. Consideration by the GAG of six other sites was deferred until field evaluations could be completed.

Site Information Summaries. Site information summaries for each of the geologic features evaluated by the GAG are listed alphabetically by BLM district (Canon City, Craig, Grand Junction, and Montrose) in Chapter Two of this report.

Benefits of GAG to BLM and State. One of the principal benefits to both the BLM and the State of Colorado resulting from the work of the Geologic Advisory Group is the contribution of voluntary expert professional identification, review, and evaluation of the scientific importance of geologic features of BLM lands. The cooperative aspects of the Geologic Advisory Group — state and federal cooperation, and public and private sector cooperation — help to ensure that reasonable and balanced land and resource management decisions are made in Colorado. The GAG provides an important forum for researchers and educators to supply information on the natural values of certain lands to its land managers.

STATE OF COLORADO

Figure 1. Special Management Area Recommendations As Made By the Geologic Advisory Group

Site Number	Site Name	BLM District
1	Garden Park Fossil NNL (RNA)	Canon City
2	Kremmling Ammonite RNA	Craig
3	Fruita Paleo RNA	Grand Junction
4	Rabbit Valley RNA	Grand Junction
5	Paradox Valley-Dolores Canyon Triassic Fish Locality(RNA)	Montrose
6	Ute Indian Fault Zone (RNA)	Montrose
7	Dotsero Crater (ACEC/NON)	Grand Junction
8	Nancy Hanks Gulch NON	Grand Junction
9	Placerville Vertebrate Site (NON)	Montrose
10	Black Ridge Angiosperm Locality (RNA)	Grand Junction
11	Black Ridge Arches (ONA)	Grand Junction
12	Black's Gulch (RNA)	Craig
13	Cactus Park Gravels RNA	Grand Junction
14	Cross Mountain Canyon(ONA)	Craig
15	Dolores Canyon Meanders (ONA)	Montrose
16	Gateway Palisade (ONA)	Grand Junction
17	Gypsum Cliffs (SMA)	Grand Junction
18	Horseshoe Basin (ONA)	Montrose
19	Indian Springs Trace Fossil Locality (RNA)	Canon City
20	Irish Canyon (ONA)	Craig
21	Juanita Arch (ONA)	Grand Junction
22	Lookout Mountain (ONA)	Craig
23	McCoy Fan Deltas (ONA)	Grand Junction
24	Needle Rock ONA	Montrose
25	Young Egg Locality (RNA)	Grand Junction
26	Sinbad Valley (SMA)	Grand Junction
27	Skull Creek Anticline (SMA)	Craig
28	Slumgullion Earthflow NNL (RNA)	Montrose
29	Unaweep Canyon Overlook REC	Grand Junction
30	Lower Phantom Canyon Paleo Site (NON)	Canon City
31	Spring Gulch Fossil Fish Locality (NON)	Canon City
32	Twin Mountain Structure Complex (NON)	Canon City
33	Wellsville Geologic Study Area (NON)	Canon City
34	Upper Arkansas Canyon Scenic Area (None)	Canon City
35	Calico Draw Paleo Locality (NON)	Craig
36	Douglas Pass Insect Locality (NON)	Craig
37	Wolford Mountain (NON)	Craig
38	Ducey Stomatrolite Locality (RNA/ACEC)	Craig
39	Debeque Canyon Landslide (NON)	Grand Junction
40	Roan Creek Goblins (None)	Grand Junction
41	Cactus Park Footprint Locality (RNA/ACEC)	Grand Junction

KEY: Those sites with ( ) around the designation have not been formally designated. Those without ( ) have been designated in a land use plan.

THE GEOLOGIC ADVISORY GROUP PROCESS

The Geologic Advisory Group functions on two levels:

1) identification, evaluation, and assessment by GAG members of significant geological sites within his/her particular area of expertise; and

2) periodic meetings of the entire Geologic Advisory Group to review and to evaluate site information and to make management recommendations.

Seven meetings of the Geologic Advisory Group were held prior to completion of this report. The first meeting was held on November 10, 1983, in Boulder, Colorado, and focused on a review of proposed site evaluation guidelines, draft site evaluation forms, and initial assessments of identified geologic sites on BLM lands in colorado. Well-known geologic sites on BLM lands which were identified in earlier studies were considered by the Geologic Advisory Group. GAG members proposed additional sites which they believed qualified for further assessment. Previously identified geologic sites and GAG proposed sites constituted the initial 39 geologic sites assessed by the GAG. The GAG reviewed draft guidelines for identifying and evaluating geologic features on BLM lands in Colorado. A draft site evaluation form was considered by the GAG. Recommendations were made on its content and format. Thirty-nine sites were proposed by members of the Geologic Advisory Group for further consideration, including twelve previously identified geologic sites on BLM lands (see "Final Report: Natural Landmarks of the Southern Rocky Mountain Region," Thorne Ecological Institute, 1980).

A second meeting of the GAG was held on January 10, 1984, in Boulder, Colorado, to consider the preliminary evaluations and recommendations on sites. Further revisions to the draft site evaluation form were made. A final site evaluation form was distributed to GAG members. The GAG made final recommendations on several sites at this meeting. Action was deferred on identified sites which required additional information or further field work.

On-site field evaluations are a valuable part of the Geologic Advisory Group's assessment of significant geological sites on BLM land in Colorado. The GAG met for a three-day field session on May 7-9, 1984, in Grand Junction to complete site evaluations and to consider management recommendations for the geologic areas in the BLM - Grand Junction district. The GAG evaluated ten sites in the field and made management recommendations for several sites. A 1984 summer field schedule for the site evaluations was developed. Several GAG members performed field evaluations during the 1984 field season.

The Geologic Advisory Group met again on September 27, 1984, in Boulder, Colorado, following the summer field season, to complete the site evaluation and management recommendation phase of the project. Further field work and site evaluations were performed by the Geologic Advisory Group and information provided in subsequent documents.

The Geologic Advisory Group met for another three-day field session, May 14-16, 1985 in Montrose, Colorado, to perform site evaluations, and to consider management recommendations for significant geologic areas in the BLM-Montrose District. Four sites were evaluted in the field and management recommendations completed by the GAG. A 1985 field evaluation schedule for additional site evaluations was developed.

The GAG met June 9-11, 1986 at the Royal Gorge Resource Area, Canon City, Colorado at which time the Lower Phantom Canyon Fossil site was evaluated, as was the Indian Springs Fossil site. The Garden Park Fossil Locality was evaluated further. In addition, the Twin Mountain Structure Complex was looked at, and the Wellsville/Spring Gulch site was examined.

The GAG met in Grand Junction Resource Area, Grand Junction, Colorado June 2-4, 1987 for the evaluation of the Juanita Arch site, and the arches in Rattlesnake Canyon (Black Ridge). The business meeting discussed the potential designation of the above sites.

The final GAG meeting was held at the White River Resource Area office, Meeker, Colorado from May 23-May 25, 1988. At that time,several sites were examined in the Rio Blanco County region, including an ongoing excavation by David Archibald, San Diego State University, a potential bone outcrop near Rangley, Colorado and several sites identified by Peter Robinson along the Colorado-Utah border. Additionally, Harley Armstrong presented the Ducey Stromatolite Locality for consideration. At this meeting the GAG was dissolved on the basis that most significant geological and/or paleontological sites on BLM lands had been identified and evaluated, thus the GAG was no longer needed.

GUIDELINES FOR IDENTIFICATION OF GEOLOGIC FEATURES ON BLM LANDS IN COLORADO

The Geologic Advisory Group developed guidelines for the identification and evaluation of geologic sites on BLM lands in Colorado to provide a uniform, and systematic, procedure for performing site identifications and evaluations (see Appendix C). The GAG guidelines focus on the delineation of sites of national or statewide significance, and on the justification of the ranking of high priority sites.

Five general criteria were used to evaluate each identified site.

1) Site is not expected to be lost due to natural catastrophe, development, land use change, or errors in management.

2) Site contains a geologic feature that is unusual or of statewide or national significance.

3) Site has significant fossil evidence illustrating the evolution of life.

4) Site is an example of scenic grandeur, high aesthetic value, or unusual natural features.

5) Site exhibits or possesses classic research or educational opportunities.

Identified sites must exhibit scientific and resource values.

1) **Quality of the site**
   Site contains an excellent example of a geologic feature or process which is particularly well-suited for research, teaching, or interpretive use (e.g., faulting, folding, mass wasting phenomena, stratigraphic sequence, history of life on earth).

2) **Condition of the site**
   Site is relatively free of disturbance, can withstand some land uses, or is adequately protected from disturbance.

3) **Viability of the site**
   Condition of the site can be maintained in the future with appropriate management.

4) **Defensibility of the site**
   Site is geographically or topographically removed from areas of development where possible, or has a small likelihood of being in the path of development, or has appropriate protective management through the BLM planning process where natural values outweigh development values. Site will be designed to minimize potential conflicts with existing land use values.

Specific guidelines for evaluating significant paleontological resources were developed by the Geologic Advisory Group (see Appendix C). The guidelines for significant paleontological resources were adopted in part from similar guidelines used by the State of New Mexico's Bureau of Mines and Mineral Resources for determining mitigation of impacts on paleontological resources from coal mining. These guidelines form the basis of a recently signed (1984) Memorandum of Understanding between BLM - New Mexico and the State of New Mexico for paleontological mitigation procedures of BLM managed lands in New Mexico.

The Geologic Advisory Group Guidelines contain three principal special management area designations used by BLM and defined in the Code of Federal Regulations and federal law: Research Natural Area (RNA); Outstanding Natural Area (ONA); and Area of Critical Environmental Concern (ACEC).

Research Natural Area (RNA). Research Natural Areas are defined in 43 CFR 8223.0-5 as areas "established and maintained for the *primary purpose of research and education* because the land has . . . the following characteristics . . . (4) a typical representation of common geologic, soil, or water features; or (5) outstanding or unusual geologic, soil, or water features" (emphasis added). Natural areas shall be used in a manner consistent with the purpose for which the area is designated. "The area shall be used by scientists and educators in a manner which is nondestructive and consistent with the purpose of the research natural area." Areas established as research natural areas shall be of sufficient number and size to adequately provide

for scientific study, research, and demonstration purposes.

Outstanding Natural Area (ONA). Outstanding Natural Areas are defined in 43 CFR 2071.1 (IV) as "areas of outstanding scenic splendor, natural wonder, or scientific importance that merit special attention and care in management to insure their preservation in their natural condition." These areas are relatively undisturbed and "representative of rare botanical, geological, or zoological characteristics of principal interest for scientific and research purposes." Outstanding natural areas are established to preserve scenic values and areas of natural wonder where management of recreation activities is necessary to preserve those characteristics.

Area of Critical Environmental Concern (ACEC). An Area of Critical Environmental Concern is an area "within the public lands where special management attention is required to protect and to prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life and safety from the natural hazards" (FLPMA, sec. 103, 1976). BLM regulations (43 CFR 1610) require that identification of potential ACEC's shall be given "priority" in the "inventory of all public lands and their resources and other values." A potential ACEC "shall not change or prevent change of the management or use of public lands." A potential ACEC must meet certain relevance and importance criteria.

Several other management categories were developed by the Geologic Advisory Group which pertain to areas which are not covered by the RNA, ONA, and ACEC management classifications (see page 13).

SITE EVALUATION FORM

The following information and recommendations are included for each evaluated site:

1) recommended name;

2) approximate site boundaries containing identified geologic feature(s);

3) summary of significance of geologic feature(s); and

4) management recommendation and rationale for recommendation.

The site evaluation form used by the Geologic Advisory Group was designed to contain pertinent geological information for BLM managers and other users, to permit easy access to the information by a variety of information queries, and to be compatible with current data management systems used by the Colorado Natural Areas Program. Specific information on each site is stored on an automated data system maintained at the University of Colorado Museum. Access to data by BLM users is provided by the University of Colorado Museum. Information contained on the GAG site evaluation form is compatible for use with other geological and paleontological information sources in Colorado (e.g., Colorado Natural Areas Inventory).

The site evaluation form contains an element occurrence code which is the principal accessing component. The code specifies BLM district and resource area, the principal significant geologic feature on the site, and the geologic age of the site. The data base can be queried by, and site information can be obtained from, the ranking of the site (global, national, state) and by county. The site evaluation form contains information on the value of the site for scientific research or education, possible threats to the site, existence of public access, and management recommendations. The automated section of the site evaluation form includes space for an abstract which summarizes the geological importance of the site. A more detailed, non-automated narrative bibliography of pertinent sources for additional information on the geological feature is included on the site evaluation form.

Areas evaluated by the Geologic Advisory Group were given a composite importance ranking according to the international and national (G) or statewide (S) significance of the site. Numbers following the letters in the composite ranking indicate the priority ranking of the site (e.g., 1 highest priority, extremely rare; 4 lowest priority, numerous occurrences). For example, G1S1 sites are extremely rare worldwide and statewide, vulnerable to loss, and the highest priority for protection. The

GAG identified and evaluated several areas having geologic features which are common nationwide, but which are of particular importance statewide or locally for scientific research and educational purposes. The geological significance of these locally important areas has resulted in management recommendations which encourage recognition by BLM of the importance of these areas for research and education.

The sensitivity of the sites to human impacts or public use is indicated on the site evaluation form. Some areas include recommendations for restricted access for research purposes.

The existing or potential scientific value of the site is denoted on the site evaluation form. A value spectrum for each site was prepared by the Geologic Advisory Group. The highest scientific use priorities are those with type locality, type specimen, current scientific research, future research potential, and academic training values.

A general category of **Special Management Area (SMA)** was used to identify areas which contained significant geologic features, but where the geologic feature was evident over a large area, the area had complex land ownership, or the importance ranking of the geologic feature did not justify more restrictive or specific management designations. Other management recommendations used by the Geologic Advisory Group included off-road vehicle restrictions (ORV), recreational or public use designations (REC), site specific surface stipulations (STP) such as no surface occupancy, and no special management necessary (NON). Off-road vehicle stipulations were recommended by the GAG for sites which would be damaged by ORV use, but which could tolerate other public uses. Site specific stipulations (i.e., no surface occupancy) were recommended for certain sites to protect geologic values in identified areas or to restrict public access during particular times or seasons. Recreational or public use designations of sites by the GAG was used to encourage interpretive or active public use of certain geologic areas. A designation of no special management by the GAG meant that the geologic feature was common or that the site was too difficult to manage. The Geologic Advisory Group reviewed and evaluated the potential or existing degree and type of threat to the geologic areas. The degree of threat was ranked from immediate to unknown. The type of threat was evaluated ranging from natural forces (weathering and erosion) to human impacts from collecting, vandalism, mining, development, or destructive land uses.

PALEONTOLOGICAL PERMITS IN COLORADO

The BLM - Colorado and BLM district offices were responsible for reviewing and approving paleontological permit applications in cooperation with the National Park Service - Washington. However, permit authority under the Antiquities Act of 1906 has been delegated to BLM State Directors. The Geologic Advisory Group has provided expertise and advice to the BLM State Office to facilitate the review of paleontological permits in Colorado.

COLORADO NATURAL AREAS PROGRAM

The Colorado Natural Areas Program coordinates the BLM Geologic Advisory Group under provisions of a Cooperative Agreement between the Bureau of Land Management and the Colorado Department of Natural Resources for the BLM Geologic Advisory Group. The Colorado Natural Areas Program (CNAP), Colorado Department of Natural Resources, identifies, registers, and designates areas in Colorado which have retained or reestablished their natural character. By state law (C.R.S. 33-33-101 *et seq.*), these areas typify native vegetation and associated biological and geologic features, provide habitat for rare or endangered plant or animal species, or include geologic or other natural features of scientific or educational value.

Identification of potentially qualified non-geologic natural areas currently occurs primarily through the Natural Areas Inventory. The Inventory identifies potential natural areas which provide habitats for threatened, endangered, and other rare plant and animal species

and plant communities — living resources faced with immediate threats. The Inventory has not systematically identified and evaluated geologic features in Colorado, nor will it provide a systematic identification in the future. The Colorado Natural Areas Inventory will incorporate data on Colorado's geologic features generated by the Geologic Advisory Group into its data base. Information developed by the BLM Geologic Advisory Group on geologic features will be used by the Colorado Natural Areas Program to work with BLM to recommend management for scientifically important sites which are of statewide or national significance. Several examples of this type of cooperation currently exist (e.g., Kremmling Cretaceous Ammonite RNA, Fruita Paleontological RNA, Indian Springs Trace Fossil Locality, Garden Park Fossil RNA, and the Rabbit Valley RNA).

CANON CITY DISTRICT

SITE INFORMATION SUMMARY

SITE NAME: Garden Park RNA/ACEC

LOCATION: T17S R70W
County: Fremont
USGS 7.5' Quad: Cooper Mountain

SIGNIFICANT FEATURES: The Garden Park RNA/ACEC is one of the most important Late Jurassic vertebrate localities in North America. Excavations in the Morrison Formation in the area has produced 20 genera and 19 described species of fossil fish, turtles, rhynchocephalians, crocodiles, dinosaurs, and mammals. Of these vertebrates, the Garden Park area is the type locality of 8 species of vertebrates, and is the type locality of the dinosaur genera *Allosaurus, Camarasaurus, Ceratosaurus,* and *Diplodocus.* Excavations in the area started in the mid-1870's. Almost every major natural history museum in the United States has specimens from the Garden Park area. The amount of fossil vertebrate material, and the long history of museum excavations (which continues today) in the area, is unique for any Morrison locality in Colorado, and is comparable only to Como Bluff in Wyoming and the Dinosaur Quarry in Utah. Unlike Como Bluff and Dinosaur Quarry, the Garden Park area produces dinosaurs throughout the Morrison Formation, not only in the upper parts of the formation. The Morrison Formation in the area also produces abundant freshwater mollusks and arthropod fossils, and is the type locality for 13 species of freshwater clams and snails, and three species of freshwater ostracodes. The Ralston Creek Formation in the area has produced a species of Todiltia — one of the oldest genera of teleost fish. The area contains well-exposed outcrops of upper Jurassic and lower Cretaceous rocks, and has numerous, large-scale landslides at the base of the Dakota Sandstone.

GENERAL DESCRIPTION: The area contains intermittent sagebrush-pinyon-juniper community interspersed among rock outcroppings.

AREA: 1280 Acres

OTHER SIGNIFICANT VALUES: Garden Park RNA/ACEC contains a plant species of special concern to the State of Colorado — *Eriogonum brandegei* Rydberg, Brandege Wild buckwheat. The species is listed as a Category 2 species (species requiring some additional study prior to a determination of threatened and endangered status) by the U. S. Fish and Wildlife Service (USFWS Notice of Review Category 2 - *Federal Register,* 1983). *Eriogonum brandegei* occurs in the Upper Arkansas physiographic region and is found in Chaffee and Fremont Counties in Colorado. The plant is endemic to Colorado, displays an ability to colonize disturbed lands in the form of roadcuts, and could be used in research on the revegetation of disturbed lands.

GAG RECOMMENDATION: Special management with RNA within an ACEC - Research Natural Area designation of Morrison Formation outcrops due to paleontological research and future paleontological research potential, this being within an Area of Critical Environmental Concern around the Dakota Sandstone slump blocks. Significant educational value due to ease of access and public land ownership pattern. GAG field evaluations occurred on April 25-26, 1985, between October and December, 1985, and on June 9-11, 1986.

BOUNDARY JUSTIFICATION: The locality includes part of the southern half of Garden Park, between the escarpments which topographically define the park, and includes the Four Mile Creek drainage. The historic Cope Quarry and the current Denver Museum of Natural History Quarry are included within the boundaries.

SITE INFORMATION SUMMARY

SITE NAME: Indian Springs Trace Fossil Locality

LOCATION: T18S, R69W
County: Fremont
USGS 7.5′ Quads: Cooper Mountain, Phantom Canyon;
Eight miles north of Florence and west of Lower Phantom Canyon

SIGNIFICANT FEATURES: The locality contains a unique assemblage of trace fossils, body fossils, and sedimentary structures, including body fossil evidence of *Ostracoderms, Merostomes,* and *Trilobites.* The locality is the type locality of eight *Ichnogenera.* The association of sedimentary structures and trace and body fossils is unique and of international interest. Important discoveries from this locality (which includes adjacent private property) are:

- an oro-bronchial mold of an ostracoderm showing the anatomy and configuration of the bronchial pouches used for respiration.
- the earliest fossil record and first occurrence of the walking, foraging, and burrowing activity of the ancestral horseshoe crab.
- the earliest record of scorpionid locomotion and some indications of scorpionid morphology.
- the first record of fossil *Eurypterids* in the western United States.
- the first body trace fossil evidence of the extinct arthropod known as *Aglaspid,* previously known from one locality in Minnesota-Wisconsin.
- detailed walking and swimming tracks of the giant *Isotelid Trilobite* revealing important data on the nature, structure, and function of both the epipodite and pre-epipodite.
- body fossil evidence of an extinct *Merostome* revealing the ventral side of the animal; this provides the basis for the recognition of a new family, genus, and species.

The locality contains an estuarine species and associated fauna and ichnofauna which demonstrates that the primitive vertebrates were part of an ecosystem including merostomes, arachnids, and trilobites. The later Paleozoic association of merostomes and ostracoderms was apparently a relationship established early in their evolution. It may have been this predator-prey relationship that stimulated the evolution of heterostracan armor plate and ultimately the vertebrate skeleton.

GENERAL DESCRIPTION: The area consists of rolling terrain and rock outcroppings, dominated by pinyon-juniper woodland and perennial grass understory with ponderosa pine in lower area.

AREA: 45 Acres

OTHER SIGNIFICANT VALUES: Private property (40A.) portion of the locality is a designated Colorado Natural Area and a registered National Natural Landmark. This portion of the locality is used as an interpretive natural area and for scientific research.

GAG RECOMMENDATION: RNA - Research Natural Area for ongoing scientific research and for educational and interpretive use. A GAG field evaluation occurred on April 25-26, 1985. The GAG also recommended initiating a withdrawal from mineral entry and amending the existing Management Framework Plan to include special management provisions.

BOUNDARY JUSTIFICATION: Locality contains known occurrences of body and trace fossil evidence from the Harding Formation (Middle Ordovician) in Colorado. Proposed boundaries were identified to BLM in 1980. The area, recommended as an RNA, has been registered by the Colorado Natural Areas Program (1983).

SITE INFORMATION SUMMARY

SITE NAME: Lower Phantom Canyon Paleo Site

LOCATION: T18S R69W, S4, 9
County: Fremont
USGS 7.5' Quad: Phantom Canyon

SIGNIFICANT FEATURES: Phantom Canyon is a scenic canyon which is cut through Precambrian igneous and metamorphic complex unconformably overlain by Ordovician Manitou and Harding Formations. Phantom Canyon displays faults, folds, unconformities, and excellent Ordovician stratigraphic sequences. Trace and body fossil remains are similar to those of the nearby Indian Spring Trace Fossil site, but of lesser quality.

GENERAL DESCRIPTION: Phantom Canyon is a box canyon, in some places less than 40 feet wide, cut in the Precambrian Pikes Peak granite. Jointing in the granite frequently controls the canyon's course. Near its southern end, the canyon cuts through Precambrian schist and gradually opens out with the transition across the Precambrian - Paleozoic contact. Pinyon-juniper scrub oak and semi-arid shrub communities with a perennial grass understory are the dominant vegetation, with cottonwoods present in more mesic areas.

AREA: 80 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: NON - No special management. GAG field evaluations occurred on April 25-26, 1985, and on June 9-11, 1986. Originally, private property posed public access problems. During the second field evaluation, private ownership and public access again posed problems. Both field evaluations determined that existing management was appropriate even though the area has supported and will continue to support research and educational use.

SITE INFORMATION SUMMARY

SITE NAME: Spring Gulch Fossil Fish Locality

LOCATION: T49N, R9E
County: Fremont
USGS 7.5′ Quad: Wellsville

SIGNIFICANT FEATURES: Devonian fish remains are the only fossils found in the Parting Formation and known from several localities in Colorado and Wyoming. Spring Gulch provides excellent stratigraphic sequences from the Precambrian through Mississippian periods. Spring Gulch is an ideal setting for interpretive geology of the Wellsville Syncline and is used by several colleges and universities for educational purposes. Spring Gulch contains disarticulated fragments of *Bothriolepis* and *Holoptychcus* in the red siltstone-dolomite bed in the Parting Formation.

GENERAL DESCRIPTION: Typical semi-arid shrub, grass, and pinyon-juniper vegetation.

AREA: 40 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: Combine into Wellsville Geologic Study Area.

BOUNDARY JUSTIFICATION: Part of Wellsville Geologic Study Area.

SITE INFORMATION SUMMARY

SITE NAME: Twin Mountain Structure Complex

LOCATION: T18S, R71W, S11, 12
County: Fremont
USGS 15′ Quad: Cover Mountain, Royal Gorge

SIGNIFICANT FEATURES: Complexly folded and faulted strata adjacent to Highway 50 provides ideal setting for geology field classes (Twin Mountain is used by universities and colleges). Precambrian Manitou Limestone contact is unique for showing minor relief. Ordovician Harding and Fremont Formations are fossiliferous and well-exposed.

GENERAL DESCRIPTION: Although relatively devoid of vegetation due to outcrop nature, the area contains typical shrub, grass, and pinyon-juniper vegetation complex on rocky terrain.

AREA: Used for educational purposes.

OTHER SIGNIFICANT VALUES: Area provides opportunities for brunton and plane table mapping. The Harding Sandstone contains conodonts, and fish plate fragments of *Eryptichius* and *Astraspis*. The type section for the Fremont Formation is close by and contains Ordovician horn corals, gastropods, and nautiloid cephalopods such as *Orthoceras*.

GAG RECOMMENDATION: NON - No special management - no destructive activity should be allowed in boundary area - special steps should be developed as part of planning. Maintain area for geologic interpretation and education. GAG recognizes its outstanding geological attributes.

BOUNDARY JUSTIFICATION: (Map and boundary are pending, but are based on area of outstanding educational values).

SITE INFORMATION SUMMARY

SITE NAME: Wellsville Geologic Study Area

LOCATION: T49N, R9E, (including S13), and T49N, R10E
County: Fremont
USGS 7.5' Quad: Wellsville, Howard

SIGNIFICANT FEATURES: Area consists of Spring Gulch and part of Arkansas Canyon, an area used by many universities, colleges, and state geological societies for educational and interpretive purposes. Spring Gulch provides excellent stratigraphic sequences from the Precambrian through Mississipian periods. The Arkansas River Canyon exposes steeply dipping Ordovician to Pennsylvanian age strata and textbook examples of folding, faulting, and unconformities.

GENERAL DESCRIPTION: Area contains typical shrub, grass, and pinyon-juniper vegetation complex on often rocky (outcrop) terrain.

AREA: Map and boundary including land ownership being studied.

OTHER SIGNIFICANT VALUES: Devonian fish fossils, including disarticulated fragments of *Bothriolepis* and *Holoptychus* are reported from the red siltstone-dolomite bed of the Parting Formation in the area. Area lends itself well to interpretation and education - a brochure and sign at a pullout at Spring Gulch would help to enhance these values. The Wellsville GSA is a combination of the formerly proposed "Spring Gulch" and "Upper Arkansas" NA's. GAG recognizes the outstanding geological attributes of this area.

GAG RECOMMENDATION: NON - No special management - need to check mining claims (patented & unpatented) - combine both the "Spring Gulch" and "Upper Arkansas" to form the Wellsville GSA and develop the interpretive aspects for this area.

BOUNDARY JUSTIFICATION: Educational and scenic qualities of Spring Gulch and the Upper Arkansas Canyon (Map and boundary including land ownerships in progress).

SITE INFORMATION SUMMARY

SITE NAME: Upper Arkansas Canyon Scenic Study Area

LOCATION: T49N R10E
County: Fremont
USGS 7.5′ Quad: Wellsville, Howard

SIGNIFICANT FEATURES: Part of Arkansas Canyon which is used by universities, colleges, and state geological societies for educational and interpretive purposes. The Arkansas River Canyon exposes steeply dipping Ordovician to Pennsylvanian age strata and textbook examples of folding, faulting, and unconformities.

GENERAL DESCRIPTION: Area contains typical shrub, grass, and pinyon- juniper vegetation complex on rocky (outcrop) terrain.

AREA: Undescribed at present.

OTHER SIGNIFICANT VALUES:

GAG RECOMMENDATION: NON-No special management needed.

BOUNDARY JUSTIFICATION: Pending further field evaluation.

CRAIG DISTRICT

SITE INFORMATION SUMMARY

SITE NAME: Blacks Gulch

LOCATION: T2N, R96W
County: Rio Blanco
USGS 7.5′ Quad: White River City

SIGNIFICANT FEATURES: Blacks Gulch is the best fossil vertebrate locality of Lysite (middle early Eocene) Age in Colorado. It has produced several hundred good specimens including the type of *Lophiparamys debequensis*. This site produces good Lysitean fauna with good quality material. A reasonably complete upper dentition of the primate *Cantius abditus*, possibly the best known specimen, was recently collected from this site. Erosion constantly produces new specimens of scientific merit.

GENERAL DESCRIPTION: The area contains a gently rolling and highly eroded terrain with a semi-arid shrubland community dominated by sagebrush.

AREA: 20 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: RNA - Research Natural Area for ongoing research projects by several universities. Oil and gas leases should be issued with no surface occupancy (NSO) stipulations attached to the leases for the identified area.

BOUNDARY JUSTIFICATION: The area includes the cliff faces with the fossil-bearing strata and the fossil producing area at the base of the cliffs. The highly erodable soils require periodic prospecting for fossils.

SITE INFORMATION SUMMARY

SITE NAME: Calico Draw Paleo Locality

LOCATION: T5N, R99W
County: Moffat
USGS 7.5' Quad: Indian Water Canyon

SIGNIFICANT FEATURES: The site has produced several species of dinosaurs based on sparse material. A fairly complete diplodocid from the locality is in the collection of Brigham Young University, Provo, Utah.

GENERAL DESCRIPTION: The area contains intermittent stands of pinyon-juniper in a semi-arid environment consisting primarily of sagebrush and saltbush.

AREA: 180 Acres

OTHER SIGNIFICANT VALUES: BLM has ranked the scenic quality as A-B for this area due to the colorful red cliffs and rock outcrops contrasting with the sagebrush gray and dark green pinyon-juniper in the valley.

GAG RECOMMENDATION: NON - No special management area designation. The area does not contain sufficiently rich or scientifically unique fossil material to justify designation as a special management area.

BOUNDARY JUSTIFICATION: Evidence of earlier excavations is clearly visible. Future potential paleontological excavations should be monitored to ensure compliance with appropriate environmental regulations.

SITE INFORMATION SUMMARY

SITE NAME: Cross Mountain Canyon

LOCATION: T6N, R98W, S13, 14, 22, 23; T6N, R97W
County: Moffat
USGS 15' Quad: Elk Springs

SIGNIFICANT FEATURES: Rugged canyon is a classic example of a superimposed river gorge first established on the Browns Park formation (Tertiary - Oligocene - Miocene), then eroded down a thousand feet into the Uinta Mountain Group (Proterozoic) in the core of the Cross Mountain anticline. The Madison Limestone (Mississippian) forms the canyon rim, making vertical cliffs more than 200 feet high. The canyon is deeper than it is wide toward the mouth of the canyon. Cross Mountain Canyon is bounded on the west by a large, well-exposed fault zone that brings Mancos Shale (upper Cretaceous) against Madison Limestone and offsets the Bishop Conglomerate. Vertical displacement is approximately 5000 feet with Mesozoic strata west of the fault in contact with Paleozoic strata east of the fault. Cross Mountain Canyon's many spectacular geologic features are contained in a relatively small area resulting in an area of great educational value.

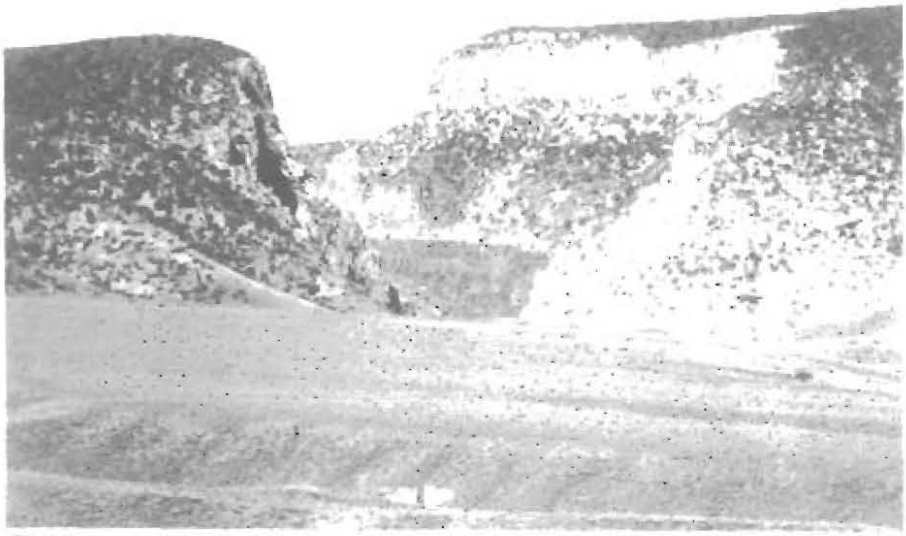
GENERAL DESCRIPTION: The scenic, three mile long canyon is carved by the Yampa River through Cross Mountain, which is uplifted along faults at both ends of the canyon. Semi-arid sagebrush and pinyon-juniper woodland communities comprise the vegetation on the area.

AREA: 1500 Acres

OTHER SIGNIFICANT VALUES: Cross Mountain Canyon is a BLM Wilderness Study Area. Cross Mountain Canyon has been assigned a scenic quality rating A by BLM and a rating of 5 (highest) for scarcity within the region. Visual sensitivity is rated High — Cross Mountain Canyon is visually interesting due to its contrasting land form to the immediate surrounding landscapes. Cross Mountain Canyon is one of Colorado's few remaining natural canyons unaltered by human impacts. Cross Mountain is habitat for *Penstemon yampaensis* (USFWS - Category 3C; Colorado list 4) and *Cirsium owenbyi* (USFWS-Catagory 2; Colorado list 1).

GAG RECOMMENDATION: ONA - Outstanding Natural Area for scenic quality and exemplary geologic features. The area is used regularly for educational purposes.

BOUNDARY JUSTIFICATION: Area includes canyon and approximately one-half mile back from the canyon rims as well as the west end of canyon to include rocks affected by the fault.



Cross Mountain Canyon Photo: Bureau of Land Management

SITE INFORMATION SUMMARY

SITE NAME: Douglas Pass Insect Locality

LOCATION: T5S, R101W, S7; T5S, R102W
County: Garfield
USGS 7.5' Quad: Foundation Creek

SIGNIFICANT FEATURES: Type locality for several fossil insects, including a recently described *Tipulidae* (Diptera). The excellent preservation of the fossil insects makes this site unique in the western United States.

GENERAL DESCRIPTION: The area contains platey shales typical of the Green River Formation. Vegetation consists of montane forest and shrub communities interspersed among rock outcrops.

AREA: Unkown

OTHER SIGNIFICANT VALUES: None Known

GAG RECOMMENDATION: NON - The GAG field evaluation in 1985 resulted in the following recommendations:

- No special management due to inadequate site information.
- Public access makes management difficult.
- Douglas Pass is a topotype locality - a locality from which previously unknown species are found.
- Another representative Green River formation locality with fossil insects with restricted public access should be protected.

SITE INFORMATION SUMMARY

SITE NAME: Irish Canyon

LOCATION: T9N, R101W, S1-3, 11-12
T9N, R100W, S5-8
T10N, R101W, S2-5, 8-11, 13-16, 21-27, 34-36
T10N, R100W, S30-31
County: Moffat
USGS 7.5' Quad: Big Joe Basin, Irish Canyon

SIGNIFICANT FEATURES: This area is an excellent example of stream superimposition and piracy resulting in a beheaded stream valley. The stream in Irish Canyon was pirated by Vermillion Creek in early Pleistocene time, leaving a 1000-foot-deep gorge high and dry without a headwaters and opened to a wind gap at its head. The beheaded stream valley contains the only continuous and complete stratigraphic section of Paleozoic through Tertiary sedimentary rocks representative of NW Colorado geology on the Uinta Overthrust.

The site has excellent examples of the two major Uinta Mountain erosional surfaces: the Gilbert Peak Surface and the Bear Mountain Surface. Remnants of the latter surface are rare in the eastern Uintas. More than four miles of strata are continually exposed in one stratigraphic section. Although the rock units have been correlated and described, their depositional histories have not been extensively studied.

Irish Lakes, two intermittent ponds, are the most notable aquatic feature on the site. Such natural ponds are rare in western Colorado at low elevations.

GENERAL DESCRIPTION: Approaching the proposed site from the southwest, the panorama includes the Vermillion Creek Gap (a superimposed stream) and the dramatic entrance to Irish Canyon (an abandoned superimposed stream). Twelve geologic units are exposed and visible from the rim of Vermillion Gap. Rock units that outcrop in the area range in age from Precambrian to Quaternary with every period represented except the Ordovician, Silurian, and Devonian. The Precambrian is represented by the Uinta Mountain Group that plunges to the southeast below the Tertiary Browns Park Formation. The Paleozoic and Mesozoic section consists of eighteen stratigraphic units of marine/nonmarine clastic and marine carbonate origin: The Section is about 13,100 feet thick and is bounded by the Precambrian on the southwest and the Uinta Thrust Fault (Sparks Fault) on the northeast. The Tertiary is composed of three gently dipping formations outcropping in the area and unconformably overlap the older formations with an overall thickness of 7400 feet. The Paleozoic and Mesozoic strata uniformly strike northwest-southeast, forming ridges in the more resistant sandstones and limestones and valleys in the less resistant siltstones, mudstones, and shales. The strata dip at approximately 30 degrees northeast at the contact with the Precambrian and are nearly vertical and locally overturned at the leading edge of the Uinta Thrust plate. The Canyon is colorful and scenic.

OTHER SIGNIFICANT VALUES: Cultural — petroglyphs occur on the site and are delineated by a small interpretive site. Prehistoric use of the area has been demonstrated by the findings of the Fremont and Ute cultures. Scenic — Irish Canyon has a high scenic value rating. Irish Canyon has 6 highly ranked plant species of special concern (Colorado Natural Areas Inventory) and several plant communities of special concern.

AREA: Approximately 11,400 Acres

GAG RECOMMENDATION: ONA - Outstanding Natural Area for scenic quality and exemplary geologic features; used for educational purposes. The geology of Irish Canyon is known nationally and geology organizations and universities frequently schedule field trips to study the geologic exposures.

BOUNDARY JUSTIFICATION: The boundary encloses the minimum area encompassing the scenic and geologic values of the proposed site. A county road through Irish Canyon provides access to the site.

SITE INFORMATION SUMMARY

SITE NAME: Kremmling Cretaceous Ammonite RNA

LOCATION: T3N, R80W
County: Grand
USGS 7.5' Quad: Hinman Reservoir

SIGNIFICANT FEATURES: Exceptional marine fossils from the Pierre Shale, of late Cretaceous age (70 million years), including an unusual concentration of the giant ammonite (*Placenticeras meeki*). Associated with several scales of these ammonites are over 100 species of mollusks, including other ammonites, nautiloids, clams, and gastropods, and rare species of bryozoans (moss animals), brachiopods (lamp shells), crabs and lobsters, vertebrates (fish and marine reptiles), and terrestrial plants. The fossils occur in a muddy sandstone, typically within large sandy calcareous concentrations that surround specimens of the giant ammontites. The muddy sandstone accumulated from a series of storm-deposited marine sand bars near the western shoreline of a shallow sea that covered much of the western interior of North America 75 million years ago. The giant ammonites may have been washed onto the sand bars by storms after dying *en masse* following mating activities. Other fauna indicate a shallow marine depositional environment that received terrestrial plant debris from the shore. The concentration of fossils at this locality allows for a remarkable view into an ancient marine ecosystem.

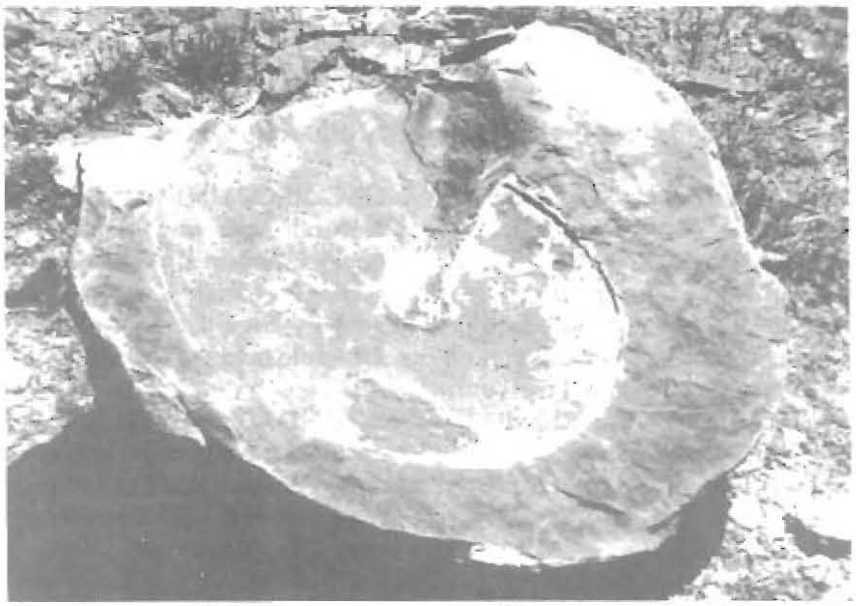
GENERAL DESCRIPTION: Sagebrush and grasses cover rolling topography broken up by ridges and sandstone outcroppings.

AREA: 160 Acres

OTHER SIGNIFICANT VALUES: Area may have archeological importance, cultural artifacts are reported from this area.

GAG RECOMMENDATION: RNA - Research Natural Area for research and educational purposes. Locality is internationally known due to uniqueness and wealth of fossil material and will be used for baseline studies. Commercial collecting has damaged the locality and requires careful monitoring to protect locality from further vandalism.

BOUNDARY JUSTIFICATION: Area contains sandstone outcropping which is known to have marine fossils. The area was registered in 1983 by the Colorado Natural Areas Program. Adjacent state-owned land (State Board of Land Commissioners) containing the sandstone outcropping was registered in 1984 by the Colorado Natural Areas Program.



Kremmling Ammonite RNA — Photo: Bureau of Land Management

SITE INFORMATION SUMMARY

SITE NAME: Lookout Mountain - Vermillion Bluffs

LOCATION: T11N, R99W, S35-36
County: Moffat
USGS 7.5' Quad: Sheepherder Spring; Coffee Pot Spring Northwest of Maybell and southwest of Powder Wash.

SIGNIFICANT FEATURES: Lookout Mountain is the highest point on the Vermillion Bluffs on the divide between Vermillion Basin and Sand Wash Basin. Lookout Mountain is an erosional outlier of the Gilbert Peak erosion surface capped by Bishop Conglomerate (Oligocene). Lookout Mountain is an excellent example of an isolated, flat-topped erosion remnant of a once-extensive middle Tertiary alluvial plain. The Bishop Conglomerate consists of cobbly, pebbly flood alluvium and mudflows derived from the Uinta Mountains, about 15 miles to the southwest. Eocene Cathedral Bluffs member of the Wasatch formation and Laney member of the Green River formation form well-exposed badlands below the Bishop caprock, particularly on the Vermillion Basin side. Excellent long-range vistas.

GENERAL DESCRIPTION: The site consists of the Vermillion Bluffs with Lookout Mountain being the highest point at 8,120 feet. The vegetation in the area is a semi-arid shrubland community dominated by sagebrush, shadscale saltbush, Utah juniper, and various perennial grasses.

AREA: Approximately 640 Acres

OTHER SIGNIFICANT VALUES: Lookout Mountain and the Vermillion Bluffs comprise a dramatic escarpment of 1,700 feet in elevation. The viewshed from Lookout Mountain encompasses the Vermillion Creek drainage, Limestone Ridge, Irish Canyon, Diamond Peak, Middle Mountain, Powder Wash, Sand Wash, and the southern crest of Horseshoe Basin in Wyoming. The area contains Holocene and Pleistocene landslide deposits composed of earthflows and rotational slumps on steep slopes. These deposits are situated below Lookout Mountain and form spectacular badlands.

The site is within a larger area proposed by BLM and the State of Colorado due to its vegetation components. Five plant species of special concern and two plant associations of special concern (Colorado Natural Areas Inventory) occur in this area.

GAG RECOMMENDATION: ONA - Outstanding Natural Area for scenic qualities and opportunities for geologic interpretations. No surface occupancy (NSO) stipulations attached to oil and gas leases in identified area will protect the geologic features on the identified site.

BOUNDARY JUSTIFICATION: The proposed boundary encloses the best representative examples of the described geologic features.

SITE INFORMATION SUMMARY

SITE NAME: Skull Creek Anticline

LOCATION: T4N, R100W, S18-20 & 29-31;
T4N, R101W, S20-29
County: Moffat
USGS 7.5' Quads: Skull Creek, Lazy Y Point Seventy miles west of Craig on US 40.

SIGNIFICANT FEATURES: This colorful, well-exposed anticline is on the flank of Blue Mountain in the eastern Uinta Mountains. The site has colorful erosional forms and large scale jointing in the Weber Sandstone. Exposed rocks range in age from Pennsylvania to Cretaceous and include the Weber, Park City, Moenkopi, Chinle, Glen Canyon, Entrada, Stump, Morrison, Cedar Mountain, Dakota, and Mancos Formations. The anticline is asymmetrical, and the outcropping rocks make sharp hogbacks and dipslopes on the south limb, especially the Dakota and Glen Canyon Formations, and dipslopes and rimrocks on the north, west, and east. The Skull Creek Anticline is one of the best exposed small anticlines in Colorado.

GENERAL DESCRIPTION: The Skull Creek Anticline is adjacent to U.S. 40, but has a very wild aspect immediately back from the highway. The area is characterized by steep and rugged topography with expansive rock outcrops, cliffs, numerous drainages, and colorful erosional forms. The site is crossed by a rough jeep road. The vegetation is a typical sagebrush and pinyon/juniper plant communities.

AREA: Approximately 53,760 Acres

OTHER SIGNIFICANT VALUES: Scenic and wilderness values.

GAG RECOMMENDATION: SMA - Special Management Area for scenic qualities and educational and interpretive opportunities. Most land uses will not impair the qualities of the geologic feature. If oil and gas development occurs, specific lease stipulations on drilling placements and roads may be appropriate to protect the scenic opportunities of the area.

BOUNDARY JUSTIFICATION: The area encompasses the entire anticline, including the complete Skull Creek rim.

SITE INFORMATION SUMMARY

SITE NAME: Wolford Mountain

LOCATION: T2N, R80W, S30
County: Grand
USGS 7.5′ Quad: Kremmling, Junction Butte, Hinman Reservoir.

SIGNIFICANT FEATURES: Wolford Mountain contains extensive exposures of the Cretaceous Pierre Shale with many invertebrate fossil occurrences. The Williams Range Thrust Fault and many younger faults occur in the complex fault zone. Exposures of the Troublesome Formation contain vertebrate fossils. The most significant feature here is the clearly exposed relation of Precambrian rocks over Cretaceous shales on the thrust fault.

GENERAL DESCRIPTION: Precambrian granite overlies Cretaceous shale. The older rocks were thrust up and over younger rocks during the Laramide Orogeny (mountain building). Sagebrush and grass community cover a gently rolling topography at the base of Wolford Mountain. Montane forest types occur on the upper levels of Wolford Mountain.

AREA: 2,560 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: NON - No Special Management. Area is used for education and research by several universities. No threats to the area have been identified. Existing uses compatible with educational use.

BOUNDARY JUSTIFICATION: Area contains geologic features which are used by educational institutions.

SITE INFORMATION SUMMARY

SITE NAME: Ducey Stromatolite Locality

LOCATION: T9N, R100W, Sec. 5, T10N, R100W, Sec. 32
County: Moffat
USGS 7.5' Quad: Irish Canyon

SIGNIFICANT FEATURES: Scenic area contains hundreds of cone, ball and egg-shaped concretions that continue to weather from a silicified layer of limestone. Concretions range in size from one metre to a norm of 3 metres for larger concretions, the largest of which is 10 metres high by 7 metres wide. Silicified limestone concretions are giant algal heads (stromatolites) that have formed about a forest of silicified rotted tree stumps; up to 47 growth rings of algae and ooliths have been counted.

GENERAL DESCRIPTION: The Ducey Stromatolite Locality is on a bench overlooking a steep drainage to Vermillion Creek, Irish Canyon, and the Gates of Lodore. The concretions are weathering out of a silicified limestone layer within the Laney Member (dated 47-45 ma) of the Green River Formation (Eocene). Sparse pinon and juniper trees dot the area, as well as low shrubs and grasses. A small part of the total 160 acre locality is on private land (less than 20 acres).

AREAS: 160 Acres

OTHER SIGNIFICANT VALUES: Paleoecological research and mineralization studies potential.

GAG RECOMMENDATION: ACEC/RNA (Area of Critical Environmental Concern/Research Natural Area).

BOUNDARY JUSTIFICATION: Actual extent of concretionary exposure and weathered concretions that have rolled downhill (boundary walked and mapped, 1987 and 1988).

Dennis Ducey Stands Next to A Stromatolite Photo: Museum of Western Colorado

GRAND JUNCTION DISTRICT

SITE INFORMATION SUMMARY

SITE NAME: Black Ridge Angiosperm Locality

LOCATION: T10S, R103W
County: Mesa
USGS 7.5′ Quad: Battleship Rock;
Area is situated within the Black Ridge Wilderness Study Area west of the Colorado National Monument.

SIGNIFICANT FEATURES: The site has produced a 115 - 120 million year old sycamore which may be among the world's oldest known flowering plants. Further research is necessary to substantiate existing data.

GENERAL DESCRIPTION: The locality contains a pinyon-juniper woodland with interspersed clearings of sagebrush and grass.

AREA: 40 Acres

OTHER SIGNIFICANT VALUES: Site is contained in a BLM Wilderness Study Area which has the largest collection of natural arches in the world.

GAG RECOMMENDATION: RNA - Research Natural Area due to continuing paleontological research interest. Several colleges and universities and USGS have conducted research on this site. Field evaluation by GAG required prior to final boundary recommendation.

BOUNDARY JUSTIFICATION: Final boundary recommendation deferred pending further evaluation.

SITE INFORMATION SUMMARY

SITE NAME: Black Ridge Canyons

LOCATION: T10, R 102W,T11S, R102W 6th PM
County: Mesa
USGS 7.5′ Quad: Battleship Rock, Colorado National Monument, Fruita, Mack, Ruby Canyon, and Sieber Canyon; Area is within Black Ridge Wilderness Study Area west of Colorado National Monument.

SIGNIFICANT FEATURES: A system of 5 scenic canyons, four of which contain 20 known arches. The largest known concentration of natural arches in the world is in the Rattlesnake Canyon drainage. Seven of the ten known arch types have been found in this area. All arches with the exception of one in Pollack Canyon East, (Wingate Fm.) are known to occur in areas of Entrada outcrop. In addition to the known arches, there are numerous balanced rocks, monoliths, and pinnacles.

GENERAL DESCRIPTION: This areas is on the northeastern flank of the Uncompaghre Uplift. It encompasses land in elevations of 4430 feet at the Colorado River to 6400 feet to the southwest at Black Ridge, and shows corresponding vegetation zones. The area is scenic with canyons and mesas and is accessible by unimproved dirt road to the south (boundary) and by foot trails.

AREA: 18,150 Acres

OTHER SIGNIFICANT VALUES: There is an opportunity for solitude in this area of outstanding scenic value. An uncommon butterfly, *Papilio indra minori*, is known to inhabit the area. Opportunities for further geologic studies include natural arches, and a chert pebble unconformity (Navajo Fm?)between the Kayenta Formation and the Entrada Sandstone. Significant fossil vertebrates (dinosaurs) are known to occur in abundance in the Morrison Fm. of the study area.

GAG RECOMMENDATION: ONA/ACEC pending WSA designation. Outstanding Natural Area within an Area of Critical Environmental Concern. If Congress does not approve this as wilderness area, it should be designated ONA/ACEC.

BOUNDARY JUSTIFICATION: Area is determined by WSA boundary by BLM (BLM Final Wilderness Study Areas, 1980). Area is bounded by Colorado River to the north, Colorado National Monument to the east, Black Ridge to the south, and unimproved dirt road to the west.

(This section was prepared by Mr. Robert Sherill, Grand Junction, Colorado.)

SITE INFORMATION SUMMARY

SITE NAME: Gunnison Gravels RNA

LOCATION: T14S, R99W, S6
County: Mesa
USGS 7.5′ Quad: Jacks Canyon

SIGNIFICANT FEATURES: The area contains a unique fluvial gravel deposit which will aid in determining the recent geologic history of Unaweep Canyon. Several hypotheses relating to the erosion of Unaweep Canyon have suggested an ancestral stream drainage southwestward along Dominquez Canyon to Cactus Park and through Unaweep Canyon to the Dolores River. The potential ancestral streams include the Colorado River, Gunnison River, and Uncompahgre River. It is assumed that the ancestral stream deposited the gravels in Cactus Park.

GENERAL DESCRIPTION: The gently rolling former stream valley floor is cut along the Cactus Park Fault by the eroded channel of an intermittent branch of Gibler Creek. The small residual sandstone bedrock outcrops form low cliffs along the gulch and small ridges and hills in the proposed area. The valley floor is sagebrush and grass covered with isolated stands of pinyon-juniper woodland community.

AREA: 5 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: RNA - Research Natural Area: Area is used regularly by local colleges for educational and research purposes. Research by USGS has occurred on the site.

BOUNDARY JUSTIFICATION: Prescribed area contains remaining gravel deposit, mined-out deposit site, and top of deposit. Gravel from deposit was used to construct state highway through Unaweep Canyon and is removed occasionally by local residents. Remaining gravel deposit is minimal and requires protection by fencing from continued taking.

SITE INFORMATION SUMMARY

SITE NAME: Debeque Canyon Landslide

LOCATION: T10S, R97W, S7
County: Mesa
USGS 7.5' Quad: Cameo;
Three miles north of Highway 65 intersection with Highway 6-24 on SE side of Colorado River.

SIGNIFICANT FEATURES: Area contains a small landslide feature displaying repeated movement of three differing modes. The sandstones with shale interbeds are of fluvial origin and have resulted in slope failure and debris production. The bedding plane features are of outstanding quality.

GENERAL DESCRIPTION: The landslide occurs on the northwest-facing steep cliffs which form the valley wall of the Colorado River in Debeque Canyon. The channel sandstones and claystone interbeds form a stair-step topography that is sparsely vegetated with pinyon-juniper and semi-arid shrubs, except where there is disturbance caused by slope failure. Fossil evidence of dinosaurs has been found on the landslide.

AREA: 5 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: NON - No Special Management Area recommendation due to nature of the geologic feature and commonness of landslides in Colorado.

BOUNDARY JUSTIFICATION: The area is bounded by the Colorado River on the north and northwest, by Roberts Canyon floor on the north and northeast and by the rim of the cliff on the south. This area included all of the existing landslide debris and the source area.

Debeque Dinosaur Footprint Photo: Bureau of Land Management

SITE INFORMATION SUMMARY

SITE NAME: Dotsero Crater

LOCATION: T4S, R86W, S33; T5S, R86W, S4
County: Eagle
USGS 7.5′ Quad: Glenwood Springs

SIGNIFICANT FEATURES: Dotsero Crater and its associated lava flow represent the youngest volcanic event, estimated at 4,150 years, in Colorado and is a good example of recent volcanism.

GENERAL DESCRIPTION: Dotsero Crater is 800 feet deep and 1/3 mile wide with a lava flow of almost one mile (crossing I-70). Sagebrush dominates the lava substrates on the valley floor, greasewood dominates on the colluvium and alluvium substrates with a pinyon-juniper woodland community. The area contains semidesert shrubland and semidesert forest communities. This area is also a good example of successional stages of vegetation on lava.

AREA: 300 Acres

OTHER SIGNIFICANT VALUES: Unknown.

GAG RECOMMENDATION: ONA - Outstanding Natural Area, although special access agreements may need to be completed with BLM Resource Area and lessee.

BOUNDARY JUSTIFICATION: The area is the best example of recent volcanism in Colorado and is used for educational purposes by several colleges and universities. The number of active and potential mining claims present management difficulties for BLM. Although Dotsero Crater is modified extensively by cinder mining, the GAG recommendation emphasizes the geologic significance of the area and the need to preserve part of the crater for educational use.

SITE INFORMATION SUMMARY

SITE NAME: Fruita Paleontological RNA

LOCATION: T1N, R3W
County: Mesa
USGS 7.5' Quad: Mack
Three miles SW of Fruita.

SIGNIFICANT FEATURES: The locality contains a unique record of Mesozoic vertebrate fossils, including a new species of triconodontid mammal (significant for its association with a diverse mammalian fauna). In addition, three species of multituberculates, four species of dryolestid eupantotheres, one species of fabrosaurid ornithischian, three species of crocodillians, two species of sphenodontid squamates, two species of carnivorous dinosaurs (*Ceratosaurus* and *Allosaurus*), one species of *Camarasaurus*, and two species of *Stegosaurus* (Colorado state fossil) have been found on the locality. The completeness and excellent preservation of the late Jurassic small vertebrates from the locality, including examples of some of the oldest mammal fossils found in the Western Hemisphere, is unique, given the limited world-wide distribution and incompleteness of the late Jurassic small vertebrate fossils. The rich assortment of small, terrestrially adapted vertebrate fossils found at the locality makes the locality especially important.

GENERAL DESCRIPTION: The area is typical in aspect for the Grand Valley, consisting of undulating terrain mixed with rocky outcrops. The locality contains outcroppings of the Morrison Formation deposited approximately 140 million years ago and composed of the lower Salt Wash Sandstone and the upper Bushy Basin Shale. The Morrison Formation is the most fossiliferous formation within the Grand Valley and has produced fossils since 1900.

AREA: 280 Acres

OTHER SIGNIFICANT VALUES: Adjacent to proposed Black Ridge Wilderness Study Area.

GAG RECOMMENDATION: RNA - Research Natural Area for international significance of Mesozoic vertebrate fossils.

BOUNDARY JUSTIFICATION: Locality has been withdrawn from mineral entry and fenced by BLM. Fenced area contains active research location and includes the known fossil bearing strata.

Fruita Paleontology Quarry

Photo: Bureau of Land Management

SITE INFORMATION SUMMARY

SITE NAME: The Gateway Palisade

LOCATION: T15S, R104W, S36
County: Mesa
USGS 7.5′ Quad: Gateway
About three miles north of Gateway.

SIGNIFICANT FEATURES: The area contains a sandstone monolith that ends in a 2000′ vertical ridge abutment of spectacular scenic beauty. Stratigraphic relationships are displayed which help to interpret the depositional pattern of the southwest flanks of the ancestral Uncompahgre Uplift of the Permian. Unconformable contacts in the Triassic units are displayed clearly.

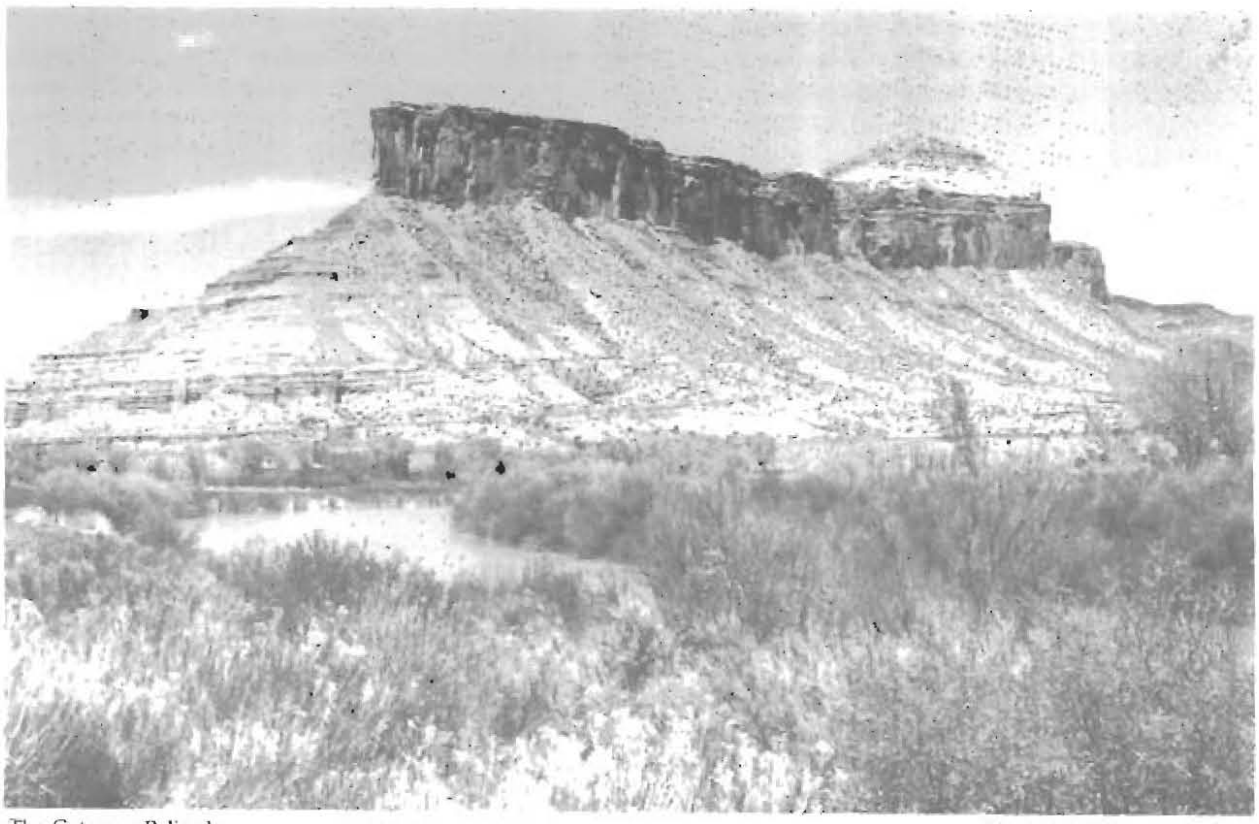
GENERAL DESCRIPTION: The area forms part of the north wall of the Dolores River and the sedimentary units eroded in alternating cliff and slope topography. Sparse semi-desert vegetation of various brush, grass, and shrub types occur with some pinyon-juniper woodland occurring in protected areas.

AREA: 1920 Acres

OTHER SIGNIFICANT VALUES: Site has spectacular scenic quality (BLM scenic quality rating A) and is within a BLM Wilderness Study Area.

GAG RECOMMENDATION: ONA - Outstanding Natural Area for geologic and scenic qualities. Area is recognized nationally for its display of stratigraphic relationships and its importance in interpreting the geology of Unaweep Canyon and southwest Colorado.

BOUNDARY JUSTIFICATION: Prescribed area contains ridge abutment and escarpment face from rim to bottom of ridge, which includes the geologically important sections.



The Gateway Palisade

Photo: W. R. Hansen, USGS

SITE INFORMATION SUMMARY

SITE NAME: Gypsum Cliffs

LOCATION: T4S, R86W, S31, 34
County: Eagle
USGS 7.5' Quad: Gypsum
Cliffs north of Gypsum, along I-70.

SIGNIFICANT FEATURES: The Gypsum Cliffs are excellent exposures of deformed gypsum, carbonates, and shales of the Pennsylvanian Minturn Formation. The deformation is due to the plastic flow of Eagle Valley Evaporites. The contorted interbedded silicic, carbonate, and gypsum beds are exposed in cliffs easily visible from I-70. The cliffs occur in the north flank of the evaporite-formed Eagle River Anticline.

GENERAL DESCRIPTION: The area contains scattered pinyon-juniper-sagebrush-grassland vegetation complex.

AREA: 30 Acres. Outcrop in SE quarter of S31 most important due to the quality of the exposure.

OTHER SIGNIFICANT VALUES: Several plant communities of special concern to Colordo are known from the vicinity and may occur on the sites.

GAG RECOMMENDATION: SMA - Special Management Area. No apparent management conflicts exist on the site. Interpretive sign could be placed along I-70 and at the BLM campground near the identified site for public use.

BOUNDARY JUSTIFICATION: Best exposure for interpretation and signing.

SITE INFORMATION SUMMARY

SITE NAME: McCoy Fan Deltas

LOCATION: T1S, R83W, S31;
T1S, R84W, S35, 36;
T2S, R83W, S6;
T2S, R84W, S1, 2
County: Eagle, Routt
USGS 7.5′ Quads: Blue Hill, McCoy

SIGNIFICANT FEATURES: Excellent exposures of Pennsylvanian fan deltas, including topset, foreset, and bottomset beds, distributary channels, storm washover fans, and nearshore marine carbonates. Nearshore carbonates are highly fossiliferous with marine invertebrates.

GENERAL DESCRIPTION: The McCoy fan deltas are some of the best exposed ancient deltas in the Rocky Mountain region. The deltas were formed by alluvial fan distributaries off the Ancestral Front Range, which deposited sediment loads into the marine waters of the Pennsylvanian Central Colorado Trough. The area contains sediments deposited in alluvial fans, in fan deltas, as nearshore marine clastics, and as nearshore marine carbonates. Interbedded with the fan delta deposits are marine limestones containing abundant fossils. The area around McCoy has produced 114 species of invertebrates, three species of vertebrates, and four species of plants, and is the type area for 19 species of Pennsylvanian plants and animals. Vegetation consists of semi-arid shrub and pinyon-juniper communities.

AREA: 1,040 Acres

OTHER SIGNIFICANT VALUES: Area is adjacent to popular Colorado River access point for river rafting.

GAG RECOMMENDATION: ONA - Outstanding Natural Area for geologic values. The area is the site of ongoing sedimentology and paleontology research and is regularly used for educational purposes by several universities in the state and the region.

BOUNDARY JUSTIFICATION: The denoted area is the primary use area for research and educational purposes and contains easily accessible geological features.

SITE INFORMATION SUMMARY

SITE NAME: Nancy Hanks Gulch

LOCATION: T14S, R100W, S11
County: Mesa
USGS 7.5' Quad: Jacks Canyon
Area is situated ten miles southwest of Whitewater.

SIGNIFICANT FEATURES: Area shows alteration by hydrothermal processes of the sandstone units overlying the Precambrian complex in the mid to late Tertiary. The altered area contains minerals, including amethyst and copper.

GENERAL DESCRIPTION: The silicified veins occur on both sides of the valley floor and extend up the steep cliffs of Precambrian schist and granite and into the overlying Triassic age mudstones and sandstones. The alluvium in the valley floor is vegetated with cottonwood, willow, various shrubs and grasses. The rock slopes are sparsely covered with pinyon-juniper woodland.

AREA: 7 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: NON - no special management area designation. Existence of patented mining claims and land ownership pattern make specific management prescriptions difficult for this site. Identified area is important for educational and interpretive use by local colleges.

BOUNDARY JUSTIFICATION: The boundaries include the exposed areas of the mineralized veins that are visible from the main highway. The area extends up Nancy Hanks Gulch and could be expanded to include the vein extension in that area. Patented mining claims exist within the identified boundaries.

SITE INFORMATION SUMMARY

SITE NAME: Rabbit Valley RNA

LOCATION: T10S, R104W
County: Mesa
USGS 7.5' Quad: Bitter Creek Well
Site is located west of Grand Junction near the Colorado-Utah border at the Rabbit Valley interchange on I-70.

SIGNIFICANT FEATURES: Rabbit Valley site contains a large section of a *Camarasaurus* axial skeleton in channel sandstone and has also produced elements of *Iguanodon, Allosaurus, Camarasaurus, Camptosaurus, Diplodocus, Apatosaurus,* crocodilians, and turtles from four horizons. Many fossil specimens from Rabbit Valley are deposited in the Museum of Western Colorado.

GENERAL DESCRIPTION: Rabbit Valley is located north of the Colorado River along the northwest flank of the Uncompahgre Uplift. The area contains sandy loam soils which are highly erosive. The area is dominated by sandstone outcrops on steep slopes. Geologic formations outcropping on the site are the Jurassic Morrison Formation, Brushy Basin Member overlaid by the Cretaceous Burro Canyon Formation. Vegetation on the area is a desert shrub community consisting of perennial grasses, pinyon-juniper, saltbush, and desert shrubs.

AREA: 75 Acres Research Area; 280 Acres Interpretive Area.

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: RNA - Research Natural Area for research and education. The Museum of Western Colorado (Grand Junction) has excavated fossil material from the site. A cooperative agreement has been signed between the BLM and the Museum to jointly manage the site.

BOUNDARY JUSTIFICATION: Includes area required for public education/ interpretive use as well as for continuing research on site. The research area contains the core fossiliferous area based on recent field surveys. The expanded interpretive area is less fossiliferous, but contains fossil bone which can be used *in situ* for educational and interpretive purposes.

SITE INFORMATION SUMMARY

SITE NAME: Roan Creek Goblins

LOCATION: County: Garfield
USGS 7.5′ Quad:

SIGNIFICANT FEATURES: Erosional feature in Wasatch formation.

GENERAL DESCRIPTION: Eroded nodules on mudstone and sandstone spires in the Wasatch Formation.

AREA: 80 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: None made.

BOUNDARY JUSTIFICATION: Follows erosional feature. A no surface occupancy stipulation for the area is delineated in the BLM-Grand Junction Resource Management Plan.

SITE INFORMATION SUMMARY

SITE NAME: Sinbad Valley

LOCATION: T48, 49N, R19W
County: Mesa, Montrose
USGS 7.5' Quads: Mt. Waas 4SE, Juanita Arch, Mt. Peale 1NE, Roc Creek.
15 miles SW of Gateway off State Highway 141, west of Salt Creek Road.

SIGNIFICANT FEATURES: Sinbad Valley is the exposed core of a breached salt-piercement anticline in a scenic structural section of the Colorado Plateau known as the Paradox Basin.

GENERAL DESCRIPTION: Sinbad Valley is a broad oval depression about eight miles long and four miles wide, encircled by high inward facing escarpments. Elevational differences from valley floor to rim average 1,500 - 2,000 feet. Rocks exposed in Sinbad Valley range in age from Pennsylvanian, in the lower slopes and valley floor, to Lower Cretaceous in the upper part of the outer rim. The broad floor of Sinbad Valley consists chiefly of the Paradox Member of the Hermosa Formation, which is mostly halite (rock salt), gypsum, limestone, sandstone, and shale. The halite is not exposed, because of its high solubility, but in the subsurface it comprises about 40% of the Paradox Member. Almost half the valley floor is Quaternary alluvium covered with sparse brush, pinyon and juniper, and grasses. The Paradox Member occasionally protrudes through the alluvium as low hills almost free of soil.

AREA: 2,000 Acres

OTHER SIGNIFICANT VALUES: Sinbad Valley is scenic with the encircling rims adding a dramatic backdrop. The valley rims vary from steep, brushy forested slopes to bare outcrops. Rock exposures on the north and northeast walls contain Triassic and Jurassic rocks forming brightly colored cliffs hundreds of feet high, particularly the Wingate, Kayenta, Navajo, and Entrada Formations. In many places the rims are broken by well-exposed faults. The core of the anticline is completely encircled by faults. All of these faults resulted from the collapse of the anticline, brought on largely by erosional exposure of the salt core, accompanied by salt extrusion and solution, and loss of support to the overlying rocks.

GAG RECOMMENDATION: SMA - Special Management Area from the rim of Sewemup Mesa to the floor of Sinbad Valley; rim-floor: three sections north of Salt Creek and three sections south of Salt Creek. Sinbad Valley is a good example of a collapsed salt anticline in a self-contained and scenic area. The geologic value of Sinbad Valley is having the area available for educational use in a relatively undisturbed condition. Minimal disturbance within the valley or on the valley rim will not harm the geologic features.

BOUNDARY JUSTIFICATION: Part of the proposed area is within the Sewemup Wilderness Study Area. The best stratigraphic exposures are contained in the delineated area.

SITE INFORMATION SUMMARY

SITE NAME: Unaweep Canyon Overlook

LOCATION: T14S, R100W, S16
County: Mesa
USGS 7.5' Quad: Jack Canyon;
Twelve miles southwest of Whitewater on Highway 141

SIGNIFICANT FEATURES: Overlook provides an awesome view of Unaweep Canyon, a scenic canyon which is the postulated course of the Gunnison and Colorado Rivers prior to their diversion in late Tertiary time. The Unaweep Canyon Overlook provides a panoramic view of outstanding geological features. Narrow V-shaped gorges at both ends of the canyon grade into a classic U-shape implying glaciation. The valley is surmounted by sheer granite walls hundreds of feet high and drainage divide near the valley center. The stratigraphy is similar to that of nearby Colorado National Monument. Precambrian rocks are correlative with those of the Black Canyon of the Gunnison. Despite the evidence of glaciation, no glacial moraines have been identified. Most of the major granite types in Unaweep Canyon occur, or are visable from, the overlook. Quartz pegmatites are frequently found in the granites. A major unconformity, Precambrian to Jurassic, is visible on the site.

GENERAL DESCRIPTION: The overlook includes a small section of the canyon rim that slopes very gently to the abrupt drop from the edge. The predominant vegetation is typical pinyon-juniper woodland with some trees that are of impressive size and age.

AREA: 5 Acres

OTHER SIGNIFICANT VALUES: Scenic.

GAG RECOMMENDATION: REC - Recreational designation for placement of interpretive sign on Divide Creek Road to encourage appropriate public use and to explain the significance of the geologic features visible from the overlook.

BOUNDARY JUSTIFICATION: Area contains best site for panoramic view of Unaweep Canyon and could include the historic Taylor Ranch Granite Quarry, if land exchange occurred between BLM and private owners.

Unaweep Canyon Overlook Photo: W. R. Hansen, USGS

SITE INFORMATION SUMMARY

SITE NAME: Cactus Park Footprint Locality

LOCATION: T14S R99W
County: Mesa
USGS 7.5 ' Quad: Triangle Mesa

SIGNIFICANT FEATURES: Intermittent drainage contains several theropod (meat-eating) dinosaur trackways with over 128 known footprints. Some footprints show claw and toe pad marks and the trackways run in many different directions. Triassic trackways, especially those in the Wingate Sandstone are rare in the area.

GENERAL DESCRIPTION: The Cactus Park Footprint Locality is in a bedrock drainage exposed in an area of alluviated soils with pinyons, junipers, and large pine trees. Tracks are exposed in a north-trending drainage intersected by an east-west road.

AREA: 10 Acres

OTHER SIGNIFICANT VALUES: This area is within the limits of a pre-historic lithic scatter and also includes a suspected Ute blaze tree. The largest pine in Cactus Park is about 50 metres south of the tracksite concentration and has a large area at its base that is bare of bark and has a surrounding scar. This site is also adjacent to the Gunnison Gravels RNA.

GAG RECOMMENDATION: ACEC/RNA (Area of Critical Environmental Concern/Research Natural Area).

BOUNDARY JUSTIFICATION: Gulley with visable trackways and area under soil tracks are leading into. If a 1 metre thick layer of soil were removed from this area, an extensive tracksite would probably be revealed.

SITE INFORMATION SUMMARY

SITE NAME: Juanita Arch

LOCATION: T50N, R18W, Secs. S 1/2 20, 29
County: Mesa
USGS 7.5' Quad: Juanita Arch

SIGNIFICANT FEATURES: The only true natural bridge in Colorado is Juanita Arch. "This is a very young meander type bridge eroded through a large fin of Wingate Sandstone . . . and has a span of 101 feet" (Vreeland: Vol. 18,p. 24, 1982). This is, by definition, a bridge, and not an arch (Vreeland: Vol. 1, pp.15-16, 1976). There are two other collapsed bridges in adjacent entrenched meanders to the west.

GENERAL DESCRIPTION: This area is on the southwestern flank of the Uncompaghre Uplift. It is in Maverick Canyon, a drainage to the nearby Dolores River. The arch is about one mile to the northeast of the Sewemup Mesa Study Area. Late Paleozoic, Triassic, and Jurassic rocks are exposed in the canyon and surrounding mesas. Juanita Arch is located in the Wingate Sandstone. Elevation ranges from 4700 feet at the Dolores River to 5400 feet.
AREA: 1,000 Acres

OTHER SIGNIFICANT VALUES: The area offers an opportunity for solitude, geologic research, and teaching (development of entrenched meanders). Candiate for federal candidate plant, Catagory II, *Astragalus linnefolias*. Prosauropod (?) trackway and highest recorded elevation for lungfish burrows in the ancestral Rockies also exist along the trail into the area. Various potholes, hanging falls, scroll patterns of scour and fill, and a very youthful fin-type arch also occur in the area.

GAG RECOMMENDATION: ONA/ACEC (Outsanding Natural Area/Area of Critical Environmental Concern).

BOUNDARY JUSTIFICATION: Canyon bottom and mesa tops with the above mentioned features.

SITE INFORMATION SUMMARY

SITE NAME: Young Egg Locality

LOCATION: T14S, R98W
County: Delta
USGS 7.5' Quad: Dominguez

SIGNIFICANT FEATURES: Scenic area at mouth of Wells Gulch by the Gunnison River, between two bench-forming sandstone layers and contains thousands of black eggshell fragments. These represent a nesting site from the upper Jurrassic (approx. 150 million years ago) that shows repeated nesting of the area. These fossil eggshells and associated bones and teeth are located in the Salt Wash Member of the Morrison Formation. These eggs and fragments are the oldest known in the northern hemisphere and are only outdated by eggs from Argentina, South Africa, and India.

GENERAL DESCRIPTION: The Young Egg Locality, located about 20 miles south of Grand Junction, Colorado is on a southwest facing slope of mudstone between two layers of bench-forming sandstone. Pinon and juniper trees dot the area which is accessible only by hiking a short steep trail or by driving a small 4 wheel vehicle overland. This locality, discovered in 1987, has been surface collected 3 times and quarried 3 times. The egg-bearing stratum goes beneath a 1 meter thick broken sandstone and more quarrying is easily possible.

AREA: 10 Acres

OTHER SIGNIFICANT VALUES: This site may yield information on dinosaur nesting patterns and information about the paleoecology of Jurassic nesting sites. The locality was found by Dr. Robert G. Young, and has been studied by paleontologists, geologists, soils experts, palynologists, dating experts, and eggshell experts. It may be possible that other nesting sites may be found exposed in this area.

GAG RECOMMENDATION: ACEC/RNA (Area of Critical Environmental Concern/ Research Natural Area).

BOUNDARY JUSTIFICATION: Area of exposed eggshells, potential eggshell zones immediately adjacent, and weathered area to bottom of hill (eggshells have been found washed out to valley floor).

MONTROSE DISTRICT

SITE INFORMATION SUMMARY

SITE NAME: Dolores Canyon Meanders

LOCATION: T47N, R19W, S35, 36
T46N, R18W, S31, 12
T46N, R18W, S31
T46N, R19W, S1, 2, 10, 11, 12, 13, 14, 23, 25, 26, 35, 36
T47N, R18W, S30, 31
Counties: Montrose, Dolores, San Miguel
USGS 7.5' Quads: Anderson Mesa, Bull Canyon, Paradox

SIGNIFICANT FEATURES: Dolores River Canyon Meanders are located in the canyonlands area of the Colorado Plateau. The meanders of the Dolores River cut the plateau between Little Gypsum Valley on the south and Paradox Valley on the north. The cliffs of the incised meanders have exposures of dipping layers of the Chinle Formation, Wingate Sandstone, Kayenta Formation, Navajo Sandstone, and Morrison Formation. The incised meanders resemble the Goosenecks of the San Juan River, but are of added interest because of the adjacent salt structure and related structural and geomorphic features.

GENERAL DESCRIPTION: The deeply incised, meandering Dolores River Canyon system is cut down through a series of sedimentary strata. Colorful ledges and massive cliffs and jumbled talus slopes combine with the Dolores River to produce spectacular scenery. Vegetation varies with terrain and elevation. The canyon rim and mesas support a pinyon-juniper woodland with interspersed sagebrush dominated open areas. The canyon slopes support a mixture of desert shrubs (sagebrush, mormon tea, squawbush, buffaloberry) and scattered pinyon-juniper, cottonwoods, and ponderosa pine. Riparian vegetation (cottonwood, willow, tamarisk) is common in the canyon bottoms.

AREA: 15,300 Acres

OTHER SIGNIFICANT VALUES: The recommended site is within the Dolores River Canyon Wilderness Study Area and adjacent to the proposed Coyote Wash Natural Area which contains occurrences of plants and plant communities of special concern to the State of Colorado.

GAG RECOMMENDATION: ONA - Outstanding Natural Area designation for scenic qualities of geologic features. Area is used for educational purposes. Public use will not affect geological features. No threats are known to geological features.

BOUNDARY JUSTIFICATION: The identified geologic area contains the most exemplary geologic features and is contained within the wilderness study area. The selected boundary utilizes both legal and topographic boundaries.

SITE INFORMATION SUMMARY

SITE NAME: Horseshoe Basin

LOCATION: T43N, R6W, S27, 28
County: Hinsdale
USGS 7.5' Quad: Handies Peak

SIGNIFICANT FEATURES: Horseshoe Basin in the San Juan Mountains of southwest Colorado contains numerous large rock glaciers (periglacial features), resembling debris-covered glaciers of ice. The surfaces are hummocky and uneven. Depressions resembling crevasses are present with ridges and depressions at the lower ends. The ends of the rock glaciers are steep and abrupt, rising as much as 100 feet. The debris forming the rock glaciers comes from mass wasting of the tuffs and flows of the Burns and Henson Formations between the Silverton and Lake City calderas of the San Juan volcanic field. Horseshoe Basin contains the largest rock glaciers in extensive accumulations in the Henson Creek drainage.

GENERAL DESCRIPTION: Elevation of Horseshoe Basin ranges between 12,000' and 13,700', with most of the area above timberline. Alpine tundra vegetation occurs in delicate clumps on the rocky slopes and in the talus. The rugged, glaciated terrain is isolated and scenic, consisting mostly of rock debris, boulder fields, and talus slopes.

AREA: 650 Acres

OTHER SIGNIFICANT VALUES: Unknown

GAG RECOMMENDATION: ONA - Outstanding Natural Area for scenic and exemplary geologic features.

BOUNDARY JUSTIFICATION: Horseshoe Basin is situated between the Silverton and Lake City calderas in the San Juan volcanic field. The calderas and associated volcanic rocks and ore deposits give the area greater geologic value than that of the glacial features alone. Private mining claims cover part of Horseshoe Basin. Although Horseshoe Basin may not be unique in any single characteristic, the combination of geologic features, access, and land ownership, make it one of the best possibilities in the range for scientific research.

SITE INFORMATION SUMMARY

SITE NAME: Needle Rock RNA

LOCATION: T15S, R91W, S27, 22
County: Delta
USGS 7.5′ Quad: Crawford

SIGNIFICANT FEATURES: Core or neck of tertiary volcano which rises 800 feet above the valley floor as a result of millions of years of the erosion of sedimentary formations around it. The igneous plug originated as molten rock intruded through sedimentary rock during active volcanism 25 million years ago.

GENERAL DESCRIPTION: Base of Needle Rock has a pinyon-juniper-grassland community. The rock monolith is barren of vegetation.

AREA: 80 Acres

OTHER SIGNIFICANT VALUES: Area used for educational and recreational purposes. Needle Rock has high scenic value.

GAG RECOMMENDATION: RNA - ONA designation may be appropriate. Support RNA as previously designated (1965) by BLM.

BOUNDARY JUSTIFICATION: Existing boundaries which include the rock monolith and lands around its base are sufficient. The existing BLM RNA is registered by the Colorado Natural Areas Program (1979).

SITE INFORMATION SUMMARY

SITE NAME: Dolores Canyon Triassic Fish Locality

LOCATION: T47N, R18W,
County: Montrose
USGS 7.5' Quad: Paradox

SIGNIFICANT FEATURES: The Dolores Canyon Triassic Fish Locality is one of the most important Triassic freshwatrer fish localities in North America. The locality has produced some of the finest articulated fish fossils from nonmarine systems of the Late Triassic age. The fish occur in the upper part of the Dolores Formation, a sequence of fluvial overbank, abandoned channel-fill, and active channel-fill deposits, about 45 meters (148 feet)thick. The fish were trapped in abandoned channels trhat then filled with overbank mud deposits. The overbank deposits contain fossils of Triassic reptiles, including various *phytosaur* (armored crocodile) remains. The locality has been richly fossiliferous, producing numerous disarticulated specimens. The overlying dune sands of the Lower Jurassic Wingate Sandstone contain footprints of bipedal dinosaurs. The locality is a good example of the relationship of fossils to their depositional environment and provides important information on the development of bony fish through time.

GENERAL DESCRIPTION: The area is characterized by semi-arid shrubland consisting of sagebrush-saltbush plant communities. Rocky terrain and outcrops (sandy, red mudstones) dominate the area.

AREA: 1 Acre for research area; 10 Acres with buffer.

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: RNA - Research Natural Area designation due to research productivity and to rarity of fossil fish locality. The recommended RNA is within the Dolores River Canyon Wilderness Study Area. Geologic and paleontologic resource maps were prepared in 1986. A joint paleontological-sedimentologic research study was organized in 1986 by the University of Colorado and the U.S. Geological Survey. Research on this project is still ongoing.

BOUNDARY JUSTIFICATION: Area encompasses known fossil-producing area.

SITE INFORMATION SUMMARY

SITE NAME: Placerville Permian Vertebrate Locality

LOCATION: T44N, R11W, S35
County: San Miguel
USGS 7.5' Quads: Placerville, Little Cone

SIGNIFICANT FEATURES: Placerville Permian Vertebrate Site is the only good condition Permian vertebrate site in Colorado with good preservation of bone material. Five new species are recorded from this site; it is a type locality for these species. The site yielded remains from sail-backed vertebrate *Platyhistrix*. The Cutler Formation has produced several vertebrate fossils of Early Permian age. The fossil bone material is very rare and occurs in near vertical exposures of the Cutler formation in San Miguel Canyon.

GENERAL DESCRIPTION: The area occurs along steep bluffs adjacent to the San Miguel River. Vegetation consists of semi-arid and montane shrub communities with pinyon-juniper woodlands or conifer forest interspersed throughout.

AREA: 40 Acres

OTHER SIGNIFICANT VALUES: None known.

GAG RECOMMENDATION: NON - no special management. The scarcity of vertebrate fossil material, the fragmented quality of the bone, and the intermixed land ownership pattern of this locality combine to provide adequate protection for the site. The area has been described in the scientific literature and will support continuing research.

BOUNDARY JUSTIFICATION: Pending evaluation - will encompass area described in scientific literature.

SITE INFORMATION SUMMARY

SITE NAME: Slumgullion Earthflow

LOCATION: T43N, R4W, S12 - 15
County: Hinsdale
USGS 7.5′ Quad: Lake San Cristobal
Two miles southeast of Lake City on Highway 149.

SIGNIFICANT FEATURES: The area contains an excellent example of a large translational landslide complex, well developed in an area which has many landslides in volcanic rocks that overlie the Cretaceous Mancos Shale. The instability of the earthflow results from the hydrothermal alteration of the basalt cap overlying the volcanic tuffs. These areas have been transformed to unstable muds. The area was glacially steepened, contributing to the instability. The first of these massive landslides occurred about 700 years ago when a huge mass of volcanic rock, perhaps saturated with water from rain and melting snow, slumped from a glacial cirque on the northeastern edge of the Lake City Caldera on Cannibal Plateau at an elevation of 11,500 feet. The mass flowed like a viscous liquid down a tributary valley to the Lake Fork of the Gunnison River where it spread out and dammed the Lake Fork of the Gunnison River to form Lake San Cristobal. This earthflow is about four miles long. A more recent active landslide began about 300 years ago and overrides the older earthflow. The active flow is about 2.4 miles long and 500 - 1000 feet wide. Movement of the younger earthflow, as great as 20 feet per year in some areas, causes trees on the landslide surface to lean in various directions.

Although this kind of feature is not uncommon in alpine Colorado, the Slumgullion Earthflow is one of the most visible to the general public and is unusual in that its movement has dammed the Lake Fork - Gunnison River to form Lake San Cristobal.

GENERAL DESCRIPTION: The sparse vegetation is representative of montane forest communities. Soil coloration varies from yellow to orange to brown.

AREA: Approximately 1600 Acres

OTHER SIGNIFICANT VALUES: The area was initially recommended as a BLM Wilderness Study Area (later dropped from further consideration due to size) and as a National Natural Landmark by the National Park Service. The U. S. Forest Service has designated the area it manages on the Slumgullion Earthflow as a Special Geologic Interest Area. The Colorado Natural Areas Program has designated the U. S. Forest Service land on the Slumgullion Earthflow as a Colorado Natural Area.

GAG RECOMMENDATION: RNA-ONA — Research Natural Area or Outstanding Natural Area for scientific value, continuing scientific research activity, and educational and interpretive value. The earthflow is nationally recognized as a textbook example of mass wasting phenomena. USGS has done research on the earthflow.

BOUNDARY JUSTIFICATION: The area includes the major part of the earthflow which occurs on public land. Colorado Highway 149 cuts through the earthflow. Public access is easy; several highway pullouts permit easy observation of the earthflow. Slumgullion Earthflow (BLM) was registered in 1984 by the Colorado Natural Areas Program. Slumgullion Earthflow (USFS) was registered in 1980 and designated in 1983 as a Colorado Natural Area by the Colorado Natural Areas Program.

SITE INFORMATION SUMMARY

SITE NAME: Ute Indian Fault Zone and Geologic Area

LOCATION: T15S, R94W; T50-51N, R9W
County: Delta, Montrose
USGS 7.5' Quad:
Access by trails, dirt roads, and river from U.S. 550 near Olathe.

SIGNIFICANT FEATURES: This well exposed fault zone trends north along the lower Black Canyon of the Gunnison River in the Gunnison Gorge National Recreation Area, crossing and re-crossing the river, and is one of the best exposed fault zones in Colorado. The canyon includes a inner rim topping the dark Precambrian metamorphic and igneous core of the canyon and an outer rim topping the overlying brightly colored Jurassic and Cretaceous sedimentary rocks. The main structural feature in the area is a series of spectacular low-angle faults that have thrust the Precambrian granitic rocks over the brightly colored Mesozoic reocks, particularly over the Entrada Sandstone. The fault planes themselves are exposed in several places. Associated with the these faults are spectacular monoclinal folds formed where the crustal displacement has been taken up by flexing. The faults in places pass laterally as well as vertically into such folds and thus demonstrate exceptionally well the tectonic forces and geologic processes that accompanied the uplift of the Rocky Mountains 65 million years ago. The area is one of the best places in the Rocky Mountains to view such faults.

GENERAL DESCRIPTION: The area is at the northwest end of the Gunnison Uplift and contains a semi-arid desert shrubland association — desert holly, ephedra, yucca, serviceberry, and sagebrush dominate. Jurassic and Cretaceous rocks overlie Precambrian metamorphic and igneous rocks. The outer rims of the canyon are capped by Dakota sandstone. The inner rims of the canyon are Precambrian rocks. The area contains many interesting metamorphic features. The elevation differential ranges from 5,200 feet at river level to 8,000 feet at Green Mountain, with corresponding vegetation ranges. The area is very scenic, and the rocks are very well exposed in cliffs and steep slopes. Parts of the area are accessible by rough jeep trails, others by river raft or foot trails. Small private land in-holdings at south end of the area.

AREA: 19,000 Acres

OTHER SIGNIFICANT VALUES: This scenic and isolated area has substantial fishing and white-water recreational values.

GAG RECOMMENDATION: ONA - Outstanding Natural Area for approximately 1,800 acre area of Chukar Canyon which abuts the boundary of the Black Canyon of the Gunnison National Monument. SMA-special management area for 17,000 acres of the Gunnison Gorge for geologic features.

BOUNDARY JUSTIFICATION: ONA boundaries should extend to the Dakota sandstone rims of the canyon. (see photo next page)

Ute Indian Fault Zone

Photo: W. R. Hansen, USGS

APPENDICES

APPENDIX A

GEOLOGIC ADVISORY GROUP

Armstrong, Harley J.

M.B.S., Museum Studies, University of Colorado, 1982.
Curator of Paleontology, Museum of Western Colorado, Grand Junction, Colorado, (1985-Present).
Instructor, Mesa State College, Grand Junction,(1984).
Project archaeologist/paleontologist, Grand River Institute, Grand Junction, (1978-1985).
Research intrests include Colorado paleontology, especially Jurassic and Cretaceous dionsaurs.

Athearn, Frederic J.

Ph.D., History, University of Texas at Austin, 1974.
Bureau of Land Management, Paleontology Program Manager (1984-Present).
Bureau of Land Management, Cultural Resources Program Manager (1984-Present).
Bureau of Land Management, Natural History Program Manager (1981 - 1987).
Bureau of Land Management, State Historian,Colorado State Office (1975 - Present).
Instructor, University of Colorado, Boulder, 1974-1976.
Instructor, University of Colorado, Denver, 1974.
Instructor, University of Texas, Austin, 1969-1972.
Consultant, Santa Clara University, California, 1973-1974.
Consultant, Utah State Historical Society, Salt Lake City, Utah, 1973.

Braddock, William

Ph.D., Geology, Princeton University, 1959.
Professor, Department of Geological Sciences, University of Colorado (1956 - Present).
Research Geologist. U.S. Geological Survey (parttime, 1952 - present). Geological mapping of northern Colorado FrontRange.
Research and teaching interests are in regional and structural geology.

Davis, Henry E.

B.S., Range/Watershed Management, Utah State University, 1952.
Director of Land and Reserve Development, Peabody Coal Company - Rocky Mountain Division. ...Responsible for acquisition and disposal of surface and coal lands and for coal related exploration and development activities in Colorado, Montana, New Mexico, Utah, and Wyoming.
Mining engineer (Missouri), Area mining engineer(Illinois and Ohio), Land agent (Western Division), Peabody Coal Company (31 years service).
Range Conservationist, Bureau of Land Management (1952 - 1954).

Ellingson, Jack A.

Ph.D., Geology, Washington State University, 1968.
Professor and chairman, Department of Geology, Fort Lewis College (1970 - Present).Teaching and research interests include mineralogy, igneous and metamorphic petrology, and structural geology. NSF Research Grant (1981).Fellow, Geological Society of America.

Evanoff, Emmett

Ph.D., Geology, University of Colorado, (in progress).
M.S., Geology, University of Colorado, 1983.
M.S., Geology, University of Wyoming, 1978.
Graduate student, Department of Geology, University of Colorado (1981 - Present).
Instructor, Department of Geology, University of Colorado (1984).
Research interests are in the paleontology of Cenozoic nonmarine mollusks, Cenozoic stratigraphy of the Rocky Mountains, and fluvial sedimentology. Research projects have included the paleontology of Paleocene and Pleistocene nonmarine mollusks from Colorado, Wyoming, and Montana.
Dissertation topic: Oliogocene nonmarine mollusks of the White River Formation in central Wyoming and northwest Nebraska.

Fischer, William A.

Ph.D., Geology, University of Colorado, 1953.
Emeritus Professor of Geology, Colorado College (1982 - Present)
Instructor - Professor and Chairman, Department of Geology, Colorado College (1949 - 1982).
Consultant (1955 - 1982).
Ford Foundation Fellow, Scripps Institution of Oceanography (1953).
Research interests include morphology and evolution of trace fossils and primitive vertebrates.

Hansen, Wallace R.

B.S., Geology, University of Utah, 1941.
U. S. Geological Survey, Research Geologist: Southern Rocky Mountains, Colorado Piedmont, Colorado Plateau (1946 - Present). Outstanding performance award, USDI (1958).Past President, Colorado Scientific Society (1966) and Lifetime Honorary Member (1976).
Editor, Association of Engineering Geologists (1971 - 1973).
Meritorious Service Award, U.S. Department of the Interior 1969).
Distinguished Service Medal, USDI (1979).
More than 100 published reports and geologic maps on Rocky Mountain region, New England, Alaska, and elsewhere.

Herrick, Rodney.

M.S. Geology, University of Wyoming, 1972
Geologist, Bureau of Land Management, Craig District Office, 1983-Present. (Mining Law, Paleontology, Mineral Materials).
Geologist, Bureau of Land Management, Colorado State Office, 1980-1983.
Geologist, U.S. Forest Service, Grand Mesa-Uncompaghre National, Gunnison National Forests, 1977-1980.

Holden, Gregory S.

Ph.D., Geology, University of Wyoming, 1977.
Associate Professor, Department of Geology, Colorado School of Mines (1978 - Present).
Teaching: Petrology and Field Methods; Advanced Igneous Petrology.
Research: Metasomatic reactions in limestones, metamorphic conditions and systematics in Colorado's Front Range.

Johnson, James.

Ph.D., Geological Sciences, University of Colorado, 1979
Professor, Department of Geology, Mesa State College, 1967-Present.
Research Associate, INSTAAR-MRS, Summers 1969-1974.
NSF Science Faculty Fellowship, 1972.
Director, Mountain Research Station, INSTAAR, University of Colorado, Summer, 1978.
Sabbatical Visitor, ETH Zurich and University of Bern, 1981.
Distinguished Faculty Award, Mesa College, 1983.
Consulting Geologist, 1968-Present

Kauffman, Erle G.

Ph.D., Geology, University of Michigan, 1961.
Professor and Chairman, Department of Geological Sciences, University of Colorado (1981 - Present).
Curator, Department of Paleobiology, U.S. National Museum (Smithsonian Institution) (1960 - 1980).
Adjunct Professor of Geology, George Washington University (1962 - present).
Visiting Professor of Geology, Oxford University, England (1970 - 1971).
Visiting Professor of Geology, University of Tubigen, Germany (1974).
Fellow, Geological Society of America.
President, Paleontological Society (1982).
"Scientist of the Year" Award, Rocky Mountain Association of Geologists (1977).
Distinguished Lecturer, American Association of Petroleum Geologists (1984).
Current research projects include: (a) study of the evolution of benthec marine communities since the Jurassic; (b) study of extinction, especially massive and/or catastrophic extinction of its causes in the Mesozoic and the Cenozoic; (c) study of evolution of biogeographic units in relation to plate tectonics and paleoclimate and paleoceanographic evolution in the Mesozoic and early Cenozoic.

Kuntz, David W.

M.A. Geography, University of Colorado.
M.A. History, University of Colorado.
B.A. History, St. Olaf College.
Program Director, Colorado Natural Areas Program, 1985-Present.
Researcher, Colorado Department of Natural Resources,1980, 1982-1985.
Consultant, National Wildlife Federation, Natural Resources Clinic, University of Colorado, 1982-1983.
Resource Policy Analyst, Fred C. Hart Associates, Denver, Colorado, 1981

Lindsey, K. Don.

M.A., Zoology, University of Colorado, 1971.
Curator of Paleontology, Denver Museum of Natural History (1971 - 1984).
Research Interests: Mesozoic, mammals and dinosaurs and field excavations of Jurassic mammals and dinosaurs.

Madsen, James H.

M.S., Geology, University of Utah, 1969.
Utah State Paleontologist, Division of State History, Salt Lake City, Utah, and Adjunct Curator of Vertebrate Paleontology, Utah Museum of Natural History (1977 - 1988).
Principal Investigator, Cleveland - Lloyd Dinosaur Quarry, Utah - National Natural Landmark (1971 - Present).
Curator of Vertebrate Paleontology, Utah Museum of Natural History, and Curator and Assistant Research Professor, Department of Geological and Geophysical Sciences, University of Utah (1970 - 1977).
Paleontological Consultant (1969 - Present).

Maytum, James R.

M. S., Geology, University of California, San Diego,1967.
Regional Exploration Manager, Champlin Petroleum Company.
Various technical and managerial assignments with Texaco Oil Company and Champlin Oil Company (1966 - present). Major responsibilities include all phases of exploration geology, geophysics, and land operations in Western United States, Canada, and foreign countries.

McCallum, M. E.

Ph.D., University of Wyoming, 1964.
Professor of Geology, Department of Earth Sciences, Colorado State University (1962 - Present). Teaching and research interests include igneous and metamorphic petrology and strucutre, and mineral resources.
Fellow, Geological Society of America.
Fellow, Mineral Society of America.

Meyer, P. A.

B.S., Geological Engineer, Colorado School of Mines, 1950.
Consulting Geological Engineer (1983 - Present).
Chief Geologist, Rocky Mountain Energy Company (mining subsidiary of Union Pacific Corporation) (1957 - 1983).
Regional Geologist, Climax Molybdenum Company (1957 - 1967).

Middleton, Michael D.

Ph.D., Geology, University of Colorado, 1983.
Assistant Professor, Department of Geology, University of Wisconsin - River Falls (1984 - Present).
Research interests in mammalion evolution spanning the Cretaceous-Tertiary boundary, and the geology and paleontology of the Denver Basin.

Neel, Robert

M.S., Geology, University of Rochester, 1951.
Manager of Lands, NICOR Mineral Ventures, Denver (1984 - Present).
Consultant, National Park Service, San Francisco (1972- 1973).
Exploration Geologist, Bear Creek Oil Company, Spokane.
District Manager and Geologist, Shell Oil Company - Rocky Mountain Region (1957 - 1965).

O'Finan-Hanas, Elizabeth

B.A., Geology, Mesa College, 1980.
Geologist, Bureau of Land Management (Colorado - Grand Junction Resource Area) (1983 - Present).Responsible for leasable minerals and development of procedures for implementing paleontological program into multiple-use resource planning.
Geologist, Bureau of Land Management (Colorado - Grand Junction District) (1978 - 1983). Responsible for environmental assessments related to saleable minerals and patented mining claims.

Prather, Thomas L.

Ph.D., Geology, University of Colorado, 1964.
Professor of Geology, Western State University (1965 - Present).
Research and teaching interest in regional and structural geology.

Robinson, Peter

Ph.D., Geology, Yale University, 1960.
Professor and Curator of Geology, University of Colorado -Museum (1961 - Present).
Director, University of Colorado - Museum (1971 - 1982).
Research interests include vertebrate paleontology with emphasis on the morphology and evolution of mammalian fauna.

Sauvage, Carlos

B.A., Outdoor Recreation Administration, Colorado State University, 1974.
Bureau of Land Management, Recreation Planner (Wyoming, Utah, Colorado) (1974 - Present). Responsible for all aspects of recreational use on federal lands in Grand Junction Resource Area, including evaluation of scenic and visual qualities of geologic features.

Shropshire, Kenneth Lee

Ph.D., Geology, University of Colorado, 1974.
Professor, Department of Geology, University of Northern Colorado (1965 - Present).
NSF Science Faculty Fellowship (1972).
Consulting Geologist (1965 - Present).

Soule, James M.

M.S., Geology, University of New Mexico, 1971.
Senior Engineering Geologist, Colorado Geological Survey (1974 - Present). Directed studies of geologic hazards and related problems in Colorado, particularly slope stability problems related to land use planning.
Project Geologist, U.S. Geological Survey (1972 - 1974). Studies of ground resource in the Colorado Front Range.

Sprouse, Benjamin

B.S., Geology, University of Southern Colorado, 1975.
Geologist, Bureau of Land Management (Oregon - Coos Bay Resource Area) (1975 - 1980), (Colorado - Gunnison Basin Resource Area) (1981 - 1984). Colorado - Montrose District) (1984 - Present). Responsible for all aspects of mineral resource management, emphasizing coal and hard rock minerals.

Underwood, Roger

B.S., Geology, Oklahoma State University, 1968.
Geology, University of Missouri (1968 - 1971).
District Geologist, Bureau of Land Management (North Dakota, and Canon City, Colorado) (1973 - Present). Responsible for managing federal minerals, including review of leases, claims, saleable minerals, and environmental impact assessments.

Wilkinson, James

B.S., Geology, Texas A&M University, 1968.
District Geologist, Bureau of Land Management (Arizona, Montana, Alaska, Colorado) (1972 - Present). Responsible for managing federal minerals, including review of leases, claims, saleable minerals, and environmental impact assessments.
Geological consultant (1971 - 1972).

Witherbee, Kermit

M. A., Geology, State University of New York, 1974.
Bureau of Land Management (Colorado State Office), Lead Petroleum Geologist (1984 - Present).
Bureau of Land Management, Area and District Geologist (1982 - 1984).
Minatome Corporation, Project Manager (1979 - 1982).
Power Resources Corporation, Exploration Geologist (1977 - 1979).
Bureau of Land Management (Wyoming State Office), Geologist (1976 - 1977).
Consulting Geologist (1974 - 1976.

APPENDIX B

GUIDELINES FOR IDENTIFICATION OF GEOLOGIC FEATURES ON BLM LANDS IN COLORADO

Purpose

The Geologic Advisory Group makes recommendations to the Bureau of Land Management on the importance of geologic features on lands which BLM manages in Colorado. Final recommendations of the Geologic Advisory Group includes: (1) information on geologic sites of statewide or national significance occurring on lands in Colorado managed by BLM; (2) justification for the ranking of high priority sites; and (3) recommended management alternatives for the high priority sites.

Guideline Criteria

The following general criteria are used to evaluate each geologic feature or site.

1) Site is not expected to be lost due to natural catastrophe, development, land use change, or errors in management.
2) Site represents an unusual geologic feature or is of statewide or national significance.
3) Site has significant fossil evidence illustrating the development of life (see addendum: paleo guidelines).
4) Site is an example of scenic grandeur, high aesthetic value, or unusual natural features.
5) Site exhibits or possesses classic research or educational opportunities.

Scientific Values

1. **Quality of the site**
   Site contains an excellent example of a geologic feature or process which is particularly well-suited for research, teaching, or interpretive use (e.g., faulting, folding, mass wasting phenomena, stratigraphic sequence, history of life on earth).
2. **Condition of the site**
   Site is relatively free of disturbance, can withstand some land uses, or is adequately protected from disturbance. The compatibility of mining or other land uses with the identified scientific values will be evaluated on a site-by-site basis.
3. **Viability of the site**
   Condition of the site can be maintained in the future with appropriate management.
4. **Defensibility of the site**
   Site is geographically or topographically removed from areas of development where possible, or has a small likelihood of being in the path of development, or protective management can be implemented through the BLM planning process where natural values outweigh development values. Site will be designed to minimize potential conflicts with existing land uses. Factors taken into consideration include existing oil and gas development on the site, existing roads and access routes, existing or proposed mineral development, grazing, and recreational use.

Recommended Management

Site will be ranked by the advisory group according to the above criteria. Justification for the ranking on each site will be included in the recommended management alternatives. Areas will be considered for three designated area categories: research natural area, outstanding natural area, and area of critical environmental concern.

Research Natural Areas

Research Natural Areas are defined in 43 CFR 8223.0-5 as areas "established and maintained for the primary purpose of research and education because the land has . . . the following characteristics . . . (4) a typical representation of common geologic, soil, or water features; or (5) outstanding or unusual geologic, soil, or water features." Natural areas shall be used in a manner consistent with the purpose for which the area is designated. "The area shall be used by scientists and educators in a manner which is nondestructive and consistent with the purpose of the research natural area."

Outstanding Natural Areas

Outstanding Natural Areas are established to preserve scenic values and areas of natural wonder. The preservation of these resources in their natural condition is a primary management objective of BLM. Outstanding Natural Areas, as defined in 43 CFR 2071.1 (IV), are "areas of outstanding scenic splendor, natural wonder, or scientific importance that merit special attention and care in management to insure their preservation in their natural condition." These areas are relatively undisturbed and "representative of rare botanical, geological, or zoological characteristics of principal interest for scientific and research purposes."

Areas of Critical Environmental Concern (ACEC)

An area of critical environmental concern is an area "within the public lands where special management attention is required to protect and to prevent irreparable damage to important historic, cultural or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life and safety from natural hazards" (FLPMA, sec. 103(a), 1976). BLM regulations require that identification of potential ACECs shall be given "priority" in the "inventory of all public lands and their resource and other values." The identification of potential ACECs "shall not change or prevent change of the management or use of public lands." A potential ACEC must meet the following criteria:

1) **Relevance.** The area contains a significant historic, cultural, or scenic value; a fish or wildlife resource or other natural system or process; or natural hazard.
2) **Importance.** The area shall have "substantial" significance and values. This criterion generally requires qualities of more than local significance and special worth, consequence, meaning, distinctiveness, or cause for concern. A natural hazard is important if it is a threat to life or property.

Site Inventories

Inventoried sites will include those areas on BLM lands which are currently used for educational and research purposes, sites identified in the literature or reports (e.g., "Natural Landmarks of the Southern Rocky Mountain Region, National Park Service), and sites recommended by BLM and participating geologists.

PALEO GUIDELINES

I. Guidelines for Significant Paleontological Resources*

For purpose of these guidelines, significance is defined as the estimation of scientific or educational importance of paleo materials. Fossil material which satisfies the following criteria is considered significant.

A. Materials Inventoried

1) Vertebrate material
   a. complete skull and/or jaw
   b. articulated or complete skeleton
   c. concentration of vertebrate material
   d. unique or rare occurrence. intimate association with paleo environment
2) Invertebrate material
   a. good-excellent preservation of shell material
   b. concentrations of diverse material
   c. intimate association with paleo environment
   d. stratigraphic sequence
3) Plant material
   a. well preserved plant material
   b. petrified wood
   c. fossil stumps
   d. intimate association of fossil plant and animal materials

B. Functional Analysis

The functional analysis consists of reviewing the inventoried materials and establishing the importance of mitigation or the need for alternatives.

1) Does material contribute to faunal or floral lists?
2) Does the material significantly contribute to the systematics of the group or groups collected?
3) Does the material contribute to our knowledge of the functional anatomy of the organism?
4) Does the material contribute to our knowledge of biostratigraphy, paleoecology, or taxonomy of the occurring organisms?
5) Does the material possibly contribute to a potential museum exhibit?

C. Criteria Used for Determination of Need for Mitigation

1) complete (i.e., greater than 75%) skeleton(s)
2) skulls and/or articulated material
3) whole isolated bones
4) significant concentration of fragmentary but identifiable elements; in general, significant would be 40 - 50 elements/ton of matrix or 10 fragments /m surface

* The paleo guidelines are adopted from similar guidelines used by the State of New Mexico Energy and Minerals Department for determining mitigation of impacts on paleontological resources from coal mining.

* U.S. GOVERNMENT PRINTING OFFICE: 1989--674-689