McKENNA PEAK AREA

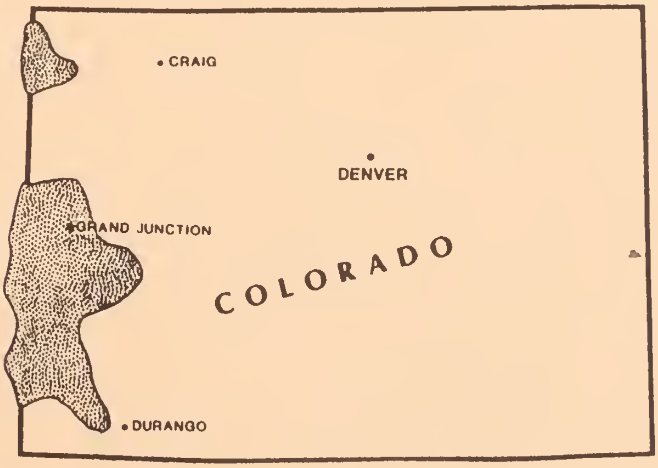
GEOLOGICAL RESOURCE AREA (GRA) 9

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.
and WALLABY ENTERPRISES, INC.

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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 to 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 Heylmun, 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 Cross Canyon - Squaw/Papoose Canyons - Cahone 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 southwestern extreme of the region and another at the northern 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 McKenna Peak area, GRA 9. Included in this GRA is the McKenna Peak WSA (CO-030-286).

The physiography of the GRA includes dissected plateau, valley, and ridge areas. The geology of the WSA is dominated by a badland topography of a maze of narrow ravines, sharp crests, and pinnacles. Rock units exposed in the GRA are sedimentary. Structurally, joint systems in the area may be important in the localization of oil, gas and uranium deposits.

The energy and mineral resources in the GRA include coal and sand and gravel. Coal is deposited in Cretaceous sedimentary units. Sand and gravel was deposited in the northeastern portion of the GRA along drainage patterns.

The McKenna Peak WSA itself contains no known deposits or mineralization.

The classification for the leasable minerals, locatable and salable resources varies. There is a moderate favorability for leasable resources in the form of oil, gas, gypsums and salts. There is an unknown potential in the WSA for locatable minerals due to lack of published literature and geologic field investigations. High favorability for saleable resources exists in the WSA in the form of bentonite and structural clays.

Overall, it is recommended that the WSA in the GRA receive additional work to determine the full economic potential of the 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 occurrence of geology, energy or mineralized commodities.

SECTION I

INTRODUCTION

The McKenna Peak GRA (Figure I-1) is located in Dolores and San Miguel Counties, Colorado. The GRA encompasses a single Wilderness Study Area (WSA), CO-030-286.

The GRA area is located approximately 80 miles south of Grand Junction, Colorado, and 40 miles north of Cortez, Colorado. Located within the boundaries of the GRA are numerous small ranching settlements, but no established towns or villages. The ranches in the area are supplied by road networks from the local supply centers of Slick Rock, Dove Creek and Naturita, and the regional supply center of Cortez, Colorado.

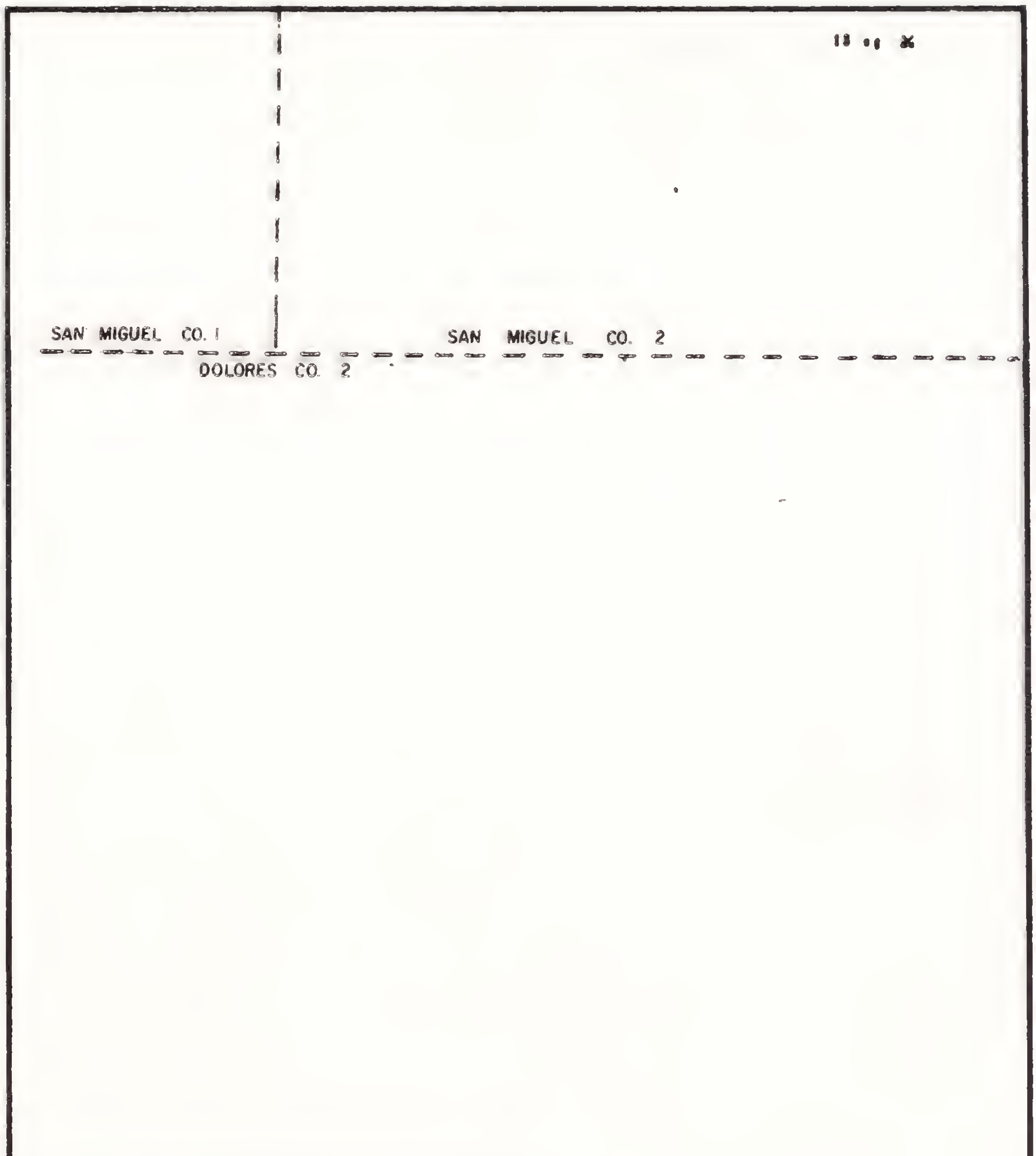
The area includes all or portions of Townships 39-43 North, Ranges 13-17 West. The entire area is bounded by west longitudes 108° 17' 11" to 108° 40' 08" and north latitudes 37° 38' 23" to 38° 00' 00". It contains approximately 507 square miles (1,362 square kilometers or 324,480 acres) of federal, state 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.

McKenna Peak, the only WSA included in this GRA, has a total of 21,900 acres of Federal land.

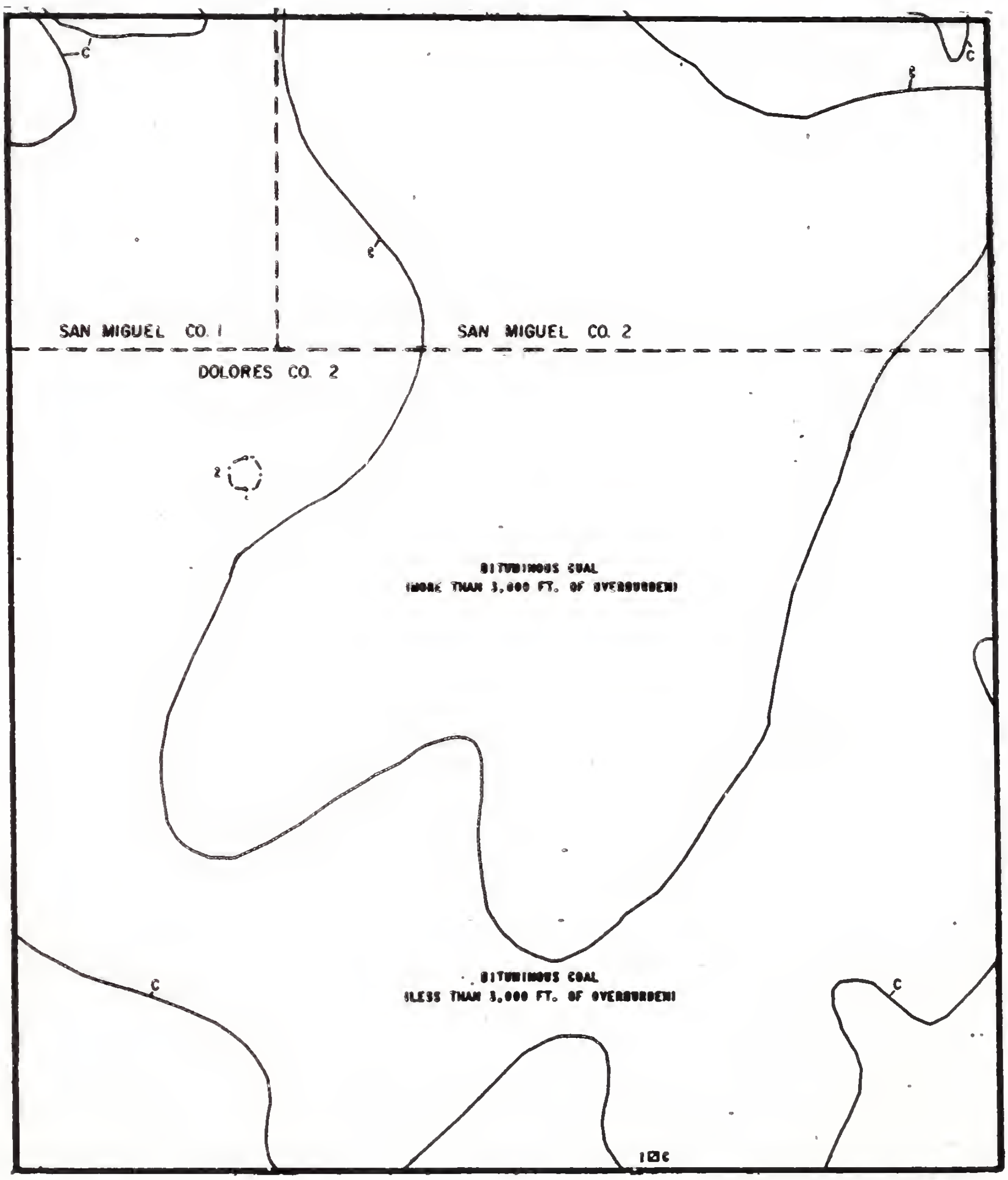
Due to the lack of available data on the WSA, emphasis was placed on gaining an understanding of the mineral potential of the WSA contained within the GRA. Information on the mineral resources of the GRA was utilized to extrapolate and estimate the potential of the WSA from the existing data that in most cases, referred only indirectly to the WSA. This is consistent with the purpose of this contract, which is to utilize the known geological information within the WSA and GRA to ascertain the GEM resource potential of the WSA. 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, company files and returned data sheets. The information was compiled into a series of files on the 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 on September 2, 1982.

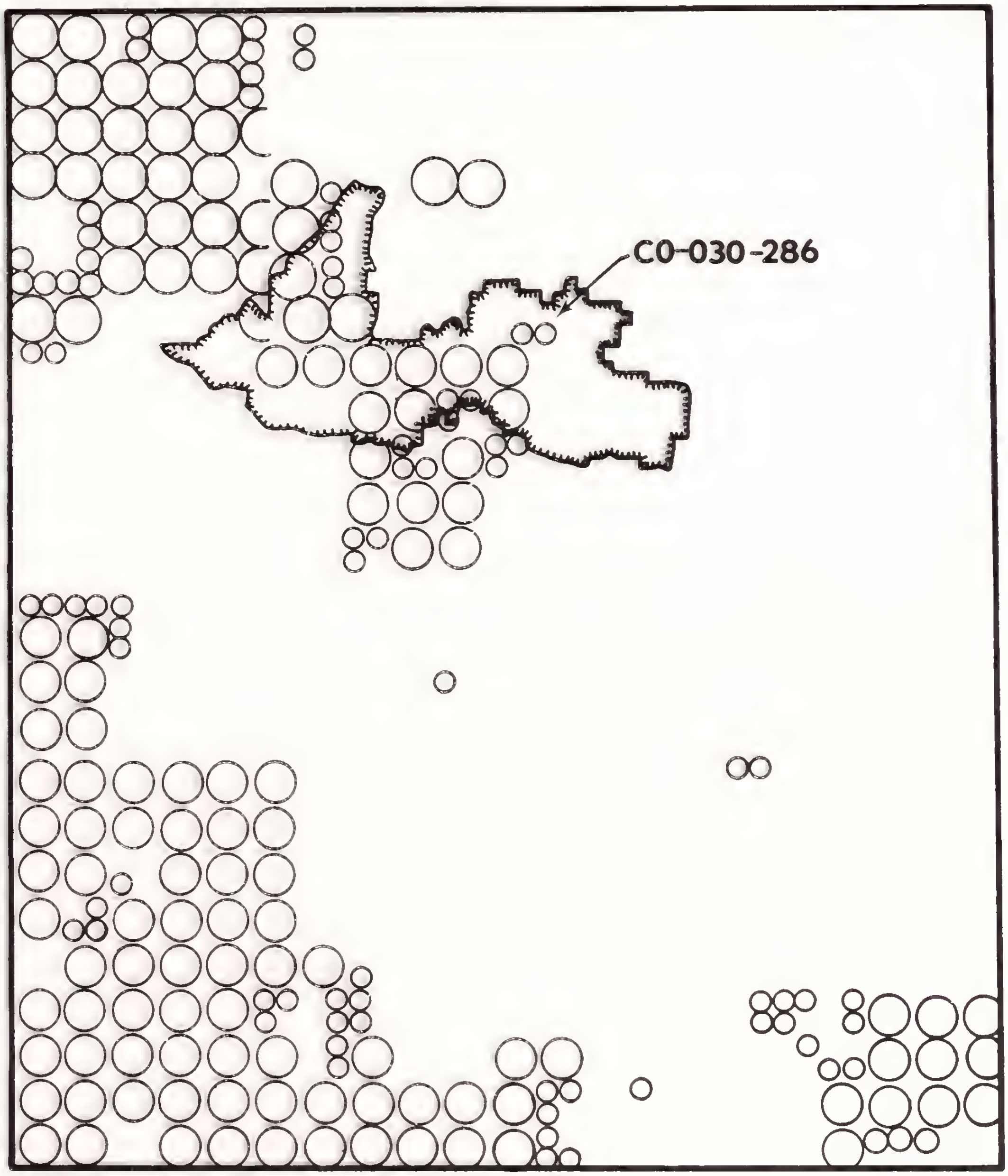
Both of these individuals are registered professional geologists and associates of MSME/Wallaby. Further analysis and study was provided through the photographic interpretation services of BLM 1:24,000 aerial photos by Dr. Larry Lepley, registered professional geologist and remote sensing specialist.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



OVERLAY D
SAND, GRAVEL AND
INDUSTRIAL MINERALS



OVERLAY C
COAL, OIL AND GAS



OVERLAY A
PATENTED AND UNPATENTED
CLAIMS AND WSA BOUNDARIES

16W 15W 14W

(Haynes et al, 1972)

McKENNA PEAK GRA

N

FIGURE I-1
GEOLOGIC MAP

SCALE 1:250,000

NOTE:

As there are no known mines, prospects, or mineral occurrences in the McKenna Peak GRA, an Overlay B was not made.

EXPLANATION

Quaternary (Approximately 2 million years before present (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 (Approximately 135-62 mybp)	Kmvg	Mesaverde Group
	Kmvu	Upper part of Mesaverde Group
	Kc	Castlegate Sandstone
	Kb	Upper member of Blackhawk Formation
	Kmv	Mesaverde 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 (Approximately 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 and 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 (Approximately 225-195 mybp)	Trk	Kayenta Formation
	Trw	Wingate Sandstone
	Tr kw	Kayenta Formation and Wingate Sandstone
	Trd	Dolores Formation
	Tr wc	Wingate Sandstone and Chinle Formation
	Tr c	Chinle Formation, undifferentiated
	Tr cu	Upper part of Chinle Formation
	Tr cb	Chinle Formation, Moss Back Member

Triassic continued	Tr cm	Chinle and Moenkopi Formations
	Tr m	Moenkopi Formation
Permian	Pe	Cutler Formation, undifferentiated
	Pca	Cutler Formation, arkose and arkosic conglomerate
(Approximately 280-225 mybp)	Pcw	Cutler Formation, White Rim Sandstone Member
	Pco	Cutler Formation, Organ Rock Tongue
	Pcc	Cutler Formation, Cedar Mesa Sandstone Member
	Pcwo	Cutler Formation, White Rim Sandstone Member and Organ Rock Tongue
	Pcac	Cutler Formation, transition zone, arkosic beds and Cedar Mesa Sandstone Member
Permian & Pennsylvanian	P Pr	Rico Formation
	P Pcr	Cutler and Rico Formations
Pennsylvanian	Ph	Hermosa Formation, undifferentiated
(Approximately	Phu	Upper member of Hermosa Formation
320-280 mybp)	Php	Paradox Member of Hermosa Formation
Precambrian (Approximately 3400-600 mybp)	pC	Precambrian rocks, undifferentiated.

LEGEND

-O OIL FIELD

-G GAS FIELD

-Os OIL SHALE

-C COAL REGION

OIL WELL

OIL & GAS WELL

GAS WELL

SHOW OF GAS

SHOW OF OIL

SHOW OF OIL & GAS

-C COAL DEPOSIT

-C COAL OCCURRENCE

SHUT-IN WELL

CO_2 OR He=HELIUM -RICH WELL

DRY WELL-ABANDONED

MILL

PLANT

NATURAL GAS PROCESSING PLANT

REFINERY

MINERAL OREBODY

MINERAL DEPOSIT

MINERAL OCCURRENCE

PROSPECT

ACCESSIBLE ADIT

INACCESSIBLE ADIT

VERTICAL SHAFT

INCLINED SHAFT

MINE TYPE UNKNOWN

ACTIVE OPEN PIT, OR QUARRY

INACTIVE OPEN PIT, OR QUARRY

ACTIVE GRAVEL OR CLAY (Cl) PIT

INACTIVE GRAVEL OR CLAY (Cl) PIT

EXPLORATION HOLE WITH DATA AVAILABLE

EXPLORATION HOLE WITHOUT DATA AVAILABLE

UNPATENTED MINING CLAIM

PATENTED MINING CLAIM

MINERAL OR OIL & GAS LEASE

O	OIL	Cb	LIGNITE	Ds	DIMENSION STONE
G	GAS	Cp	PEAT	Fe	IRON
Os	OIL SHALE	Ag	SILVER	Mn	MANGANESE
Ot	TAR SANDS	Au	GOLD	Pb	LEAD
Gi	GILSONITE	Cu	COPPER	U	URANIUM
C	COAL	Cl	CLAY	V	VANADIUM
				Zn	ZINC

SECTION II

GEOLOGY

PHYSIOGRAPHY

Within the GRA boundary are plateau, valley and ridge areas that have been dissected by several northwest and northeast trending fluvial systems. In the northern portion of the GRA are a series of prominent ridges and mesa tops that rise above the gently rolling topography of the surrounding basins and valleys. This system of mesas and ridges is dissected by the northwestward drainage of Disappointment Creek and rises to an elevation of nearly 10,000 feet. Vertical relief in this area is approximately 3,500 feet. The areas directly north of Disappointment Creek can be best characterized as low, rolling hills with local cliff forming canyons that dissect the area and give it a "badland" topography (a maze of narrow ravines and sharp crests) and pinnacles (See Figures II-1 and 2).

South of Disappointment Creek is the most prominent physiographic feature in the GRA upland composed of two mountains: Thomas Mountain and Belmear Mountain. This prominent upland rises approximately 2,000 feet above the level of Disappointment Creek, and is partially cut by a southward flowing drainage. Surrounding this mesa top and ridge system is an example of badland topography. Numerous local stream channels draining this area flow into two major canyons (Plateau Creek Canyon and Cottonwood Creek Canyon) that are found in the southwest and southeast portions of the GRA. The canyons are a part of the tributary drainage of the Dolores River and have a vertical relief of approximately 1,500 feet. Isolated topographic highs are found in this area of rolling hills and badland topography. These features (Beaver Mountain, Narraguinnep Mountain, Glade Mountain and Easton Mountain) rise less than 1,000 feet above the surrounding badlands and are erosion remnants. In the extreme western portion of the GRA are a series of fluvial drainages that trend northwest and flow into Disappointment Creek. Vertical relief within the southern and western areas of the GRA is rarely greater than 500 feet.

The following description addresses the physiographic composition of the single WSA within the McKenna Peak GRA:

MCKENNA PEAK WSA (CO-030-286)

The geomorphology of the area is dominated by the aforementioned badland topography and includes sandstone cliffs, canyons, and rolling hills. McKenna Peak, the predominant topographic feature of the area, rises approximately 1,000 feet above the surrounding terrain. Northeast-trending drainages cut through the WSA and break the area up into a series of shallow canyons and low ridges. Vertical relief within the WSA is approximately 1,500 feet. The WSA is approximately 40 miles north of Cortez, Colorado.

ROCK UNITS

Within the McKenna Peak 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 boundaries of the GRA but is thought to exist at depth (Baars, et

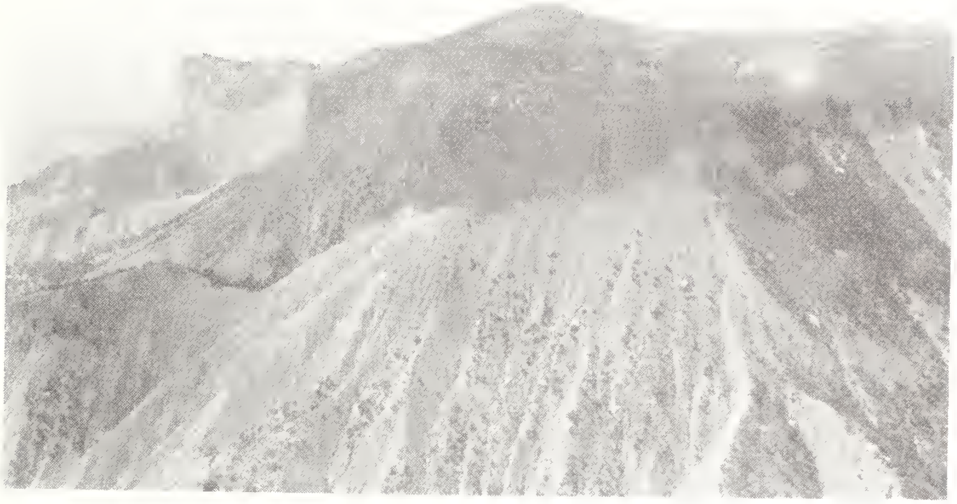


FIGURE II-1
View looking N at
McKenna Peak.

McKENNA PEAK AREA

FIGURE II-2
View of
badland topography
comprising the WSA.

McKENNA PEAK AREA

al, 1981). These Mesozoic units have been extensively studied by companies for their oil and gas potential. Of particular interest is the Pennsylvanian Hermosa Formation and its evaporitic Paradox Member. These units are thought to underlie most of the GRA, as the GRA is located on the extreme northeastern edge of the Paradox structural basin. The basin 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; Heylmun, Personal Communication, 1982). These units are also known to exist from the rather spotty drilling data, and are thought to consist of a series of mudstones, shales, sandstones, and siltstones that were deposited in a near-shore marine or lagoonal environment with occasional fluvial and lacustrine episodes (Molenaar, 1981). It is thought that the Triassic-Jurassic Navajo Sandstone was not deposited in the area of the GRA (Molenaar, 1981; Baars, et al, 1981; Heylmun, 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 outcrop within the GRA. These units have also 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 considered to have been deposited in a shallow-water marine environment that was adjacent to a major ocean basin 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 or tongue 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 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, et al, 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, Colorado, 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 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 et al, 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). There are no known occurrences of uranium-vanadium mineralization within the boundaries of the GRA (Nelson-Moore, et al, 1978).

Directly overlying the Jurassic stratigraphic units is the Lower Cretaceous Burro Canyon Formation and the Dakota Sandstone. This unit consists 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). This unit crops out throughout the western part of the GRA and are overlain by the Cretaceous Mancos Shale. The Mancos Shale occurs throughout the GRA and forms the basal portions of the cliffs south of the WSA (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 (Wanek, 1959; Haynes et al, 1972).

Tertiary and Quaternary gravel deposits are found to directly overlie the exposed Jurassic and Cretaceous stratigraphic units 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).

The following description addresses the rock units in the WSA in the McKenna Peak GRA.

McKENNA PEAK WSA (CO-030-286)

Within this area, the Mancos Shale crops out as a series of low hills that have been eroded into a "badlands' topography. The prominent erosion remnants of the sandstone, shale, and sandy calcareous shale units comprise the Cretaceous section of the area. There are no known mineral deposits within the Mancos, but the coal bearing units of the underlying Dakota Sandstone crop out only a short distance to the southwest of the WSA (Haynes, et al, 1972). In adjacent areas to the north and east of the WSA carbonaceous shales of the Mesaverde Formation are known to exist and may have potential as a coal resource (Gentry, Personal Communication, 1982). Uranium mineralization in the Salt Wash Member of the underlying Jurassic Morrison

Formation has been reported from the Nucla area to the west of the WSA and outside of the GRA. Quaternary alluvium and terrace gravels are found throughout the WSA and directly overlie the exposed Cretaceous section (Haynes et al, 1972; Nelson-Moore, et al, 1978).

STRUCTURAL GEOLOGY AND TECTONICS

Tectonic features found within the GRA include high angle faults, shear zones and joint systems that strike northwest and west-northwest paralleling the major regional structural features of Hamilton Creek Anticline, Dry Creek Syncline, Gypsum Valley Anticline, Disappointment Syncline, and the Dry Creek Basin Fault. In the southeastern portion of the GRA are a series of northeast and east-northeast-striking faults, shear zones and joint systems that parallel the drainage of the West Dolores River and Stoner Creek. The faults and shear zones mapped in this area form a series of horst and grabben features (a series of parallel, linear ridges that are separated by linear valleys with flat bottoms and steep, bounding cliffs). Northwest- and northeast-striking joint systems form the structural fabric of the area, and may be important in the localization of oil, gas, and uranium deposits (Gilmour, Personal Communication, 1982; Lepley, Personal Communication, 1982; Heylmun, Personal Communication, 1982; Carpenter, Personal Communication; 1982).

The major fold structures (Hamilton Creek Anticline, Dry Creek Syncline, Gypsum Valley Anticline, and Disappointment Syncline) are mapped as extending into this area (Williams, 1964). These folds represent deformation in the buried Paleozoic strata by compressional and extensional forces (Baars et al, 1981; Withington, 1955), with at least two periods of tectonism (Withington, 1955). These surface fold structures are only known from reconnaissance mapping throughout most of the GRA and have not been extensively tested by drilling (Heylmun, Personal Communication, 1982). The exposed Mesozoic strata within the GRA appears to rest conformably upon the Paleozoic section (Williams, 1964). Precambrian units do not outcrop with the GRA, but are thought to exist at depth. The Precambrian complex of deformed gneisses, schists, and felsic intrusives that forms the core of the Uncompahgre Uplift may be unconformably overlain by the lower Paleozoic section within the GRA, or may have been overthrust over some of the Paleozoic units of the Paradox structural basin (Baars et al, 1981; Heylmun, Personal Communication, 1982).

No major unconformities have been mapped or identified in the rock units that crop out in the GRA (Williams, 1964; Haynes et al, 1972). Other areas of Colorado contain a known unconformity at the base of the Upper Cretaceous Dakota Sandstone. Within the GRA, such an unconformity has not been indicated in the mapping (Haynes et al, 1972). Throughout the GRA, the Jurassic and Cretaceous units have been covered by local Quaternary colluvial, alluvial, and glacial deposits.

The following description addresses the structural and tectonic characteristics of the McKenna Peak WSA (CO-030-286).

MCKENNA PEAK WSA (CO-030-286)

Structural features within the study area include west-northwest striking high angle faults, shear zones and joint systems that are parallel to the Dry Basin Creek Fault, and the axis of the Dry Creek Syncline (Williams, 1964; Haynes et al, 1972). Other north-northeast striking joint systems appear to control the major drainages that cut through the WSA. The Dry Creek Syncline is thought to have been formed by compressional and extensional forces (Baars, 1966), and has known oil and gas deposits associated with it in other areas of western Colorado (Heylmun, Personal Communication, 1982).

PALEONTOLOGY

Paleontological resources of the GRA are not well known. From the literature, it is known that the Cretaceous Mancos Shale Formation contains fossil plant remains in other areas of Colorado (Wanek, 1959; NPS File Data 1982). In areas north and west of the GRA, the Dakota Sandstone is also known to contain abundant plant remains and have associated coal seams (Shawe et al, 1968). These units outcrop throughout the GRA but have no recorded fossil localities (NPS File Data 1982). Other units cropping out within the GRA known to contain fossil material associated with them in other areas include:

Jurassic Morrison Formation (fossil plants, reptiles, birds, mammals)
Cretaceous Mesaverde Formation (marine fishes, mollusks)
Quaternary Gravels (mammals)

None of these units have known fossil localities with the GRA (NPS File Data 1982).

The following addresses the paleontology of the WSA located in the McKenna Peak GRA.

MCKENNA PEAK WSA (CO-030-286)

Within the WSA, there are no reported occurrences of fossil material (NPS File Data 1982). The Cretaceous Mesaverde Group does not appear to have any known fossil localities or verifiable coal seams. The information on this unit is based on reconnaissance mapping by the United States Geological Survey, which is not of sufficient detail to allow an assessment of the paleontological resource potential of the area (Haynes et al, 1972).

HISTORICAL GEOLOGY

During Middle Precambrian time it is thought that the entire GRA was receiving sediments from both cratonic and island arc sources (Gilmour, Personal Communication). 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 metamorphased, deformed, and intruded by a series of younger Precambrian mafic and felsic bodies. In areas to the northwest of the GRA, 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 (Vanterwilt, 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. The Precambrian sequence is unknown in this area, the nearest outcrops being 25 miles to the northwest of the GRA. 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 younger Precambrian units were not deposited within the GRA (Baars et al, 1981).

Approximately 1,700 million years before present, during the Precambrian, a period of uplift and rift formation set the stage for all subsequent events in southwestern Colorado (Baars et al; 1981). These events, which caused the formation of a large and deep rift basin adjacent to the Uncompahgre Uplift, were caused by deep north-south compressional crustal forces (Baars et al; 1981). With the formation of this deep basin, all sedimentation was restricted to the basinal area, and the exposed deformed and intruded Precambrian basement complex was subjected to erosion. Within the GRA, it is thought that this deposition continued through Permian time, and that a complete Paleozoic section exists at depth (Heylmun, Personal Communication, 1982; Baars et al, 1981).

This period of early and middle Paleozoic deposition was characterized by the 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 much in the way of 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 marine evaporite sequences (Baars et al, 1981). As a result of these evaporites being isolated, basins, salt domes, anticlines, and diapirs formed with succeeding tectonic movements. These structural 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 stratigraphy in 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 features were active in Pennsylvanian and Permian time, and added to the structural complexity of the pre-existing basins.

In the Mesozoic, the area was the site of fluvial and lacustrine deposition in a terrestrial environment. The Triassic Chinle Formation is thought to directly overlie the Paleozoic units in much of the GRA. The Chinle, Wingate, and 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 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 are thought to have 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" mineralization that was deposited in areas of rapidly changing Eh-pH conditions in the aqueous solutions within the rock strata. The presence of these deposits within the GRA and 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 Wingate Formation and the overlying Jurassic Entrada Sandstone is probably a local feature that represents a period of non-deposition (Shawe, 1968). 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 et al, 1965). The Wingate-Entrada unconformity may then represent a period when the last remnants of the Uncompahgre topographic high were being eroded into flanking shallow Jurassic basins. The Jurassic Summerville and overlying Morrison Formations, thought to have been deposited in near-shore lagoonal environments or shallow water marine and fluvial systems, outcrop in the southern portion of the GRA. Some fresh-water lacustrine and fresh-water fluvial deposits have also been identified from these rocks. As in the earlier Triassic section, mineral deposits commonly found in other areas of Colorado are associated with limey sandstones, shales, and siltstones that were deposited in shallow, neritic basins that have fluvial channels meandering through them. Copper-silver-uranium-vanadium mineralization occurs in these units as "roll-front" and organically precipitated "stream channel" deposits in the near-by Uravan and Slick Rock uranium-vanadium districts. "Roll-front" deposits consist of 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 clastic organic accumulations, depositing the minerals in a reducing environment. Such mineral deposits are very important economically as they contain high grade uranium-vanadium ores, and are known to occur in areas adjacent to the GRA. 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 et al, 1965). Portions of the Dakota are found as channel fillings in the Upper Burro Canyon paleosurface. From fossil evidence, it appears that the lower sections of the Dakota were deposited in shallow basins or stream channels, and having the source of the material being eroded masses of Pennsylvanian and Permian rocks, that were then exposed just to the west of the GRA (Carter et al, 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 beds 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. Thin coal beds in the correlative Blackhawk Formation may have some local economic significance. In the GRA proper, these units are represented by the carbonaceous units of the Mancos Upper Shale unit (Wanek, 1959). The Cretaceous Mesaverde Group units crop 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, 1959). The Menefee Mountain Formation contains coal beds that have been mined in the past. The upper members of this formation also contain thin, discontinuous coal seams of minor economic importance (Wanek, 1959). These units were also laid down in a near-shore swamp or lagoonal environment.

The area was uplifted and subjected to erosion in Middle Tertiary times. 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.

The following addresses the historical geology of the WSA in the McKenna Peak GRA.

MCKENNA PEAK WSA (CO-030-286)

According to the well information available, the Precambrian section is present under the WSA. No other information on the lithologies encountered is currently available. Within the boundaries of the WSA, only the Cretaceous and Quaternary units are exposed. The near-shore environments of the Mancos Shale Formations characterize the Cretaceous section in this area. Isolated outcrops of marine sandstone cap the rolling hills and represent a period of fluvial or lacustrine deposition adjacent to major marine basins.

SECTION III

ENERGY AND MINERAL RESOURCES

KNOWN MINERAL DEPOSITS

The McKenna Peak GRA contains two known deposits, consisting of the North Star Coal Mine, located in Section 17, T39N, R14W, and a sand and gravel pit, located in section 18, T43N, R13W (Overlays C and D). Production statistics were not available. There are however, no known deposits in the McKenna Peak WSA.

KNOWN PROSPECTS, MINERAL OCCURRENCES AND MINERALIZED AREAS

The McKenna Peak GRA contains two dry holes located in section 22, T41N, R16W and section 10, T41N, R15W (Appendix A: Mapco Data).

Another prospect or mine is delineated on aerial photograph 2-11-2 (Appendix A). This prospect is located in section 31, T42N, R15W, south of the WSA. The commodity and status are not known.

There are however, no known prospects, mineral occurrences or mineralized areas in the McKenna Peak WSA.

MINING CLAIMS, LEASES AND MATERIAL SITES

The McKenna Peak GRA contains approximately 6,500 unpatented mining claims located in the northwestern and southwestern portions of the GRA (Overlay A). There are no major exploration companies with claim holdings in the GRA. The unpatented claim data was obtained from the Bureau of Land Management's June 14, 1982, Geographic Index (Appendix C). The exact number of claims can not be readily determined from the Geographic Index since duplication of claims listed occurs if a claim boundary crosses a section line. It is estimated that the above figure is accurate within 2 percent.

There are no patented mining claims located in the GRA.

Information on leases and material sites was not compiled for the entire GRA. Please refer to the Oil and Gas Plats in Appendix A.

The following addresses the mining claims, leases, and material sites for the McKenna Peak WSA.

McKENNA PEAK WSA (CO-030-286)

As of June 14, 1982, the McKenna Peak WSA contained approximately 436 unpatented mining claims, as recorded in the BLM Geographic Index (Overlay A, Appendix C). These claims are situated in the central and northwestern portions of the WSA.

There are no patented claims in the WSA. For data on leases, please refer to the Oil and Gas Plats in Appendix A.

MINERAL DEPOSIT TYPES

The McKenna Peak GRA contains two deposits: coal, and sand and gravel.

The two prominent coal-bearing formations present in the GRA are the lower Cretaceous Dakota Sandstone and the upper Cretaceous Mesaverde Group. The Dakota Sandstone is composed of three members: the upper sandstone member; the middle coal-bearing member; and the lower conglomeratic sandstone member (Landis, 1959). The coal beds are extremely lenticular, discontinuous and contain a high percentage of impurities, such as, shale, bone and bony coal. Lateral correlation of the Dakota coal beds is difficult. In most cases, only one bed is of a minable thickness, however, in the Nucla-Naturita field, located to the north of the GRA, at least three relatively thick beds are present (Landis, 1959). The Dakota coal is ranked as high-volatile bituminous (Landis, 1959). The Mesaverde Group is composed of sandstone, shale and coal beds. The upper portion of the Mesaverde is composed of prominent sandstone layers with interbedded shale and thin coal beds. The middle portion is composed of shale, coal beds and sandstone. In this portion, shale is predominant. The lower portion of the Mesaverde consists of a white sandstone (Shaler, 1907 and Schwochow, 1978). Coal from the Mesaverde is ranked as high-volatile A and B bituminous.

Sand and gravel, deposited along drainage patterns in the northeastern corner of the GRA, have been exploited.

MCKENNA PEAK WSA (CO-030-286)

There are no known deposits in the McKenna Peak WSA, therefore, any discussion on the deposit types would be theoretical.

MINERAL ECONOMICS

The inherent nature of disccussing the economics of the minerals existing within the McKenna Peak GRA and its WSA 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.

Specific information relating to the known oil and gas reserves and reserve potential in the McKenna Peak WSA (CO-030-286) was not obtainable from the published literature or industry sources (Heylmun, Personal Communication, 1982). Known oil and gas resources are found in nearby areas in the Cretaceous Manco Shale Formation. 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 furture (Petroleum Times Price Report, Oct. 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).

There are no known deposits or mineralized areas of base or precious metals, energy minerals, or industrial minerals in the WSA. Thus, the economic potential for the development of mineral resources appears to be marginal at this time.

SECTION IV

LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

After thoroughly reviewing the existing literature and data base sources, MSME/Wallaby personnel plotted all known documented 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 and Stream Sediment Reconnaissance - Airborne Radiometric and Magnetic Survey (NURE-HSSR-ARMS) 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 the selected classification level. This is denoted by the letter associated 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, for the most part, is 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 therefore, address those resources considered to be leasable, locatable and/or salable with associated maps locating the resource area.

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.

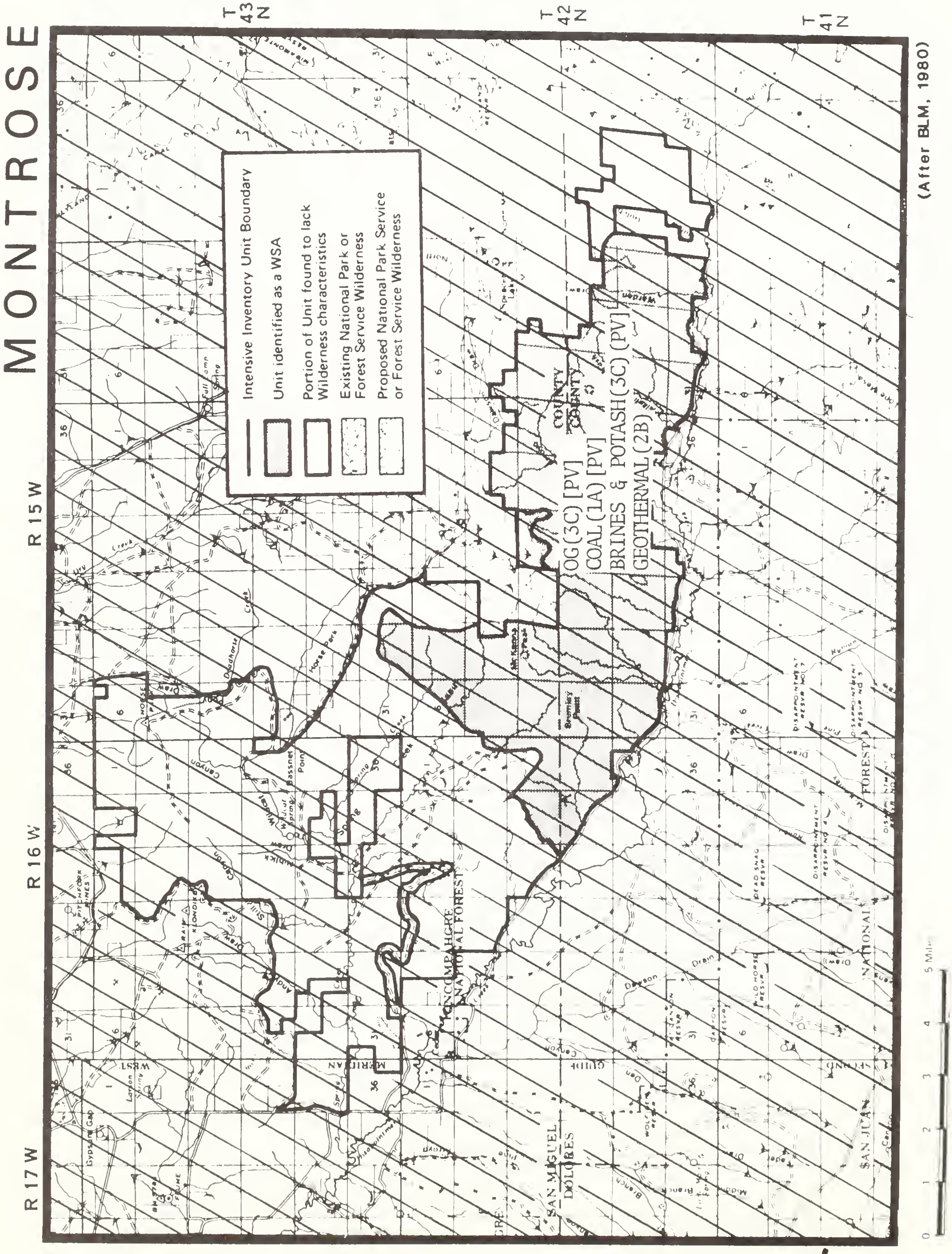
C. The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.

D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

LEASABLE RESOURCES

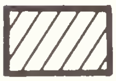
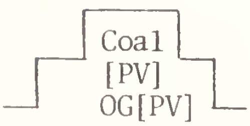
MCKENNA PEAK WSA (CO-030-286)

Resource	Classification	Comments
Oil & Gas	3C	The WSA covers part of a faulted surface syncline in an area of Cretaceous Mesaverde and Mancos sandstones and shales, in the southern part of the Paradox Basin. The principal objective zones for oil and gas would be in Pennsylvanian, Mississippian and Devonian rocks found at depth.
Coal	1A	Lack of coal-bearing units in the WSA.
Brines & Potash	3C	Known to occur in the Paradox Formation. Moderate economic potential.
Geothermal	2B	Unknown potential.



MMS/LEASABLE RESOURCES
Figure IV-1

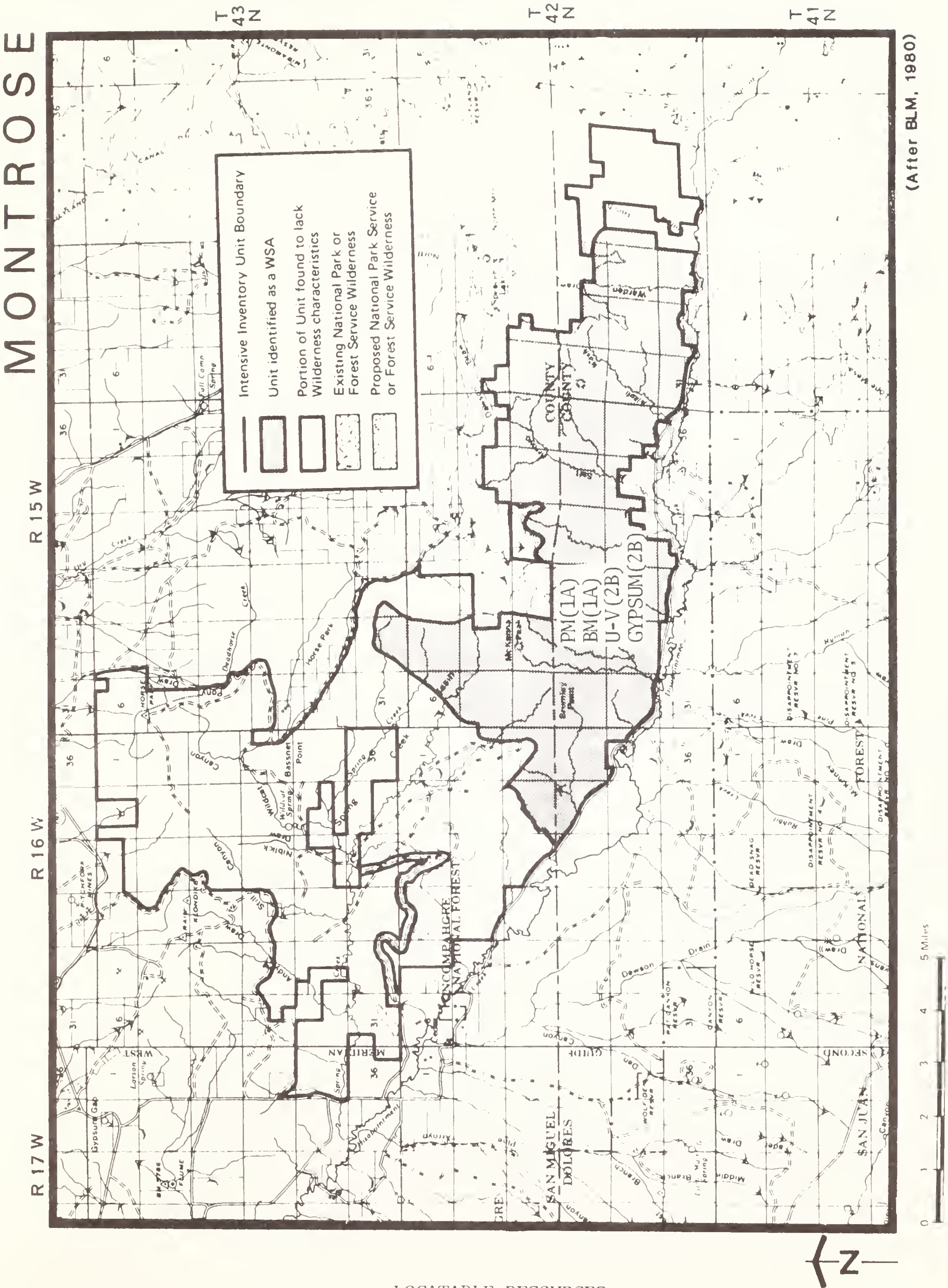
LEGEND FOR MINERALS MANAGEMENT SERVICE CLASSIFICATIONS

	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

MCKENNA PEAK WSA (CO-030-286)

Resource	Classification	Comments
Precious Metals	1A	
Base Metals	1A	
Locatable Energy Minerals	2B	Uranium-Vanadium mineralization potential in Jurassic Morrison Formation.
Other Locatable Minerals	2B (Gypsum)	Known to occur in the Paradox Formation Moderate economic potential.

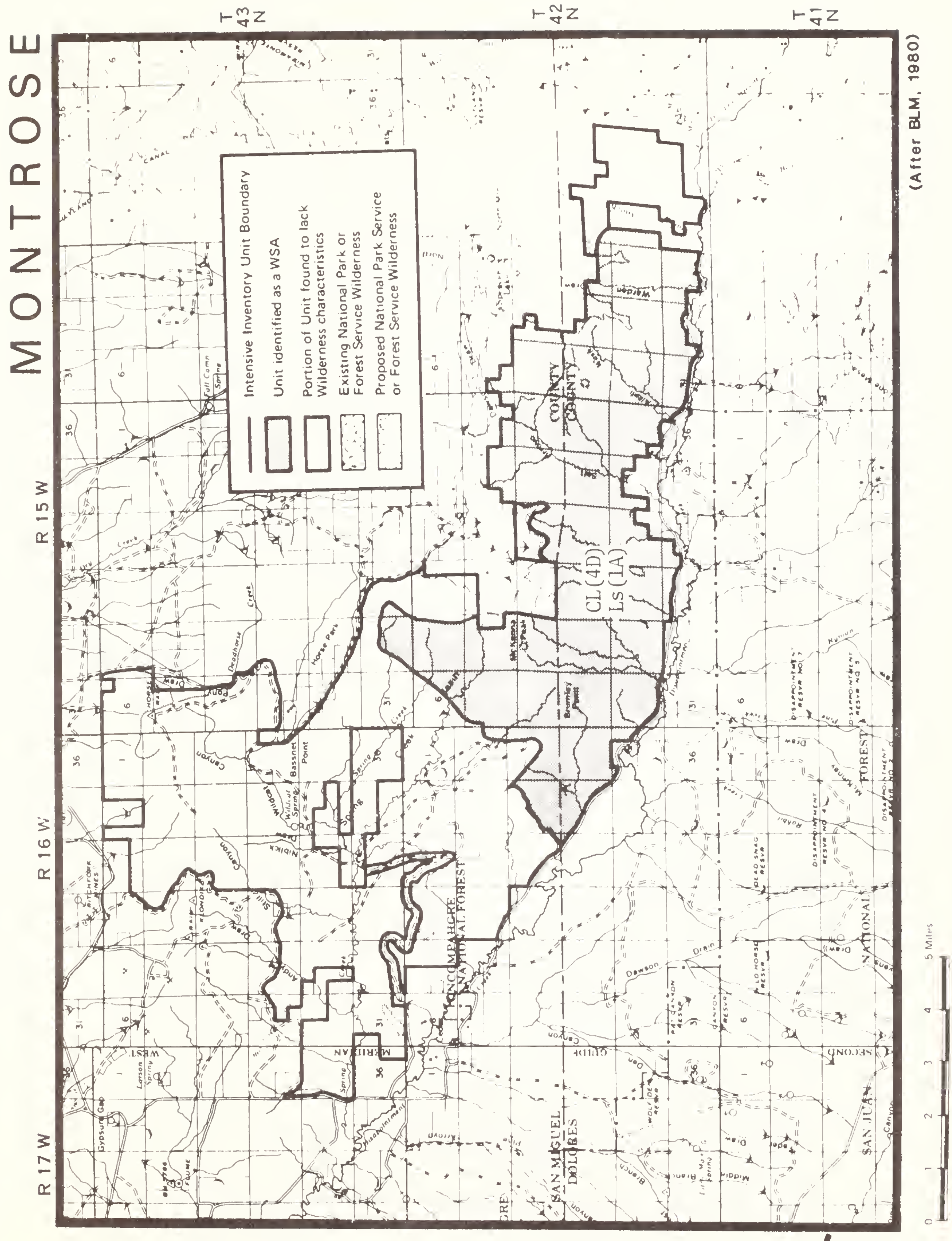


LOCATABLE RESOURCES
Figure IV-2

SALABLE RESOURCES

MCKENNA PEAK WSA (CO-030-286)

Resource	Classification	Comments
Bentonite Clays & Structural Clays	4D	Derived from the Mancos Formation. Moderate economic potential.
Limestone	1A	The Paradox Formation contains favorable limestone units, however, the limestone occurs at depth.



SALABLE RESOURCES
Figure IV-3

SECTION V

RECOMMENDATIONS FOR FURTHER STUDY

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

MCKENNA PEAK WSA (CO-030-286)

Since this area is known potentially for oil and gas 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 any coal bearing horizons in the adjacent Cretaceous Dakota 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 northeastern extent of any coal measures and thus, the viability of the coal as a minable resource.

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

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.

In conclusion, from the work to date and the material compiled in the course of this project, it appears that the potential for GEM resources in this area is largely unknown. It is recommended that this area receive further extensive study prior to any decision as to its inclusion in the Wilderness System. (For further detailed discussion of the potential thought to exist within the WSA, please refer back to Section IV).

SECTION VI

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