

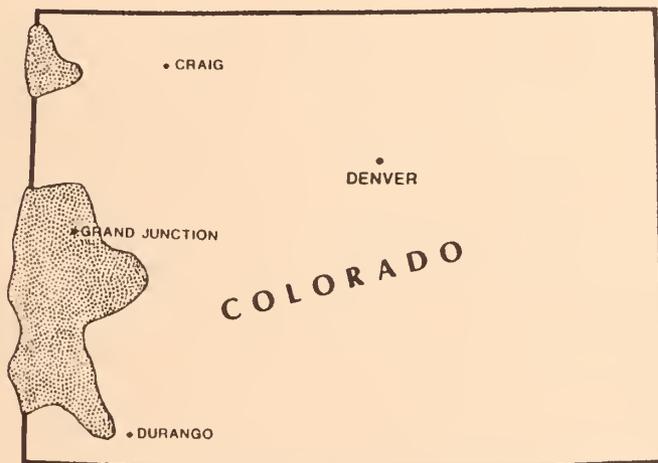


## FINAL REPORT

# PHASE 1: GEM

(GEOLOGICAL, ENERGY and MINERALS)

## RESOURCE ASSESSMENT FOR REGION 4, COLORADO PLATEAU



SUBMITTED TO:  
U.S. DEPARTMENT OF THE INTERIOR  
BUREAU OF LAND MANAGEMENT  
DENVER SERVICE CENTER  
DENVER, COLORADO 80225



**MSME/WALLABY ENTERPRISES**  
A JOINT VENTURE OF  
MOUNTAIN STATES MINERAL ENTERPRISES, INC.  
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# FINAL REPORT

## PHASE 1: GEM

(GEOLOGICAL, ENERGY and MINERALS)

## RESOURCE ASSESSMENT FOR REGION 4, COLORADO PLATEAU

MENEFEE MOUNTAIN – WEBER MOUNTAIN AREA

GRA 11

SUBMITTED TO:  
U.S. DEPARTMENT OF THE INTERIOR  
BUREAU OF LAND MANAGEMENT  
DENVER SERVICE CENTER  
DENVER, COLORADO 80225



MAY 1983



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## FOREWORD

This report is one of a series of eleven reports addressing the Wilderness Study Areas (WSA's) located in what has been designated as the Colorado Plateau, Region 4, by the Bureau of Land Management (BLM), Denver Federal Center. The study was under the direction of Mr. Robert J. Coker, the Contracting Officer's Authorized Representative (COAR).

The WSA's have been segregated into eleven G-E-M (Geology, Energy, Minerals) Resources Areas (GRA's). Each designated GRA constitutes one report. The purpose of these reports is assess the potential for geology, energy, and mineral (GEM) resources existing within a WSA and GRA. This information will then be used by BLM geologists in completing the assessment for GEM resources potential within the WSA's, and for the integration with other resource data for the decision on suitability for recommendation of the respective WSA.

The reports were developed and prepared by the Joint Venture team of MSME/Wallaby Enterprises, Tucson, Arizona, by Patricia J. Popp (Geologist), and Barbara J. Howie (Geologist) under the direction of Eric A. Nordhausen (Project Manager) and Richard Lundin (Principal Investigator), under BLM Contract No. YA-553-CT2-1041.

Consulting support was provided by a highly specialized geological team composed of: Ted Eyde, Dr. Paul Gilmour, Dr. Robert Carpenter, Dr. Donald Gentry, Dr. Edger Heylman, Dr. Larry Lepley, Annon Cook, Walter Heinrichs, Jr., and Charles Campbell. Their contribution is both acknowledged and appreciated. The work of Dr. Gilmour, Mr. Cook and Dr. Lepley should receive special acknowledgement. It was from the work of these consultants that this report on the Menefee Mountain-Weber Mountain GRA was able to be completed.

## EXECUTIVE SUMMARY

The BLM has adopted a two-phase procedure for the integration of geological, energy and minerals (GEM) resources data for suitable/nonsuitable decisions for wilderness study areas (WSA's). The two-phased approach permits termination of a GEM resources data gathering effort at the end of Phase One. The objective of this Phase One GEM resources assessment is the evaluation of existing data (both published and available unpublished data) and their interpretation for the GEM resources potential of the WSA's included in each region. Phase Two is designed to generate new data needed to support GEM resources recommendations.

Over 10 million acres of WSA's require GEM resources data input. These WSA's are unequally distributed in the eleven western states of the coterminous United States. The WSA's are grouped in six large regional areas. The WSA's within the western part of Colorado, and a few crossing into Utah, were included as region 4, also known as the Colorado Plateau Region. Except for one small area at the southwest extreme of the region and another at the north extreme, the region is within the northern half of the known Colorado Plateau physiographic province.

The 32 WSA's within Region 4 encompass 474,620 acres. These have been geographically segregated within 11 designated GEM Resource Areas (GRA's). This report addresses the Menefee Mountain-Weber Mountain area, GRA 11. Included in the GRA is the Menefee Mountain WSA (CO-030-251), and the Weber Mountain WSA (CO-030-252).

The physiography of the GRA includes valley, plateau, and canyon areas along the courses of the Mancos River, Lost Canyon Creek, and La Plata River. The rock units present are all sedimentary. Faults and shear zones in the GRA are thought to be responsible for localizing oil and gas.

The energy and mineral resources include coal, gas, uranium and vanadium, precious and base metals, construction stone, and sand and gravel. Both the coal and gas have been produced from Cretaceous units.

The uranium and vanadium occur in Jurassic rock units. Precious and base metals are produced in the East Mancos Mining District from quartz fissure veins in Jurassic Formations. Construction stone is produced from various sedimentary units. Sand and gravel consists of deposits in valley areas and along fluvial systems.

There are no known deposits in the Menefee Mountain WSA and Weber Mountain WSA. Each WSA does contain a few coal prospects.

The classification for the leasable minerals, locatable and salable resources varies. There is high favorability in both WSA's for leasable resources in the form of oil, gas, coal, gypsum, salts, potash and brines. Each WSA has moderate favorability for locatable minerals in the form of uranium and vanadium. Salable resources in each WSA shows high favorability for structural and bentonitic clays, and limestone.

Overall, it is recommended that each WSA in the GRA receive additional work to determine the full economic potential of each area. This work should include further research in the unpublished and proprietary literature, a detailed program of geologic mapping and sampling, and additional geochemical and stratigraphic studies to confirm the occurrence or lack of geology, energy or mineralized commodities.

## SECTION I

### INTRODUCTION

The Menefee Mountain-Weber Mountain GRA (Figure I-1) is located in La Plata and Montezuma Counties, Colorado. The GRA encompasses two Wilderness Study Areas (WSA's) (CO-030-251 and CO-030-252).

The GRA area is located approximately 120 miles south of Grand Junction, Colorado and includes portions of the Southern Ute Indian Reservation and Mesa Verde National Park. Within the GRA is the major regional supply center of Cortez, Colorado, and a number of small towns. These towns are local supply centers for agriculture, ranching, livestock herding, mining, oil and gas exploration and development activities. Some of the smaller settlements in the GRA (Mancos, Dolores & Lebanon) also serve as local supply and distribution centers for the oil, gas and coal operations in the area.

The area includes all or portions of Townships 33-37 North, Ranges 12-16 West. The entire GRA is bounded by west longitudes 108° 09' 54" to 108° 37' 14" and north latitudes 37° 08' 07" to 37° 29' 08". It contains approximately 553 square miles (1,574 square kilometers or 353,930 acres) of Federal, state, tribal and private lands. The Bureau of Land Management portion of these holdings are under the jurisdiction of the Montrose District and San Juan Resource Area Offices.

The specific WSA's within the GRA have a total of 13,680 acres of Federal land. The acreages of the various contained WSA's are:

Menefee Mountain (CO-030-251) - 7,360 acres  
Weber Mountain (CO-030-252) - 6,320 acres

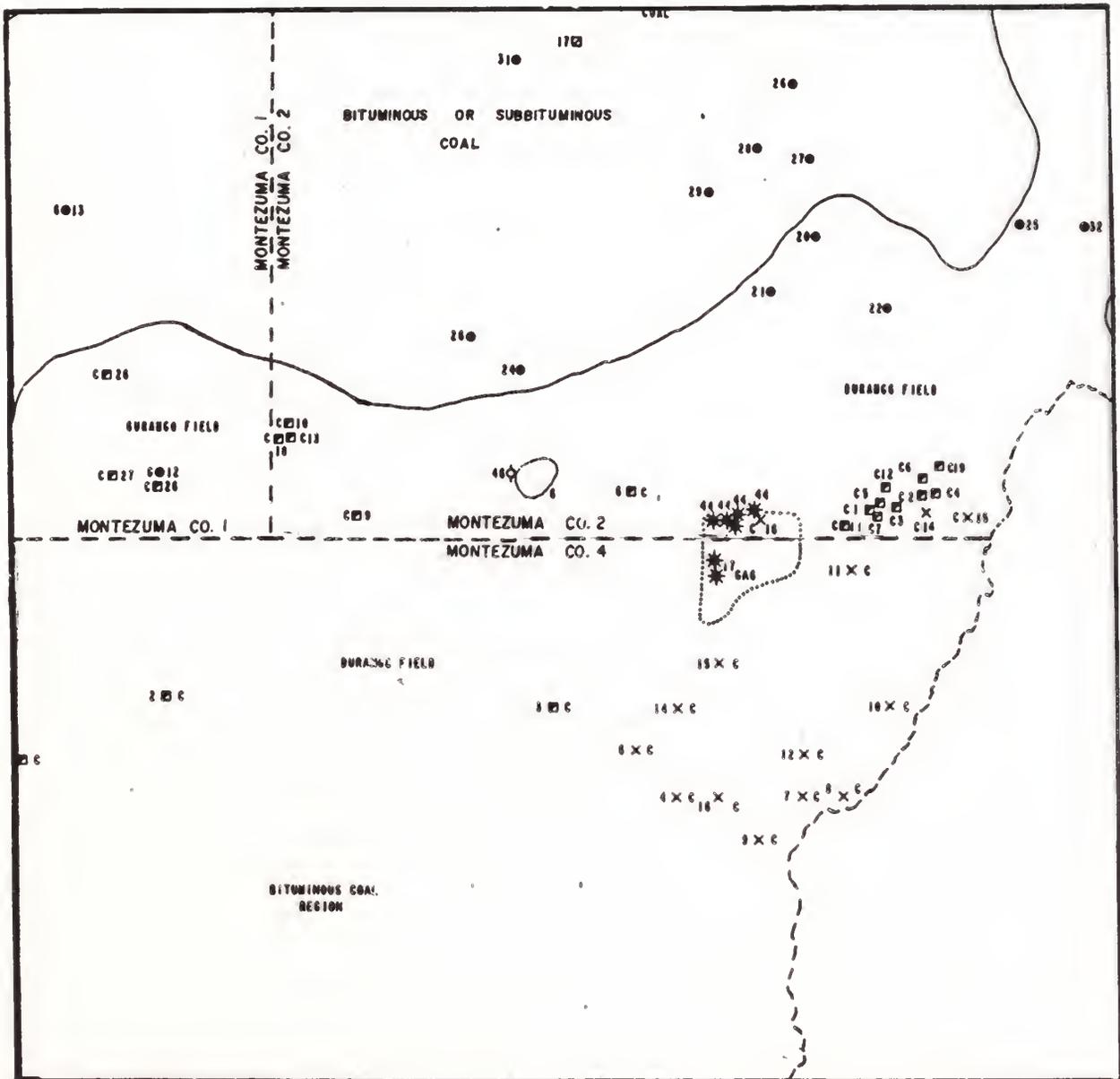
The Menefee Mountain-Weber Mountain WSA's are both located in the east-central portion of the GRA, and are approximately 150 miles south of the nearest major regional urban center, Grand Junction, Colorado. These units are approximately 15 miles east of Cortez, Colorado and 20 miles west of Durango, Colorado.

Due to the lack of available data on each WSA, emphasis was placed on gaining an understanding of the mineral potential of each WSA within the GRA. Information on the mineral resources of GRA was utilized to extrapolate and estimate the potentials of the WSA's from the existing data that in most cases, referred only indirectly to the WSA's. The purpose of this contract was to utilize the known geological information within each WSA and GRA to ascertain the GEM resource potential of the WSA's. The known areas of mineralization and claims have been plotted as overlays to Figure I-1.

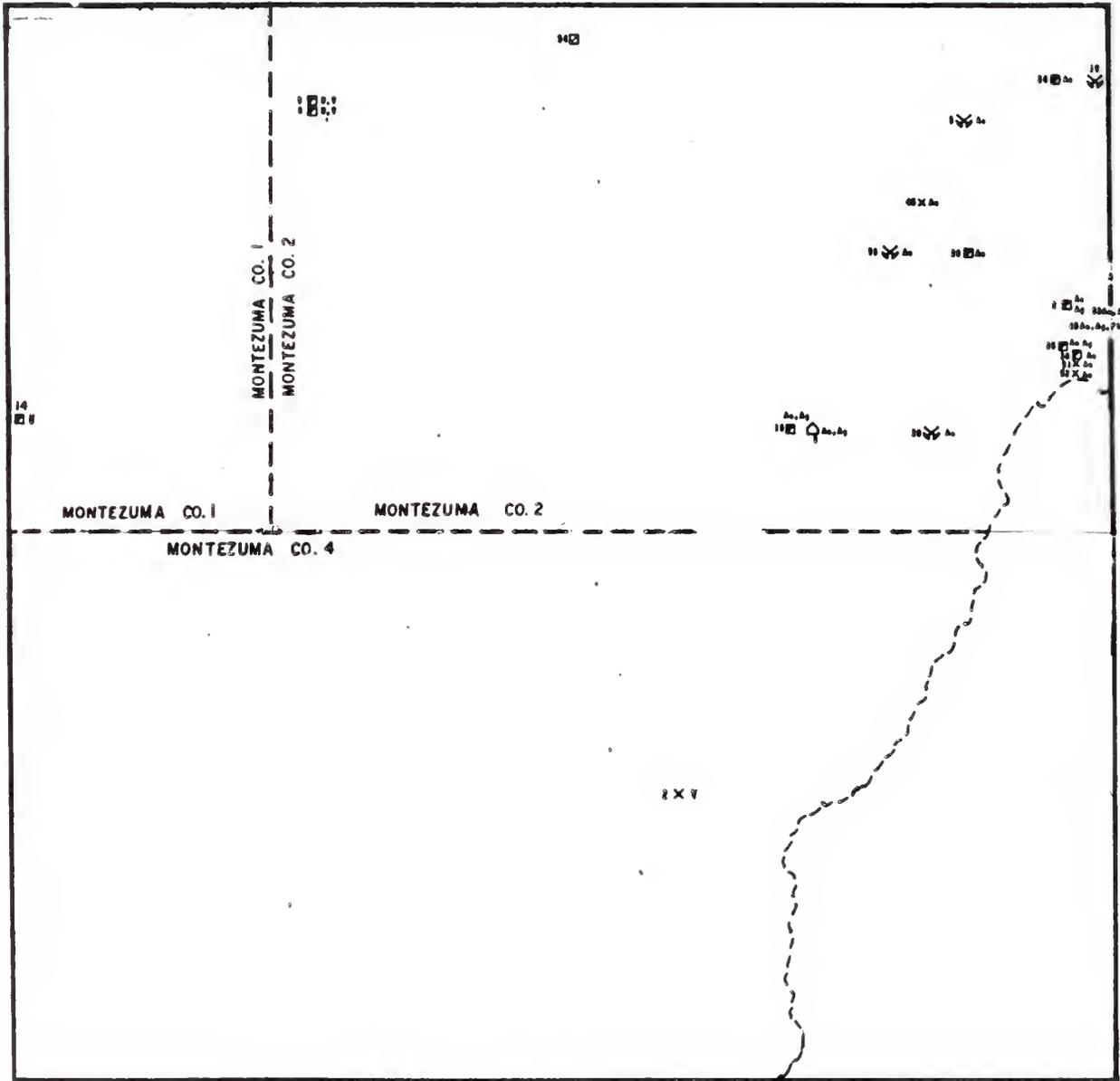
The information contained in this report was obtained from published literature, computerized data base sources, Bureau of Land Management File Data, and certain company files and returned data sheets. The information was compiled into a series of files on each WSA and a series of maps that covered the entire western portion of Colorado. After a thorough review of the existing data, a program of field checking was carried out by MSME/Wallaby's team of experts. Field investigations in the GRA were carried out by Dr. Paul Gilmour and Mr. Annan Cook during the period of August 30 - September 2, 1982.

All of these individuals are registered professional geologists and associates of MSME/Wallaby. Further analysis and study was provided through the photographic interpretation services of BLM 1:24,000 aerial photos by Dr. Larry Lepley, registered professional geologist and remote sensing specialist. The aerial photos used are included in Appendix A.

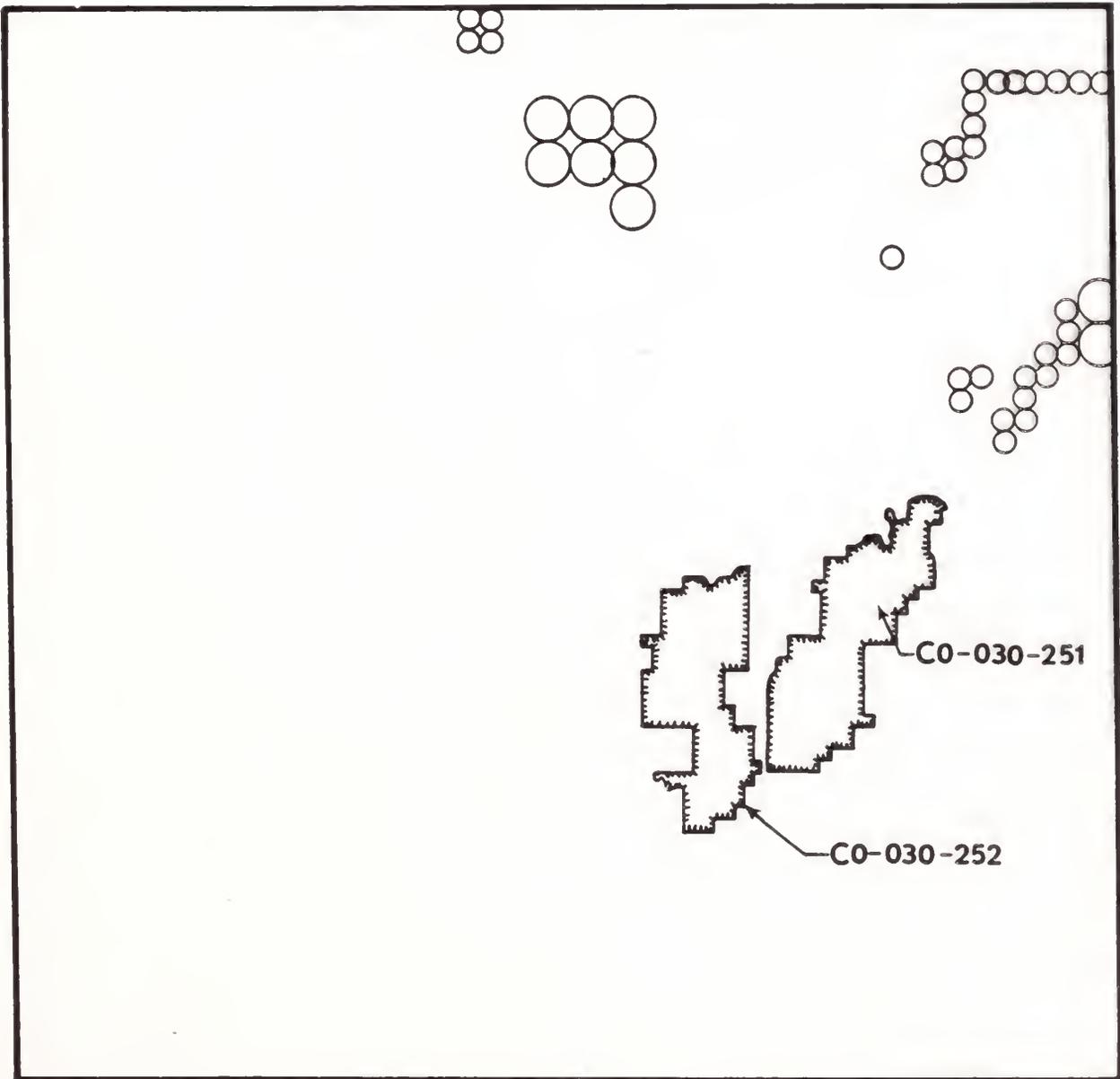




OVERLAY C  
COAL, OIL AND GAS



OVERLAY B  
MINES, PROSPECTS  
AND MINERAL OCCURENCES



OVERLAY A  
PATENTED AND UNPATENTED  
CLAIMS AND WSA BOUNDARIES

15W

14W

13W



37N

36N

35N

(Haynes et al, 1976)

## MENEFEE MOUNTAIN/WEBER MOUNTAIN GRA



SCALE 1:250,000

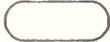
FIGURE I-1  
GEOLOGIC MAP

## EXPLANATION

|   |  |   |
|---|--|---|
| Quaternary<br>(Approximately<br>2 million years<br>before present<br>(mybp) to present) | Qae  | Alluvial and eolian deposits  |
|   | Qa   | Alluvial deposits   |
|   | Qap  | Pediment gravels  |
|   | Qc   | Colluvial deposits  |
|   | Qct  | Talus   |
|   | Qcl  | Landslide deposits  |
|   | Qat  | Terrace gravels   |
| Cretaceous<br>(Approximately<br>135-62 mybp)  | Kmvg   | Mesaverde Group   |
|   | Kmvu   | Upper part of Mesaverde Group   |
|   | Kc   | Castlegate Sandstone  |
|   | Kb   | Upper member of Blackhawk Formation   |
|   | Kmv  | Mesaverde Formation   |
|   | Kmf  | Menefee Formation   |
|   | Kmvr   | Mesaverde Formation, Rollins Sandstone Member                                 |
|   | Kmb  | Buck Tongue of the Mancos Shale   |
|   | Km   | Mancos Shale, undifferentiated  |
|   | Kmu  | Mancos Shale, upper shale Member  |
|   | Kmfe   | Mancos Shale, Ferron Sandstone Member   |
|   | Kml  | Mancos Shale, lower shale Member  |
|   | Kd   | Dakota Sandstone  |
|   | Kbc  | Burro Canyon Formation  |
| Kdb   | Dakota Sandstone and Burro Canyon Formation                |   |
| Kmdb  | Mancos Shale, Dakota Sandstone, and Burro Canyon Formation |   |
| Jurassic<br>(Approximately<br>195-135 mybp)   | Jm   | Morrison Formation  |
|   | Jmb  | Morrison Formation, Brushy Basin Shale Member                                 |
|   | Jms  | Morrison Formation, Salt Wash Sandstone Member                                |
|   | Js   | Summerville Formation   |
|   | Jem  | Entrada Sandstone, Moab Sandstone Member                                      |
|   | Je   | Entrada Sandstone   |
|   | Jsem   | Summerville Formation and Moab Sandstone Member of Entrada Sandstone          |
|   | Jse  | Summerville Formation and Entrada Sandstone                                   |
|   | Jwe  | Wanakah Formation and Entrada Sandstone                                       |
| Jurassic<br>and<br>Triassic   | J Tr sen   | Summerville Formation, Entrada Sandstone, and Navajo Sandstone                |
|   | J Tr n   | Navajo Sandstone  |
|   | J Tr gc  | Glen Canyon group - Navajo Sandstone, Kayenta Formation and Wingate Sandstone |
| Triassic<br>(Approximately<br>225-195 mybp)   | Trk  | Kayenta Formation   |
|   | Trw  | Wingate Sandstone   |
|   | Trkw   | Kayenta Formation and Wingate Sandstone                                       |
|   | Trd  | Dolores Formation   |
|   | Trwc   | Wingate Sandstone and Chinle Formation  |
|   | Trc  | Chinle Formation, undifferentiated  |
|   | Trcu   | Upper part of Chinle Formation  |
| Trcb  | Chinle Formation, Moss Back Member                         |   |

|  |  |  |
|--|--|--|
| Triassic<br>continued                            | Trcm<br>Trm  | Chinle and Moenkopi Formations<br>Moenkopi Formation   |
| Permian<br>(Approximately<br>280-255 mybp)       | Pe<br>Pca<br>Pcw<br>Pco<br>Pcc<br>Pcwo<br><br>Pcac | Cutler Formation, undifferentiated<br>Cutler Formation, arkose and arkosic conglomerate<br>Cutler Formation, White Rim Sandstone Member<br>Cutler Formation, Organ Rock Tongue<br>Cutler Formation, Cedar Mesa Sandstone Member<br>Cutler Formation, White Rim Sandstone Member and<br>Organ Rock Tongue<br>Cutler Formation, Transition zone, arkosic beds and<br>Cedar Mesa Sandstone Member |
| Permian &<br>Pennsylvanian                       | P Pr<br>P Pcr                                      | Rico Formation<br>Cutler and Rico Formations   |
| Pennsylvanian<br>(Approximately<br>320-280 mybp) | Ph<br>Phu<br>Php                                   | Hermosa Formation, undifferentiated<br>Upper Member<br>Paradox Member  |
| Precambrian<br>(Approximately<br>3400-600 mybp)  | pE   | Precambrian rocks, undifferentiated.   |

# LEGEND

|   |   |   |   |
|---|---|---|---|
|     | -O OIL FIELD                            |    | MINERAL OREBODY                         |
|     | -G GAS FIELD                            |    | MINERAL DEPOSIT                         |
|     | -O <sub>s</sub> OIL SHALE               |    | MINERAL OCCURRENCE                      |
|     | -C COAL REGION                          |    | PROSPECT                                |
|    | OIL WELL                                |    | ACCESSIBLE ADIT                         |
|     | OIL & GAS WELL                          |    | INACCESSIBLE ADIT                       |
|     | GAS WELL                                |    | VERTICAL SHAFT                          |
|     | SHOW OF GAS                             |    | INCLINED SHAFT                          |
|    | SHOW OF OIL                             |    | MINE TYPE UNKNOWN                       |
|     | SHOW OF OIL & GAS                       |    | ACTIVE OPEN PIT, OR QUARRY              |
|    | -C COAL DEPOSIT                         |    | INACTIVE OPEN PIT, OR QUARRY            |
|    | -C COAL OCCURRENCE                      |    | ACTIVE GRAVEL OR CLAY (CI) PIT          |
|  | SHUT-IN WELL                            |  | INACTIVE GRAVEL OR CLAY (CI) PIT        |
|  | CO <sub>2</sub> OR He=HELIUM -RICH WELL |  | EXPLORATION HOLE WITH DATA AVAILABLE    |
|  | DRY WELL-ABANDONED                      |  | EXPLORATION HOLE WITHOUT DATA AVAILABLE |
|   | MILL                                    |  | UNPATENTED MINING CLAIM                 |
|   | PLANT                                   |  | PATENTED MINING CLAIM                   |
|  | NATURAL GAS PROCESSING PLANT            |  | MINERAL OR OIL & GAS LEASE              |
|  | REFINERY                                |   |   |

|                |           |                |         |                |                 |
|----------------|-----------|----------------|---------|----------------|-----------------|
| O              | OIL       | C <sub>b</sub> | LIGNITE | D <sub>s</sub> | DIMENSION STONE |
| G              | GAS       | C <sub>p</sub> | PEAT    | F <sub>e</sub> | IRON            |
| O <sub>s</sub> | OIL SHALE | A <sub>g</sub> | SILVER  | M <sub>n</sub> | MANGANESE       |
| O <sub>t</sub> | TAR SANDS | A <sub>u</sub> | GOLD    | P <sub>b</sub> | LEAD            |
| G <sub>i</sub> | GILSONITE | C <sub>u</sub> | COPPER  | U              | URANIUM         |
| C              | COAL      | C <sub>l</sub> | CLAY    | V              | VANADIUM        |
|                |           |                |         | Z <sub>n</sub> | ZINC            |

## SECTION II

### GEOLOGY

#### PHYSIOGRAPHY

Within the GRA boundary (see Figure I-1) are valley, plateau and canyon areas along the courses of the Mancos River, Lost Canyon Creek and La Plata River. The northern half of the GRA is characterized by low rolling hills and a few deeply cut canyons along the courses of Lost Canyon Creek, Chicken Creek and the Mancos River. Vertical relief is less than 2,000 feet, and the area gently slopes up to the mountainous areas around Hesperus Mountain in the northeast portion of the GRA.

In the southern part of the GRA, the predominant physiographic features are a series of bluffs and ridges. They are composed of an uplifted block of the Cretaceous Mancos Shale and the overlying Mesaverde Group sediments. The sedimentary units have been deeply dissected by the north-south fluvial drainages of the Mancos River. The Mancos further cuts through and separates portions of the Cretaceous Mancos Shale into a series of isolated ridges that form the distinct topographic features of Weber Mountain and Menefee Mountain. Total vertical relief in this part of the GRA is approximately 2,000 feet.

The following descriptions address the physiography of each of the individual WSA's within the Menefee Mountain-Weber Mountain GRA.

#### MENEFEE MOUNTAIN WSA (CO-030-251)

The Menefee Mountain area includes areas of mountain and associated canyon topography. Within the boundaries of the WSA are contained a number of physical features such as vertical canyons and overhanging cliffs. North-south drainages of the Mancos River cut through the area. Vertical relief within the WSA is approximately 1,300 feet. The unit is located approximately 20 miles southeast of Cortez, Colorado.

#### WEBER MOUNTAIN WSA (CO-030-252)

The area consists of numerous small canyons radiating from Weber Mountain, a linear shaped mountain that is an erosion remnant of the Cretaceous section. Along the slopes of Weber Mountain, and within the adjacent canyons are exposed sandstone rocks of the Cretaceous Mancos Shale and sandstone series. Vertical relief in the WSA is approximately 1,100 feet. The unit is located approximately 18 miles southeast of Cortez, Colorado.

#### ROCK UNITS

Within the Menefee Mountain-Weber Mountain GRA is found a variety of rock units that represent portions of Mesozoic time. The Precambrian and all of the pre-Jurassic section is not exposed within the boundaries of the GRA but is thought to exist at depth (Baars et al, 1981). These units have been extensively studied by oil and gas companies for their oil, gas and carbon dioxide potential. Of

particular interest is the Pennsylvanian Hermosa Formation and its Paradox Member. These units are thought to underlie most of the GRA, as the GRA is located on the extreme southeastern edge of the Paradox Basin which was receiving sediments during the period from Precambrian through Permian and, in this area, possibly through the Triassic (Molenaar, 1981; Baars et al, 1981; Wanek, 1959; Haynes et al, 1972).

During the Triassic, it is thought that the Chinle, Wingate, and Kayenta Formations were deposited in the area of the GRA (Molenaar, 1981; Baars et al, 1981). From the drilling and geophysical information, it is thought that the Chinle was deposited directly upon a Permian erosion surface over much of the GRA (Molenaar, 1981; Baars et al, 1981; Heylman, Personal Communication, 1982; Haynes et al, 1972).

Directly and unconformably overlying the Triassic sequence are the Jurassic Entrada Sandstone, Wanakah and Morrison Formations. Of these units, only the Morrison is known to crop out within the GRA. These units have been well studied by the oil, gas, and mineral industry for their energy and mineral resources. In addition, extensive studies have been made of these units by various government agencies (Baars et al, 1981; Wanek, 1959; Shawe, 1976).

Within the GRA the Entrada Sandstone is known from seismic and drilling information (Molenaar, 1981). The Entrada consists of three members, in ascending order; Dewey Bridge, Slick Rock, and Moab. The Dewey Bridge Member of the Entrada is characterized as a series of sandy siltstones and sandstones with clastic conglomerate units at the base of the section (Molenaar, 1981). This unit is thought to have been deposited in a shallow-water marine environment that was adjacent to a major ocean basin or seaway (Molenaar, 1981). The overlying Slick Rock Member is a sandstone unit that grades into a silty sandstone west of the Paradox Basin. The unit is thought to be of eolian origin and exhibits prominent cross-bedded structures. The Moab Member of the Entrada is very similar in appearance to the Slick Rock Member, but is thought to have been deposited in a coastal dune environment.

In other areas of the Paradox Basin, the Entrada Sandstone is unconformably overlain by the Curtis Formation, a glauconitic marine sandstone. Within the GRA, the Curtis is not found in drilling and may have as an equivalent the Summerville Formation (Molenaar, 1981). The Summerville Formation, thought to directly overlie the Entrada within the GRA, consists of a series of mudstone, sandstone, and shale units with occasional beds and masses of chert. The Summerville is interpreted as a marginal marine, tidal flat series of deposits (Molenaar, 1981; Baars et al, 1981; Haynes et al, 1972; Carter and Gualtieri, 1965; Shawe, 1976; Wanek, 1959).

The Jurassic Wanakah Formation has been mapped as a separate unit from the Summerville in much of southwestern Colorado and consists of three distinct members in the Silverton area (Molenaar, 1981). Within the Paradox Basin areas of Utah, the Wanakah units lose their distinction from those of the Summerville Formation and have been mapped together with the Summerville (Molenaar, 1981). Within the GRA, the Wanakah is comprised of a series of mudstone, cherty algal limestone, gypsiferous mudstone, sandstone and limestone units (Tweto et al, 1976; Haynes et al, 1972). Due to stratigraphic intertonguing, the Wanakah and Morrison Formation units are often mapped together (Haynes et al, 1972).

The Upper Jurassic Morrison Formation generally overlies the Wanakah Formation and consists of a series of units that comprise four distinct and separate members in the southern portion of the Paradox Basin. The units that are thought to outcrop within the GRA are the Salt Wash and Brushy Basin Members. These units consist of a series of mudstone, shale, limestone and conglomerate units. Major uranium-vanadium deposits have been found in the Salt Wash Member of the Morrison in western Colorado (Molenaar, 1981; Carter and Gualtieri, 1965; Vanderwilt, 1947). The entire Jurassic section is known to contain uranium-vanadium deposits in various areas of Arizona, Colorado, New Mexico, and Utah. Local conditions and the occurrence of favorable stratigraphy determine the potential for economic deposits (Nelson-Moore et al, 1978).

Directly overlying the Jurassic stratigraphy are the Cretaceous Burro Canyon and Dakota Sandstone Formations which consist of a series of fluvial sandstone, conglomerate, siltstone, shale, mudstone and limestone units having interbedded non-marine shale and coal units (Haynes et al, 1972). The Dakota Sandstone is known to contain minable coal resources in other areas of Colorado (Vanderwilt, 1947; Speltz, 1979). These units crop out throughout the northern part of the GRA and are locally overlain by the Cretaceous Mancos Shale. The Mancos Shale crops out throughout the GRA and forms the basal portion of cliffs south of Cortez, Colorado that are a part of Mesa Verde National Park (Haynes et al, 1972). The cliff-forming units in the southern portion of the GRA are composed of several members of the Mesaverde Formation (Wanek, 1959; Haynes et al, 1972). This sequence of sandstone, shale, siltstone, carbonaceous shale and coal units crops out throughout most of the area and has several important coal-bearing units in the Menefee Formation. There has been important past production from these coal units, and the Menefee Formation has been delineated as an energy resource by the United States Geological Survey (USGS and CGS, 1977; Wanek, 1959).

Tertiary and Quaternary gravel deposits directly overlie the exposed Jurassic and Cretaceous stratigraphy in most of the GRA. Quaternary alluvial material is found along the drainages of the major fluvial systems of the area (Haynes et al, 1972; Wanek, 1959).

#### MENEFEE MOUNTAIN WSA (CO-030-251)

Units outcropping within this area include the sandstone, shale, siltstone, carbonaceous shale, and coal units of the Cretaceous Menefee Formation. The unit contains several coal beds of economic importance and has been mined in the past as a source of high quality coal (Wanek, 1959; Cook, Personal Communication, 1982). In the northern end of the WSA are a number of oil and gas operations that are exploiting deposits in the Dakota Sandstone and Mancos Shale. These are thought to have been localized by east northeast structures that cut through the area (Heylman, Personal Communication, 1982; Wanek, 1969).

#### WEBER MOUNTAIN WSA (CO-030-252)

Units cropping out within this area include the sandstone, shale, siltstone, carbonaceous shale and coal units of the Menefee Formation of the Mesaverde Group.

The Menefee Formation contains several coal outcrops of possible economic significance (Cook, Personal Communication, 1982). The northern portion of the WSA contains a known gas field that produces from horizons in the underlying Mancos Shale. It is thought that these deposits may have been localized by the same structures that came through the nearby Menefee Mountain WSA (Heylman, Personal Communication, 1982).

In both the Menefee Mountain and Weber Mountain WSA's, there are Quaternary alluvial deposits associated with the various fluvial systems.

## STRUCTURAL GEOLOGY AND TECTONICS

Tectonic features found within the GRA include high-angle northeast-striking faults, shear zones and joint systems. In the southern portion of the GRA northeast and north-northwest striking joint systems interact to determine the drainages of the Mancos River, south of Mesa Verde National Park, on the Southern Ute Indian Reservation (Haynes et al, 1976). In the Menefee Mountain-Weber Mountain area the dominant structural feature is a series of north-northwest striking joint sets that determine the secondary drainage pattern (Lepley, Personal Communication, 1982).

The GRA is located within the Paradox Basin and has numerous units that are known to contain oil and gas deposits. The current oil and gas production from the area is from structural traps in the Cretaceous Dakota Sandstone and Mancos Shale (Heylman, Personal Communication, 1982). Faults and shear zones within the Mancos Shale, thought to be directly responsible for the accumulation of oil and gas, have great economic importance. A east-northeast fault that runs along the major escarpment south of Cortez, Colorado may be partially responsible for the accumulations of oil and gas in the northern Menefee Mountain area (Wanek, 1959; Heylman, Personal Communication, 1982).

Folding within the GRA is restricted to the Mesa Verde Syncline and the Cortez Anticline. The Mesa Verde Syncline is a shallow structure that trends to the south in Mesa Verde National Park and the Southern Ute Indian Reservation. The Cortez Anticline trends to the northeast and has a few local faults and shear zones along the trace of the axial plane (Wanek, 1959).

The oldest units cropping out within the area are the sediments of the Jurassic Morrison Formation (Haynes et al, 1976). It is thought that a complete stratigraphic sequence upwards from the Jurassic through the base of the Cretaceous Dakota Sandstone exists within the GRA. In other areas of Colorado the base of the Dakota is marked by an unconformity that may reflect a period of nondeposition and transition from a terrestrial to marine environment (Shawe, 1976; Wanek, 1959). Current drilling and stratigraphic studies by oil companies and the United States Geological Survey indicate that such an unconformity does exist within the GRA (Baars et al, 1981; Molenaar, 1981).

Tertiary pediment gravels unconformably overlie the exposed Cretaceous section in the southern portion of the GRA. In addition, Quaternary alluvial, fluvial and eolian deposits are found throughout the GRA in valley areas and along fluvial systems. These units have been deposited on top of the exposed Jurassic, Cretaceous and Tertiary exposures (Wanek, 1959; Haynes et al, 1976).

The pre-Jurassic section is thought to exist at depth under much of the GRA, but is known only from a few scattered drill holes that penetrated the section as far as the Pennsylvanian Paradox Formation (Wanek, 1959; Baars et al, 1981; Molenaar, 1981). Major unconformities in the pre-Jurassic units have been postulated from drilling and seismic information (Molenaar, 1981; Baars et al, 1982).

#### MENEFEE MOUNTAIN WSA (CO-020-152)

Within this unit the dominant structural features are a series of north-northwest striking joint systems that determine the drainage patterns on the western flank of Menefee Mountain. East-northeast striking faults and the axial plane of a minor fold structure may control and delineate oil and gas deposits in the northern part of the WSA (Wanek, 1959; Heylmun, Personal Communication, 1982).

There are no mapped unconformities within the Cretaceous units that crop out within the WSA. A regional unconformity at the base of the underlying Cretaceous Dakota Sandstone is thought to exist at depth (Baars et al, 1981; Wanek, 1959; Molenaar, 1981; Haynes et al, 1976). Local jointing and faults have exposed coal seams in the Menefee Formation (Cook, Personal Communication, 1982).

The pre-Cretaceous section is thought to exist under the WSA and has major unconformities associated with it that have been discovered by drilling and seismic studies (Heylmun, Personal Communication, 1982; Molenaar, 1981). The nature of these unconformities and the Lower Paleozoic section is known only from a few deep drill holes that penetrated the Pennsylvanian Paradox Formation. Detailed information on pre-Pennsylvanian rocks is not currently available (Molenaar, 1981; Baars et al 1981).

Within the WSA the Cretaceous units are directly overlain by Quaternary fluvial and alluvial deposits (Haynes et al, 1976).

#### WEBER MOUNTAIN WSA (CO-030-252)

North-northwest striking joint systems control the drainage patterns on the northwest portion of Weber Mountain (Lepley, Personal Communication, 1982). East-northeast faults and minor fold structures that have been mapped in the northern portion of the WSA may control and delineate oil and gas deposits in the sandstone units of the Dakota Sandstone and the Mancos Shale (Wanek, 1959; Heylmun, Personal Communication, 1982). Local jointing and fold structures are thought to have a direct influence on the localization of oil and gas deposits and are considered very important in the search for structural traps (Heylmun, Personal Communication, 1982; Cook, Personal Communication, 1982).

There are no known or mapped unconformities within the Cretaceous units that outcrop within the WSA. A regional unconformity at the base of the underlying Dakota Formation has been encountered in drill holes southeast and south of the area (Baars, 1966; Molenaar, 1981). Local jointing and faults have exposed coal seams in the Mancos Formation (Cook, Personal Communication, 1982).

The Pennsylvanian-Cretaceous section is known from a few holes that were drilled to test the oil and gas possibilities of the Mancos Shale and Paradox Formations (Baars et al, 1981; Baars, 1966; Molenaar, 1981; Heylmun, Personal Communication,

1982; Cook, Personal Communication, 1982). These tests encountered several regional unconformities in the Pennsylvanian-Cretaceous section (Molenaar, 1981; Baars, 1966). No detailed information is currently available on the pre-Pennsylvanian units that are thought to underlie the WSA (Baars, 1966).

## PALEONTOLOGY

Paleontological resources of the GRA have been studied by the United States Geological Survey and oil companies in conjunction with oil, gas and mineral exploration and stratigraphic studies (Wanek, 1959; Wengerd et al, 1958; Baars et al, 1981). It is known that the Mesaverde Group contains invertebrate mollusk remains and fossil plant material (Wanek, 1959; NPS File Data, 1982).

Tertiary and Quaternary units cropping out within the GRA are not known to contain fossil remains (NPS File Data, 1982).

The Jurassic Morrison Formation is known to contain reptile, bird and mammal fossils in other parts of Colorado but has not been reported to contain any significant fossil material within the GRA (NPS File Data, 1982). Organic material in the form of coal and fossil plant remains have been found in the coal seams of the Mancos Shale (Cook, Personal Communication, 1982), Dakota Sandstone and Menefee Formation (Cook, Personal Communication, 1982; Wanek, 1959; NPS File Data, 1982). The literature that directly pertains to the GRA does not describe any fossil localities of major scientific significance.

### MENEFEE MOUNTAIN WSA (CO-030-251)

The Mancos Shale and Menefee Mountain Formation are both known to contain fossil wood material within the WSA (Cook, Personal Communication, 1982; Wanek, 1959). No other fossil localities have been recorded within the WSA (NPS File Data, 1982).

### WEBER MOUNTAIN WSA (CO-030-252)

Coal seams of the Menefee Formation and the Mancos Shale are known to contain fossil plant material (Cook, Personal Communication, 1982; Wanek, 1959). The literature reports that the Mancos Shale contains invertebrate remains in the general area of the WSA (Wanek, 1959). No other fossil localities have been reported within the WSA (NPS File Data, 1982).

## HISTORICAL GEOLOGY

Knowledge of the Precambrian-Paleozoic section in this area is based on limited published information, drill-hole data and the character of outcrops in the Uncompahgre Uplift area.

During Middle Precambrian time, it is thought the entire GRA was receiving sediments from both cratonic and island-arc sources (Gilmour, Personal Communication, 1982). It appears that this was a time of persistent volcanism and tectonic activity. Marine deposition of eugeosynclinal sediments was interrupted by the ebb and flow of cratonic and island-arc volcanism, and a period of extreme deformation was caused by plate collisions and regional uplifting. These older Precambrian units were metamorphosed, deformed, and intruded by a series of younger Precambrian mafic

and felsic bodies. In this study area, the exposed older Precambrian rocks are mainly intrusive masses of granite that have partially absorbed the earlier gneiss and schist material.

Some of these intrusives contained anomalous amounts of metals and have mineral deposits associated with them in other parts of Colorado and western United States (Vanderwilt, 1947). Other base and precious metal deposit types, called exhalative deposits, are commonly found in Precambrian lithologies. These exhalative deposits, found in association with marine basins and rhyolitic volcanic systems, are commonly associated with the older Precambrian lithologies. Younger Precambrian or Paleozoic intrusives have intruded the older, highly metamorphosed and deformed complex of granite, gneiss, schist, pegmatite, aplite and lamprophyre lithologies. This later granitic unit appears to have altered the units it intruded, and may be partially responsible for vein deposits of base and precious metals, beryl, and fluorspar that are found in other areas of Colorado. The Precambrian sequence is relatively unstudied in this area and has only been partially correlated with other areas of Colorado (Cater, 1955). In parts of northwestern Colorado, the younger Precambrian is partially preserved, and consists of a thick section of clastic sediments. These lithologies represent a period of clastic deposition in a marine environment. From the seismic and drilling information that is currently available, it appears that the Precambrian units of this area are present at depths up to 10,000 feet (Baars et al, 1981).

Approximately 1,700 million years before present during Precambrian, there was a period of uplift and rift formation that set the stage for all subsequent events in southwestern Colorado (Baars et al, 1981). These events were caused by deep north-south compressional crustal forces that formed a deep rift basin (Baars et al, 1981). With the formation of a rift basin adjacent to the Uncompahgre Uplift, all sedimentation was restricted to the basin area, and the exposed, deformed and intruded Precambrian basement complex was subjected to erosion. In areas north and east of the GRA, it is thought that this deposition continued through Permian time. Though the only Paleozoic rocks that have been encountered in drilling within the GRA are the Pennsylvanian and Permian lithologies, it is very probable that the full Paleozoic section exists throughout the GRA (Baars et al, 1981).

This period of early and middle Paleozoic deposition was characterized by a formation of a series of shallow basins along the deep rift valley. It is thought that these basins were progressively filled by Cambrian, Devonian, and Mississippian sediments (Baars et al, 1981). These units were then downfaulted into the rift zone during periods of tectonic activity. These periods of vertical movement were precursors to the extreme orogenic episodes that occurred in the beginning of Middle Pennsylvanian time, when Precambrian units were uplifted rapidly and formed highlands that shed between 15,000 and 20,000 feet of clastic sediments (Baars et al, 1981). These sediments filled the deeper parts of the adjacent structural trough. This highland continued to exist throughout Pennsylvanian and Permian time, and was partially inundated by the clastic sequences of the Permian Cutler Formation.

During most of the Paleozoic, the deep rift basins teemed with plant and animal life. Reef communities grew on shallow, marine bedrock highs in association with algal bioherms. Northwest-striking faults and shear systems were active within the basins and caused up-and-down movement of the basement blocks that formed the floor

of these basins. Certain basins along the rift zone were isolated by tectonic activity and became stagnant, inland, lacustrine bodies that were so filled with terrestrial sediments that they were unable to support life and became depositories of thick evaporite sequences (Baars et al, 1981). As a result of the evaporites being in isolated basins, salt domes, anticlines, and diapirs formed with succeeding tectonic movements. These features were caused when the plastic evaporitic lithologies began to flow in response to tectonic stresses. The result of this movement was to form structures that displaced up to 14,000 feet of strata and created a series of diapirs and tight folds (Shoemaker, 1951; Baars et al, 1981). Faults that formed along the margins and axial planes of these flowage structural features were active in Pennsylvanian and Permian time, and added to the structural complexity of the basins. These faults acted as traps for oil and gas deposits.

In the Mesozoic ERA, the area was the site of fluvial and lacustrine deposition in a terrestrial environment. The Triassic Moenkopi Formation overlies the Paleozoic unit in much of the GRA, and is thought to represent a period when shallow, fresh water lakes in enclosed basins were subjected to periods of dessication and shallow water, clastic deposition. The Moenkopi Formation is known for its saurian tracks and vertebrate fossils in other areas of western Colorado. Thus, it is reasonable to assume that amphibian and reptile life may have existed within the GRA during this period (NPS File Data, 1982). The Chinle-Wingate-Kayenta Formations of the Glen Canyon Group represent a time of Triassic sedimentation in a near-shore environment with episodes of eolian deposition of well cross-bedded beach and dune sand deposits. Certain fluvial and shallow water lacustrine deposits have also been identified in this sequence of sandstone, shale, siltstone, mudstone, limestone and identified in this sequence of sandstone, shale, siltstone, mudstone, limestone and conglomerate. It appears that the Triassic units were deposited along the margins of great, open seas and restricted inland basins that had existed since Paleozoic time. As the shorelines of these seas moved back and forth in response to orogenic episodes and basin filling, the localized environments in the GRA changed from marine to terrestrial. During this time, shallow-water and near shore swamps were formed. In other areas of Colorado, these Upper Triassic near-shore sediments are the host for copper-silver "redbed" deposits that were deposited in areas of rapidly changing Eh-pH conditions in the aqueous solutions within the rock strata. The presence of these deposits in other, widely dispersed areas of western Colorado is ample evidence that conditions favorable for these types of environments did, indeed, exist in the Triassic Period.

The unconformity between the Triassic section and the overlying Jurassic Entrada Formation is probably a local feature that represents a period of non-deposition. The Jurassic Entrada is thought to have been deposited during a period of terrestrial fluvial and eolian deposition in small, restricted basins that eventually coalesced and buried the majority of the Uncompahgre Uplift features (Carter and Gaultieri et al, 1965). The Jurassic Summerville and Morrison Formations were deposited in near-shore lagoonal environments, or shallow-water marine and fluvial systems. Some fresh-water lacustrine and fresh-water fluvial deposits have also been identified from these rocks. As in the earlier Triassic section, mineral deposits are commonly associated with limey sandstones, shales, and siltstones that were deposited in shallow, neritic basins that had fluvial channels meandering through them. Uranium-vanadium mineralization occurs in these units as "roll-front" and organically precipitated "stream channel" deposits. "Roll-front"

deposits are elongate concretionary structures encompassed by rich vein-like concentrations of uranium-vanadium-bearing clay minerals. "Stream channel" deposits occur where uranium-vanadium waters encountered structural traps and/or clastic organic accumulations and deposited minerals in a reducing environment. Such mineral deposits are very important economically as they contain high grade mineralization. These deposits are thought to have been emplaced in an environment similar to that of the present lower Mississippi Basin. Fossil-plant material from this period is indicative of a tropical environment that was adjacent to an active fluvial or lacustrine system.

During Lower Cretaceous time, the area was the site of shallow water deposition in a lagoonal or swamp environment. The Lower Cretaceous Burro Canyon Formation appears to have been deposited in a series of meandering river systems with adjacent terrestrial lakes. The terrestrial, clastic nature of this formation is thought to be characteristic of a beach or littoral environment (Young, 1955). The Upper Cretaceous Dakota Sandstone unconformably overlies the Burro Canyon Formation, and was probably deposited on an irregular upper surface of Burro Canyon rather than a true erosion surface (Carter and Gaultieri, 1965). Portions of the Dakota are found as channel fillings in the Burro Canyon paleosurface. From fossil evidence, it appears that the lower sections of the Dakota were deposited in shallow basins or stream channels (Carter and Gaultieri, 1965). The carbonaceous shales of the Dakota are known to contain abundant plant remains and were probably deposited in a near-shore swamp or lacustrine environment. Thin coal seams are known to exist within the Dakota and may have economic potential.

Units of the Cretaceous Mancos Shale have been described as being sandstone and shale units deposited in a near-shore environment.

The Cretaceous Mesaverde Group crops out throughout the central and northern portions of the GRA and represent a period of cyclical deposition of shale, coal, limestone and sandstone units in a near-shore marine environment adjacent to the deep-water basins where the bulk of the Mancos Shale unit was deposited (Wanek, 1969). The Menefee Formation contains thick persistent coal beds. The upper members of this formation also contain thin, discontinuous coal seams of minor economic importance (Gentry, Personal Communication, 1982). These units were also laid down in a near-shore swamp or lagoonal environment.

The Mesaverde Group units are unconformably overlain by Tertiary gravel units.

The area was uplifted and subjected to erosion in Middle Tertiary times with the formation of the ancestral Mancos River Valley. Quaternary pediment, terrace gravel and eolian deposits formed on the exposed Cretaceous surfaces and alluvial deposits were formed along the various fluvial systems that were established.

Figures II-1 through II-2 illustrate oil and gas operations and coal occurrences in the GRA.

#### MENEFEES MOUNTAIN WSA (CO-030-251)

According to the available well information available, the Precambrian-Jurassic section is present under the WSA and was encountered in drill holes on the flanks



**FIGURE II-1**  
Four oil well pumps in  
small oilfield W of  
Menefee Mountain.

**MENEFEE MOUNTAIN**



**FIGURE II-2**  
Small coal prospect SE  
of Menefee Mountain -  
off WSA. Only seen  
from air.

**MENEFEE MOUNTAIN**



**FIGURE II-3**  
Coal prospect. E side  
of Menefee Mountain.  
Seen only from air.

**MENEFEE MOUNTAIN**



**FIGURE II-4**  
Mr. J. Kendrick,  
Manager BLM Durango  
office, at coal seam in  
Menefee Formation.

**WEBER MOUNTAIN**

of the Paradox Basin (Baars et al, 1981). No other information on the pre-Cretaceous lithologies is currently available. Within the boundaries of the WSA, only the Cretaceous, Tertiary, and Quaternary units are exposed. The near-shore environments of the Mesaverde Group and Menefee Formation characterize the Cretaceous section in this area.

The Cretaceous Mesaverde Group crops out throughout the WSA and represents a period of cyclical deposition of shale, coal, limestone and sandstone units in a near-shore marine environment adjacent to the deep-water basins where the bulk of the Mancos Shale was deposited (Wanek, 1957). The Menefee Formation contains thick persistent coal beds in lower units. The upper members of this formation also contain thin, discontinuous coal seams of minor economic importance (Gentry, Personal Communication, 1982). These units were also laid down in a near-shore swamp or lagoonal environment. The Cretaceous section is unconformably overlain by Tertiary pediment gravels. This unconformable situation may represent a period of uplift and erosion prior to the formation of the Tertiary sedimentary basins.

The area was uplifted and subjected to erosion in Middle Tertiary times with the formation of the ancestral Mancos River Valley. Quaternary pediment, terrace gravel and eolian deposits formed on the exposed Cretaceous surfaces and alluvial deposits were formed along the various fluvial systems that were established.

#### WEBER MOUNTAIN WSA (CO-030-252)

The Precambrian-Jurassic section in this area is known only from a few drill holes as consisting of gneisses, schists and intrusive rocks of middle Precambrian age. As in the adjacent Menafee Mountain Area, a thick section of Paleozoic units occurs (Baars et al, 1981). The environments of deposition are nearly identical with those in the Menefee Mountain area with the exception that the units have been eroded. There are no known metal deposits within the area, but the potential for oil and gas deposits exists in the Cretaceous Mancos Shale (Heylmun, Personal Communication, 1982). The Mesaverde Group is not known to contain any uranium-vanadium deposits within the boundaries of the WSA (Nelson-Moore et al, 1979).

## SECTION III

### ENERGY AND MINERAL RESOURCES

#### KNOWN MINERAL DEPOSITS

The known mineral deposits in the Menefee Mountain-Weber Mountain GRA have been categorized into 3 groups: 1) coal, oil and gas; 2) metallic and nonmetallic minerals; and 3) sand, gravel and industrial minerals. These three groups, in turn, have been subdivided according to operating status; i.e. active or producing, inactive or unknown. Each of the three categories is summarized below, followed by a brief narrative.

Category 1: Coal, oil and gas

| Commodity/Type         | # of producing wells | # of active operations | # of inactive operations | total |
|------------------------|----------------------|------------------------|--------------------------|-------|
| Oil & Gas Wells        | 11                   | -                      | -                        | 11    |
| Coal-underground mine  | -                    | -                      | 21                       | 21    |
| Coal-mine type unknown | -                    | -                      | 1                        | 1     |

The producing oil and gas wells are located in sections 5, 6, 7, 9, 16 and 17, T35N, R13W, in the Sierra Oil and Gas Field (Overlay C and Appendix A; field notes and aerial photograph 1-3-92). Since the discovery of the Sierra Field in 1957, the field has yielded 13,251 barrels of oil and 26,240 million cubic feet (Mcf) of gas, through 1974 (Jones and Murray, et al, 1976). The producing rock formation in the Sierra Field is the Upper Cretaceous Dakota Sandstone.

The Point Lookout Gas Field, located in section 32, T36N, R14W, was discovered in 1930. However, in 1954, the field was shut in. Cumulative production from the Dakota Sandstone was 23,000 Mcf of gas (Jones and Murray, 1976).

Of the 21 coal mines in the GRA, 11 are located in the Durango Field in sections 1, 2 and 3, T35N, R13W and sections 35 and 36, T36N, R13W (Overlay C and Appendix B). The Durango Coal Field occupies the central eastern portion of the GRA. The coal occurs in the Dakota Sandstone and the Menefee Formation of the Mesaverde Group (Landis, 1959). The remaining coal mines are primarily located in the central western portion of the GRA, east of Cortez. Production data was not available for the mines in the GRA.

Category 2: Metallic and nonmetallic minerals

| Commodity/Type                    | # of active operations* | # of inactive operations* |
|-----------------------------------|-------------------------|---------------------------|
| Uranium-vanadium-underground mine | -                       | 3                         |
| Gold-placer                       | -                       | 4                         |
| Gold-underground mine             | -                       | 3                         |
| Gold-Silver-underground mine      | -                       | 3                         |
| Gold-Silver-Lead-underground mine | -                       | 1                         |

\*Status as of January 1, 1982.

The uranium-vanadium mining operations are located in T35N, R16W and T36N, R15W, in the northwestern portion of the GRA (Overlay B and Appendix B). These deposits are believed to occur in the Jurassic Morrison Formation which is exposed, in places, in the northern portion of the GRA (Figure I-1).

The base-and precious-metal mining operations are in the East Mancos Mining District, in the northeastern portion of the GRA.

Production statistics for the above operations were not available.

Category 3: Sand, gravel and industrial minerals

| Commodity/Type     | # of active operations* | # of inactive operations* | status unknown |
|--------------------|-------------------------|---------------------------|----------------|
| Sand & gravel pits | 6                       | 6                         | -              |
| Stone quarry       | -                       | -                         | 1              |

Sand and gravel operations are located near the town of Dolores, Colorado, along the Dolores River and it's tributaries, west of the town of Mancos, Colorado, on U.S. Rt. 160, and on a tributary of the Mancos River (Overlay D and Appendix B). The stone quarry is located in Mesa Verde National Park, T34N, R15W.

Production statistics for these operations are not known.

MENEFEE MOUNTAIN WSA (CO-030-251)

There are no known deposits in the Menefee Mountain WSA.

WEBER MOUNTAIN WSA (CO-030-352)

There are no known deposits in the Weber Mountain WSA.

## KNOWN PROSPECTS, MINERAL OCCURRENCES AND MINERALIZED AREAS

As in the previous section, the known prospects in the Menefee Mountain-Weber Mountain GRA have been categorized into three groups: coal, oil and gas; metal and nonmetallic minerals; and sand, gravel and industrial minerals. Each of the three groups will be summarized below in table form, followed by a brief narrative that will include a description of the mineralized areas.

Category 1: Coal, oil and gas

| <u>Type</u>       | <u>Number</u> |
|-------------------|---------------|
| Coal prospects    | 15            |
| Show of oil & gas | 1             |
| Exploration wells | 15            |

The coal prospects are situated in T34 and 35N, R14, 15W, south of the known mining operations in the Durango Coal Field (Overlay C, Appendix B). The exploration wells are located throughout the northern portion of the GRA. It is unknown if a show of oil or gas was encountered in any of the wells. A show of oil and gas was encountered in a well drilled to a depth of 8,661 feet in section 14, T35N, R13W.

In category two, the metallic and nonmetallic mineral prospects in the GRA consists of 1 vanadium, 1 gold-silver and 4 gold prospects (Overlay B; Appendix B). The precious metal prospects are in the East Mancos Mining District in the northeastern portion of the GRA. The vanadium prospect is located in section 5, T34N, R14W.

In the third category, the sand, gravel and industrial minerals prospects consist of 7 sand and gravel prospects and 1 clay prospect (Overlay D, Appendix B). These prospects are all located in close proximity to the towns of Cortez, Mancos and Dolores, Colorado.

### MENEFEE MOUNTAIN WSA (CO-030-251)

In the Menefee Mountain WSA, there are 2 coal prospects and 1 well with a show of oil and gas (Overlay C, Appendix B). The coal prospects are located in sections 10 and 33, T35N, R13W in the Mesaverde Formation (Appendix A, topographic maps and aerial photography). The well is located in section 14, T35N, R13W and was drilled to a depth of 8,661 feet (Appendix A, evaluations and topographic maps).

### WEBER MOUNTAIN WSA (CO-030-252)

The Weber Mountain WSA contains 3 coal prospects located in section 19, T35N, R13W, section 25, T35N, R14W and section 6, T34N, R13W (Overlay C, Appendix B). The Sierra Oil and Gas Field may extend into the WSA in section 7, T35N, R13W.

## MINING CLAIMS, LEASES AND MATERIAL SITES

In the Menefee Mountain-Weber Mountain GRA, there are 241 unpatented mining claims, of which, 225 are lode claims, 15 are placer and 1 mill site (Overlay A). The claims are located north of the WSA's in T37N, R14W and T36 and 37N, R12W. There are no major exploration companies with unpatented claim holdings in the GRA.

Unpatented claim data were obtained from the Bureau of Land Management's June 14, 1982, Geographic Index (Appendix C).

There are no patented mining claims located in the GRA.

Information on leases and material sites was not compiled for the entire GRA. Refer to the oil and gas plats and master title plats in Appendix A.

#### MENEFEE MOUNTAIN WSA (CO-030-251)

There are no known claims, leases and material sites in this WSA. Coal, oil and gas leases border the WSA (Oil and Gas Plats, Appendix A).

#### WEBER MOUNTAIN WSA (CO-030-252)

There are no patented or unpatented claims in this WSA. As of August 27, 1982, there were several leases contained within the WSA. Refer to the Oil and Gas Plats and Master Title Plats (Appendix A).

### MINERAL DEPOSIT TYPES

The Menefee Mountain-Weber Mountain GRA contains several different types of deposits consisting of coal, oil, gas, uranium, vanadium, precious and base metals, construction stone and sand and gravel.

Coal has principally been mined from the lower Cretaceous Dakota Sandstone and the Upper Cretaceous Mesaverde Group. The Dakota Sandstone is composed of an upper sandstone member, a middle coal-bearing member, and a lower conglomeratic sandstone member (Landis, 1959). The coal is lenticular, discontinuous and contains a high percentage of impurities. In the GRA, coal mined from the Dakota Sandstone is primarily for local use. The principal source of coal in the GRA is from the Menefee Formation of the Mesaverde Group. The Mesaverde Group is composed of, in ascending order, the Point Lookout Sandstone, the Menefee Formation, and the Cliffhouse Sandstone. The Point Lookout Sandstone is composed of a lower interbedded sequence of sandstone and shale. The proportion of sandstone to shale increases upward. The upper part of the Point Lookout Sandstone is composed of a massive cliff-forming, fine-to-medium-grained sandstone (Wanek, 1959). The Point Lookout Sandstone is of marine origin deposited in a regressing sea. The Menefee Formation conformably overlies the Point Lookout Sandstone. The Menefee Formation is a thick sequence of massive lenticular sandstone that is interbedded with siltstone, shale and coal (Wanek, 1959). The sandstone is fine-to-medium grained and is cross laminated. The shale is generally carbonaceous and is closely associated with coal. The Menefee Formation contains three zones of coal. The lowest zone contains up to four beds of relatively pure coal. This zone is found above the contact with the Point Lookout Sandstone. The middle zone, which overlies the lowest zone, consists of thin impure coal beds. The upper zone consists of lenticular coal beds in carbonaceous shale underlying the Cliffhouse Sandstone (Wanek, 1959). The most productive zone has been the lower zone, 50-to-80 feet above the Point Lookout-Menefee contact.

The Cliffhouse Sandstone is a thin to thick bedded, fine grained sandstone intercalated with thick beds of fossiliferous shale. The Cliffhouse sandstone is of marine origin deposited in a transgressing sea (Wanek, 1959).

The gas production in the GRA has been derived from the Dakota Sandstone. The original sediments of the Dakota were deposited under swamp and lagoonal conditions. Gas production is from stratigraphic and structural traps in the Dakota Sandstone.

The uranium and vanadium deposits occur in the Jurassic Morrison Formation, which is exposed in the northern portion of the GRA. In the Morrison Formation carnotite, a uranium and vanadium oxide, is the principal ore mineral. Carnotite is a secondary mineral deposited by waters that were in contact with primary uranium and vanadium minerals. Uranium mineralization occurs in the Salt Wash and Brushy Basin Members of the Morrison Formation. The Salt Wash Member consists of interstratified sandstone and claystone units (Craig et al, 1955). The Brushy Basin Member consists of variegated claystones with few lenticular conglomeratic sandstone strata. The Brushy Basin Member was formed in fluvial and lacustrine environments with large amounts of clay (Craig et al, 1955). It is thought the introduction of the ore was done by mineral-bearing solutions that seeped through the permeable layers after sediments accumulated. The source of the primary minerals is currently under dispute (Craig et al, 1955).

The northeastern corner of the GRA is the location of the East Mancos River Mining District. In this area, base and precious metal bearing veins are found in the La Plata Sandstone. The La Plata Sandstone consists of the upper Junction Creek Sandstone, the middle Wanakah Formation and the lower Entrada Sandstone. The Junction Creek Sandstone is a white massive, friable, cross-bedded sandstone that is locally altered to a white to brown quartzite (Wanek, 1959). The precious and base metal deposits are generally small and mineralization is not persistent, however, rich pockets of gold-silver ore have been found. The Wanakah Formation is divided into an upper sandstone unit and a lower limestone unit. The sandstone unit is composed of sandy marls alternating with lenses of light-colored sandstones. This unit is generally an unfavorable host for ore deposition (Wanek, 1959). The lower limestone unit is composed of a gray to black massive limestone. Pyrite and gold tellurides occur as replacement minerals in the limestone. In the central part of the district, minerals have been altered as a result of contact metamorphism (Wanek, 1959). Mineralization in the limestone is locally abundant. The lowest unit, the Entrada Sandstone, is similar to the Junction Creek Sandstone. Placer gold has been recovered, in relatively small quantities, from streams within the district.

Sand and gravel deposits consist of Quaternary alluvial, fluvial and eolian material found in valley areas and along fluvial systems.

#### MENEFEE MOUNTAIN USA (CO-030-251)

There are no known deposits in this WSA.

#### WEBER MOUNTAIN WSA (CO-030-251)

There are no known deposits in this WSA.

## MINERAL ECONOMICS

The inherent nature of discussing the economics of the minerals existing within the Menefee Mountain-Weber Mountain GRA and its WSA's can only provide for a general approach inasmuch as there are many economic factors that enter into the development of an ore body. These include access, market value, grade, transportation, recovery and extraction methods, etc. Therefore, the discussion herein addresses the U.S. and Colorado demand and production status of each of the existing minerals in the WSA's.

Mineral resources in the GRA include coal, oil, and gas, uranium and vanadium, precious and base metals, construction stone and sand and gravel.

Coal is produced mainly from Cretaceous units. Coal production for Colorado mines is currently at an all time high. Approximately 20,000,000 tons of high-grade low-sulphur coal was produced from open pit and underground operations (Colo. Div. Mines Rept., 1980; and Schwochow, 1978). The future looks encouraging for coal as more and more utilities are switching back to coal for power generation (Schwochow, 1978; Colo. Div. Mines Rept., 1980). Changes in technology and improvements in combustion/distillation techniques will increase the demand for Colorado coal, and coal byproducts (Gentry, Personal Communication, 1982). All the coal mines in the GRA are inactive. Production statistics for these operations were not available.

Producing oil and gas wells are located in the Sierra Oil and Gas Field. This field (through 1974) has yielded 13,251 barrels of oil, and 26,240 million cubic feet of gas (Jones and Murray, 1976). These deposits will have continuing importance as long as the United States is a net importer of oil and gas. Current demand for petroleum products will maintain current levels or increase in the future (Petroleum Times Price Report, October 1982). Exploration activity in western Colorado has slackened in the last six months with the number of active rigs drilling dropping approximately 15% (Heylmun, Personal Communication, 1982). Areas of current drilling activity include the Paradox Basin of Colorado and Utah, and areas north of the Colorado River in Mesa, Garfield and Moffat Counties, Colorado (Heylmun, Personal Communication, 1982).

Energy mineral occurrences (uranium and vanadium) in the GRA are known in the Jurassic Morrison Formation. Current production is down from past production levels due to a general drop in the price of uranium (Eng. and Mining Journal, Dec., 1982). Uranium and vanadium are currently being produced at very little or no profit by many of the major mining operations in Colorado (Carpenter, Personal Communication, 1982). The GRA contains three inactive uranium mines (Production statistics are not available). Future demand for uranium and vanadium is dependent on foreign production and the needs of the nuclear generating industry (Schwochow, 1978).

The northeastern corner of the GRA contains the East Mancos River Mining District which is responsible for the base and precious metal production in the GRA. There are no known active, and eleven inactive mines for precious and base metals in the GRA (Production statistics were not available). Currently, a strong demand for precious metals exists in the U.S. and Colorado. Production and demand for base metals, however, is down from past levels due to a general down-turn in the U.S.

and world economies (Eng. and Mining Journal, Dec. 1982). Commodities such as copper, lead, and zinc are not being currently produced at a substantial profit by any of the major mining operations in Colorado (Eng. and Mining Journal, Dec. 1982; Carpenter, Personal Communication, 1982).

Construction stone and gravel are considered "high place value" industrial minerals. These minerals are only of economic value when the deposits are readily accessible and in close proximity to a market.

The economic viability of the WSA's in the Menefee Mountain-Weber Mountain GRA are summarized as follows:

| <u>WSA</u>                                 | <u>MINERAL POTENTIAL</u> | <u>ACCESSIBILITY</u> | <u>ECONOMIC POTENTIAL [a]</u> |
|--|--------------------------|----------------------|-------------------------------|
| Menefee<br>Mountain<br>WSA<br>(CO-030-251) | Oil, Gas*<br>Coal*       | Fair/Poor<br>Poor    | Poor<br>Poor                  |
| Weber<br>Mountain<br>WSA<br>(CO-030-252)   | Oil, Gas*<br>Coal*       | Poor<br>Poor         | Poor<br>Poor                  |

[a] The economic potential rating is notwithstanding market demand fluctuations.

\*Occur as prospects in the WSA. No further information is available.

## SECTION IV

### LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

After thoroughly reviewing the existing literature and data-base sources, MSME/Wallaby personnel plotted all known mineral occurrences, mines, prospects, oil and gas fields, sand and gravel operations, processing facilities, mining claims, mineral leases, and the locations of anomalous geochemical samples from the National Uranium Resource Evaluation - Hydrological Stream Sediment Reconnaissance - Airborne Radiometric and Magnetic Survey (NURE-HSSRARMS) programs. This plotted information and the data bases on each WSA was made available to a multi-faceted team of experts which made three successive evaluations of the GEM resource potential of each of the WSA's.

The team or panel of geological experts was comprised of:

Dr. Paul Gilmour: Base and precious metal deposits in western U.S. and Canada, expert on Precambrian mineral resources.

Mr. Ted Eyde: Base and precious metal deposits in western U.S., expert on industrial mineral resources.

Mr. Annan Cook: Base and precious metal deposits in western U.S., expert on porphyry deposits and mine evaluation.

Mr. Edward Heylmun: Oil, gas and oil shale deposits of western U.S.

Dr. Robert Carpenter: Mineral deposits of Colorado and western U.S., expert on geology of Colorado.

Dr. Donald Gentry: Expert in coal and oil shale deposits of Colorado and western U.S.

Dr. Larry Lepley: Expert in remote sensing and geothermal resources.

Mr. Walter E. Heinrichs: Geophysics and base and precious metal deposits of western U.S., expert on porphyry copper deposits.

As indicated earlier, Dr. Gilmour and Mr. Cook made certain field investigations as result of the base data analysis phase. The purpose of the field investigations was to either verify the existing data or assess relatively unknown areas. Dr. Lepley, reviewed all aerial photographs for observable anomalies, which were then investigated by the field team, or verified against the existing base data.

The evaluations were then made on the basis of examination of the data bases, field investigations and the individual experiences of the members of the panel in such areas as base and precious metal, industrial and energy mineral deposits; oil and gas deposits; and geothermal resources. In the course of these evaluations, every attempt was made to objectively rate the potential for a particular commodity within the respective study area. In this effort, the evaluation criteria proposed by the Bureau was rigorously used. The classification scheme used is shown in Table IV-1. In many cases the lack of information did not allow for a full determination

of the GEM resource potential and the panel was forced to leave some areas unranked or classified for some commodities. The situation thus arises where there is an area that has been unclassified for a commodity, despite it's reported occurrence, because it is next to an area where there is insufficient data to make a meaningful attempt at classification. Nonetheless, each resource has been additionally rated as to what level of confidence the panel of experts attached to their selection of classification level. This is denoted by the letter association with each rate classification. These are defined in Table IV-1.

A further restraint on this classification and delineation effort comes in the area of the lack of subsurface information. Some areas are very well known from past exploration efforts and have an abundance of subsurface information. Other areas are practically unknown due to an absence of any past exploration or development efforts.

The WSA's, for the most part, are not well known geologically. For this reason, our expert team had to extrapolate geologic information from adjacent areas to make any sort of reasonable classification with some level of confidence. The following pages address those resources considered to be leasable, locatable, and/or salable with associated maps (Figures IV-1 through IV-2) locating the resource areas.

**TABLE IV-1**  
**RESOURCE RATING CRITERIA**

**CLASSIFICATION SCHEME**

1. The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.
2. The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.
3. The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.
4. The geologic environment, the inferred geologic processes, the reported mineral occurrences, and the known mines or deposits indicate high favorability for accumulation of mineral resources.

**LEVEL OF CONFIDENCE SCHEME**

- A. The available data are either insufficient and/or cannot be considered as direct evidence to support or refute the possible existence of mineral resources within the respective area.
- B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.
- C. The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.
- D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resource.

**LEASABLE RESOURCES**

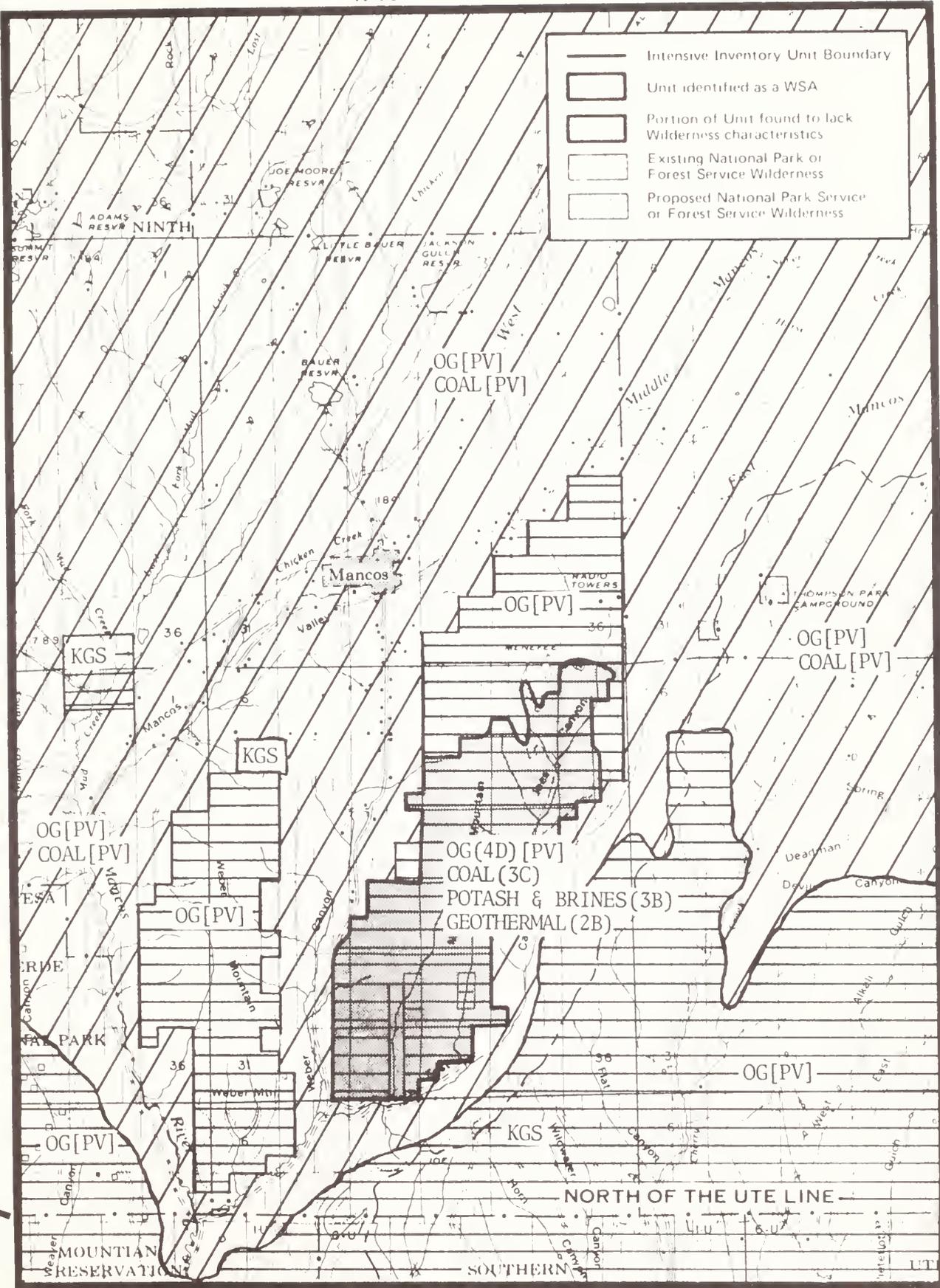
MENEFEE MOUNTAIN WSA (CO-030-251)

| <u>Resource</u>   | <u>Classification</u> | <u>Comments</u>   |
|-------------------|-----------------------|---|
| Oil and Gas       | 4D                    | The WSA is composed of the Cretaceous Mesaverde Group overlying the Mancos Shale. Oil and gas production from wells adjacent to the WSA is due to stratigraphic traps in the Mancos Shale, in locally-developed sandstone lenses. Adjacent to a known oil and gas leasing area. |
| Coal              | 4D                    | The coal-bearing Mesaverde group extends throughout the WSA, known coal leasing area.   |
| Potash and Brines | 3B                    | Unknown, the area is known to be prospectively valuable for potassium from the Paradox Formation.   |
| Geothermal        | 2B                    | Unknown potential.  |

WEBER MOUNTAIN WSA (CO-030-252)

| <u>Resource</u>   | <u>Classification</u> | <u>Comments</u>   |
|-------------------|-----------------------|---|
| Oil and Gas       | 4D                    | The WSA is composed of the Cretaceous Mesaverde Group overlying the Mancos Shale. Oil and gas production from wells adjacent to the WSA is due to stratigraphic traps in the Mancos Shale, in locally-developed sandstone lenses. Adjacent to a known oil and gas leasing area. |
| Coal              | 4D                    | The coal-bearing Mesaverde group extends throughout the WSA, known coal leasing area.   |
| Potash and Brines | 3B                    | Unknown, the area is known to be prospectively valuable for potassium from the Paradox Formation.   |
| Geothermal        | 2B                    | Unknown potential.  |

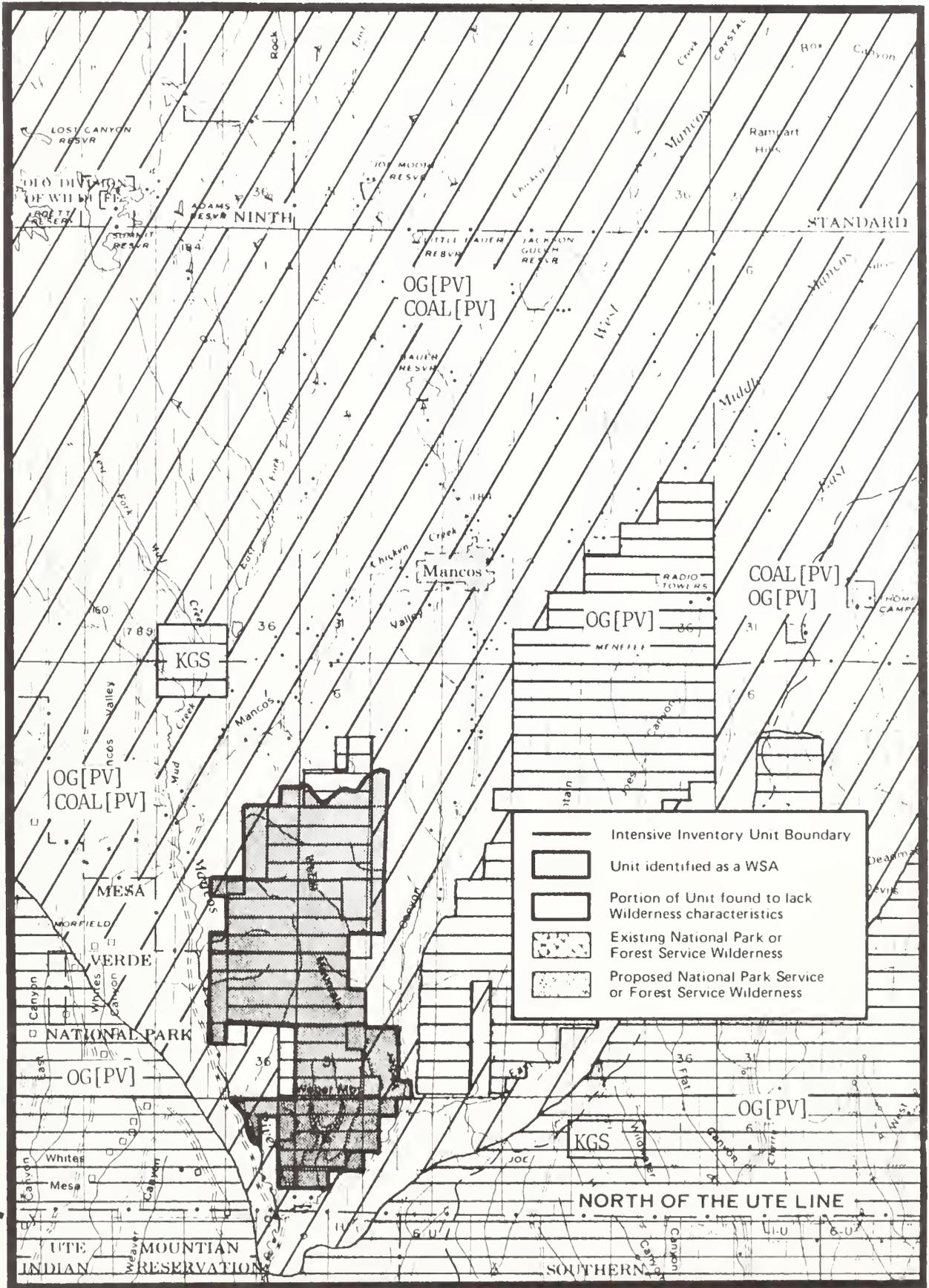
MONTROSE



(After BLM, 1980)

MMS/LEASABLE RESOURCES  
Figure IV-1a

MONTROSE



|  |   |
|--|---|
|  | Intensive Inventory Unit Boundary                           |
|  | Unit identified as a WSA                                    |
|  | Portion of Unit found to lack Wilderness characteristics    |
|  | Existing National Park or Forest Service Wilderness         |
|  | Proposed National Park Service or Forest Service Wilderness |



MMS/LEASABLE RESOURCES

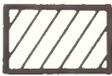
Figure IV-1b

(After BLM, 1980)

LEGEND FOR MINERALS MANAGEMENT SERVICE CLASSIFICATIONS



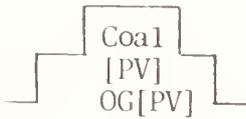
Defined KGS and/or Coal Leasing Areas



Areas Prospectively Valuable for Sodium or Potassium



Defined Oil Shale Leasing Area



Areas Identified as Prospectively Valuable for  
Coal or Oil, Gas

Coal [NPV]  
OG [NPV]

Areas Identified as Not Being Prospectively Valuable  
for Coal, or Oil, Gas

**LOCATABLE MINERALS**

MENEFEE MOUNTAIN WSA (CO-030-252)

| <u>Resource</u>           | <u>Classification</u> | <u>Comments</u>  |
|---------------------------|-----------------------|--|
| Precious Metals           | 1A                    | Unknown potential in Mesozoic strata.  |
| Base Metals               | 1A                    | Unknown potential in Mesozoic strata.  |
| Locatable Energy Minerals | 3B                    | Mineralization potential in Jurassic Morrison Cretaceous Mesaverde Formations, favorable rock types present, nearby prospects, anomalies and minor production. |

WEBER MOUNTAIN WSA (CO-030-251)

| <u>Resource</u>           | <u>Classification</u> | <u>Comments</u>  |
|---------------------------|-----------------------|--|
| Precious Metals           | 1A                    | Unknown potential in Mesozoic strata.  |
| Base Metals               | 1A                    | Unknown potential in Mesozoic strata.  |
| Locatable Energy Minerals | 3B                    | Mineralization potential in Jurassic Morrison and Cretaceous Mesaverde Formations, favorable rock types present, nearby prospects, anomalies and minor production. |





**SALABLE RESOURCES**

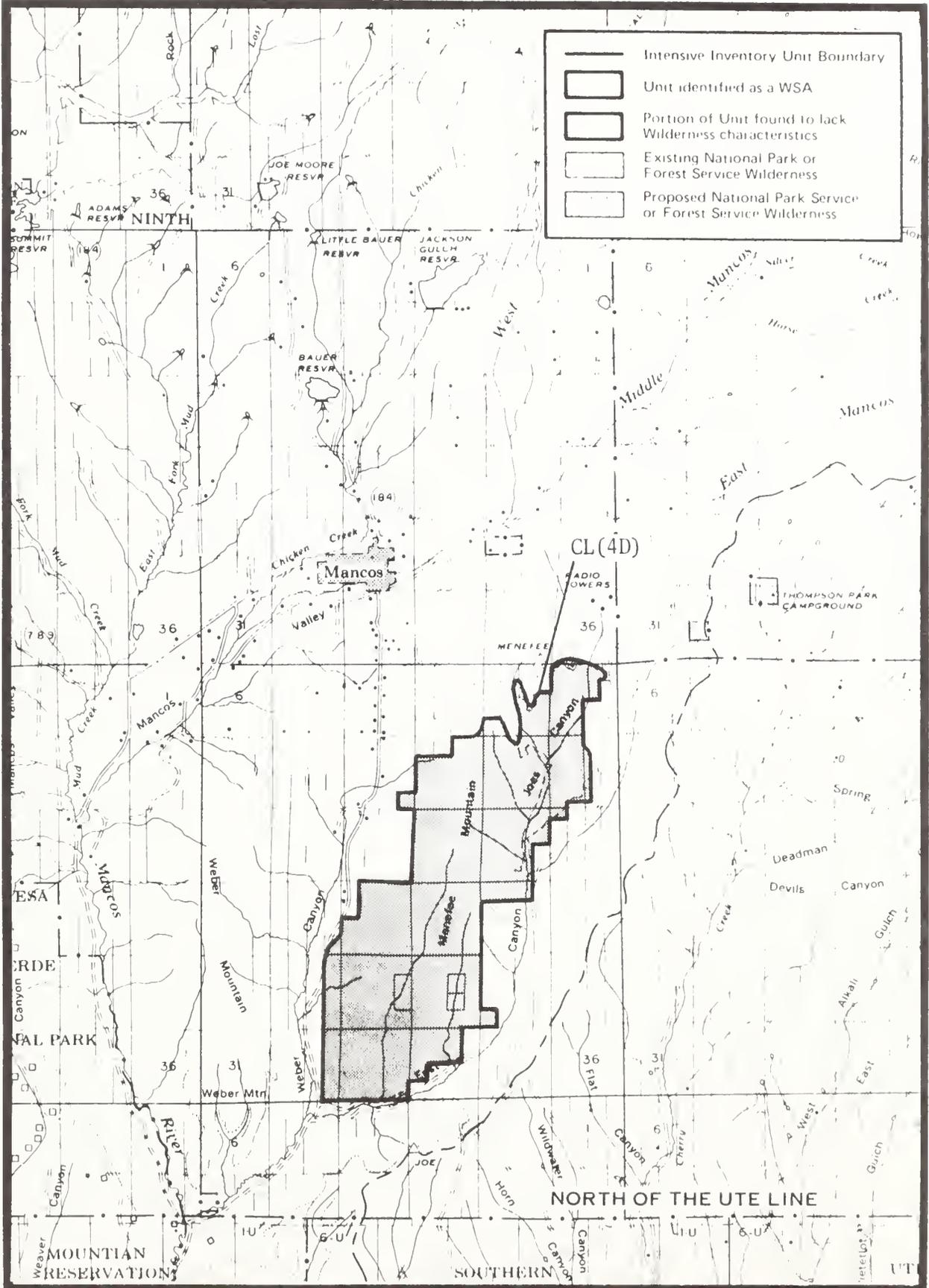
MENEFEE MOUNTAIN WSA (CO-030-251)

| <u>Resource</u>                  | <u>Classification</u> | <u>Comments</u>  |
|----------------------------------|-----------------------|--|
| Structural and<br>Bentonic Clays | 4D                    | The economic potential is rated as moderate. The Mancos Shale may contain favorable units. |

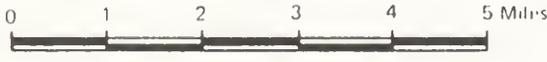
WEBER MOUNTAIN WSA (CO-030-252)

| <u>Resource</u>                  | <u>Classification</u> | <u>Comments</u>  |
|----------------------------------|-----------------------|--|
| Structural and<br>Bentonic Clays | 4D                    | The economic potential is rated as moderate. The Mancos Shale may contain favorable units. |

MONTROSE



- Intensive Inventory Unit Boundary
- Unit identified as a WSA
- Portion of Unit found to lack Wilderness characteristics
- Existing National Park or Forest Service Wilderness
- Proposed National Park Service or Forest Service Wilderness



SALABLE RESOURCES  
Figure IV-3a

(After BLM, 1980)



## SECTION V

### RECOMMENDATIONS FOR FURTHER STUDY

In the course of analyzing, assessing and evaluating each of the WSA's in the Menefee Mountain-Weber Mountain GRA - both in the field and in available data - certain unknowns were uncovered that should be investigated in order that each WSA's GEM resources be more fully documented. This section recommends the type of studies and data gathering that should be made to inventory more completely each WSA.

#### MENEFEE MOUNTAIN WSA (CO-030-251)

Since this area is known to have great potential for oil, gas and coal resources, it is recommended that every effort be made to ascertain the full extent of this potential. Cooperative agreements should be made with various oil and gas producers to obtain proprietary information not available to this study. Such information as the projected reserves of the area, the importance of structural zones in localizing oil and gas pools, and the exact identification of pay zones within the generally favorable lithologies is of vital importance in the exact areal delineation of sub-surface potential.

In addition, a detailed program of geologic mapping and sampling should be carried out to fully delineate the extent of the coal bearing horizons in the Cretaceous section. Any sampling carried out under such a program must include analysis of the coal material for the ash and sulphur content as well as Btu content. Much work has already been done on lithofacies reconstruction in the Cretaceous in adjacent areas. Studies of this nature would be useful in determining the probable northern extent of the coal measures and thus, the viability of the coal as a minable resource.

All existing mines, prospects and known mineral occurrences should be mapped and thoroughly sampled to delineate the full extent of the existing mineralization and the potential of the host lithologies. This is of particular importance in the determination of the uranium-vanadium potential of the Cretaceous Mancos Shale and the coal potential of the Mesaverde Group. With regards to these specific units, a detailed study should be made of facies changes within these units, and the correlations with other units in western Colorado and eastern Utah. In other areas these units have significant potential GEM resources and thus, should be studied in this area where there is little available information. Though the airborne and ground NURE-HSSR-ARMS information does not delineate any areas with anomalous values, ground radiometrics in conjunction with the geological-geochemical would be helpful in identifying any areas of mineral potential.

The known coal seams in the Menefee Mountain Formation should be mapped in detail and sampled. Analysis for Btu, ash and sulphur content of each deposit should be made and the extent of the seam or seams delineated.

Stream sediment samples should be analyzed for their copper, molybdenum, lead, arsenic, uranium, vanadium and gold content. This data will supplement the existing NURE-HSSR information.

Examination of any outcrops of the Mancos Shale for specialty or structural clays should be made in the course of any geologic mapping program.

From the work to date and the material compiled in the course of this project, it appears that this area has significant potential for GEM resources.

#### WEBER MOUNTAIN WSA (CO-030-252)

The GEMS potential of this area is essentially the same as the adjacent Menefee Mountain area. This being the case, it is recommended that the same sort of geological mapping and geochemical sampling program also be done in this area. Such a program should concentrate on the favorable sections of the Cretaceous lithologies and seek evidence of favorable environments for coal, oil, and gas.

All existing mines, prospects and known mineral occurrences should be mapped and thoroughly sampled to delineate the full extent of the existing mineralization and the potential of the host lithologies. This is of particular importance in the determination of the uranium-vanadium potential of the Cretaceous Mancos Shale and the coal potential of the Mesaverde Group. With regards to these specific units, a detailed study should be made of facies changes within these units and the correlations with other units in western Colorado and eastern Utah. In other areas these units have significant potential GEM resources and thus, should be studied in this area where there is little available information. Though the airborne and ground NURE-HSSR-ARMS information does not delineate any areas with anomalous values, ground radiometrics in conjunction with the geological-geochemical would be helpful in identifying any areas of mineral potential.

The known coal seams in the Menefee Formation should be mapped in detail and sampled. Analysis for Btu, ash and sulphur content of each deposit should be made and the extent of the seam or seams delineated.

From the work to date and the material compiled in the course of this project, it appears that this area has significant potential for GEM resources.

## SECTION VI

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