Dolores River Canyon - Tabeguache Creek Area

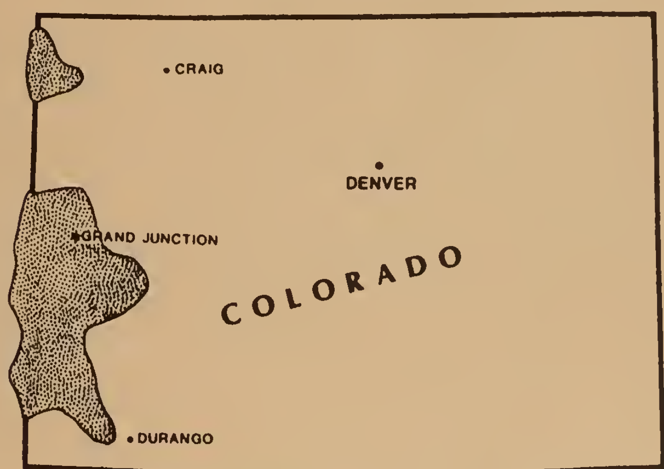
GEOLOGICAL RESOURCE AREA (GRA) 8

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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TABLE OF CONTENTS

SECTION		PAGE
	FOREWORD	i
	EXECUTIVE SUMMARY	ii
I	INTRODUCTION	I-1
II	GEOLOGY	II-1
	Physiography	II-1
	Rock Units	II-2
	Structural Geology and Tectonics.	II-6
	Paleontology.	II-8
	Historical Geology	II-9
III	ENERGY AND MINERAL RESOURCES	III-1
	Known Mineral Deposits	III-1
	Known Prospects, Mineral Occurrences, and Mineralized Areas	III-2
	Mining Claims, Leases, and Material Sites . .	III-3
	Mineral Deposit Types	III-3
	Mineral Economics	III-6
IV	LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL . .	IV-1
	Leasable Resources	IV-4
	Locatable Resources	IV-5
	Salable Resources	IV-6
V	RECOMMENDATIONS FOR ADDITIONAL WORK	V-1
VI	REFERENCES AND SELECTED BIBLIOGRAPHY	VI-1
APPENDICES	(SEPARATE ATTACHMENTS)	

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, Dr. Gentry, Mr. Eyde, and Dr. Lepley should receive special acknowledgement. It was from the work of these consultants that this report on the Dolores River Canyon-Tabeguache Creek 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 resource 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 Dolores River Canyon-Tabeguache Creek Area, GRA 8. Included in the GRA is Dolores River Canyon WSA, CO-030-290, and Tabeguache Creek WSA, CO-030-300.

The physiography and geology of the GRA includes valley, canyon, and plateau areas along the course of the Dolores and San Miguel Rivers in the Paradox Valley area. Metamorphic Precambrian rocks are exposed in the GRA, but are relatively unstudied. The remaining rock formations are sedimentary. The Castle Valley and Paradox Valley Anticline systems have helped in localizing oil and gas deposits, and may have structurally controlled salt dome deposits. High angle faults, shear zones and joint systems have had base and precious metal mineralization associated with them in other parts of western Colorado.

The energy and mineral resources in the GRA include gas, coal, uranium and vanadium, base and precious metals, industrial minerals, including sand and gravel. Gas is produced from structural and stratigraphic traps in sedimentary units. Coal is also produced from sedimentary units in the Nucla-Naturita Coal Field. Sedimentary units in the Uravan Mineral Belt province produce uranium and vanadium. Copper and silver occur at the faulted, mineralized contact between Triassic and Jurassic sedimentary units. The industrial minerals are produced from evaporite deposits formed during the Pennsylvanian Period. Sand and gravel occurs along the San Miguel River and it's tributaries.

Neither of the two WSA's in the GRA contain known mineral deposits. The Dolores River Canyon WSA possibly contains copper and/or uranium prospects, as delineated through aerial photo interpretation by Dr. Lepley.

The classification for the occurrences of leasable minerals, locatable and salable resources varies. There is moderate to high favorability for leasable resources in both WSA's in the form of oil, gas, and coal. The Tabeguache Creek WSA has an

unknown to low favorability for locatable resources. The Dolores River Canyon WSA has a high favorability in the form of copper, gold, and silver. There is high favorability for saleable resources in the Dolores River Canyon WSA and Tabeguache Creek WSA for limestone and building stone, respectively.

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 Dolores River Canyon-Tabeguache Creek GRA (Figure I-1) is located in western Montrose County, Colorado. The GRA encompasses two Wilderness Study Areas, the Dolores River Canyon WSA (CO-030-290), and the Tabeguache Creek WSA (CO-030-300).

The GRA area is located approximately 50 miles south of Grand Junction, Colorado. Located within the boundaries of the GRA are a number of towns that are local supply centers for agriculture, ranching, and mining activities. These towns are supplied over road networks from Grand Junction, the regional supply center. The towns (Uravan, Nucla, Naturita, Vancorum, Bedrock, Paradox and Redvale) are also local supply centers for the oil and gas operations in the area.

The GRA encompasses all or portions of Townships 45-48 North, Ranges 14-20 West. The entire area is bounded by west Longitudes 108° 26' 41" and 109° 02' 34" and north Latitudes 38° 09' 00" and 38° 25' 32". It contains approximately 612.5 square miles (1,650 square kilometers or 392,000 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.

The specific WSA's within the GRA have a total of 32,820 acres of Federal land. The acreages of the various contained WSA's are:

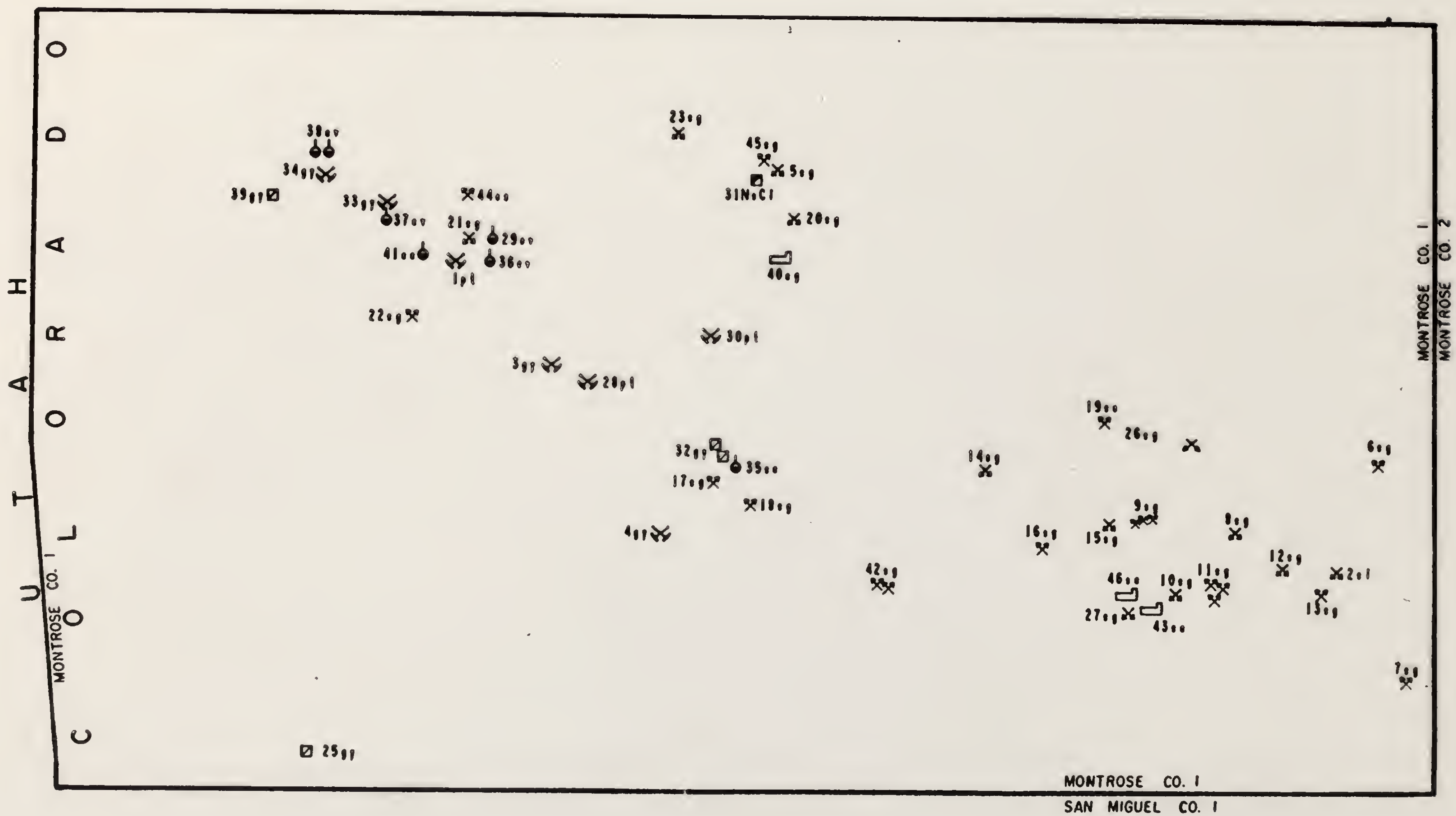
Dolores River Canyon (CO-030-290) - 25,550 acres
Tabeguache Creek (CO-030-300) - 7,270 acres

The Dolores River Canyon WSA is located in the southwestern part of the GRA, and is approximately 70 miles southwest of the nearest major regional urban center, Grand Junction, Colorado. The WSA is located directly south of the settlement of Bedrock, Colorado and west of the settlements of Vancorum, Naturita, and Nucla. The Tabeguache Creek WSA is located approximately 50 miles south of Grand Junction, and 3 miles north of Nucla, Colorado. This unit is located in the northeast part of the GRA.

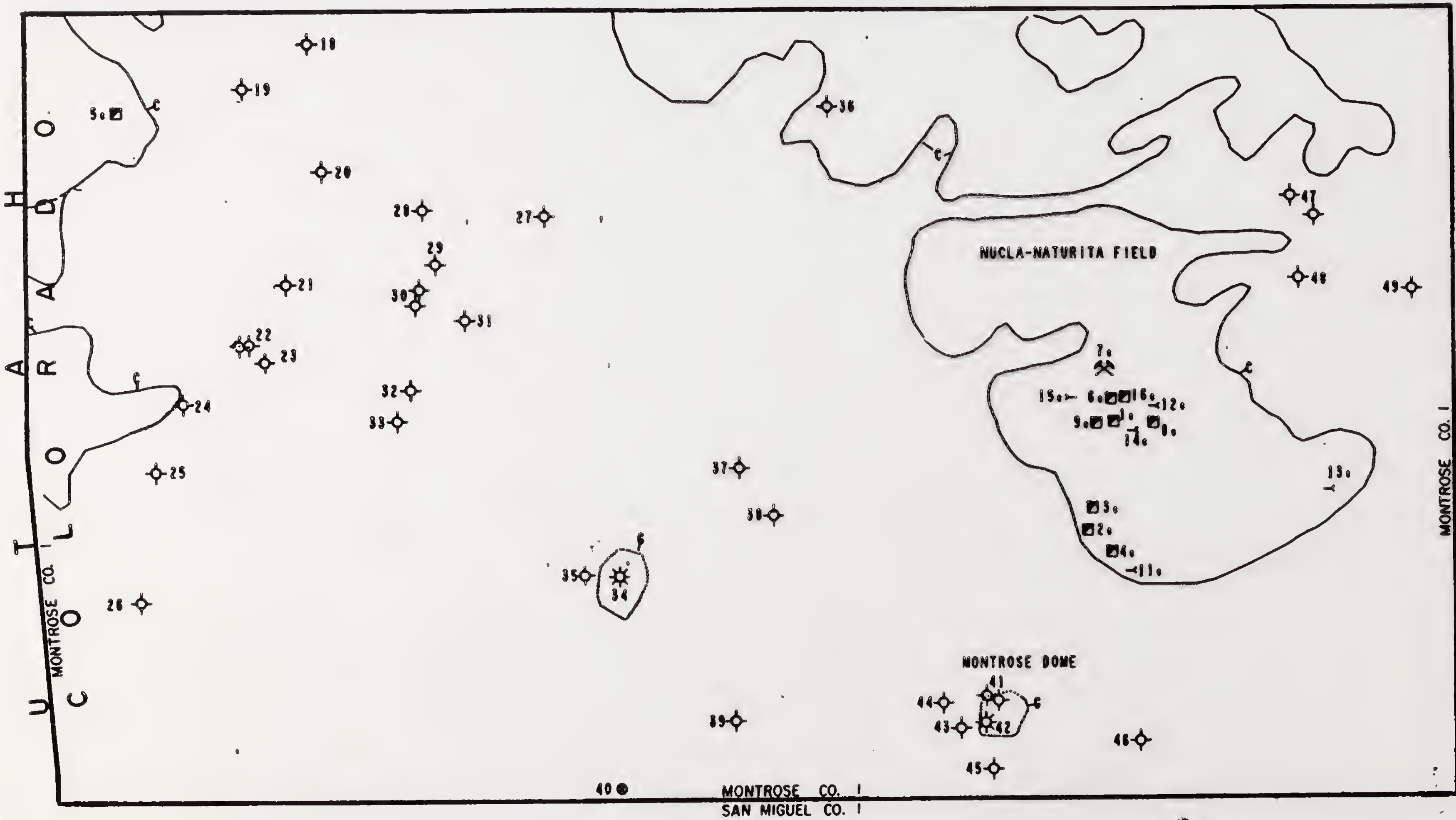
Due to the lack of available data on each WSA, emphasis was placed on gaining an understanding of the mineral potential of each WSA within the GRA. Information on the mineral resources of GRA was utilized to extrapolate and estimate the potentials of the contained WSA's from the existing data that in 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 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, Dr. Donald Gentry and Mr. Ted Eyde during the period of August 31 - September 1, 1982.

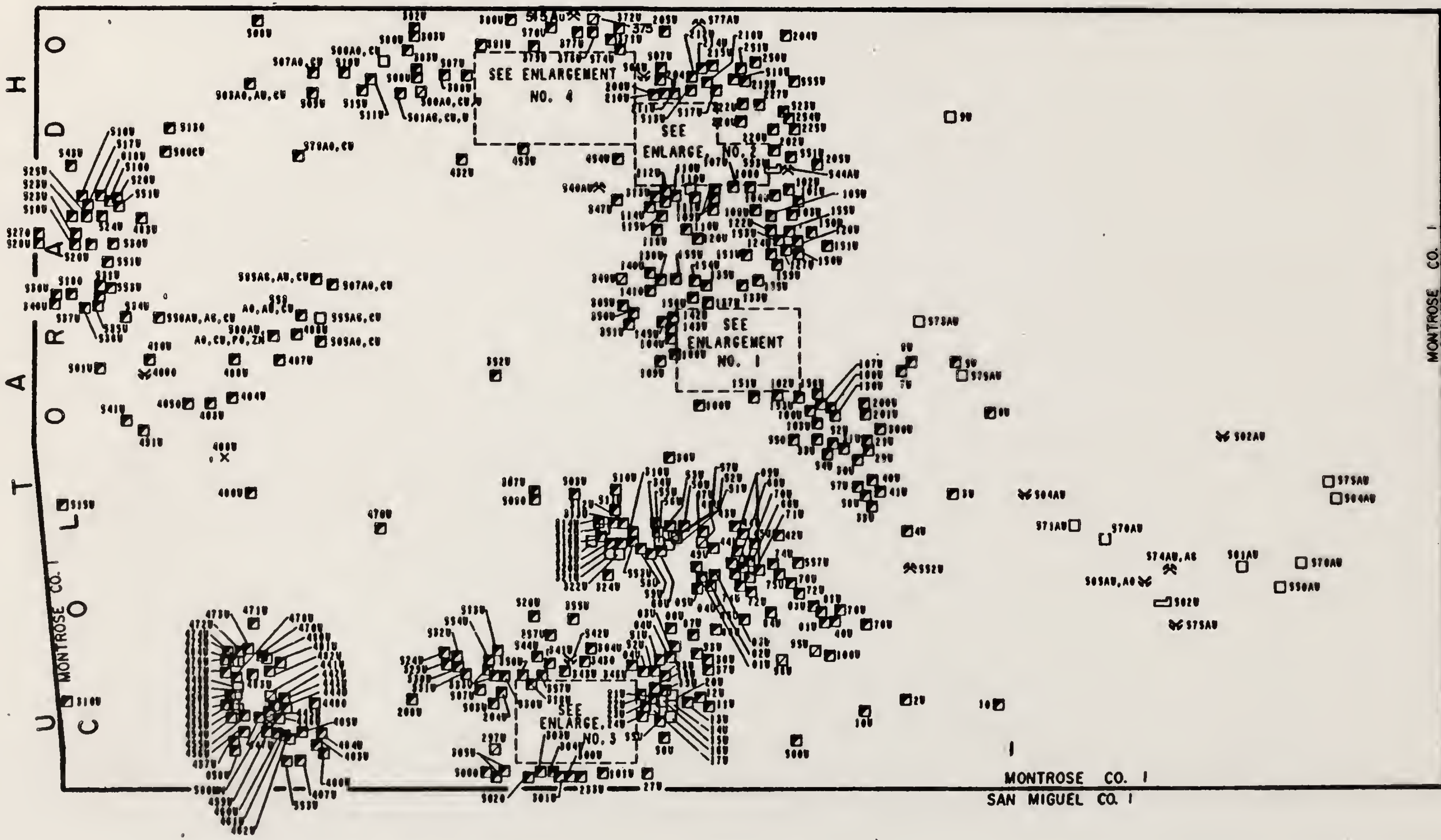
All of these individuals are registered professional geologists and associates of MSME/Wallaby. Further analysis and study was provided through the photographic interpretation services of BLM 1:24,000 aerial photos by Dr. Larry Lepley, registered professional geologist and remote sensing specialist.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



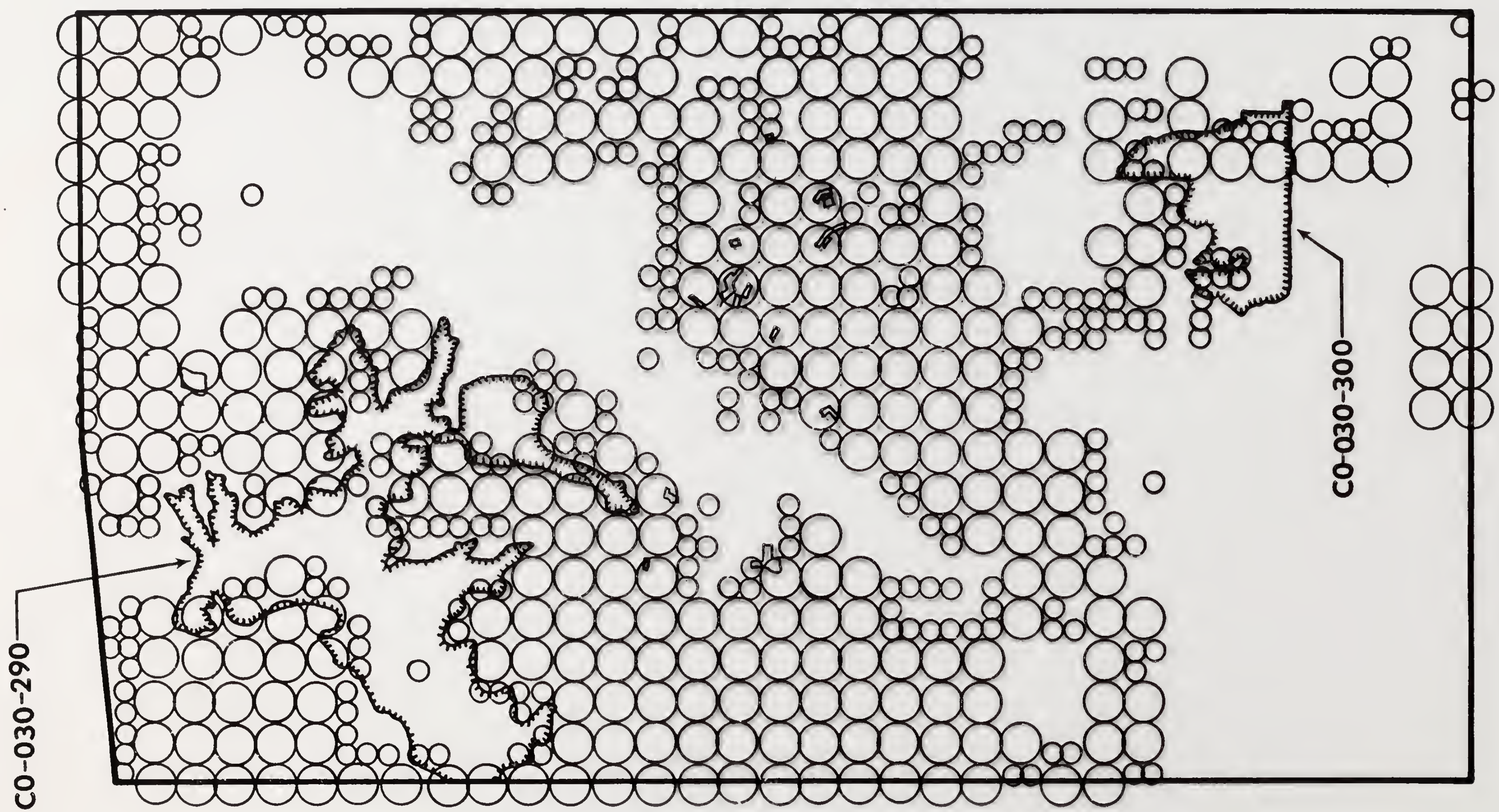
OVERLAY D
SAND, GRAVEL AND
INDUSTRIAL MINERALS



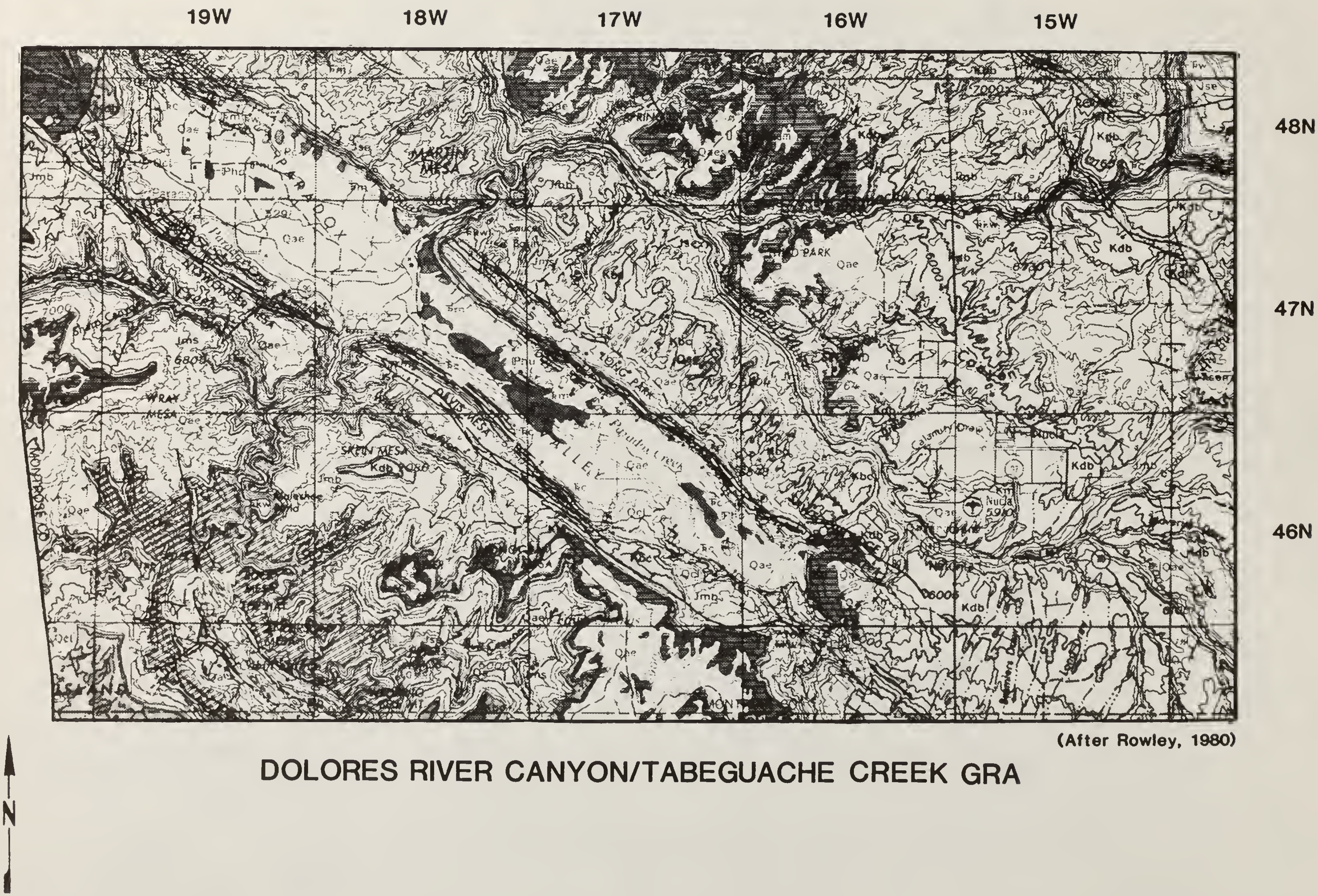
OVERLAY C
COAL, OIL AND GAS



OVERLAY B
MINES, PROSPECTS
AND MINERAL OCCURENCES



OVERLAY A
PATENTED AND UNPATENTED
CLAIMS AND WSA BOUNDARIES



(After Rowley, 1980)

DOLORES RIVER CANYON/TABEGUACHE CREEK GRA

SCALE 1:250,000

FIGURE I-1
GEOLOGIC MAP

EXPLANATION

Quaternary (Approximately 2 million years before present (mybp) to present)	Qae	Alluvial and eolian deposits
	Qa	Alluvium 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 (Approximately 280-255 mybp)	Pe	Cutler Formation, undifferentiated
	Pca	Cutler Formation, arkose and arkosic conglomerate
	Pcw	Cutler Formation, White Rim Sandstone Member
	Pco	Cutler Formation, Organ Rock Tongue
	Pcc	Culter 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 (Approximately 320-280 mybp)	Ph	Hermosa Formation, undifferentiated
	Phu	Upper Member of Hermosa Formation
	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
G	GAS
Os	OIL SHALE
Ot	TAR SANDS
Gi	GILSONITE
C	COAL
Cb	LIGNITE
Cp	PEAT
Ag	SILVER
Au	GOLD
Cu	COPPER
Cl	CLAY
Ds	DIMENSION STONE
Fe	IRON
Mn	MANGANESE
Pb	LEAD
U	URANIUM
V	VANADIUM
Zn	ZINC

SECTION II

GEOLOGY

PHYSIOGRAPHY

The GRA boundary includes valley, canyon, and plateau areas along the course of the Dolores and San Miguel Rivers and in the Paradox Valley area. In the northeast portion of the GRA, an area essentially bounded by the Paradox Valley area on the southwest, are the drainages of the Dolores River, San Miguel River and Tabegauche Creek. This area is characterized by deep canyons that cut into the resistant Mesozoic rocks and leave behind a series of ridges, mesas and rough tributary drainages that feed into the main river systems. The ridges stand out as prominent topographic highs that rise almost 1,000 feet above the river beds. Such features as Martin Mesa, Atkinson Mesa, Atkinson Breaks, Spring Creek Mesa, Long Mesa, and Third Park are local flat-topped mesa, ridge and park areas where the topography gently slopes down to the west. The valleys of the major fluvial systems that cut through the area (Dolores River, San Miguel River and Tabeguache Creek) are narrow. The Dolores and San Miguel River drainages are alligned northwest-southeast and are parallel to the axes of the major fold structures that are found in the region, and the trend of the Uncompahgre Plateau. Within the GRA, the valley of the Dolores River is a narrow meandering canyon until it meets the San Miguel River just east of Martin Mesa. Upstream from the junction of the San Miguel with the Dolores River, to the point where the Dolores begins to cross Paradox Valley, there are a series of "goosenecks" in the river channel flanked by a spectacular canyon feature on the southeast side of Martin Mesa.

The Paradox Valley cuts across the GRA in a northwest to southeast direction and is a prominent feature of the region. The valley floor is relatively flat with less than 500 feet of vertical relief. The valley is approximately 23 miles long, 2 to 4 miles wide and is crossed at right angles by the Dolores River.

To the northwest and southwest of the Paradox Valley are a series of ridges and cliffs that define the valley. The vertical relief from the floor of the Paradox Valley to the tops of these ridge and cliff features is approximately 1,000 feet. The ridges and mesa tops southwest of Paradox Valley include resistent remnants of Mesozoic rocks and include such prominent topographic features as Skein Mesa, Monogram Mesa, Steer Mesa, Davis Mesa, Nyswonger Mesa, Buck Mesa and The Horn. These mesa areas are relatively flat, and have been moderately incised by the tributary drainage systems of the Dolores River. The most prominent physiographic feature of the area southwest of Paradox Valley is the Dolores River canyon. This major fluvial feature is found along the course of the upper-middle drainages of the Dolores River and includes the La Sal Creek and Coyote Creek Drainages. Vertical relief in the canyon is approximately 1,000 to 1,200 feet. The Dolores has cut down into resistant beds of the Mesozoic section and carved a meandering canyon.

The following descriptions address the physiographic composition of each of the individual WSA's within the Dolores River Canyon-Tabeguache Creek GRA.

DOLORES RIVER CANYON WSA (CO-030-290)

Within the boundary of the WSA the Dolores River has cut a deep canyon into the resistant Mesozoic rock section. The vertical relief within the meandering canyon is approximately 1,000 to 1,200 feet. Lower benches of resistant bedrock and a few rocky ridges are found within the WSA. These features rise 500 to 700 feet above the bottom of the canyon. Also included within the WSA are various tributary drainages that flow into the La Sal Creek-Coyote Wash-Dolores River drainage system.

TABEGUACHE CREEK WSA (CO-030-300)

Within this WSA is found a series of connected canyons that form the tributaries and main portion of Tabeguache Creek canyon. Within the canyon system, the vertical relief is approximately 800-1,000 feet. The adjacent ridges and mesa tops have been included within the WSA and are cut by the crooked tributary canyons of the Tabeguache Creek canyon system. Vertical relief from the bottom of the Tabeguache Creek drainage to the top of the mesas and ridges is approximately 1,000-1,200 feet.

ROCK UNITS

Within the Dolores River Canyon-Tabeguache Creek GRA is found a variety of rock units that represent a large part of Precambrian, Paleozoic, Mesozoic and Quaternary time.

The Precambrian section is represented by a complex of quartz-biotite and quartz-feldspar gneisses and schists that have been intruded by younger Precambrian felsic and mafic bodies (pegmatites-aplites-lamprophyres). All of these units have been moderately deformed. The Precambrian sequence is relatively unstudied in this area and has not been extensively dated or correlated to other sections of Colorado. The exposures of these units are found in the northern and central parts of the GRA. The best described and exposed section of Precambrian Rocks is found in the nearby Unaweep Canyon area (Williams, 1964).

In the Paradox Valley area, the Paleozoic section has been brought to the surface by tectonic and salt dome activity. The Pennsylvanian Hermosa Formation is exposed and consists of sandstone, black shale, gypsum, salt, fossiliferous limestone and thin bedded shale units (Cater, 1955). This portion of the sequence is thought to represent a period of rapidly fluctuating marine and terrestrial deposition. The basal portion of the Hermosa Formation is the well-known Paradox Member, which is thought to be a part of a salt dome system. This unit consists of a thick section of alternating gypsum, salt, anhydrite and marine limestone units with occasional units of gray sandstone and black shale (Williams, 1964). This unit has associated gas deposits in the south-central portion of the GRA, and is a potential source of brines, sulfur, gypsum, salt and anydrite. Also in the Paradox Valley are exposures of fluvial arkoses and conglomerates of the Permian Cutler Formation. This unit is thought to represent a period of fluvial deposition in shallow basins adjacent to the eroding Precambrian highlands (Carter et al, 1965; Williams, 1964).

The overlying Mesozoic section consists of Triassic mudstones, sandstones, siltstones and conglomerates of the Chinle, Wingate, and Kayenta Formations. These units are thought to be of terrestrial origin and were probably deposited in a fluvial or eolian environment adjacent to a series of shallow inland lacustrine basins. Thin limestone units in the Kayenta Formation are thought to represent periods of fresh water lacustrine deposition (Carter et al, 1965; Williams, 1964).

Directly underlying this sequence and conformably overlying the Paleozoic stratigraphy is the Triassic Moenkopi Formation. This unit is separated from the rest of the Triassic stratigraphy by a regional unconformity. It consists of sandstone and mudstone members with local beds of arkosic conglomerate and gypsum (Carter et al, 1965 ; Williams, 1964). The Moenkopi appears to have been deposited in a shallow water fluvial or lacustrine setting that was subjected to periodic dessication. The overlying Moss Back Member of the Chinle Formation is known to contain abundant plant remains in other parts of Colorado and Utah, and is the uranium-vanadium bearing host rock in the Lisbon Valley area of eastern Utah. An equivalent to this unit may exist in the GRA, and, thus, have potential for the occurrence of uranium-vanadium deposits (Carter et al, 1965; Williams, 1964). Directly overlying the Triassic sequence and sometimes mapped with it is the Navajo Sandstone. This Triassic-Jurassic eolian terrestrial sandstone is found in only a few areas in the southwestern part of the GRA, and is thought to represent a period of inland sand dune deposition or a desert environment (Carter et al, 1965). The Jurassic overlying sequence begins with Entrada Sandstone and the overlying Summerville Formation. These units are thought to represent a period of terrestrial fluvial and eolian deposition in small, restricted basins (Carter et al, 1965). They outcrop throughout the GRA and have been known to contain tabular uranium-vanadium deposits in the nearby Slick Rock area (Williams, 1964).

The Morrison Formation completes the upper Jurassic sequence of terrestrial fluvial and lacustrine sediments. This unit is well known for its uranium-vanadium deposits in this and other areas of Colorado. This unit is known to contain numerous uranium-vanadium deposits within the GRA. The fluvial and lacustrine shale, mudstone, sandstone, and limestone units of the Morrison Formation are thought to have been deposited in fluvial environments adjacent to shallow, fresh-water lakes in shallow, inland, terrestrial basins (Carter et al, 1965).

The major uranium-vanadium deposits of the region have been found in the sandstones units of the Salt Wash Sandstone Member. This unit outcrops throughout the central, southern, and northern portions of the GRA and has major potential for "roll-front" sandstone hosted uranium-vanadium mineralization. "Roll-front" mineralization consists of elongate concretionary structures encompassed by rich vein-like concentrations of uranium-vanadium-bearing clay minerals. The upper member (Brushy Basin Shale Member) of the Morrison is also known to contain uranium-vanadium deposits. This unit contains beds of bentonitic mudstone, fluvial sandstone and conglomerate lenses. The uranium-vanadium mineralization of the Brushy Basin Shale Member appears to be confined to the fluvial environment with the best concentrations of mineralization being found in conglomerate lenses, and in association with organic "trash." Some of this "trash" is fossil plant and saurian material (Carter et al, 1965; Williams, 1964); and, thus, has been recognized as a paleontological resource for Jurassic vertebrates.

The Lower Cretaceous section is represented in the GRA by the Burro Canyon Formation. This unit consists of a series of mudstone, siltstone, and shale units that are interbedded with fluvial sandstone and conglomerate units, and a few, thin beds of impure limestone (Williams, 1964). The fluvial character of these clastic units suggests that the environment of deposition was one of sedimentation along meandering river systems with adjacent, shallow terrestrial lakes. The area may have also been undergoing uplift during this period, as there is an unconformity at the top of Burro Canyon which represents a period of nondeposition and erosion (Carter et al, 1965). As a result, the Upper Cretaceous Dakota Sandstone unconformably overlies the Burro Canyon Formation. This unit consists of quartzitic sandstone, conglomeratic sandstone, carbonaceous non-marine shale and a coarse, basal conglomerate (Williams, 1964). The shale units of the Dakota are well known for fossil plant remains, and locally contain thin seams of coal (Gentry, Personal Communication, 1982). This unit has some potential as a source of coal, but it outcrops in only a few areas within the GRA. It is mainly found on mesa tops in the central and western portion of the GRA. The basal part of the Upper Cretaceous Mancos Shale outcrops in the Nucla syncline and consists of a series of black fissile shale units with interbedded sandstone beds (Williams, 1964).

The rest of the Mesozoic and all of the Cenezoic section does not outcrop within the GRA.

Unconformably overlying the exposed Precambrian, Paleozoic, and Mesozoic stratigraphy is a series of Quaternary fluvial, eolian, colluvial, and alluvial deposits- that represent periods of recent erosion and fluvial deposition.

The following descriptions address the rock units of each of the individual WSA's within the Dolores River Canyon-Tabeguache Creek GRA.

DOLORES RIVER CANYON WSA (CO-030-290)

Within the boundaries of the WSA, the Precambrian rocks are not exposed. According to drilling information, the Paleozoic Hermosa Formation underlies most of the WSA (Heylmun, Personal Communication, 1982; Shoemaker, 1955; Cater, 1955; Cater, 1970). Pre-Pennsylvanian Paleozoic Formations are also thought to exist at depth under the WSA and are thought to represent a thick sequence of marine sedimentation (Baars et al, 1981). The Precambrian probably does exist at great depth (10,000 feet or more) and probably consists of older Precambrian gneisses, schists and felsic intrusives that have been deformed and intruded by a later, granitic intrusive felsic-mafic complex (Williams, 1964; Baars et al, 1981).

Northwest striking fault systems that bound the Paradox Valley on the southwest side separate outcrops of the Pennsylvanian Hermosa Formation in the Paradox Valley from the Triassic section that crops out(Cater, 1955). The oldest Triassic unit that crops out within the WSA is the Triassic Chinle Formation, a series of terrestrial sandstone, shale, siltstone, limestone-pebble conglomerate and quartz pebble conglomerate units. The lower clastic units may be equivalent to the uranium-vanadium bearing units of the Lisbon Valley area of Utah. Directly overlying these units are the massive, thick bedded eolian sandstone units of the Wingate Sandstone. Within the WSA both the Chinle and the Wingate are known to host copper-silver deposits (Cliff Dweller and Cashin Mines) that may be partially syngenetic in origin (Gilmour, Personal Communication, 1982; Williams, 1964; Shoemaker, 1956). Similar deposits have been found in other areas of Colorado in association with fault and shear systems that cut the Chinle-Wingate strata.

In all cases, mineralization occurred at specific horizons in the units, and was only brought up to economic grade by remobilization of the mineral material along faults and within shear zones (Gilmour, Personal Communication, 1982; Schwochow, 1978; Vanderwilt, 1947).

Directly overlying the Wingate Sandstone is the Triassic Kayenta Formation which is characterized within the WSA as a series of fluvial sandstone, shale, and siltstone units with thin beds of limestone and shale-pellet conglomerate (Williams, 1964). Throughout the WSA, the Triassic-Jurassic Navajo Sandstone Formation crops out and lies directly on the Kayenta. This well-crossbedded eolian sandstone unit is thought to represent a period of terrestrial arid deposition in an inland basin. (Carter, 1958; Cater, 1955; Shoemaker, 1955; Cater, 1954).

The Jurassic section that has been included within the WSA include outcrops of the Entrada Sandstone, Summerville and Morrison Formations. These units are exposed in only a few areas of the WSA, and are characterized as a series of sandstone, siltstone, shale, mudstone, fluvial mudstone, bentonitic mudstone and lacustrine shale units with local conglomerate and limestone beds. All of these units are known to contain uranium-vanadium mineralization in areas surrounding the WSA, and in other portions of the Uravan Uranium-Vanadium Belt (Schwochow, 1978; Vanderwilt, 1947).

Quaternary fluvial deposits and alluvial material are found lying directly upon the exposed Triassic and Jurassic stratigraphic units in the canyon bottoms.

TABEGUACHE CREEK WSA (CO-030-300)

Within the boundaries of the WSA the Triassic Chinle, Wingate and Kayenta Formations,in ascending order, crop out in the bottom of Tabeguache Creek canyon. These units represent a section of mudstones, shales, sandstones and siltstones that are thought to be of terrestrial origin. Within the WSA, there is no reported copper-silver or uranium-vanadium mineralization, as is often found in other areas of Colorado and Utah. The Triassic-Jurassic Navajo Sandstone is not found in this area and probably was never deposited this far east (Carter et al, 1958).

Jurassic Units that have been mapped in the area include, in descending order, the Brushy Basin Member of the Morrison Formation, and the Summerville Formation and Entrada Sandstone. These units are characterized within the WSA as a series of sandstone, shale, siltstone and mudstone units with conglomerate and limestone members (Williams, 1964). While these units are the major producers of uranium and vanadium in other, adjacent areas of the Uravan Uranium-Vanadium Belt, they are not known to contain such mineralization within the boundaries of the Tabeguache WSA (Williams, 1964a).

Cretaceous units that crop out on mesa tops include the Burro Canyon Formation and the Dakota Sandstone. These units are characterized as a series of shale, sandstone, siltstone, mudstone, and conglomerate units with beds of nonmarine carbonaceous shale and coal in the Dakota. The coal beds within the Dakota are considered an energy resource by the United States Geological Survey and are being mined commerciably in the nearby Nucla-Naturita Coal Field, found within the GRA. (USGS & CGS, 1978; Speltz, 1978; Gentry, Personal Communication, 1982).

Quaternary fluvial material directly overlies the exposed Triassic and Jurassic rocks throughout most of the Tabeguache Creek drainage.

STRUCTURAL GEOLOGY AND TECTONICS

Tectonic features found within the GRA include high angle faults, shear zones and joint systems that strike northwest and northeast and parallel major regional structural features (Shoemaker, 1951). In the southern part of the GRA, in the Paradox 7.5 minute quadrangle, is a series of north-northeast and northeast striking faults and shear zones that have associated copper-silver mineralization (Withington, 1955).

One of the major regional structural systems that cuts through the area is the Castle Valley-Paradox Valley Anticlinal trend. Part of this major fold system is found in the Paradox Valley area and consists of a belt of folded and faulted Paleozoic and Mesozoic units. Numerous northwest striking, high angle, normal and reverse faults, found along the margins of this fold feature, are associated with the trace of the axial plane of this fold system (Williams, 1964; Withington, 1955; Mattox, 1968). On the northeastern flank of this anticlinal trend is a series of paralleling structures that mark a major rift system that has been active since the Precambrian and defines the northeast edge of the Paradox Basin, a regional structural feature (Baars et al, 1981).

The northwest and northeast striking structures of the Paradox Valley have localized oil and gas deposits within the area, and have acted as structural controls for the salt dome deposits of salt, anhydrite, gypsum, and metal-rich brines (Baars et al, 1981; Heylmun, Personal Communication; Mattox, 1968; Shoemaker, 1951; Eyde, Personal Communication, 1982).

In the northeast portion of the GRA are found a series of northwest and west-northwest striking high angle faults that expose the Precambrian and Lower Mesozoic units that rest on the Precambrian strata of the Uncompahgre Uplift. The Uncompahgre Uplift is a highland area in western Colorado that rises 3,000 to 5,000 feet higher than the surrounding terrain (Baars et al , 1981). These structures have a similar orientation to others that have localized copper-silver-gold-amythyst mineralization in other areas of western Colorado (Unaweep Canyon & Dominguez Canyon areas). (Schwochow, 1978; Vanderwilt, 1947).

Within the GRA are a number of major unconformities that have been identified by drilling and stratigraphic studies. The stratigraphy of the southwestern portion of the GRA has been extensively studied by major oil companies and the Federal government (Williams, 1964; Baars et al, 1981; Heylmun, Personal Communication, 1982). In addition, the stratigraphy of the central area of the GRA has also been thoroughly investigated due to the potential for occurrence of uranium-vanadium in the Mesozoic rocks in the area. Other parts of the GRA have been mapped by the United States Geological Survey and various students. From the work that has been done, it appears that there is a major unconformity at the base of the Paleozoic section. The stratigraphy in the Paradox Valley area tends to indicate that there is some break in sedimentation in the lower Paleozoic time and that the Pennsylvanian underlying the Middle Paleozoic units may rest directly upon the Precambrian basement complex (Baars et al, 1981). In areas to the northeast of the Paradox Valley and adjacent to the Paradox structural basin the Permian Cutler Formation lies directly upon the Precambrian basement.

In the extreme northeast portion of the GRA, the Triassic Chinle Formation, together with its overlying Wingate Sandstone, lies directly and unconformably upon the Precambrian units (Williams, 1964). This situation probably describes a time-transgressive unconformity that existed from lower Paleozoic to lower Mesozoic time. During this period, the mass of the Uncompahgre Uplift was shedding sediments into a series of deep basins that made up the Paradox structural basin feature (Baars et al, 1981).

The following descriptions address the structural and tectonic characteristics of each of the individual WSA's within the Dolores River Canyon-Tabeguache Creek GRA.

DOLORES RIVER CANYON WSA (CO-030-290)

Structural features within the Dolores River Canyon WSA include northwest striking faults that parallel the axes of the various regional fold structures; north-northeast and northeast striking faults and shear zones that have associated copper-silver mineralization, and northwest striking fold structures that were caused by periods of Paleozoic and Tertiary tectonism (Withington, 1955; Baars et al, 1981).

High-angle joint systems parallel most of the major faults and control the drainage pattern of the Dolores River within the WSA. Northeast trending canyons are intersected by northwest-striking drainages. The result is a meandering river system characterized by canyons and cliffs.

Within the WSA are a number of northwest striking faults that have acted as structural traps for oil and gas deposits in other parts of the Paradox Valley (T46N, R 17-18W). The north-northeast and northeast striking faults that have localized copper-silver mineralization at the Cliff Dweller and Cashin Mines in the northern part of the WSA are thought to be earlier features that were rejuvenated in Tertiary time (Withington, 1955).

There are no known unconformities exposed within the WSA. A possible unconformity at the base of the Paleozoic section may exist at great depth under the WSA but has not been confirmed. The Jurassic Morrison Formation is the youngest Mesozoic unit that crops out within the WSA. Quaternary alluvial material has been deposited along the course of the Dolores River and directly overlies Triassic and Jurassic units (Withington, 1955).

TABEGUACHE CREEK WSA (CO-030-300)

Significant structural features within this WSA include high-angle northeast-striking faults, shear zones, and joint systems that cut across the dominant northwesterly striking structural fabric of the area. Northwest striking faults and joint systems cut through the northeastern portion of the WSA paralleling the axial plane of the regional fold systems and the trend of the Uncompahgre Uplift. Tabeguache Creek canyon trends generally east-west and is primarily controlled by a series of intersecting northwest and northeast striking joint systems. Underlying the WSA, the Mesozoic section is thought to directly and unconformably overlie the Precambrian basement complex. This relationship is not exposed, but exists 2 miles northeast of the WSA. If such an unconformity does indeed exist, it would indicate that the area within the WSA was undergoing uplift and erosion in Paleozoic and part of Mesozoic times.

The WSA is located on the east flank of the Paradox Basin in an area thought to be underlain by the Uncompahgre Uplift Precambrian complex. Recent seismic work and stratigraphic studies suggest that the area is underlain by a major thrust system at depth and that portions of the Precambrian section have been thrust southwestward, over units of the Paleozoic, that are known to contain oil and gas deposits (Heylmun, Personal Communication, 1982). This relationship has not been confirmed as of this date by drilling.

Within the WSA, there may exist an unconformity at the base of the Cretaceous Dakota Sandstone that represents a period of nondeposition (Withington, 1955). Directly overlying the Mesozoic section are a series of Quaternary deposits which represent periods of alluvial and eolian deposition on existing bedrock surfaces and along fluvial systems.

PALEONTOLOGY

Paleontological resources of the GRA have been extensively studied by both private industry and the Federal government in conjunction with oil, gas, and mineral exploration and stratigraphic studies (Shawe et al, 1968; Craig et al, 1955; Baars et al, 1981; Wengerd et al, 1958; NPS File Data, 1982). Most of these were detailed studies of various units in the Mesozoic and Paleozoic stratigraphy and dealt only superficially with the fossil occurrences and localities.

From the studies, it is known that fossiliferous units do occur in various members of the Pennsylvanian Hermosa Formation (Withington, 1955). This is a normally thick sequence that has abundant marine fossils (Withington, 1955). The Salt Wash member of the Jurassic Morrison Formation is also known to contain fossil wood, carbonaceous material, plant remains and occasional reptile remains (Withington, 1955). Plant remains have been reported associated with impure coal seams in the Cretaceous Dakota Sandstone (Withington, 1955).

The Triassic Moenkopi, Chinle and Wingate Formations that crop out throughout the GRA are also known to contain fossil reptile, amphibian and wood material in other areas of Colorado, Utah and Arizona (NPS File Data, 1982), and may contain such material within the GRA.

The following description address the paleontological resources of each of the individual WSA's within the Dolores River Canyon-Tabeguache Creek GRA.

DOLORES RIVER CANYON (CO-030-290)

Within the WSA, the Chinle Formation and Wingate Sandstone may contain fossil reptile, amphibian, and wood remains as are found in other, surrounding areas of western Colorado and Utah. The Triassic-Jurassic Navajo Sandstone is known to contain saurian tracks in other areas of Colorado and Arizona, and may also in areas of the WSA. These resources are considered of scientific interest and it is recommended that a thorough study be made prior to any evaluation of the potential for paleontological resources within the WSA (NPS File Data, 1982; Withington, 1955).

Isolated outcrops of the Jurassic Morrison Formation occur within the boundary of the WSA and probably contain fossil plant and animal material (Withington, 1955; Gilmour, Personal Communication, 1982).

TABEGUACHE CREEK WSA (CO-030-300)

The WSA contains no known or reported localities of fossil material. In other areas of Colorado, the Upper Cretaceous Dakota Sandstone is known to contain fossil plant material (Shawe et al, 1968). Isolated outcrops of the Jurassic Morrison Formation occur within the boundary of the WSA and may contain fossil plant material (Craig et al, 1955).

HISTORICAL GEOLOGY

During Middle Precambrian time 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 collissions and regional uplifting. These older Precambrian units were metamorphased, deformed, and intruded by a series of younger Precambrian mafic and felsic bodies. In this study area, the Precambrian rocks are thought to be 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 exahalative 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 adjacent areas to the east of the GRA. 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. The only area within the boundaries of the GRA where such an environment may have existed is along southern and western boundaries of the GRA, west of the Uncompahgre Uplift. From the seismic and drilling information that is currently available, it appears that the younger Precambrian units of this area were deposited in a deep, marine basin that persisted through Paleozoic time (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, 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 ringing the basin was subjected to erosion. Within the GRA, it is thought that this deposition continued through Permian time. Though the only Paleozoic rocks that outcrop in the GRA are the Pennsylvanian and Permian lithologies, it is very probably that the full Paleozoic section exists under the western portion of the GRA (Baars et al, 1978; Shoemaker, 1951).

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 teamed 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 in isolated basins, salt domes, anticlines, and diapirs formed. 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 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 Moenkopi Formation overlies the Paleozoic units in portions of the GRA, and is thought to represent an era 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, 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 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 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 Navajo Sandstone outcrops in the southwestern portion of the GRA and is thought to represent a period of inland sand dune accumulation in a terrestrial desert environment (Carter et al, 1965). This Triassic-Jurassic time unit thins to the east and probably was not deposited on top of the Uncompahgre Uplift (Baars et al, 1981).

The unconformity between the Navajo Sandstone and the overlying Jurassic Entrada Formation is probably a local feature that represents a period of non-deposition (Shawe, 1968). The Navajo is known to exist only in selected, desert environments or basins, and may have never been deposited in some areas west of the Uncompahgre Uplift. The Jurassic Entrada, however, 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 Navajo-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 were being 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 found associated with limey sandstones, shales, and siltstones that were deposited in shallow, neritic basins that had fluvial channels meandering through them. Uranium-vanadium and minor copper-silver mineralization occurs in these units as roll-front and organically precipitated "stream-channel" deposits (Withington, 1955). "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 uranium-vanadium ores, and are known to occur throughout 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, much of western Colorado was the site of the 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 eroding masses of Pennsylvanian and Permian rocks that were then exposed to the west (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 in certain areas and these may have economic potential.

During the Tertiary, the thick Pennsylvanian salt sequences and the overlying Paleozoic and Mesozoic clastic, terrestrial sediments were folded and uplifted along the flanks of the Uncompahgre Plateau. The evaporitic sequences actually were deformed into topographic highs within the areas of the sedimentary basins (i.e., Sinbad Valley, Castle Valley and Paradox Valley), which were subjected to rapid erosion (Cater, 1955). During this time, at least two periods of major uplift along the Uncompahgre Plateau have been identified. These orogenic episodes caused highlands to be formed which may have had topographic relief of several thousands of feet equivalent to the present day Front Range near Denver, Colorado. This area shed sediments into the ancestral Colorado River drainage Basin and major Uinta and Wasatch basins of northwestern Colorado. Within the GRA, the majority of the Upper Cretaceous and Tertiary section is missing. The Upper Cretaceous Mancos Formation was probably deposited over much of the GRA and is preserved along the west of the Uncompahgre Plateau. The Upper Cretaceous and Lower Tertiary was a time of mountain building, base and precious metal mineralization and sedimentation in shallow, broad basins (Carpenter, Personal Communication, 1982). Within the GRA, the dominant processes evolving the region were tectonic and orogenic rather than sedimentary (Carter, 1955; Baars et al, 1981).

The unconformably, overlying the older rocks, Quaternary fluvial, eolian, colluvial and alluvial deposits represent periods of recent erosion and fluvial deposition. These units contain fragments of the Precambrian, Paleozoic, and Mesozoic strata that were exposed and have been eroded since the Tertiary.

The following addresses the historical geology of each of the WSA's in the Dolores River Canyon - Tabeguache Creek GRA.

DOLORES RIVER CANYON WSA (CO-020-290)

The basal Precambrian section is thought to consist of quartz-feldspar, and quartz-biotite gneisses containing schists that have been intruded by older and younger Precambrian granites, aplites, pegmatites, and lamprophyres. This group of units may exist at depth but is not exposed in the WSA. The units are probably moderately deformed. Base and precious metal deposits associated with these lithologies have been found in the Unaweep Canyon area 24 miles to the north (Schwochow, 1981).

The Paleozoic section is found outcropping within the WSA in the Little Gypsum Valley area. On the eastern side of the WSA, a fault system exists between Mesozoic section and the adjacent Pennsylvanian Hermosa Formation. This probably represents a period during which most of the Paradox Valley was undergoing subsidence and uplift. The Hermosa and Permian Cutler Formations are thought to represent a period of clastic and chemical deposition on the flanks of the Uncompahgre Uplift. These units are thought to exist at depth under the WSA and are known oil-and gas-bearing units, southeast of the WSA.

The mesozoic rocks exposed within the WSA are thought to represent periods of fluvial and lacustrine deposition in a terrestrial environment. The lacustrine deposits of the Triassic Moenkopi Formation are thought to exist under the WSA and may contain thin gypsum and anhydrite beds which have possible economic potential. In other areas of Utah and Colorado, the Chinle Formation is the host for major uranium/vanadium deposits. Within the GRA, this unit and the overlying Wingate Sandstone are known to contain copper-silver deposits that have been mined in the past. The Chinle, Wingate, and Kayenta Formations of the Glen Canyon Group are thought to represent a time of Triassic sedimentation in a near-shore environment with episodes of eolian deposition of cross-bedded sandstones. Fluvial portions of the sequence include fresh water sandstone, shale, siltstone and mudstone with interbedded impure limestone units. Though the information pertaining directly to the WSA is limited, it is reasonable to assume that the Triassic environments favorable for copper-silver mineralization may have existed throughout this area during this period. The Jurassic rocks exposed in the WSA are thought to represent a period of fluvial and eolian deposition in small, restricted basins. The outcrops of the Jurassic Entrada, Summerville, and Morrison Formations have been heavily prospected for uranium-vanadium mineralization. Airborne radiometric anomalies were followed up by the Department of Energy and other government agencies under a number of different programs. To date, no major orebodies have been identified within the boundaries of the WSA. Conditions favorable for uranium-vanadium mineralization are thought to exist in this general suite of Jurassic rocks, but the only known mineralization is found associated with outcrops of the Salt Wash Member of the Morrison in the Wild Steer Canyon area.

Subsequent to Jurassic time, the area underwent uplift and erosion. No post-Jurassic Mesozoic or Cenezoic rock units are known to exist within the boundaries of the WSA, only on nearby mesas. Quaternary alluvial and colluvial deposits exist along La Sal Creek and the Dolores River. These Quaternary units have provided sand and gravel material for local use in the past and may represent an industrial mineral resource (BLM MRI Maps and File Data).

TABEGUACHE CREEK WSA (CO-030-300)

Within the boundaries of the WSA, the Precambrian section is not exposed. The Precambrian units are known to underlie this area, but have been found only in upfaulted blocks that are within 10,000 feet of the present surface. This was a time of intrusion of granitic bodies into the older Precambrian sequence of gneiss, schist and intrusives. The drilling in the nearby Paradox Valley area has encountered granitic units at depths up to 10,000 to 15,000 feet (Baars et al., 1981). The pre-Pennsylvanian Paleozoic section is not exposed within the study area, but may exist at some depth under the WSA. During this period of early and middle Paleozoic deposition, basins that formed along the margins of the Uncompahgre Uplift were receiving sediments from the adjacent terrestrial highlands. These basins were filled with clastic marine sediments and were, in turn, downfaulted into mobile rift zones (Baars et al., 1981). During Pennsylvanian times, thick evaporite sequences were laid down in these basins and were subsequently deformed by tectonic stresses into salt anticlinal and domal features (Baars et al., 1981). Directly west of the WSA in the Paradox Valley area, the clastic units of the Permian Cutler Formation are locally directly underlain by the Triassic Moenkopi Formation. The Culter, thus, may also be present within the boundaries of the WSA. This unit represents a period of clastic deposition adjacent to a terrestrial highland. It is thought that this sedimentation continued until the Precambrian and Lower Paleozoic topographic highs were inundated by sediments. It is thought that this unit was deposited as a fanglomerate adjacent to a rapidly eroding terrestrial high (Shoemaker, 1956).

The basal units exposed within the WSA include the Triassic Chinle Formation and Wingate Sandstones. The Chinle and Wingate Formations crop out in the bottom of the canyons that cut through the WSA. These units and the overlying Jurassic section are thought to represent a period of sedimentation in a near-shore marine and terrestrial environments with episodes of eolian deposition. The overlying Kayenta Formation units were probably also deposited in a terrestrial and near-shore marine environment. The Jurassic sequence is represented by a few outcrops of the Entrada Sandstone and Summerville Formation in the central part of the WSA. These units were deposited in fluvial and lacustrine environments that were adjacent to near-shore lagoons. The outcrops of the Jurassic Morrison Formation found in the WSA are thought to have been deposited in a fluvial environment. Uranium-vanadium-copper mineralization has been found nearby associated with the Salt Wash Member of the Morrison in the vicinity of Uravan, Colorado some 10 miles to the west. Uranium-vanadium mineralization commonly occurs in the Salt Wash Member associated with roll fronts and accumulations of organic material in meandering fluvial systems (Shoemaker, 1956).

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 marine environment (Young, 1955). The Upper Cretaceous Dakota Sandstone unconformably overlies the Burro Canyon Formation, and was probably deposited on an irregular surface of Burro Canyon outcrops rather than a true erosion surface (Carter et al, 1965). Portions of the Dakota are found as channel fillings upon the Burro Canyon paleosurface. From fossil evidence, it appears that the lower sections of the Dakota were deposited in shallow basins or stream channels with the source of the material being eroded masses of Pennsylvanian and Permian rocks that were then exposed (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 seams are known to exist within the Dakota may have economic potential. The marine Mancos Shale is known to outcrop along the crest of the Nucla syncline and was probably deposited over much of the WSA.

Subsequent to the Cretaceous, the area underwent uplift and erosion. No post-Cretaceous or Cenezoic deposits are known to exist within the boundaries of the WSA. Quaternary alluvial and colluvial deposits exist in the stream bed of Tabeguache Creek and may to represent a sand and gravel resource (BLM MRI Maps and File Data).

Figures II-1 through II-8 is a pictoral summary of the geological and physiographic characteristics of the GRA and associated WSA's.

FIGURE II-1
Confluence of Wild Star Canyon (right) and the Dolores River (looking NW). Area contains oil and gas wells (extension of producing field of Paradox Basin to right of photo).

DOLORES RIVER CANYON

FIGURE II-2
View looking SE along front of Davis Mesa. Uranium workings in Jurassic Morrison.

DOLORES RIVER CANYON

FIGURE II-3
La Sal Creek Cashin copper-silver mine.

DOLORES RIVER CANYON

FIGURE II-4
La Sal Canyon, Cliff Dweller mine in WSA.

DOLORES RIVER CANYON

FIGURE II-5

DOLORES RIVER CANYON

Closeup of portal of Cliff Dweller mine.

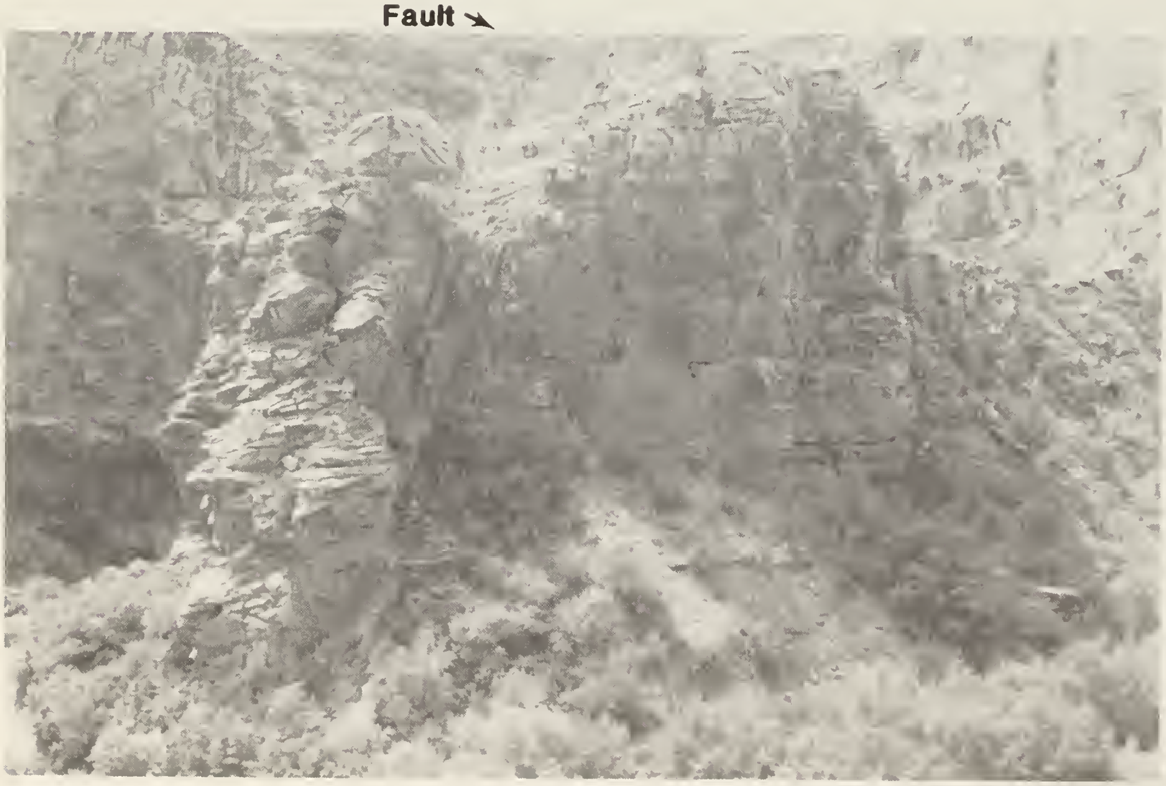


FIGURE II-6

DOLORES RIVER CANYON

S side of Dolores River Canyon, opposite Cliff Dweller mine. Note fault, copper-bearing horizon at contact between Dolores sandstone above and Chinle (?) below.

FIGURE II-7

TABEGUACHE CREEK

FIGURE II-8

TABEGUACHE CREEK

SECTION III

ENERGY AND MINERAL RESOURCES

KNOWN MINERAL DEPOSITS

The known deposits in the Dolores River Canyon - Tabeguache Creek GRA can be categorized into three groups: 1)coal, oil and gas; 2)metals and nonmetals; and 3)sand, gravel and industrial minerals.

In the first category, there are two producing gas wells and 15 active and inactive coal mines (Overlay C and Appendix B). The gas wells are located in the southern portion of the GRA in section 4, T45N, R16W and section 24, T46N, R18W, the former being in the Montrose Dome Gas Field. From 1958-1963, the Montrose Dome Gas Field produced 58,092 million cubic feet of gas (Jones & Murry, 1976). Another gas field has been delineated in section 24, T46N, R18W. Of the 15 known coal mines, 14 are in the Nucla - Naturita Coal Field located in the eastern portion of the GRA. The one remaining coal mine is located in section 25, T48N, R20W near the northwest end of Paradox Valley. The only known active coal mine is the Nucla Strip mine is owned by the Peabody Coal Company. In 1980, the mine produced 92,068 tons of coal (Colo. Div. Mines, 1981).

In the second category of metals and nonmetals, the known deposits have been summarized as follows (Overlay B and Appendix B):

Commodities Produced	Number of Deposits
Uranium-Vanadium	544
Uranium-Vanadium-Copper	1
Uranium-Vanadium-Gold	1
Gold and/or Silver	20
Gold-Silver-Copper	7
Copper-Silver	7
Copper-Silver-Uranium-Vanadium	2
Gold-Silver-Copper-Lead-Zinc	1
Manganese	1

A comment should be made regarding the number of uranium and vanadium deposits. In many cases, the extent of development was not fully known, therefore, some of these deposits might in fact actually be prospects. Based upon this information, the large number of uranium-vanadium deposits may be misleading.

In 1981, there were 36 active uranium-vanadium mines in the GRA, while in 1980 there were 58 active uranium-vanadium mines (Colo. Div. Mines, 1981 and 1982). These mines were in the Uravan Mineral Belt. Production from the mines is not known.

The Cashin Copper mine, a producer of copper and silver, located in section 22, T47N, R19W, was the only active copper operation in 1981. Copper and silver production from the mine for 1981 is not known (Colo. Div. Mines, 1982).

The following summarizes the third category of sand, gravel and industrial minerals (Overlay D and Appendix B):

Commodities Produced	Number of Deposits
Gypsum	7
Brines	7
Potash	2
Salt	1
Sand and gravel	22
Construction stone	1
Clay	1

The operating status, and production data is not known for these operations.

DOLORES RIVER CANYON WSA (CO-030-290)

There are no known mineral deposits in the Dolores River Canyon WSA.

TABEGUACHE CREEK WSA (CO-030-300)

There are no known mineral deposits in the Tabeguache WSA.

KNOWN PROSPECTS, MINERAL OCCURRENCES AND MINERALIZED AREAS

In the Dolores River Canyon - Tabeguache Creek GRA, the known prospects and occurrences consist of oil and gas, uranium, vanadium, copper, silver and gold.

The Paradox Valley is the principal location for 33 dry holes (Overlay C). Of the 33 dry holes, 8 are situated along the northern boundary of the Dolores River Canyon WSA, and 4 dry holes are located east of the Tabeguache Creek WSA.

There are at least 12 uranium-vanadium prospects or occurrences, 8 gold occurrences, 2 copper-silver occurrences, and 4 uranium? or copper? prospects (Overlay B and Appendix B). In the case of uranium-vanadium prospects, this figure may be misleading since many prospects may have been classified as a known deposit. The 4 uranium? or copper? prospects were delineated through aerial photo interpretation (Aerial photo 1-6-14, Appendix A). The 8 known gold prospects are located in the eastern portion of the GRA along the San Miguel River. The known copper-silver prospects are located in section 23, T47N, R19W and section 24, T48N, R19W (Overlay B and Appendix B).

DOLORES RIVER CANYON WSA (CO-030-290)

The only known prospects or occurrences contained within the WSA are four copper? and/or uranium? prospects that were delineated by Dr. Larry Lepley through aerial photo interpretation (photo 1-6-14, Appendix A). These prospects are located in section 11, T46N, R18W.

TABEGUACHE CREEK WSA (CO-030-300)

There are no known prospects, occurrences or mineralized areas in the Tabeguache Creek WSA.

MINING CLAIMS, LEASES OR MATERIAL SITES

As of June 14, 1982, approximately 13,198 unpatented lode and placer claims were located within the GRA boundary (Overlay A; Appendix C). An exact figure could not be obtained since mining claims situated across a section boundary or township, range boundary are often listed twice in the Bureau of Land Management Geographic Index. It is estimated that the above figure is accurate within 200 claims.

The principal mining or exploration companies with controlling interests in the GRA are Union Carbide, Minerals Engineering Company, Pioneer Uranium, Houston Oil and Minerals, Cotter Corporation, Foote Minerals, and Atlas Corporation.

The GRA contains approximately 130 patented mining claims. The claim blocks are outlined on overlay A.

Lease and material site data is contained in Appendix A, Oil and Gas Plats.

DOLORES RIVER CANYON WSA (CO-030-290)

Information regarding unpatented mining claims was obtained from the Bureau of Land Management Geographic Index, June 14, 1982 (Appendix C). However, the Geographic Index only locates claims to within a quarter-section, therefore, it is not possible to accurately determine the number of unpatented mining claims within the WSA. There are approximately 299 unpatented lode and placer claims located within, on, or near the WSA (Overlay A). Of this number, 295 are unpatented lode claims.

There are no patented mining claims located in the WSA, however, a block of patented claims border the WSA in sections 22, 23, and 27, T47N, R19W.

The location of existing coal, oil and gas leases is contained in the Oil and Gas Plats (Appendix A).

TABEGUACHE CREEK WSA (CO-030-300)

Based upon the June 14, 1982, BLM Geographic Index, 152 unpatented lode claims were located within or bordering the Tabeguache Creek WSA.

Oil, gas and coal lease location information is contained on the Oil and Gas Plats (Appendix A).

MINERAL DEPOSIT TYPES

In the Dolores River Canyon-Tabeguache Creek GRA, the mineral deposit types are described according to the commodity produced. The GRA has yielded production of gas, coal, uranium, vanadium, precious and base metals, industrial minerals, sand and gravel.

Gas from the producing wells in the GRA is derived from structural and stratigraphic traps in the Pennsylvanian Honacker Trail Unit of the Hermosa Formation and the Permian Cutler Formation. The structural traps are a result of anticlinal closures, faulted anticlines or monoclinal folding. Stratigraphic traps are the result of sandstone lenses pinching out or unconformities (Scott et al, 1981). The depositional features associated with the anticlines have provided ideal conditions for a variety of traps for gas (reef environments, fossil trash accumulations). The Honacker Trail Unit is composed of a gray to reddish gray crystalline limestone to coarse granular limestone with chert, and light gray to reddish-gray calcareous siltstones (Wengerd et al, 1958). Overlying the Honaker Trail Unit is the Permian Cutler Formation which is composed of coarser grained clastic rocks (Peterson et al, 1969).

In the GRA, the known coal deposits, for the most part, are located in the Nucla-Naturita Coal Field. Coal occurs in the Upper Cretaceous Dakota Sandstone. The Dakota Sandstone is a yellowish-brown to gray, friable to quartzitic fluvial sandstone and conglomeratic sandstone with interbedded gray to black carbonaceous nonmarine shale (Williams, 1964). Generally, in western Colorado the Dakota can be divided into three members: an upper sandstone member, a middle coal-bearing member, and a lower conglomeratic sandstone member (Landis, 1959). The coal beds are lenticular and are relatively impure. In the Nucla-Naturita Coal Field at least three relatively persistent beds are present (Landis, 1959). The coal beds are usually split by partings, however a bench in the middle bed approximately 4.5 feet thick contains no partings. The rock strata in the Nucla-Naturita Coal Field are nearly horizontal, although some local folds and faults are present. The coal is generally ranked as high-volatile bituminous (Landis, 1959).

The uranium and vanadium deposits are located in the Uravan Mineral Belt. The deposits usually occur in the Jurassic Morrison Formation. 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 and vanadium mineralization occurs in the Salt Wash Member and the overlying Brushy Basin Member of the Morrison Formation. The Salt Wash Member consists of interstratified sandstone and claystone units. The unit was formed as a large alluvial fan by an aggrading system of braided streams (Craig et al, 1955). The Brushy Basin Member consists of variegated claystones with few lenticular conglomeratic sandstone strata. The Brushy Basin was formed in fluvial and lacustrine environments with large amounts of clay (Craig et al, 1955). As a whole, the sandstone beds of the Morrison are light gray to buff, fine to medium grained, lenticular, cross-bedded and irregularly bedded (Molenaar, 1981). 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). To a lesser extent, uranium and vanadium deposits occur in the Triassic Chinle Formation. The Chinle Formation consists of shale, siltstone, and sandstone beds, which may be conglomeratic. Also present are thin layers of limestone and limestone conglomerate (Fisher, 1956). The uranium deposits generally occur in the conglomeratic sandstone beds, however, a few deposits may occur in highly argillaceous limestone beds. Copper mineralization is usually associated with this type of deposit.

The copper and silver deposits occur at or near the contact of the Triassic Chinle Formation and the overlying Triassic Wingate Sandstone. The Wingate Sandstone is a massive cliff-forming, fine-to medium grained sandstone (Molenaar, 1981). Mineralization is associated with relatively small north-northeast trending faults and fractures. The ore consists primarily of copper sulfides. Sphalerite and galena are abundant and minor amounts of copper arsenides and native copper have been noted. The primary sulfide minerals are argentiferous. The gangue minerals consist of dolomite, calcite, and barite. The primary deposit types consist of sandstone replacement and vein-filling. The replacement ore consists principally of chalcopyrite occurring in irregular masses along fractures. The vein-filling ore consists of sulfide minerals and wall rock fragments cemented by crystalline dolomite. The last deposit type consists of native copper with copper arsenides in a gangue of barite and calcite. This deposit type is not very abundant (Fisher, 1936). In addition to the copper and silver produced, lesser amounts of gold, lead, and zinc has been produced from these deposits.

The evaporite deposits are located in restricted basins formed during the Pennsylvanian Period, with vertical movement continuing through late Triassic. There is much controversy involving the development of the salt anticlines, such as, the initial forces involved in the development of faults and folds. However, it is recognized that an increase in saline material is a major contributing factor in the development of salt anticlines, causing flowage from the limbs of the structures to the crests, thus causing further development of the attendant fold features (Mattox, 1968). The northwest trending salt anticlines have been defined as a structural feature thought to have originated by the intrusion of overlying rocks by salts and other evaporites, which have a tendency to deform plastically under great pressure (Schwochow, 1978). The evaporites were deposited during Pennsylvanian time. The oldest known unit consists of 100 to 150 feet of shales and some limestone beds of the Rico Formation, which are overlain by a 125 to 275 foot thick sequence of interbedded shales, anhydrites, and carbonates (Mattox, 1968). These units are overlain by the salt-bearing unit consisting of thin-bedded anhydrites, gypsum, dolomite, radioactive black shales, siltstone, and 29 potash salts and halite units, which are separated by thin beds of shale or anhydrite (Mattox, 1968; Schwochow, 1978). The original maximum thickness of the salt bearing units was estimated to be 7,000 feet, however post-despositional flowage of salt increased the core to a thickness in excess of 12,000 feet (Mattox, 1968).

The pediment gravels, deposited by the San Miguel River and its tributaries, have been exploited as a source of sand and gravel.

DOLORES RIVER CANYON WSA (CO-030-290)

There are no known mineral deposits in the Dolores River Canyon WSA, therefore, any description of mineral deposit types would be theoretical.

TABEGUACHE CREEK WSA (CO-030-300)

There are no known mineral deposits in the Tabeguache Creek WSA, therefore, any description of mineral deposit types would be theoretical.

MINERAL ECONOMICS

The inherent nature of discussing the economics of the minerals existing within the Dolores River Canyon-Tabeguache Creek 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.

The mineral resources found in this GRA include gas, coal, uranium and vanadium, precious and base metals, and industrial minerals in the form of evaporites and sand and gravel.

Specific information on gas reserves and potential was not available for the Dolores River Canyon - Tabeguache Creek GRA. Known gas resources are found in Pennsylvanian and Permian age sedimentary rock units.

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).

Coal is produced mainly from the Cretaceous Dakota Sandstone. The GRA contains only one coal mine, the Nucla Strip Mine. In 1980, the mine produced 92,068 tons of coal (Colorado Division of Mines, 1981).

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 by-products (Gentry, 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 more than 500 known uranium deposits. Production statistics however, are not available. Future demand for uranium and vanadium is dependent on foreign production and the needs of the nuclear generating industry (Schwochow, 1978).

Precious and base metals are found in the mineralized contact between the Triassic Chinle and Wingate Sandstone Formations. 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 economy (Eng. and Mining Journal, Dec. 1982).

Commodities such as copper, lead, zinc, manganese, iron, and molybdenum 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). The Cashin Copper Mine, a producer of copper and silver, was the only active operation in 1981. Copper and silver production from the mine for 1981 is not known (Colorado Division Mines, 1982).

The industrial minerals in the GRA can be placed into two groups. In the first, sand and gravel are considered to be "high place value" industrial minerals (Eyde, Personal Communication). These minerals are of economic value only when the deposits are readily accessible, and in close proximity to a market. In the second group, evaporites are considered to have a "high unit" value. These minerals are of economic value wherever found as the commodity values exceeds transportation costs (Eyde, Personal Communication, 1982). Generally, high place value minerals have almost no economic value in the GRA where the location is remote from urban markets. Conversely, high unit value minerals in the GRA are of potential economic value (Eyde, Personal Communication, 1982).

The economic viability of the mineral resources in the WSA's in the Dolores River Canyon - Tabeguache Creek GRA are summarized as follows:

WSA	Mineral Potential	Accessibility	Economic Potential[a]
Dolores River Canyon WSA	Oil, Gas*	Unknown	Unknown
(CO-030-290)	Base Metal*	Unknown	Unknown
	Uranium-Vanadium*	Unknown	Unknown
Tabegauche Creek WSA	Oil, Gas*	Unknown	Unknown
(CO-030-300)			

[a] The economic potential rating is not withstanding market demand fluctuations.

* No known deposits or occurrences of these commodities in WSA. Please see following Section IV for further discussion of potential.

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 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.'s Gilmour and Gentry and Mr. Eyde made a two-day field investigation as result of the base data analysis phase. The purpose of the field investigation 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

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.

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 of Land Management 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 unclassified 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 leasabale, locatable, and/or salable with associated maps (Figures IV-1 through IV-3) locating the resource areas.

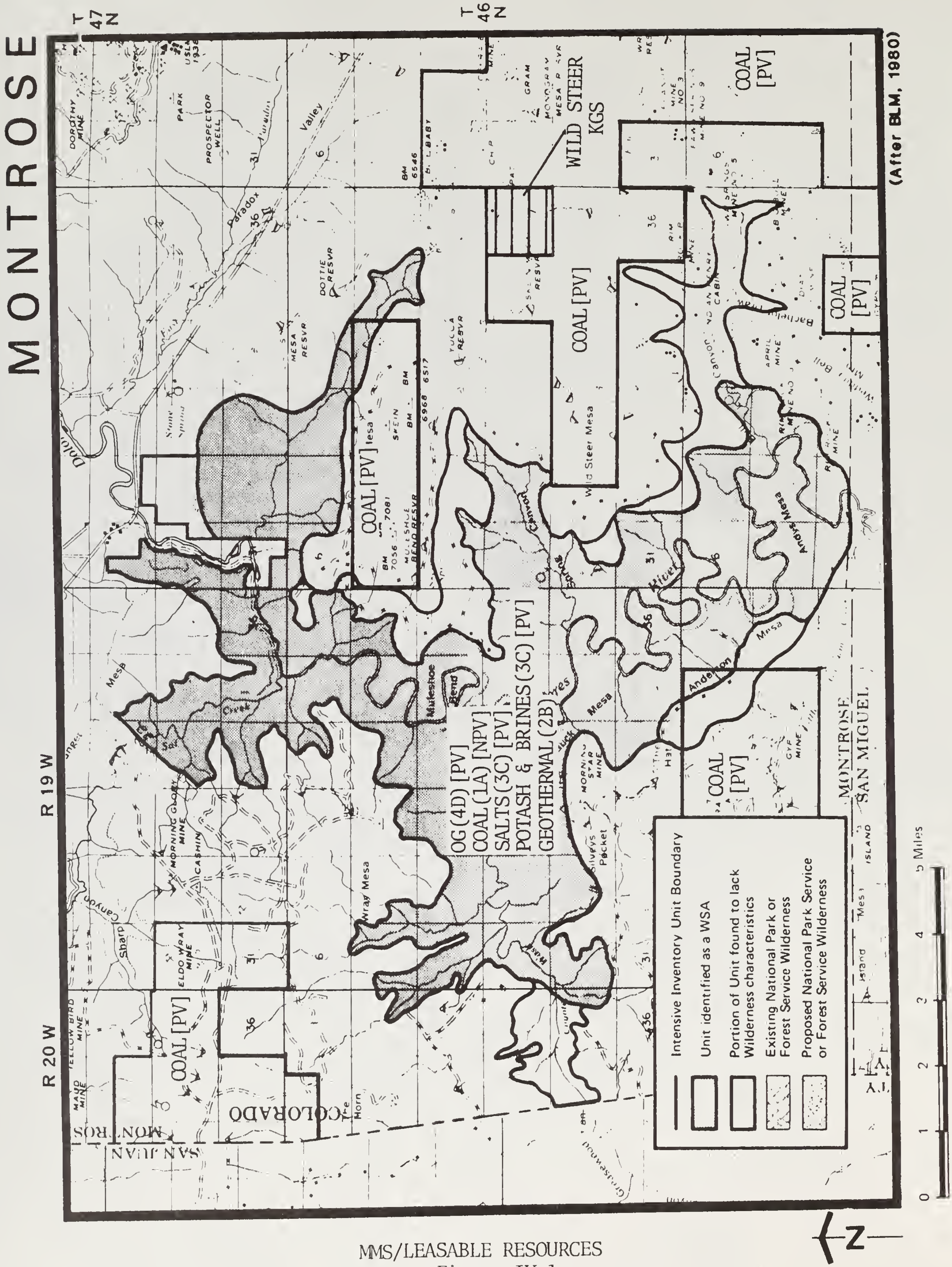
LEASABLE RESOURCES

DOLORES RIVER CANYON WSA (CO-030-290)

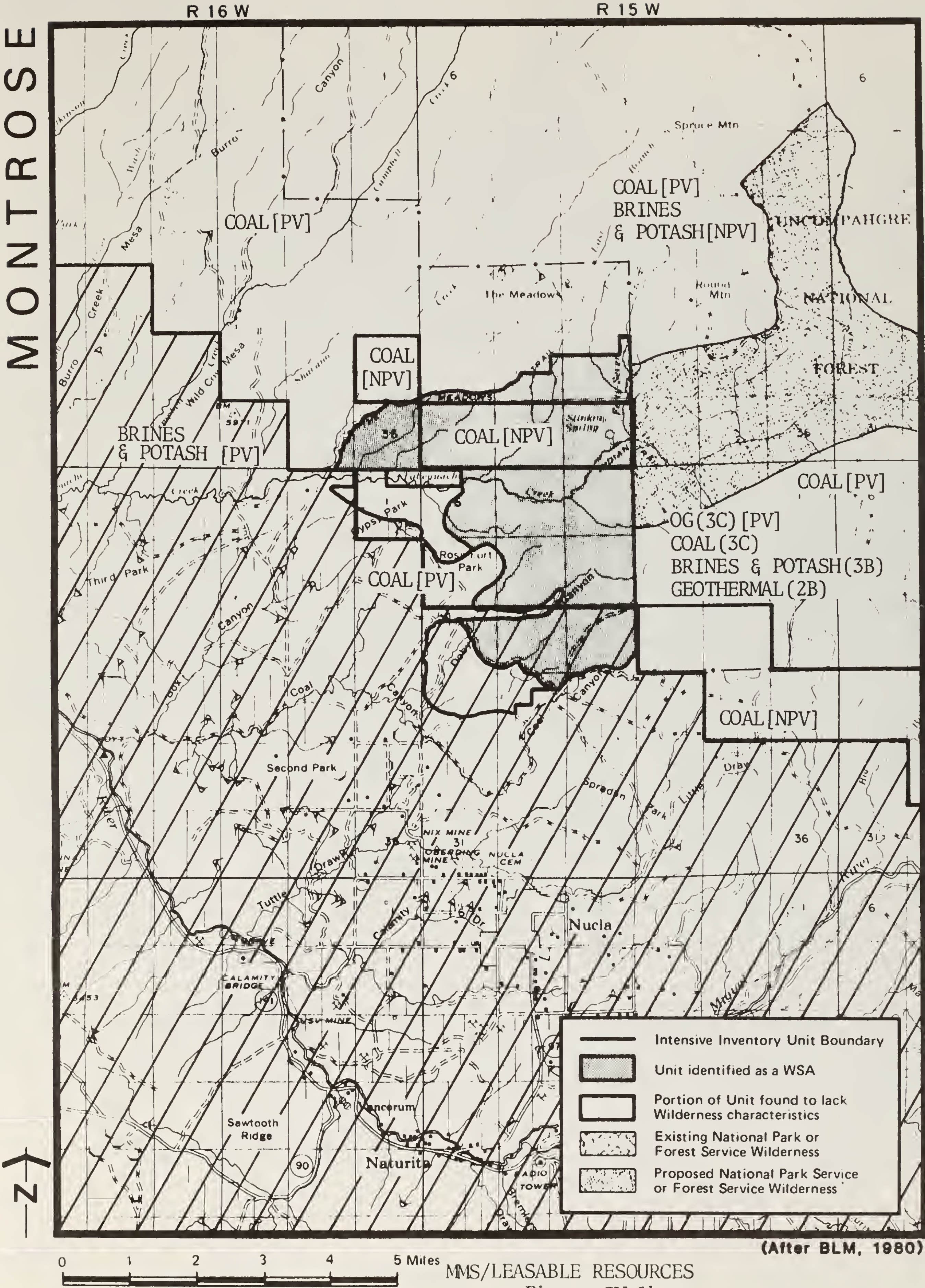
Resource	Classifications	Comments
Oil & Gas	4D	The WSA lies in the Paradox Basin on the northeast flank of the Gypsum Valley Salt Anticline. The block contains a thick stratigraphic section of Mississippian, Pennsylvanian and Devonian age sedimentary rocks. Favorable structural conditions exist.
Coal	1A	Lack of coal-bearing formations in the WSA.
Salts	3C	Known to occur in the Paradox Member moderate economic potential.
Potash & Brines	3C	Known to occur in the Paradox Member moderate economic potential.
Geothermal	2B	Unknown potential.

TABEGUACHE CREEK WSA (CO-030-300)

Resource	Classifications	Comments
Oil & Gas	3C	Possibilities of a major overthrust system at depth, where the older rocks of the Uncompahgre Uplift are thrust southwestward over the sedimentary strata of the Paradox Basin.
Coal	3C	Coal-bearing units in the Cretaceous Dakota formation present.
Brines & Potash	3B	Known occurrences in the Paradox Formation. Low to moderate economic potential.
Geothermal	2B	Unknown potential.



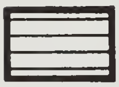
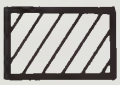
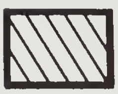
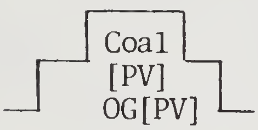
MMS/LEASABLE RESOURCES
Figure IV-1a



MMS/LEASABLE RESOURCES

Figure IV-1b

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

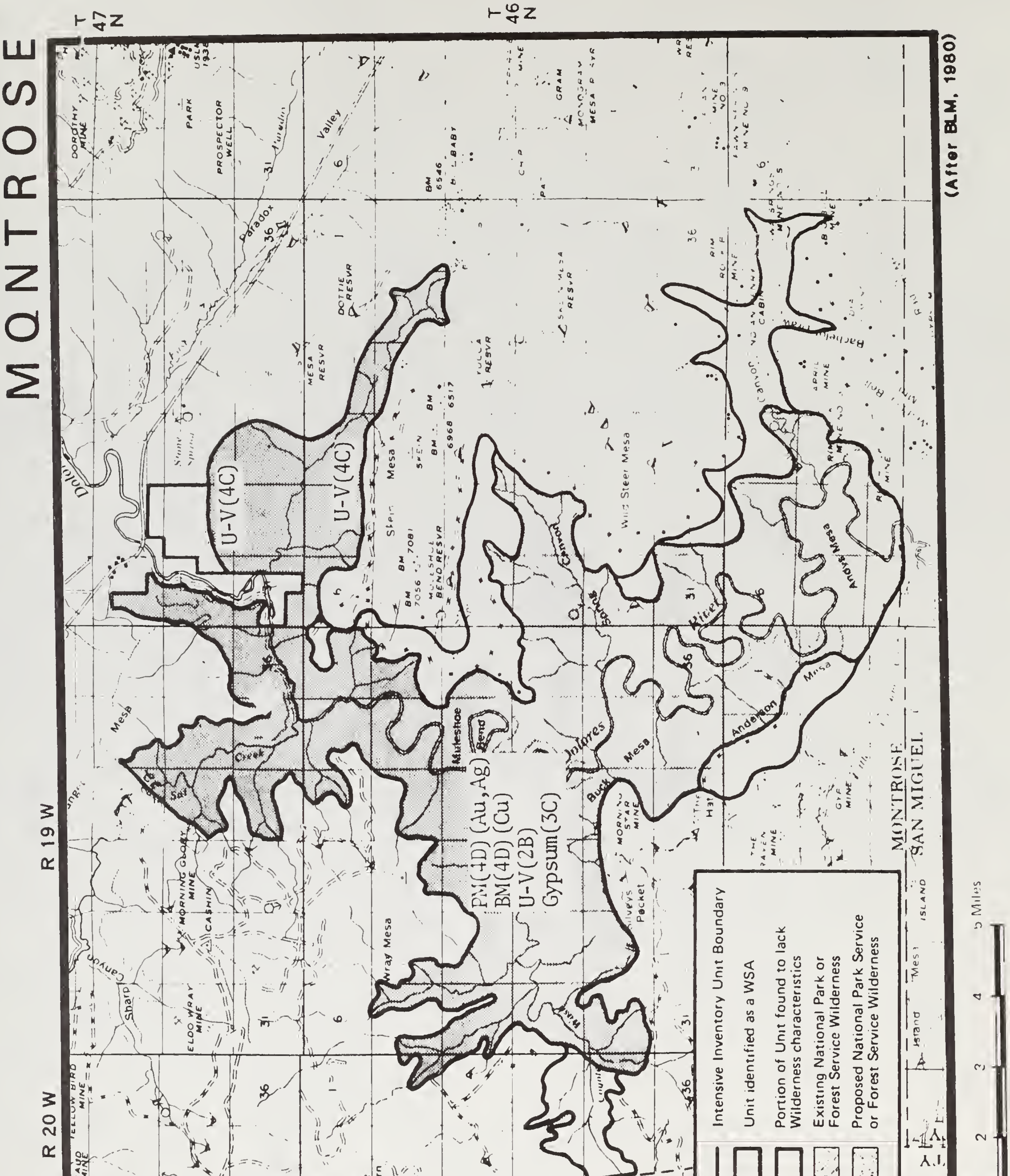
LOCATABLE MINERALS

DOLORES RIVER CANYON WSA (CO-030-290)

Precious Metals	4D	Ag, Au mineralization associated with Triassic Chinle and Wingate Formations, post production, active mining operations in adjacent areas.
Base Metals	4D	Cu mineralization associated with Triassic Chinle and Wingate Formations, post production, active mining operations in adjacent area.
Locatable Energy Minerals	2B	U-V mineralization potential associated with Triassic Chinle Formation.
Other Locatable Minerals	3C	Cypsum is known to occur in the Paradox Member, moderate economic potential

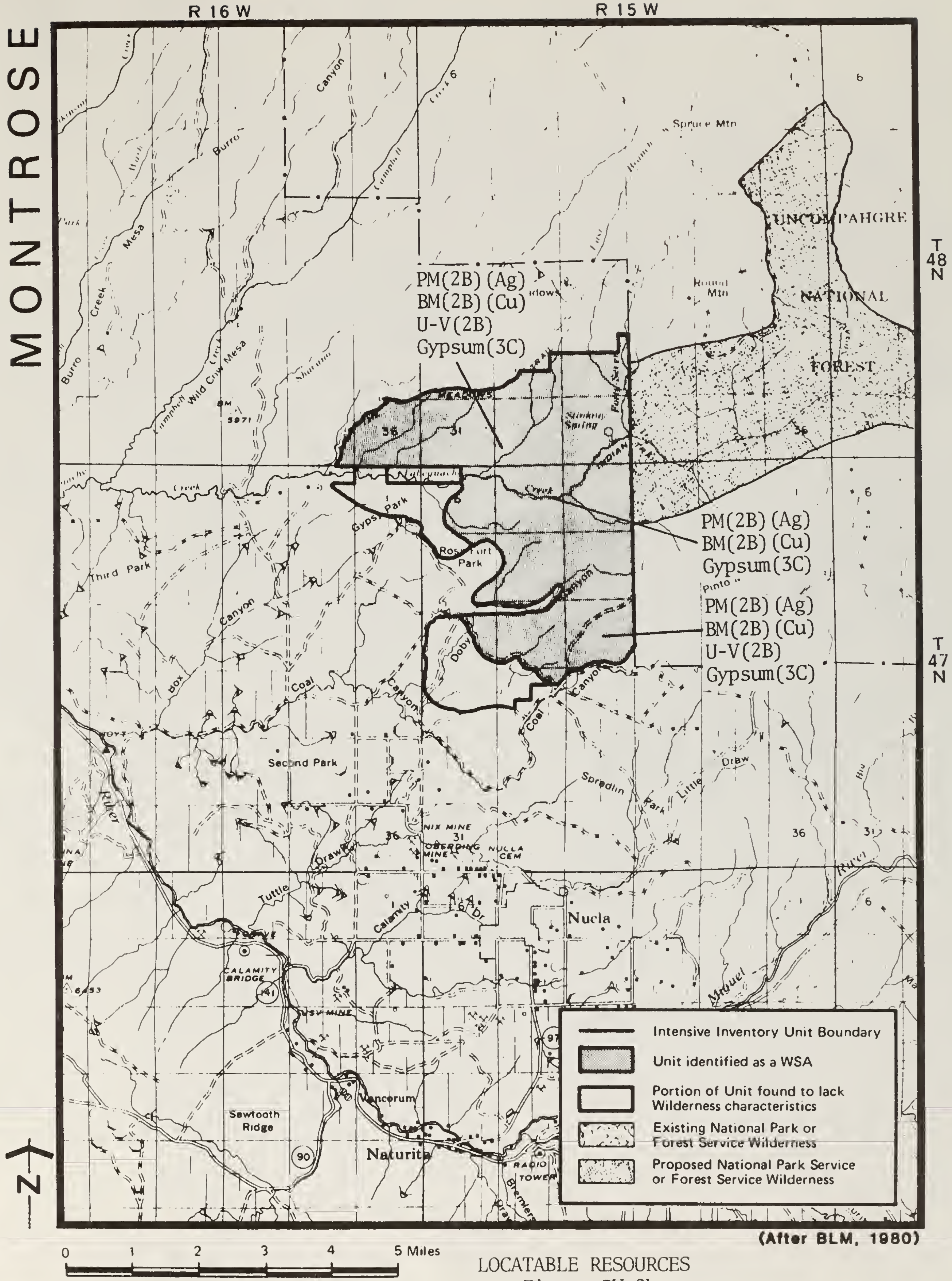
TOBEGUACHE CREEK WSA (CO-03-300)

Precious Metals	2B	Ag mineralization potential in Triassic Chinle and Wingate Sandstone Formations, favorable section present.
Base Metals	2B	Cu mineralization potential in Triassic Chinle and Wingate Sandstone Formations, favorable section present.
Locatable Energy Minerals	2B	U-V mineralization potential in Jurassic Morrison Formation.
Other Locatable Minerals	3C	Gypsum is known to occur in the Paradox Member, poor economic potential



LOCATABLE RESOURCES
Figure IV-2a

CO-030-300 Tabeguache Creek



LOCATABLE RESOURCES
Figure IV-2b

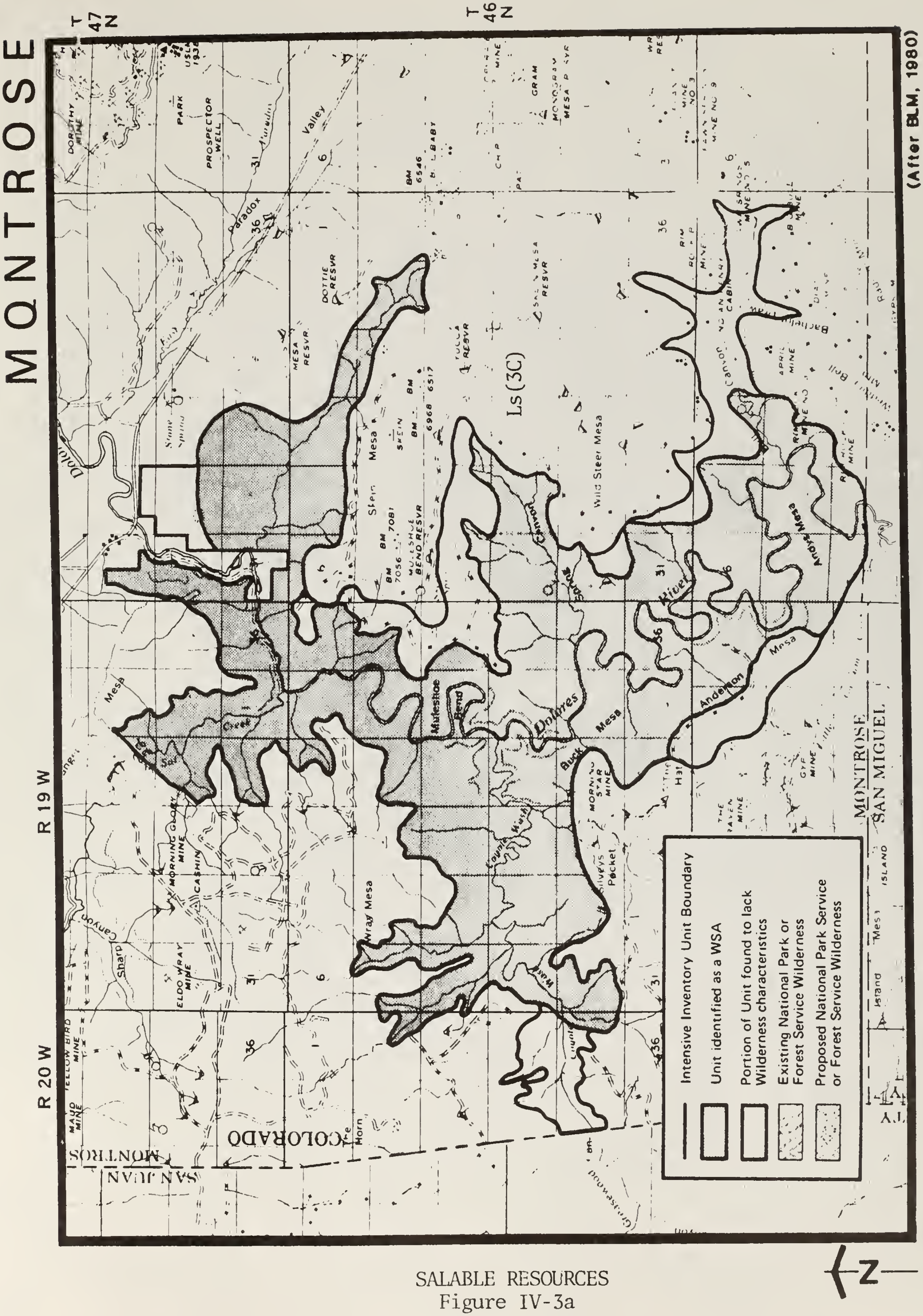
SALABLE RESOURCES

DOLORES RIVER CANYON WSA (CO-030-290)

Resource	Classifications	Comments
Limestone	3C	The Paradox Formation may contain favorable units. Moderate economic potential.

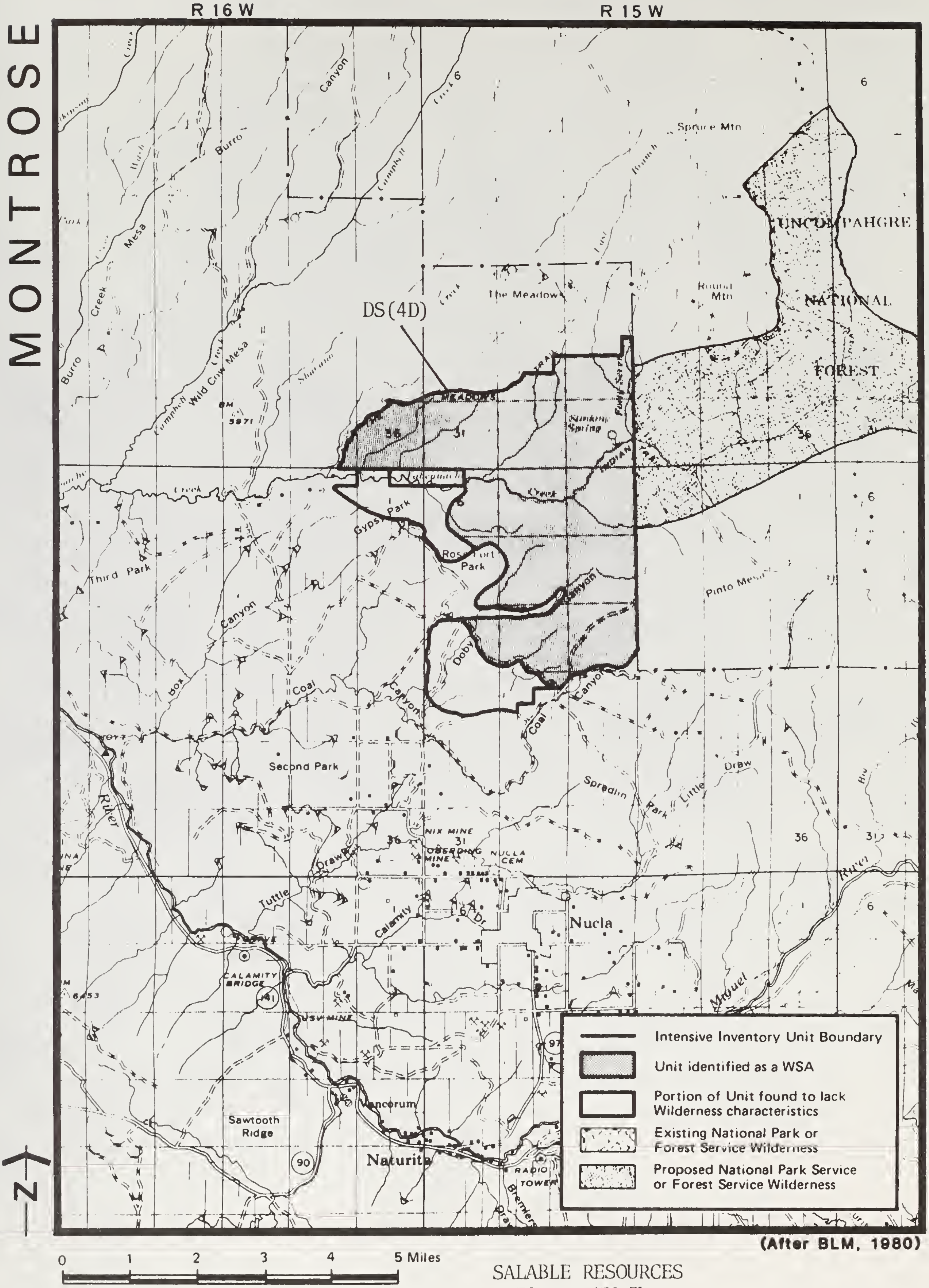
TABEGUACHE CREEK WSA (CO-030-300)

Resource	Classifications	Comments
Building or Dimension Stone	4D	The Dakota Formation is a favorable unit. The economic potential is low to moderate.



SALABLE RESOURCES
Figure IV-3a

CO-030-300 Tabeguache Creek



SALABLE RESOURCES
Figure IV-3b

SECTION V

RECOMMENDATIONS FOR FURTHER STUDY

In the course of analyzing, assessing, and evaluating each of the WSA's in the Dolores River Canyon-Tabeguache Creek 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.

DOLORES RIVER CANYON WSA (CO-030-290)

Since this area is known to have potential for oil, gas, base, precious metal, and uranium 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 and stratigraphic 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 subsurface potential.

Examination of any outcrops of the Jurassic Morrison within the WSA for uranium-vanadium should be made in the course of any geologic mapping program.

Detailed geologic and geochemical studies are warranted to ascertain the mineral potential of the Mesozoic lithologies. Within Triassic Chinle and Wingate Formations, stratigraphic and lithogacies mapping should be carried out to determine if any environments with favorable depositional characteristics exist. A relatively low-cost way to accomplish these goals is to conduct a stream sediment and outcrop sampling program in conjunction with a geologic mapping effort.

Any prospects and known mineral occurrences within the WSA should be verified, 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 Jurassic Morrison Formation. With regards to this specific unit, a detailed study should be made of facies changes within it and correlation made with other units in western Colorado and eastern Utah. Within the WSA and in adjacent areas, the Salt Wash Member of the Morrison Formation is known to have significant uranium-vanadium mineralization and thus, should be studied in this area. Though the airborne and ground (NURE-HSSR-ARMS) information does not delineate any specific areas within the WSA with anomalous values, ground radiometrics in conjunction with the geological-geochemical would be helpful in identifying any areas of mineral potential.

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-ARMS information.

Since some of the Mesozoic units have been used in the past as a source of local road building material, it would be wise to do further work on the demand for this material.

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, refer to Section IV).

TABEGUACHE CREEK WSA (CO-030-300)

In this area the potential for GEM resources is largely unknown. Detailed geologic and geochemical studies are warranted to ascertain the mineral potential of the Precambrian and Mesozoic lithologies. Special attention should be paid to possible sedimentary and felsic lithologic assemblages associated with Precambrian base and precious metal exhalite systems. Of equal importance is the potential for base metal mineralization in the Triassic Chinle and Wingate Formations. Stratigraphic and lithofacies mapping should be carried out to determine if any environments with favorable depositional characteristics exist. A relatively low-cost way to accomplish these goals is to conduct a stream sediment and outcrop sampling program in conjunction with a geologic mapping effort.

Any prospects and mineral occurrences should be verified, 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 Jurassic Morrison Formation and the coal potential of the Cretaceous Dakota Sandstone. 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 potential coal beds in the Cretaceous Dakota section 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 bed or beds 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.

In conclusion, from the work to date and the material compiled in the course of this GRA, it appears that the potential for GEM resources in this area is largely unknown. It is recommended that this are receive further extensive study (For further detailed discussion of the potential thought to exist within the WSA, please refer to Section IV).

SECTION VI
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