DOMINGUEZ CANYON - ADOBE BADLANDS - CHACRA MESA

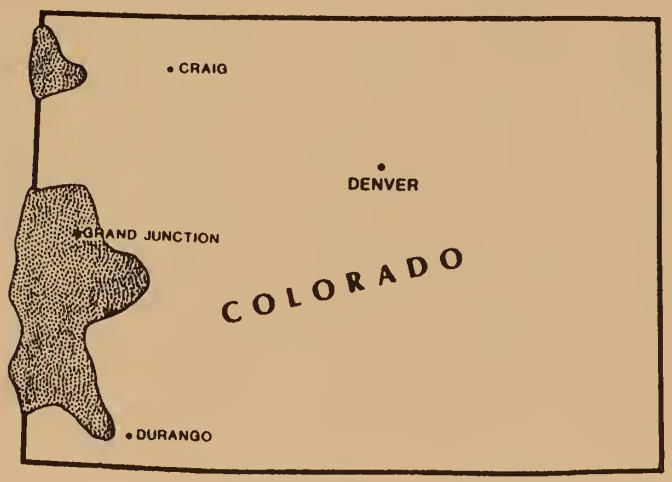
GEOLOGICAL RESOURCE AREA (GRA) 6

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

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. Carpenter and Dr. Lepley should receive special acknowledgement. It was from the work of these consultants that this report on the Little Book Cliffs/Wildhorse Area 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 southwest extreme of the region and another at the north extreme, the region is within the northern half of the known Colorado Plateau physiographic province.

The 32 WSA's within Region 4 encompass 474,620 acres. These have been geographically segregated within 11 designated GEM Resource Areas (GRA's). This report addresses the Dominguez Canyon-Camel Back area, GRA-6. Included in the GRA is Dominguez Canyon WSA (CO-170-150 & CO-030-363), Adobe Badlands WSA (CO-030-370B) and Camel Back WSA (CO-030-353).

The physiography of the GRA includes valley, canyon, and plateau areas along the courses of major river systems. Grand Mesa, a major topographic feature, is included in the GRA. Metamorphic units of Precambrian age are present in the GRA. Base and precious metal mineralization is sometimes associated with these lithologies in other areas of western Colorado. The majority of the remaining rock formations are sedimentary. Fault and joint systems in the GRA may have localized base and precious metal mineralization. An unconformity in the GRA may have importance in the localization of uranium mineralization.

The energy and mineral resources in the GRA include coal, copper, gemstones, gold and silver, uranium and vanadium, sand and gravel, clays, and construction stone. The coal occurs in the sedimentary rocks of the Grand Mesa Coalfield. Copper occurs in both mineralized veins between intrusive and igneous Precambrian rocks, and as mineralized veins in sedimentary Triassic rocks. Gold, silver, and gemstones also occur in these mineralized veins. The uranium and vanadium deposits occur as secondary mineralization in sedimentary Triassic and Jurassic rocks. Clays and construction stone were also produced from sedimentary units. Sand and gravel occur in alluvial fans, and along the Gunnison River and it's tributaries.

The three WSA's in the GRA contain no known deposits. There is a coal prospect and some copper and/or amythyst prospects in Dominquez Canyon WSA.

The classification for the leasable minerals, locatable and salable resources varies. The potential for leasable minerals ranges from low to moderate favorability in the form of oil, gas, and geothermal. The locatable resource potential for the three WSA's ranges from moderate to high favorability in the form of base, and

precious metals, uranium, and vanadium. There is high favorability for salable resources in all three WSA's in the form of dimension stone, clays and industrial minerals.

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 occurrence of geology, energy or mineralized commodities.

SECTION I

INTRODUCTION

The Dominguez Canyon/Adobe Badlands/Camel Back GRA (Figure I-1) is located in portions of Delta, Mesa, and Montrose Counties, Colorado. The GRA encompasses three Wilderness Study Areas (WSA's) (CO-070-150/CO-030-363, CO-030-353, and CO-030-370B).

The GRA area is located approximately 20 miles southwest of Grand Junction, Colorado. Located within the boundaries of the GRA are a number of small settlements that are local supply centers for agriculture and ranching. These towns are supplied by road and rail networks from the regional supply centers of Grand Junction and Delta, Colorado. These towns (Dominguez, Bridgeport, Huff, Escalante, Escalante Forks, Roubideau, Pea Green Corner and Chipeta) are also local supply centers for the oil, gas and mineral industries of the area.

Included in the GRA are portions of Townships 14-15 South, Ranges 95-101 West; Townships 49-51 North, Ranges 10-16 West; and Townships 4 South, Ranges 2-3 East. The entire area is bounded by west Longitudes 108° 01' 25" and 108° 40' 48" and north Latitudes 38° 31' 37" and 38° 53' 00". It contains approximately 849 square miles (2,287 square kilometers or 543,360 acres) of Federal, State and Private lands. The Bureau of Land Management portion of these holdings are under the jurisdiction of the Grand Junction and Montrose District and the Grand Junction and Uncompahgre Resource Area Offices.

The specific WSA's within the GRA have a total of 97,260 acres of Federal land. The acreages of the various contained WSA's are:

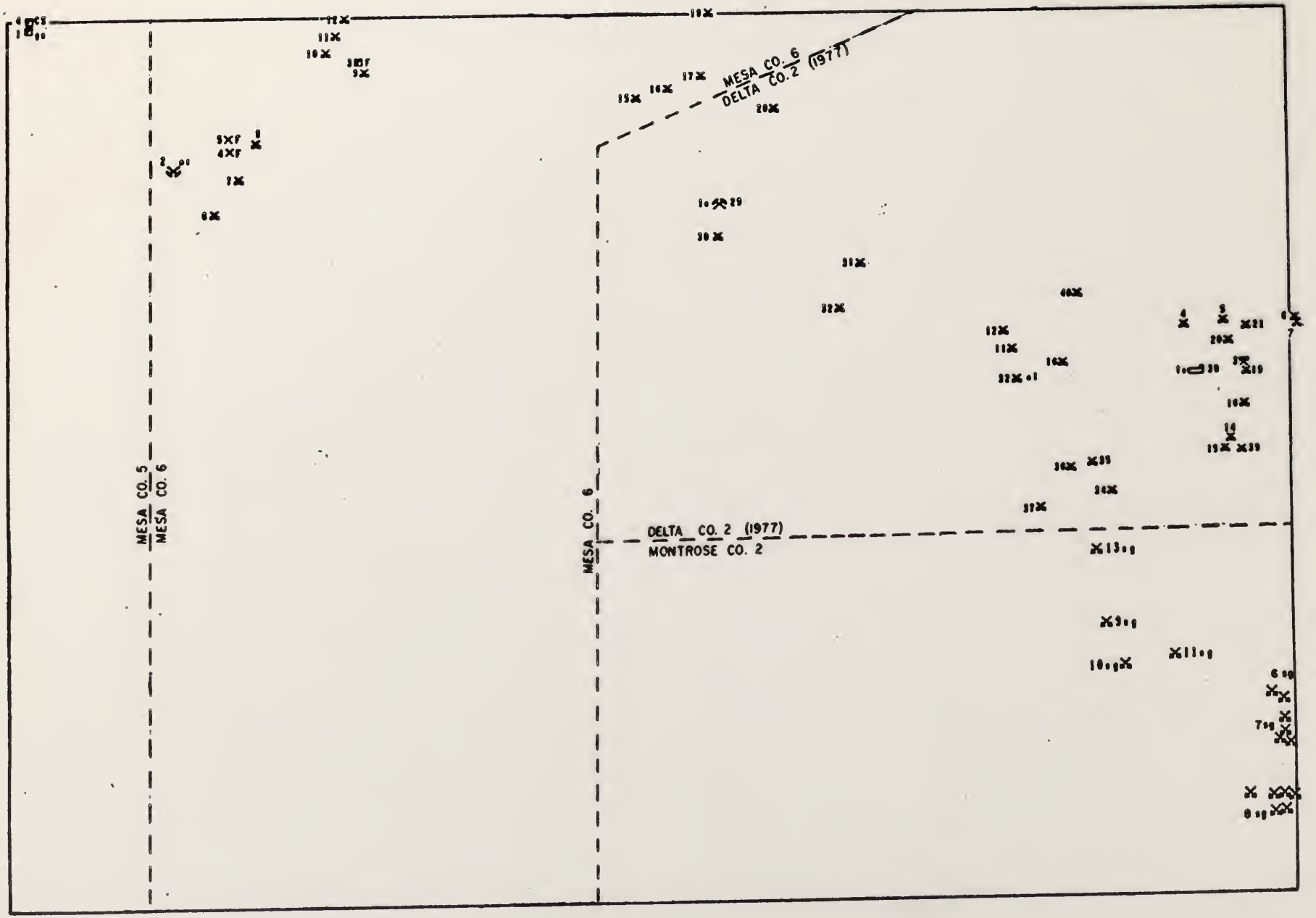
Dominguez Canyon (CO-070-150/CO-030-363) - 75,800 acres
Adobe Badlands (CO-030-370B) - 10,560 acres
Camel Back (CO-030-353) - 10,900 acres

The Dominguez Canyon WSA is located in the northwest portion of the GRA and is approximately 20 miles southeast of Grand Junction, the nearest major urban center. The WSA is directly southwest of the settlements of Bridgeport and Dominguez and lies 10 miles west of Delta, Colorado. The Camel Back WSA is located in the southeast portion of the GRA and is approximately 10 miles southwest of Delta, Colorado. The Adobe Badlands WSA is in the north-central part of the GRA, and is three miles northwest of Delta, Colorado (figure).

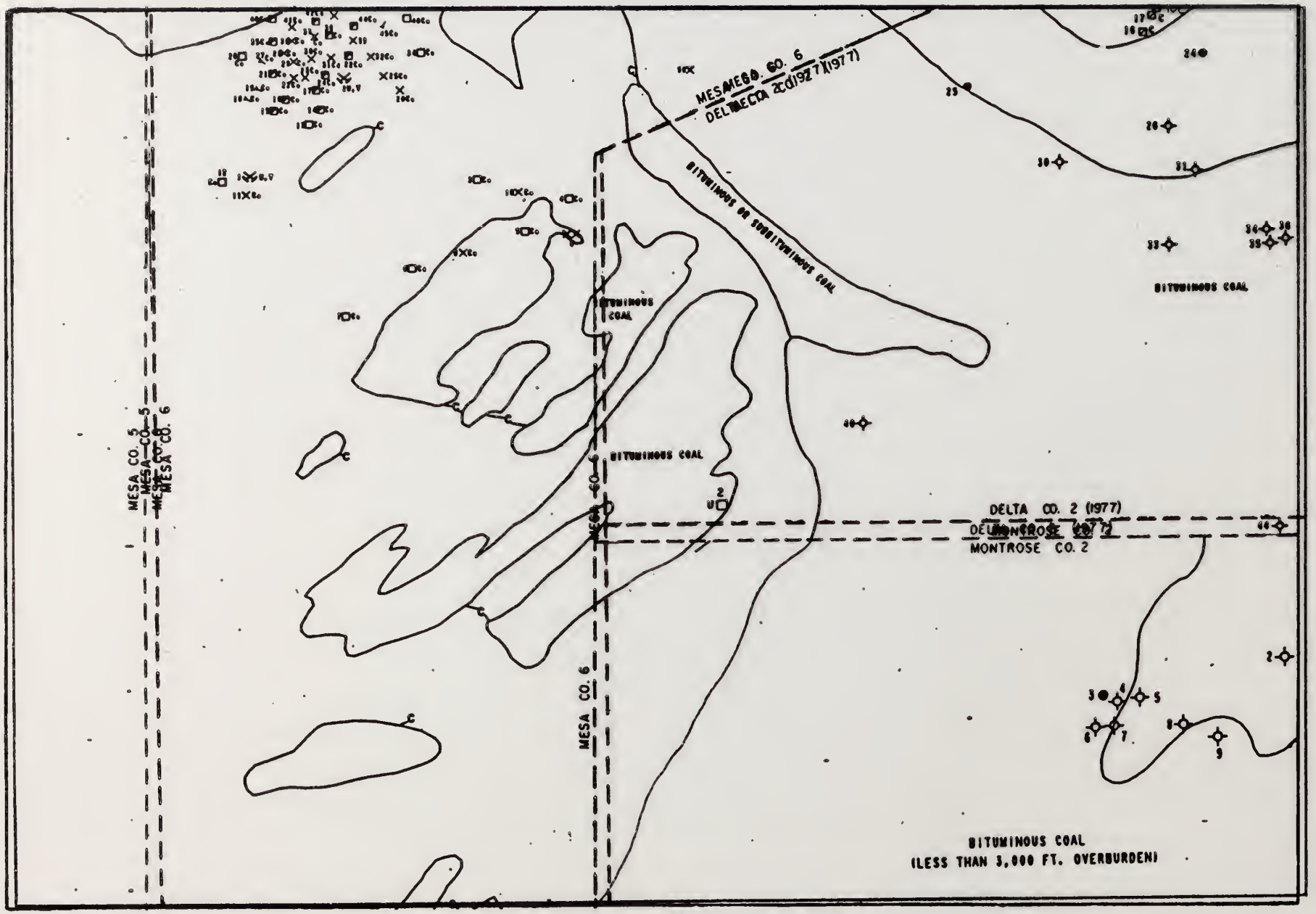
Due to the lack of available data on each WSA, emphasis was placed on gaining an understanding of the mineral potential of each WSA within the GRA. Information on the mineral resources of GRA was utilized to extrapolate and estimate the potentials of the contained WSA's from the existing data that, in 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, company files and returned data sheets. The information was compiled into a series of files on each WSA and a series of maps that covered the entire western portion of Colorado. After a thorough review of the existing data, a program of field checking was carried out by MSME/Wallaby's team of experts. Field investigations in the GRA were carried out by Dr. Paul Gilmour, Dr. Donald Gentry and Mr. Ted Eyde during the period of August 31 - September 2, 1982.

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



OVERLAY D:
SAND, GRAVEL AND
INDUSTRIAL MINERALS



OVERLAY B:
MINES, PROSPECTS
COAL, OIL AND GAS
AND MINERAL OCCURENCES

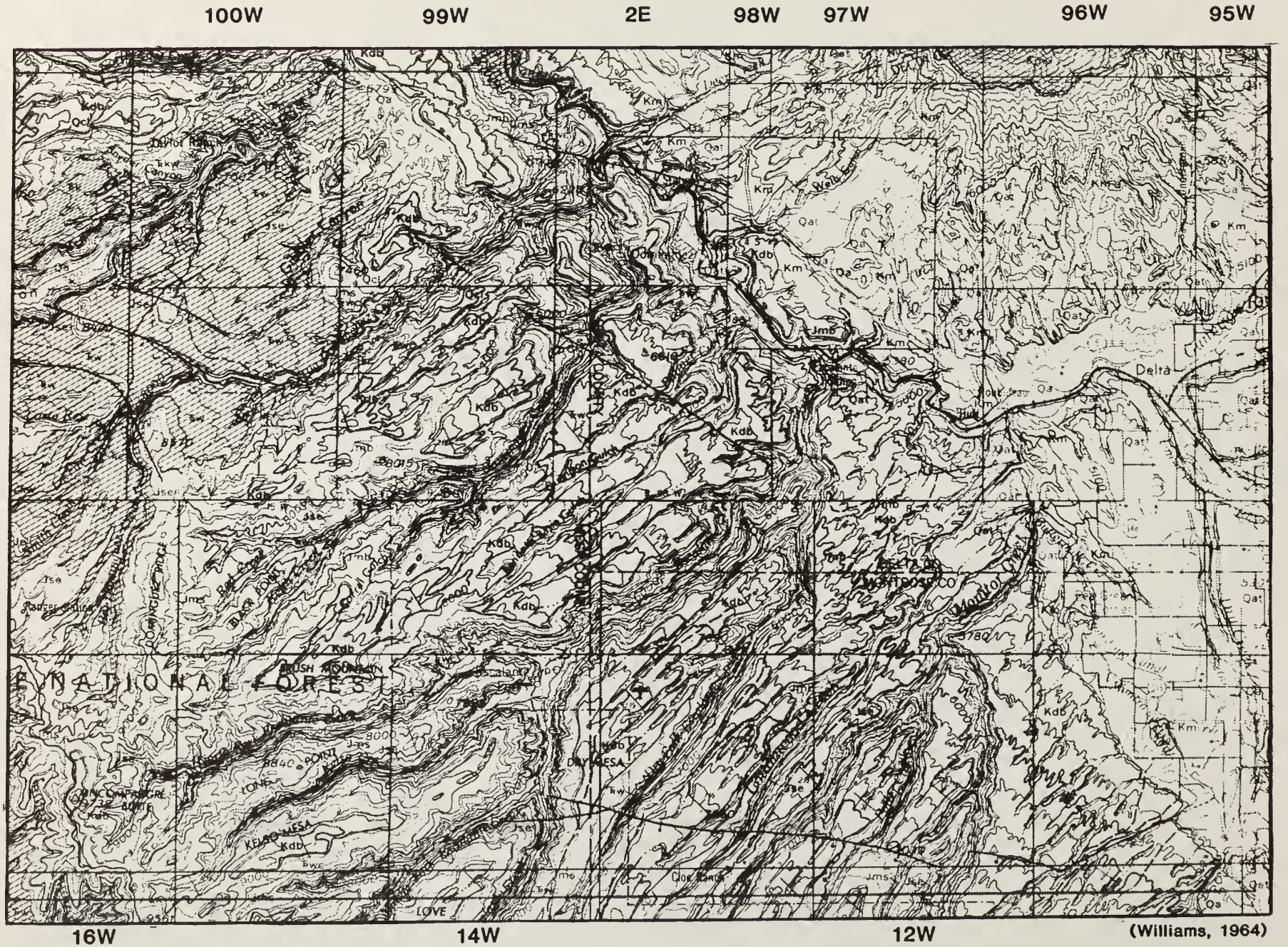


FIGURE I-1
GEOLOGIC MAP

EXPLANATION

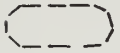
Quaternary (Approximately 2 million years before present (mybp) to present)	Qae	Alluvial and eolian deposits
	Qa	Alluvium deposits
	Qap	Pediment gravels
	Qc	Colluvial deposits
	Qct	Talus
	Qcl	Landslide deposits
	Qat	Terrace gravels
Cretaceous (Approximately 135-62 mybp)	Kmvg	Mesaverde Group
	Kmvu	Upper 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)	Jml	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
	Trkw	Kayenta Formation and Wingate Sandstone
	Trd	Dolores Formation
	Trwc	Wingate Sandstone and Chinle Formation
	Trc	Chinle Formation, undifferentiated
	Trcu	Upper part of Chinle Formation
	Trcb	Chinle Formation, Moss Back Member

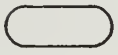
Triassic continued	Trcm	Chinle and Moenkopi Formations
	Trm	Moenkopi Formation
Permian (Approximately 280-255 mybp)	Pe	Cutler Formation, undifferentiated
	Pca	Cutler Formation, arkose and arkosic conglomerate
	Pcw	Cutler Formation, White Rim Sandstone Member
	Pco	Cutler Formation, Organ Rock Tongue
	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
	Php	Paradox Member
Precambrian (Approximately 3400-600 mybp)	pC	Precambrian rocks, undifferentiated

LEGEND


-O OIL FIELD


-G GAS FIELD


-Os OIL SHALE


-C COAL REGION


OIL WELL


OIL & GAS WELL


GAS WELL


SHOW OF GAS


SHOW OF OIL


SHOW OF OIL & GAS


-C COAL DEPOSIT

-C COAL OCCURRENCE

SHUT-IN WELL

CO_2 OR He=HELIUM -RICH WELL


DRY WELL-ABANDONED


MILL


PLANT


NATURAL GAS PROCESSING PLANT


REFINERY


MINERAL OREBODY


MINERAL DEPOSIT


MINERAL OCCURRENCE


PROSPECT


ACCESSIBLE ADIT


INACCESSIBLE ADIT

VERTICAL SHAFT

INCLINED SHAFT


MINE TYPE UNKNOWN


ACTIVE OPEN PIT, OR QUARRY


INACTIVE OPEN PIT, OR QUARRY


ACTIVE GRAVEL OR CLAY (Cl) PIT


INACTIVE GRAVEL OR CLAY (Cl) PIT


EXPLORATION HOLE WITH DATA AVAILABLE


EXPLORATION HOLE WITHOUT DATA AVAILABLE


UNPATENTED MINING CLAIM


PATENTED MINING CLAIM


MINERAL OR OIL & GAS LEASE

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

SECTION II

GEOLOGY

PHYSIOGRAPHY

The GRA boundary includes valley, canyon and plateau areas along the course of the Gunnison River, Dominguez Creek, Little Dominguez Creek, Escalante Creek and Uncompahgre River. In the northeast portion of the GRA, north of the Gunnison River Drainage, are areas along the southwest flank of the most prominent topographic feature of the area, Grand Mesa. In this area the southwest and south trending drainages have eroded the Cretaceous section into a series of low, rolling hills and shallow fluvial systems that make up a "badlands" topography of a maze of narrow ravines, sharp crests, and pinnacles. Vertical relief in these areas is approximately 2,000 feet.

South and west of the Gunnison River are a series of northeast trending ridges and mesas that have been isolated from each other by the Dominguez Creek, Little Dominguez Creek and Escalante Creek drainages. These ridges are composed of resistant Mesozoic units and are relatively flat topped with a gentle dip to the northeast. The canyons that separate these ridges have relatively steep walls, and have a vertical relief of between 1,500 and 2,000 feet. These canyons and their tributary drainages form a part of the drainage system of the Gunnison River, the most important physiographic feature of the GRA.

The Gunnison cuts through the GRA from northwest to southeast, and is characterized as a narrow, meandering fluvial system having a restricted canyon that has been partially filled by fluvial sedimentation. Vertical relief in the immediate area of the river course is less than 500 feet. The river valley widens in the vicinity of Delta, Colorado and forms a valley 2-3 miles wide. In this area is the confluence of the Gunnison and Uncompahgre River, a north flowing fluvial system that drains most of the flat lying areas south of Delta. Along the drainage of the Uncompahgre and in the areas south and directly north of Delta, the vertical relief is less than 500 feet.

The following descriptions address the physiographic composition of each of the WSA's within the Dominguez Canyon/Adobe Badlands/Camel Back GRA.

DOMINGUEZ CANYON WSA (CO-030-363 & CO-070-150)

Within the boundary of the WSA are found a series of northeast trending drainages of Dominguez Creek, Little Dominguez Creek and other minor drainages of the Gunnison. Dominguez Creek and Little Dominguez Creek, two major drainages off of the Uncompahgre Plateau, go into the Gunnison River, and form canyons that cut through the Mesozoic and Precambrian stratigraphy. The drainages have contributed to the formation of isolated northeast-southwest trending plateaus, ridges and mesas (Long Mesa, Rough Mesa, Middle Mesa and Steamboat Mesa). Vertical relief in the canyon areas is approximately 1,500 to 2,000 feet. The mesa and ridge tops are relatively flat and dip gently to the northeast. They are cut by shallow drainages that empty into the canyon systems, and have a vertical relief of approximately 500 - 1,000 feet.

ADOBE BADLANDS WSA (CO-030-370B)

The rolling, badland topography of the WSA is caused by the meandering stream systems that have cut down through the soft, clay-forming units of the Cretaceous Mancos Shale. Vertical relief in the area is generally less than 1,000 feet. The erosion remnants of shale and mudstone, in conjunction with the meandering fluvial systems, form a "maze" of hills, outcrops and gullies that are the transition physiographic features between the alluvial plains along the course of the Gunnison to the foothills of Grand Mesa.

CAMEL BACK WSA (CO-030-353)

This unit is characterized by a series of canyons and mesas sculptured by numerous intermittent streams. Mesozoic units remain as topographic highs as ridges and mesa tops. Vertical relief within the unit is generally less than 1,000 feet. The ridge and mesa tops are relatively flat with a vertical relief of less than 500 feet. They gently dip to the northeast. The canyon areas of the WSA have relatively gentle talus slopes and a vertical relief of approximately 300 - 500 feet.

ROCK UNITS

Within the Dominguez Canyon/Adobe Badlands/Camel Back GRA is found a variety of rock units that represent a large portion of Precambrian, Mesozoic and Cenozoic time. The Precambrian section is represented by a complex of gneisses and schists that indicate periods of volcanic, volcaniclastic and sedimentary deposition (Gilmour, Personal Communication, 1982, Williams, 1964). These units have been moderately deformed and intruded by a series of felsic through mafic bodies. The Precambrian sequence is relatively unstudied in this area and has not been extensively dated, mapped or correlated to other sections of Colorado (Gilmour, Personal Communication, 1982; Schwochow, 1978; Williams, 1964). Base and precious metal deposits have been found associated with Precambrian units in the Copper City - Unaweep Canyon District area and within the GRA in the Dominguez District area. These deposits were worked intermittently during the period from 1870 - 1900 (Schwochow, 1978; Gilmour, Personal Communication, 1982; Eyde, Personal Communication, 1982). Mineralization consisted of copper oxides and carbonates with minor amounts of pyrite and chalcopyrite in association with fluorite and amythyst bearing quartz veins and pegmatites (Schwochow, 1978; Gilmour, Personal Communication, 1982). In other areas of Colorado, western United States and Canada, primary, syngenetic mineralization has been found associated with Precambrian felsic and sedimentary sequences (Gilmour, Personal Communication, 1982). Minor amounts of gold were recovered from placers that drained the Unaweep Canyon area, west of the GRA (Schwochow, 1978; Vanderwilt, 1947).

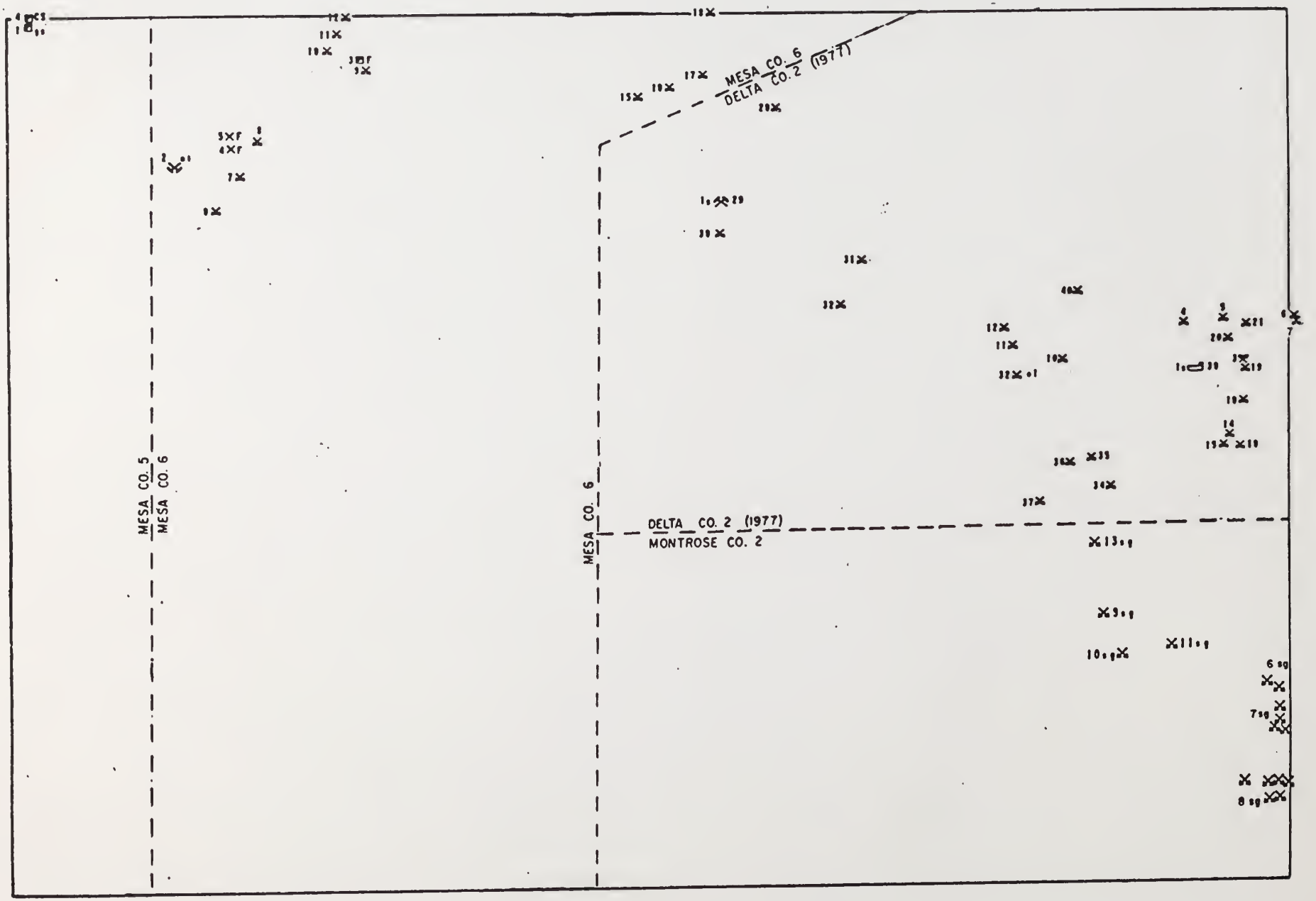
The Paleozoic section does not crop out within the GRA and is thought to be missing. It is thought that it was never deposited on the flanks of the Uncompahgre Uplift and may have never been deposited within the GRA. Where the Precambrian is exposed in Dominguez Canyon, the Triassic Chinle Formation lies directly upon the Precambrian erosion surface (Schwochow, 1978; Gilmour, Personal Communication, 1982). Farther to the east in the Gunnison Gorge area, the Jurassic Morrison Formation lies directly upon the basement Precambrian complex (Tweto et al, 1978), an indication that there was a topographic high throughout most of the GRA during much of Paleozoic and Mesozoic time (Baars et al, 1981).

The Mesozoic section consists of Triassic mudstones, shales, and sandstones of the Chinle, Wingate Sandstone and Kayenta Formations. Within the GRA, the Triassic Chinle Formation is a siltstone interbedded with lenses of red sandstone, shale limestone-conglomerate and a basal conglomerate unit that may be the equivalent of the Shinarump Formation in southeastern Utah and Arizona (Williams, 1964). The Wingate Sandstone is a massive, thick-bedded eolian sandstone that was probably deposited in a desert environment (Williams, 1964). Both the Chinle and the Wingate Sandstone Formations are known to contain copper-silver mineralization in areas of western Colorado, and within the GRA. This type of mineralization is thought to be related to fracture zones in the Precambrian and Lower Triassic stratigraphy (Schwochow, 1978; Fisher, 1936), but may, in fact, have an original syngenetic origin (Gilmour, Personal Communication, 1982). The occurrence of copper-silver mineralization in the Dominguez Canyon area is restricted to selected zones in the Chinle - Wingate stratigraphy adjacent to and associated with a series of northwest striking faults and shear zones (Schwochow, 1978; Gilmour, Personal Communication, 1982; Eyde, Personal Communication, 1982).

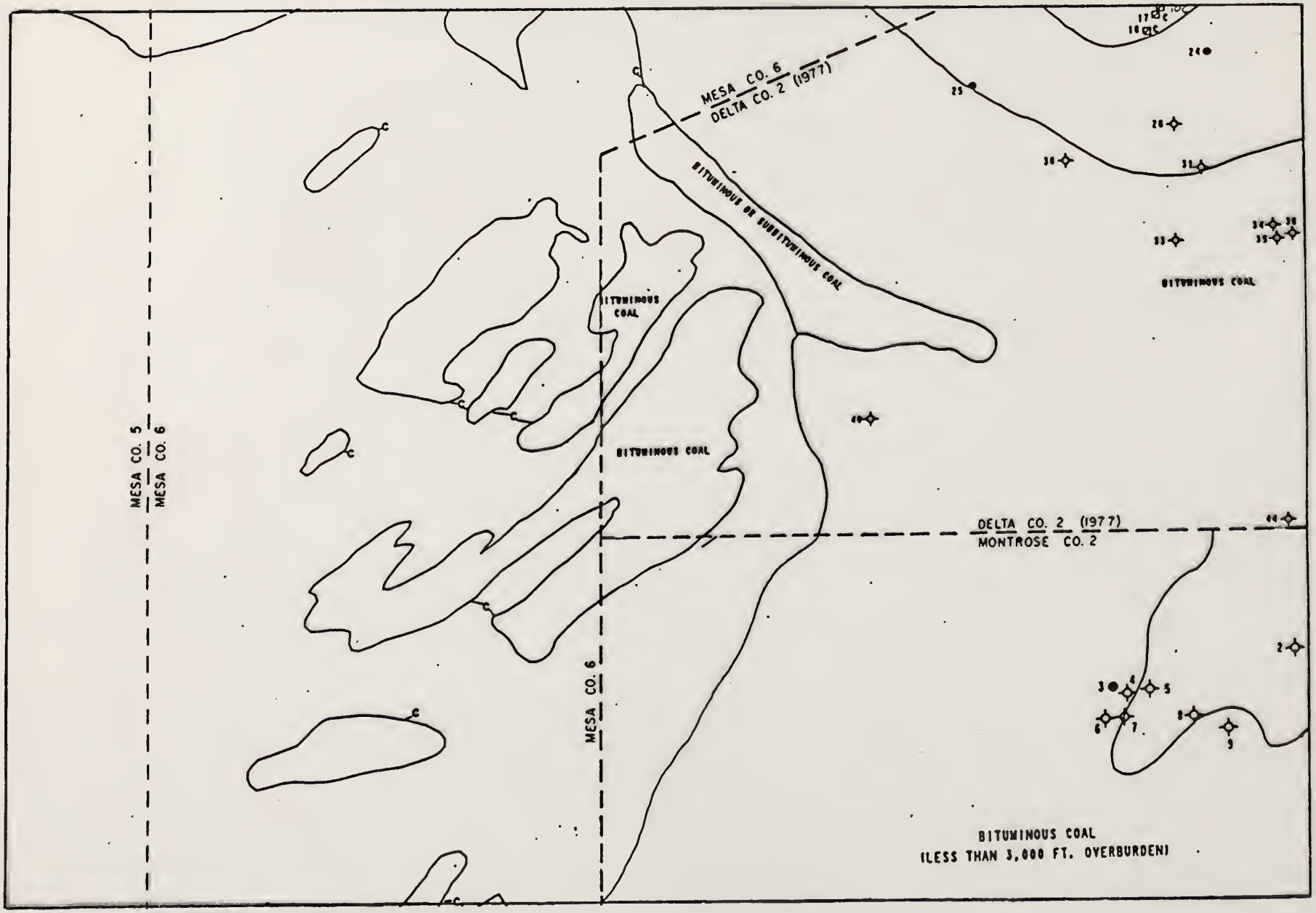
The Lower Triassic units are thought to represent a period of deposition in a near-shore marine or lagoonal environment with periods of terrestrial deposition in a near-shore arid environment (Williams, 1964; Carter et al, 1965).

The Jurassic Entrada Formation directly overlies the Triassic Chinle - Wingate stratigraphy. Within the GRA, this is thought to represent a conformable situation in that the Triassic units were uplifted and formed a topographic high during Late Triassic time (Carter et al, 1965). This situation continued until the beginning of the Jurassic when the Entrada Sandstone was deposited in a terrestrial eolian environment (Williams, 1964). In other areas of Colorado, the Entrada contains uranium-vanadium deposits associated with a basal siltstone-sandstone unit that is described as the Carmel Formation (Williams, 1964). This type of mineralization is not known to occur within the GRA. Directly overlying the Entrada is the Jurassic Summerville Formation which consists of a series of sandy shale, mudstone and chert units. The units are thought to be of terrestrial origin and do not have associated uranium-vanadium deposits within the GRA. Several deposits in the Summerville have been mined in the past from the Uravan uranium-vanadium belt (Williams, 1964a). Throughout most of the GRA, the Jurassic Morrison Formation overlies the Summerville. The Morrison units that crop out within the GRA represent a series of mudstone, shale, conglomerate, fluvial sandstone and limestone beds (Williams, 1964). Uranium-vanadium mineralization is normally associated with conglomeratic units within the upper or Brushy Basin Member of the Morrison (Williams, 1964; Vanderwilt, 1947). The Morrison Formation units that outcrop within the GRA are not known to contain ore-grade uranium-vanadium mineralization and are thought to have been deposited in a terrestrial fluvial environment (Carter et al, 1965; Vanderwilt, 1947, Williams, 1964a). The Morrison Formation is known to contain uranium-vanadium deposits in other areas of western Colorado (Williams, 1964a, Schwochow, 1968; Vanderwilt, 1947).

The Cretaceous section is represented within the GRA by the Burro Canyon Formation, the Dakota Sandstone, the Mancos Shale Formation, and the Mesaverde Group (Williams, 1964). These units can be described as a series of shales, sandstones, mudstones and conglomerates with interbedded coal seams (Williams, 1964). The Burro Canyon Formation consists of a sequence of fluvial sandstone, conglomerate, siltstone, shale, and mudstone units with thin beds of impure limestone



OVERLAY D:
SAND, GRAVEL AND
INDUSTRIAL MINERALS



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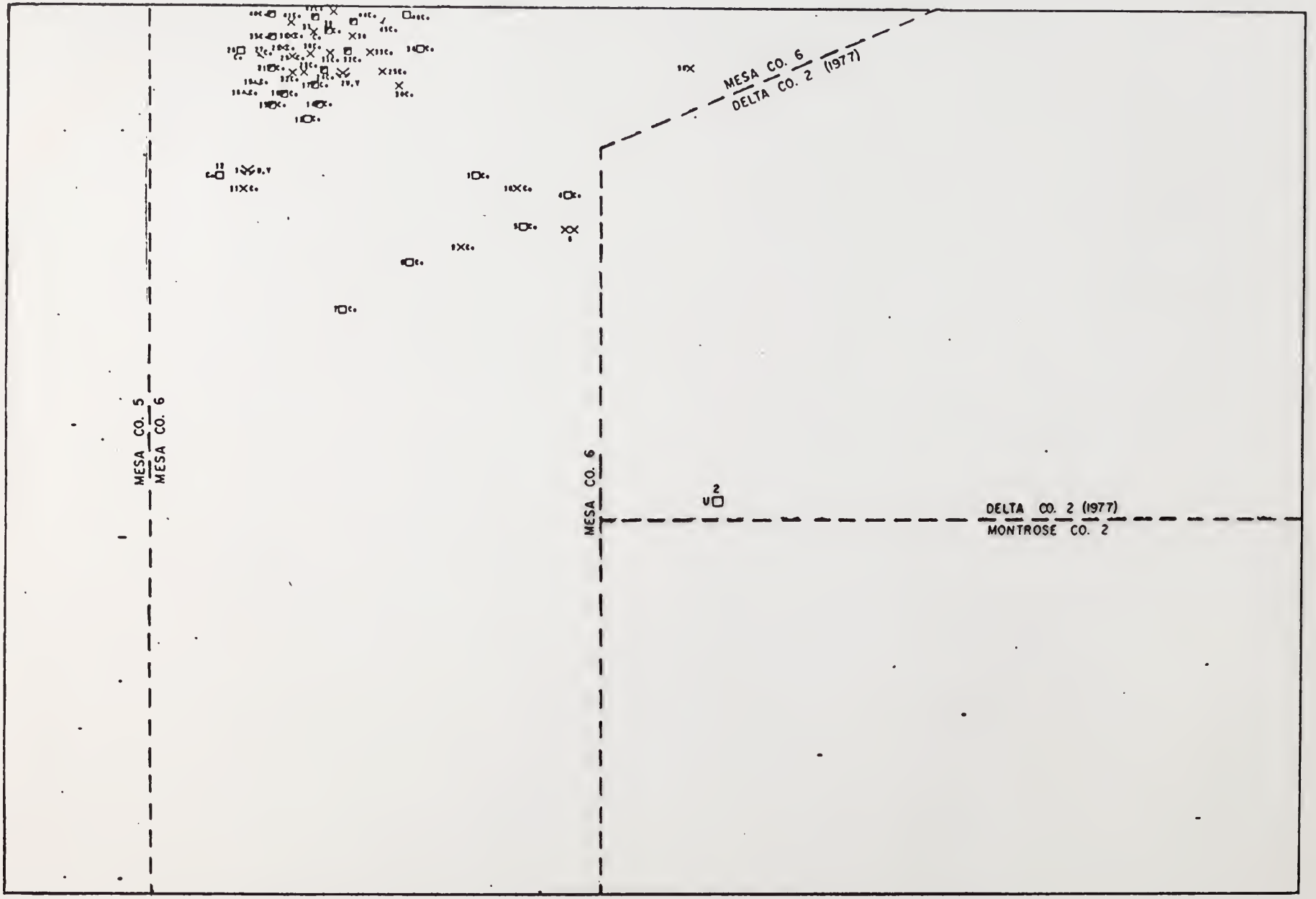
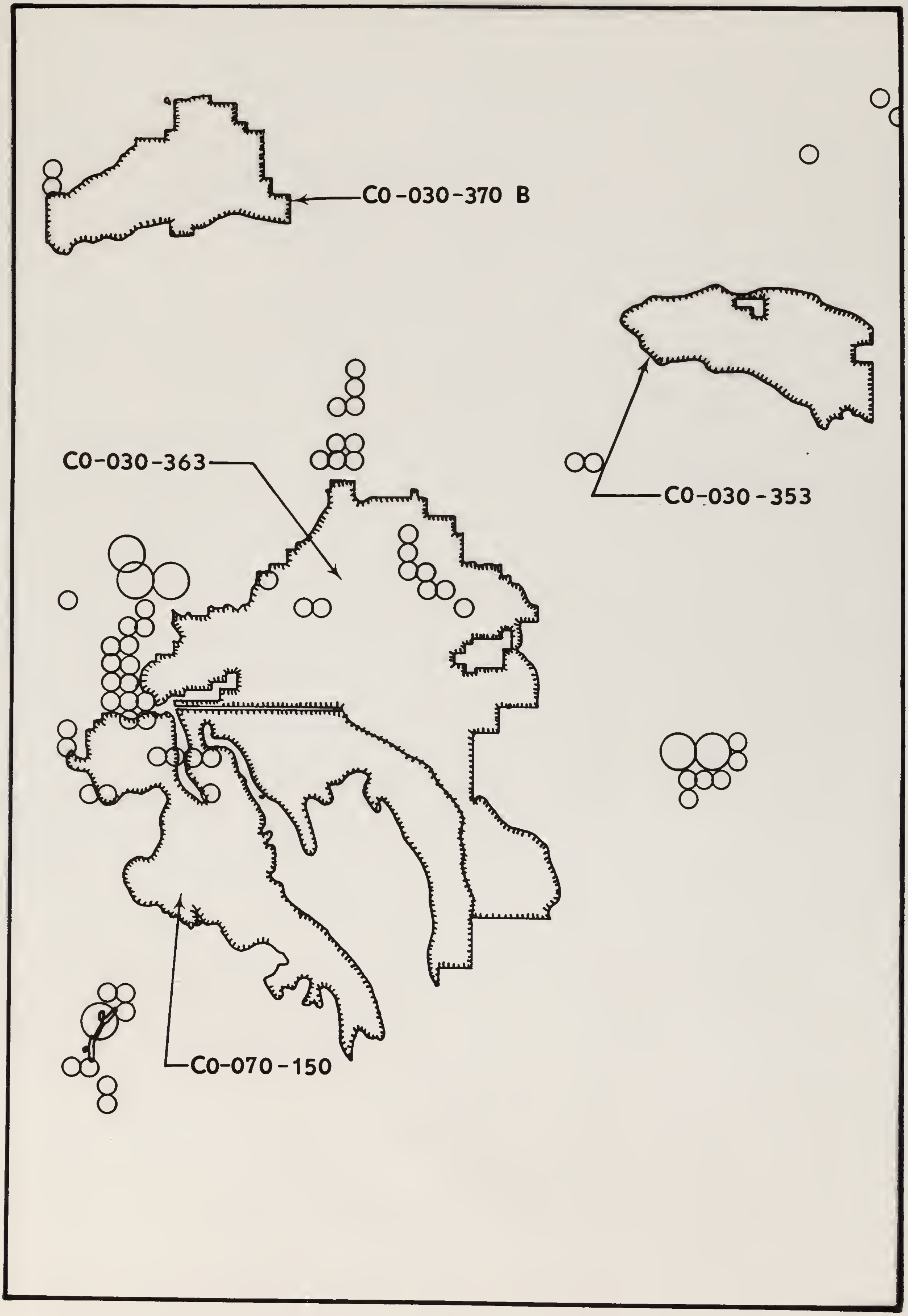
COAL, OIL AND GAS



OVERLAY B:
MINES, PROSPECTS
AND MINERAL OCCURENCES



OVERLAY A:
PATENTED AND UNPATENTED
CLAIMS AND WSA BOUNDARIES

(Williams, 1964). The overlying Dakota Sandstone is a group of sandstone and conglomerate units with interbedded carbonaceous non-marine shale and coal units. Plant fossils usually associated with this unit and minable coal seams have been identified within the GRA (Speltz, 1976), and mined in other areas of Colorado (Vanderwilt, 1947; Speltz, 1976; Gentry, Personal Communication, 1982; Williams, 1964).

The Mancos Shale formation consists of black fissle shale units with thin sandstone beds. The Mesaverde Group units that crop out within the GRA include a series of non-marine sandstone, shale and coal units with a massive, crossbedded sandstone unit (Rollins Sandstone Member). Coal beds within the Mesaverde are thought to be thin and discontinuous (Gentry, Personal Communication, 1982; Speltz, 1976) within the GRA. The Mesaverde produces major quantities of coal in other areas of Colorado, and is considered a coal resource within the GRA (USGS & CGS, 1977). Past mining operations within the GRA have delineated coal bearing units with the Mesaverde that could be mined if economic condition warranted (Gentry, Personal Communication, 1982; Speltz, 1976; USGS & CGS, 1977).

The Cenozoic stratigraphy is represented by sandstone, shale and siltstone units of the Tertiary Wasatch Formation. This unit unconformably overlies the Cretaceous section and is thought to represent a period of shallow water deposition in a marine or neritic environment (Young, 1959; Williams, 1964; Carter et al, 1965).

Quaternary alluvial, fluvial, and terrace deposits are found along the Gunnison River Valley and on the gently sloping outcrops of the Cretaceous section south and west of Grand Mesa (Williams, 1964). Alluvial material directly north of Delta, Colorado and at various locations along the Gunnison River has been exploited in recent times as a source of sand, gravel and clays (Williams, 1964; Eyde, Personal Communication, 1982).

The following descriptions address the rock units within the various WSAs included in the Dominguez Canyon/Adobe Badlands/Camel Back GRA.

DOMINGUEZ CANYON WSA (CO-030-363 & CO-070-150)

Within the WSA, the Precambrian basement complex of schist, gneiss and felsic intrusives is directly overlain by the mudstone, shale, and sandstone units of the Triassic Chinle and Wingate Sandstone Formations. In the Dominguez Canyon area, both the Precambrian and Triassic units have fault controlled vein copper-silver mineralization. The mineralization appears to be restricted to certain lithologic units and may be partially syngenetic (Williams, 1964; Schwochow, 1978; Gilmour, Personal Communication, 1982). Directly overlying the Triassic section are the Jurassic Entrada, Summerville and Morrison Formations. These units consist of a series of eolian sandstones, fluvial sandstones, siltstones, shales, mudstones and conglomerates. Occasional limestone and chert units are found in the Morrison and Summerville Formations (Williams, 1964). These units are known to contain uranium-vanadium deposits in other areas of Colorado, but have none reported within the boundaries of the WSA (Williams, 1964a).

The Cretaceous Burro Canyon and Dakota Formation directly overlie the Jurassic unit and form ridge and mesa tops (Williams, 1964). Within the WSA, the Burro Creek Formation is a series of shales, sandstones, siltstones, and conglomerates with occasional beds of limestone. The Dakota Sandstone is a group of sandstone and conglomerate units with interbedded carbonaceous shale and coal units. The Dakota Sandstone coal outcrops are considered by the United States Geological Survey to be an energy resource (UGGS & CGS, 1977). Quaternary alluvium is found overlying the Precambrian and Mesozoic section along the bottoms of the major fluvial systems, and is reported to have been worked in the past for placer gold values. Any post-Dakota, Cretaceous section that originally may have been deposited over the WSA was probably stripped away by erosion during Tertiary and Quaternary time (Schwochow, 1978; Carpenter, Personal Communication, 1982; Williams, 1964; Vanderwilt, 1947).

ADOBE BADLANDS WSA (CO-030-370B)

The only rock units that crop out within this area are shale and sandstone units of the Cretaceous Mancos Formation (Williams, 1964). Directly overlying the Cretaceous units are alluvial and terrace deposits of Quaternary age. The Mancos Shale has associated with it in adjacent areas thin coal seams that may have economic importance (Speltz, 1976; Gentry, Personal Communication, 1982; USGS & CGS, 1977). Clay units within the Mancos may have important industrial uses (Eyde, Personal Communication, 1982). It is thought that the Jurassic - Cretaceous and the underlying Precambrian basement complex exists at depth under the WSA (Heylmun, Personal Communication, 1982).

Directly overlying the Jurassic section is the Cretaceous Burro Creek Formation. This unit consists of a series of mudstones, shales, sandstones, siltstones and conglomerates that are essentially flat within the WSA and form cliffs and overhangs along the major drainages (Gilmour, Personal Communication, 1982). The overlying Dakota Sandstone is a group of sandstone, shale and conglomerate units with interbedded carbonaceous shales and coal seams (Williams, 1964). No coal beds thick enough to be economically important were observed during field reconnaissance of the area (Gilmour, Personal Communication, 1982). The Dakota Sandstone crops out within the WSA have been designated as an energy resource by the United States Geological Survey (USGS & CGS, 1977).

Quaternary alluvium directly overlies outcrops of the Precambrian and Mesozoic units in the major drainages that cut through the area.

CAMEL BACK WSA (CO-030-353)

Within this area, the Precambrian basement complex of gneiss, schist and felsic intrusives is thought to be directly overlain by the Triassic Chinle and Wingate Formations which, in turn, are overlain by the Jurassic Entrada, Summerville and Morrison Formations (Williams, 1964). No mineralization has been reported from the Precambrian, Triassic and Jurassic units though there is a northwest striking fault system that cuts through the WSA and could have acted as a conduit for copper-silver mineralization as in other locations in western Colorado and eastern Utah (Sharpe, 1936; Williams, 1964; Williams, 1964a). The units of the Morrison are generally favorable for uranium-vanadium mineralization (Carter et al, 1965). No anomalous values were detected in the area by the United States Department of Energy NURE programs.

STRUCTURAL GEOLOGY AND TECTONICS

Tectonic features within the GRA include northwest and west-northwest-striking high angle faults that cut across the dominant northeast structural grain of the area. The northwest striking faults and joint systems have associated copper-silver-gold-amythyst bearing quartz veins (Gilmour, Personal Communication, 1982; Schwochow, 1978), and may have localized syngenetic mineralization in the Triassic section (Gilmour, Personal Communication, 1982; Schwochow, 1978).

Northeast-striking joint systems determine the drainage of the Gunnison River throughout much of the GRA (Williams, 1964). Most of the stream drainages that cut through the Mesozoic section are aligned in this northeast direction. In the eastern portion of the GRA, the badland topography of the Adobe Badlands area is caused by meandering stream courses that trend generally north-south (Williams, 1964).

Within the GRA are a number of major unconformities within the Precambrian, Paleozoic, Mesozoic and Tertiary sections. The Precambrian units exposed within the GRA are unconformably overlain by the Triassic Chinle and Wingate Sandstone Formations. The entire Paleozoic section is missing from the study area. The oldest Precambrian rocks exposed within the GRA are thought to be 1700 million years old, and have been extensively deformed and intruded by younger Precambrian granitic bodies (Williams, 1964). This mass of highly deformed gneiss, schist and granite was uplifted in an early stage of the Uncompahgre Event (Baars et al, 1981), and remained as a topographic highland during much of the Paleozoic and Mesozoic. Within the GRA, the Paleozoic was probably a time of continual uplift and erosion with actual sedimentation occurring in the areas to the west and east of the GRA boundary (Baars et al, 1981).

The Jurassic Entrada Formation directly overlies the Triassic Wingate Sandstone Formation over much of the area. This represents an unconformable situation in that the Triassic Kayenta and Navajo Sandstone Formations were either not deposited or were eroded during a phase of Uncompahgre uplift (Baars, et al, 1981; Williams, 1964).

In the Cretaceous section, an unconformity has been noted at the base of the Dakota Sandstone. Within the study area, the Dakota and the underlying Burro Canyon Formation have been mapped together and may be stratigraphically continous (Williams, 1964). This unconformity may be important in the localization of uranium mineralization as a surface where conditions were favorable for the precipitation of uranium-vanadium minerals from Tertiary hydrothermal sources (Kelley, 1956; Carpenter, Personal Communication, 1982).

The Tertiary Wasatch Formation may lie unconformably over the Cretaceous Mesaverde Group in the northeast portion of the GRA. The exact relationship here is obscured by post-Tertiary cover and colluvial deposits (Williams, 1964).

Deformation has obscured the true stratigraphic sequence within the Precambrian rocks cropping out within the GRA. No major folds of significance have been mapped within the GRA. Minor folds have been noted in the Precambrian and Cretaceous units (Gilmour, Personal Communication, 1982; Speltz, 1976).

The following descriptions address the structural and tectonic characteristics of each of the individual WSA's within the Dominguez Canyon/Adobe Badlands/Camel Back GRA.

DOMINGUEZ CANYON WSA (CO-070-150/CO-030-363)

Structural features found within the WSA include northwest and west-northwest striking high angle faults and shear zones with accompanying joint systems. These features may have localized copper-silver-gold-amythyst bearing quartz veins, and copper-silver syngenetic mineralization in the Triassic Chinle and Wingate Sandstone Formations. Northeast striking joint systems control the drainage patterns throughout most of the WSA, and may have acted as a secondary control on mineralization in the Triassic units (Gilmour, Personal Communication, 1982; Schwochow, 1978; Carpenter, Personal Communication, 1982).

Throughout all of the WSA, the Triassic Chinle and Wingate Sandstone Formations lie unconformably upon the basement Precambrian complex, representing a period of non deposition and erosion during the Paleozoic and part of Mesozoic time (Baars et al, 1981). Within the WSA is a conformable sequence of Triassic, Jurassic and Cretaceous stratigraphy. The youngest Mesozoic mapped unit within the WSA is the Cretaceous Dakota Formation.

Quaternary gravels and alluvium are found to directly overlie exposed outcrops of Precambrian, Triassic and Cretaceous units.

ADOBE BADLANDS WSA (CO-030-370B)

This area is cut by north-south striking stream drainages that probably reflect an inherent jointing pattern in the Cretaceous Mancos Shale. The area is probably underlain by a relatively complete Mesozoic and early Cretaceous section that directly overlies the Precambrian basement complex. No pre-Cretaceous units crop out within the WSA, and it is probable that the entire Paleozoic section was never deposited in this area (Williams, 1964; Baars et al, 1981; Gentry, Personal Communication, 1982). A monoclinal structure has been identified in the coal beds of the Mancos Shale Formation, but it is only thought to have local importance in exposing the units to erosion and decarbonization (Speltz, 1976; Gentry, Personal Communication, 1982).

Within the WSA is a complete section of Mesozoic stratigraphy. It is thought that the Triassic Chinle Formation lies directly and unconformably upon the Precambrian basement complex. Thus, it appears that the entire Paleozoic section is missing and probably was never deposited within the WSA (Baars et al, 1981; Williams, 1964; Heylmun, Personal Communication, 1982).

Quaternary alluvial deposits are found in the various washes and creek beds that are found throughout the area.

CAMELBACK WSA (CO-030-353)

This area is cut by a single west-northwest striking high angle fault which has been mapped in the southern part of the WSA. This structure cuts the prominent

north-northeast structural grain that characterizes the area. North-northeast joint systems appear to control the drainage patterns in the area, and may have actually post-dated the west-northwest faults.

PALEONTOLOGY

Paleontological resources of the GRA have not been extensively studied by government or private industry. The Triassic Chinle and Wingate Formations are known to contain reptile, amphibian and bird remains in other areas of Colorado (NPS File Data, 1982; Shawe et al, 1968). The Jurassic Morrison Formation is known to contain plant, reptile bird and mammal remains in areas to the west and within the GRA (Gilmour, Personal Communication, 1982; Shawe et al, 1968; BLM file data). The Cretaceous Dakota Sandstone Formation is also known to contain plant remains in the Slick Rock District and other areas of Colorado (Shawe et al, 1968). All of these units are not known to contain fossil material within the GRA as there are no known occurrences or reported localities.

The Cretaceous Mancos Shale outcrops of the Gunnison River Coal Field are known to contain fossil plant remains associated with the coal seams (Speltz, 1976; NPS File Data, 1982; Weeks, 1925). These occurrences are the only reported fossil localities within the GRA.

The Tertiary Green River Formation is known to contain fossil marine fishes in other areas of Colorado, but has unknown potential for paleontological resources within the boundaries of the GRA (NPS File Data, 1982).

The following descriptions address the paleontological resources of each of the individual WSA's within the Dominguez Canyon/Adobe Badlands/Camel Back GRA.

DOMINGUEZ CANYON WSA (CO-070-150 & CO-030-363)

This WSA does not contain reported localities or fossil occurrences of major scientific importance (NPS File Data, 1982). Cropping out units of the Triassic Chinle and Wingate Formations may contain fossil, reptile, amphibian, and bird remains as are found in other areas of Colorado (NPS File Data, 1982). In addition, the outcrops of the Jurassic Morrison Formation may contain reptile, bird, mammal, and plant remains that are commonly found in this unit (NPS File Data, 1982; Shawe et al, 1968). The Cretaceous Dakota Formation crops out within this unit and may contain significant plant remains. The potential for paleontological resources within these units in this specific area is largely unknown due to lack of data.

ADOBE BADLANDS WSA (CO-030-370B)

No occurrences or localities of fossil material have been reported from this area (NPS File Data). In adjacent parts of the Gunnison River Coal Field, fossil plant remains have been reported in association with the coal seams (Speltz, 1976; Weeks, 1925; NPS File Data, 1982). The units of the Cretaceous Mancos Formation that crop out may contain similar material. Any evaluation of the potential for paleontological resources of this area must await further investigations.

The area contains no reported occurrences or fossil localities of major scientific interest (NPS File Data, 1982). No reported coal seams are known from the area. The Jurassic units that crop out in the area may contain reptile, bird, mammal and plant fossils, as are found in other areas of Colorado (NPS File Data, 1982; Shawe et al, 1968). The cropping out units of the Cretaceous Dakota Formation are not thought to contain coal seams, but may contain plant fossil remains as is common in the rest of the state (Shawe et al, 1968). More information needs to be obtained before any appraisal of the paleontological resources of the area can be made.

HISTORICAL GEOLOGY

During middle Precambrian time, the southern portion of the GRA received sediments from both cratonic and island arc sources. 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 an extreme period of deformation caused by plate collisions and regional uplifting. These older Precambrian units were metamorphosed, deformed and intruded by a series of younger Precambrian mafic to felsic bodies. 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. Other base and precious metal deposit types, called exhalative deposits, are commonly found in Precambrian lithologies. These exhalative deposits are found in association with marine basins and rhyolitic volcanic systems, and are commonly associated with the older Precambrian lithologies.

The younger Precambrian units are not thought to exist on the crest of the Uncompahgre Uplift and have not been encountered in drilling operations. In parts of Northwestern Colorado the younger Precambrian sedimentary section is partially preserved. The environment is of a predominantly clastic deposition in a marine environment. The Paleozoic section is entirely missing in the GRA, and was probably never deposited as the area was a topographic high for most of the Paleozoic and Mesozoic.

Other areas of Colorado contain complete sections of the Lower Jurassic. Within the GRA these units are missing, and the Jurassic Entrada Sandstone lies unconformably on top of the folded and intruded Precambrian units. This unconformity represents the lower and middle Mesozoic section and would indicate that the area was undergoing erosion and non-deposition. This may have been a period when the GRA was a terrestrial topographic high that was rapidly eroding and shedding sediments into shallow Jurassic basins. The Jurassic Summerville and Morrison Formations were deposited in near-shore lagoonal environments or shallow water marine and fluvial systems. Some lacustrine and fresh water fluvial deposits have also been identified from these rocks. Mineral deposits are commonly found associated with limey sandstones, shales, and siltstones deposits in shallow, neritic basins that have fluvial channels meandering through them. Copper-silver-uranium-vanadium mineralization occasionally occurs in these units as "roll-front" and organically precipitated "stream channel" deposits. "Roll-front" deposits are elongate concretionary structures encompassed by rich vein-like concentrations of uranium-vanadium - bearing clay minerals. "Stream channel" deposits occurred where uranium-vanadium

waters encountered structural traps and clastic organic accumulation, depositing minerals in a reducing environment. Such mineral deposits are very important economically and are known to occur in other portions of the Jurassic section in western Colorado, Utah, Arizona and New Mexico. These deposits are thought to represent 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 Cretaceous time the area was the site of shallow water deposition in a lagoonal or swamp environment. The Lower Cretaceous Burro Canyon and Dakota Sandstone Formations contain thin coal seams that may have economic significance. During most of the Lower Cretaceous, however, the GRA was a part of a beach or littoral environment adjacent to the Mancos Basin of central Colorado (Tweto et al, 1976).

Units of the Cretaceous Mancos Shale have been described as being sandstone and shale units deposited in a near-shore environment. Thin coal beds in the nearby Gunnison Coal Field may have some local economic significance (Speltz, 1979). In the GRA proper, these units are represented by the carbonaceous units of the Mancos upper shale unit (Tweto et al, 1976). The Mesaverde Group Cretaceous units crop out throughout the central and northern portions of the GRA and represent a period of cyclical deposition of shale, coal, limestone and sandstone units in a near-shore marine environment adjacent to the deep-water basins where the bulk of the Mancos Shale unit was deposited (Richardson, 1909). The upper members of this formation also contain thin, discontinuous coal seams of minor economic importance (Gentry, Personal Communication, 1982). These units were also laid down in a near-shore swamp or lagoonal environment.

The Mesaverde Group units are unconformably overlain by the Tertiary Wasatch Formation. This unconformity may represent a period of uplift and erosion prior to the formation of the Uinta sedimentary basin. The Wasatch Formation represents a period of shallow water terrestrial lacustrine deposition.

The area was uplifted and subjected to erosion in Middle Tertiary times with the formation of the ancestral Gunnison River Valley. In the eastern portion of the GRA are volcanic flows and intrusives that are a part of the Silverton Caldera complex. These units were part of a great volcanic system that existed in southern Colorado and other parts of the west and have valuable base and precious metal deposits associated with them. Quaternary pediment, terrace gravel and eolian deposits formed on the exposed Cretaceous surfaces and alluvial deposits were formed along the various fluvial systems that were established.

DOMINGUEZ CANYONS WSA (CO-070-150 & CO-030-363)

Precambrian gneisses, schists and intrusive rocks are unconformably overlain by the Mesozoic section. The Triassic Chinle and Wingate Sandstone Formations were deposited in the near-shore marine or lagoonal environment. Within the WSA there are known occurrences of copper-silver "redbed" deposits. The Jurassic section is represented by the Entrada Sandstone, Summerville and Morrison Formations. These rocks are thought to represent near-shore lagoonal and shallow water marine conditions with periods of transgressive and regressive marine and lacustrine

shorelines. Fluvial terrestrial and delta-flood plain deposits have also been identified from these rocks. The characteristic sandstone hosted roll-front copper-silver-uranium-vanadium deposits which occur in these lithologies and in other parts of Colorado have not been identified within these units in the WSA. An occurrence of uranium-vanadium mineralization has been reported in the eastern portion of the WSA, but has not been positively correlated to these lithologies.

The Cretaceous Burro Canyon and Dakota Sandstone Formations directly overlie the Jurassic section and represent periods of shallow water deposition in the lagoonal or swamp environment. Coal seams have not been identified from the field reconnaissance efforts. In other areas of Colorado and Utah, the Lower Cretaceous section has produced oil and gas (Brainard et al, 1962). Within the WSA, the rest of the Cretaceous and Tertiary section has been eroded. Quaternary fluvial deposits are found along the eastern boundary of the WSA and along the canyons that cut through the area.

ADOBE BADLANDS WSA (CO-030-370B)

According to the well information available, the Precambrian Jurassic section is thought to be present under the WSA and was encountered in drill holes on the flanks of the Uncompahgre Uplift (Heylmun, Personal Communication, 1982). No other information on the lithologies encountered is currently available. Within the boundaries of the WSA, only the Cretaceous and Tertiary units are exposed. The near-shore environments of the Mancos Shale Formation characterize the Cretaceous section in this area. Quaternary alluvium and eolian material is found lying uncomformably upon the exposed Cretaceous units.

CAMELBACK WSA (CO-030-353)

The Precambrian section in this area is known only from USGS maps as consisting of gneisses, schists and intrusive rocks of older Precambrian age. As in the nearby Dominguez Canyon area, a thick section of Mesozoic units occurs. The environments of deposition are nearly identical with those in the Dominguez Canyon area with the exception that the Cretaceous units are not known to to contain coal. There are no known metal deposits within the area but potential for copper-silver mineralization exists in the Triassic Chinle and Wingate Sandstone Formations. The Jurassic Morrison and Brushy Basin Formations are not known to contain any uranium-vanadium deposits within the boundaries of the WSA, but occurrences of uranium-vanadium mineralization have been reported from outcrops in the Jurassic Morrison Formation in adjacent areas (Nelson-Moore et al, 1979).

Figures II-1 through II-8 illustrate the geology and physiology of the GRA.

FIGURE II-1
Precambrian block, contains pegmatites (first set down).

DOMINGUEZ CANYON

FIGURE II-2
Pegmatite in Precambrian. Principally feldspar and quartz.

DOMINGUEZ CANYON

FIGURE II-3
Pegmatite in Precambrian. Principally coarsely crystalline quartz and feldspar.

DOMINGUEZ CANYON

FIGURE II-4
Pegmatite quartz, feldspar, muscovite in Precambrian granodiorite and quartz diorite.

DOMINGUEZ CANYON

FIGURE II-5
Swingset Mine. Copper minerals, amethyst, quartz, feldspar. Pegmatite in Precambrian.

DOMINGUEZ CANYON

FIGURE II-6
Swingset Mine shaft - note Precambrian outcrops. Looks like Precambrian pegmatite with copper minerals and amethyst, quartz, feldspar.

DOMINGUEZ CANYON

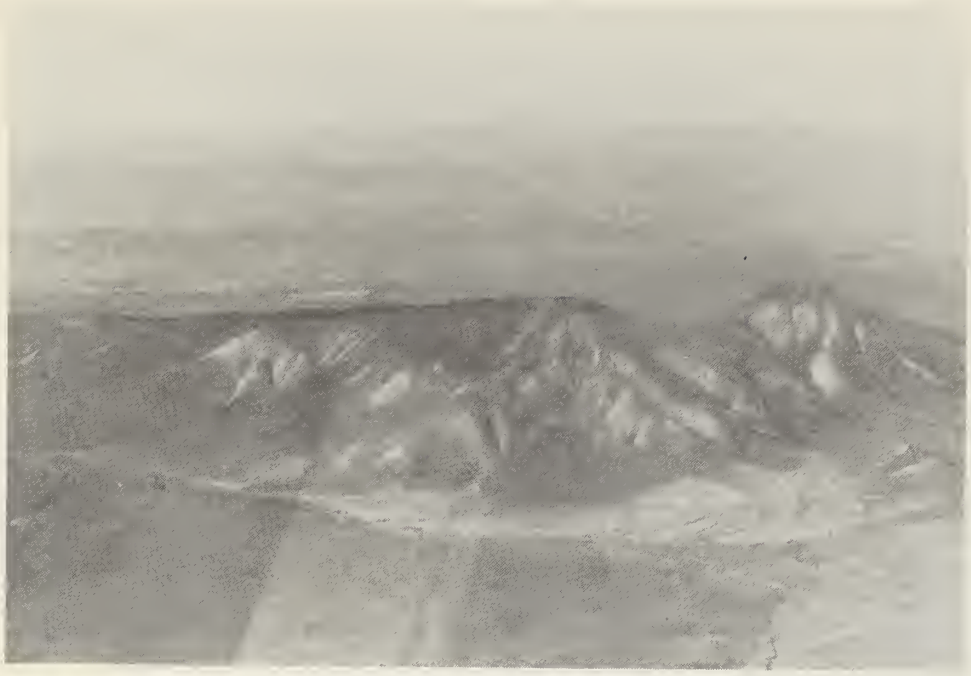


FIGURE II-7
Mancos Shale
outcrops.

ADOBE BADLANDS

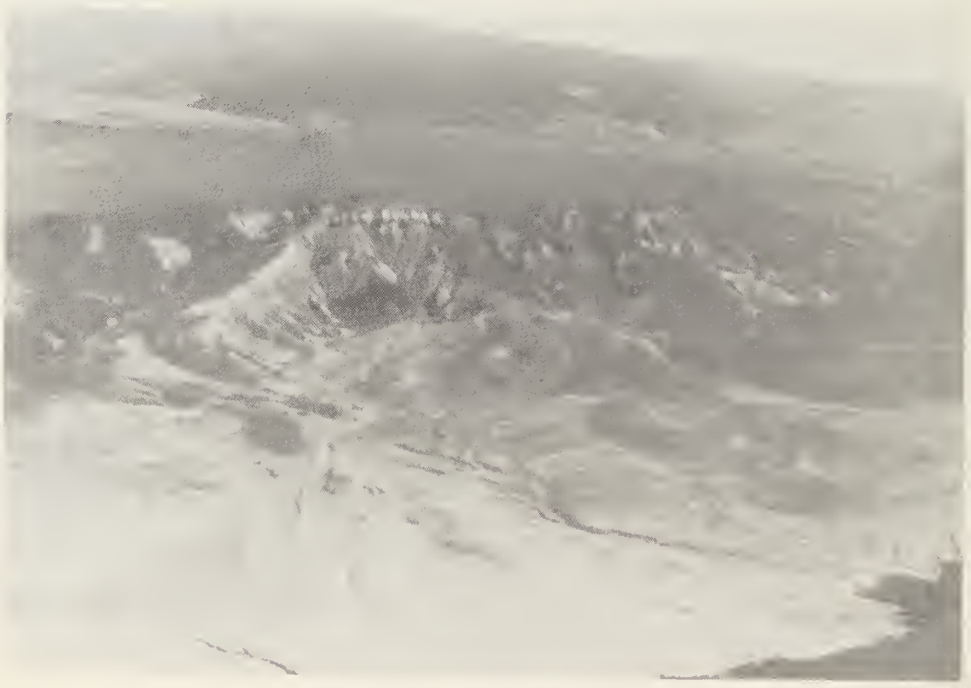


FIGURE II-8
Mancos Shale
outcrops.

ADOBE BADLANDS

SECTION III

ENERGY AND MINERAL RESOURCES

KNOWN MINERAL DEPOSITS

In the Dominguez Canyon-Camel Back-Adobe Badlands GRA the known deposits consist of coal, copper, uranium-vanadium, sand and gravel, and industrial minerals. The following summarizes the types of deposits found in the GRA:

Type of deposit	Total number
Coal mines	3
Copper mines	17
Uranium-vanadium mines	2
Sand & gravel pits	50
Clay pit	1
Construction stone quarry	1
Limestone quarry	1
Fluorspar mine	1
Mica mine	1
Gemstone	2

The three known coal mines, the North Star, Rollins and Kuhnley, are located in sections 34 and 35, T13S, R96W, at the southern end of the Grand Mesa Field. The Grand Mesa coals are ranked as high-volatile C bituminous to subbituminous A. Production statistics from the North Star, Rollins and Kuhnley are not known.

The known copper deposits are located in the Unaweep Mining District in T14S, R100W (Overlay B). Some of the more notable mines in the district are the Nancy Hanks, Last Chance, McKinley and Bell mines. The McKinley mine was developed by a 600 foot deep shaft and the Nancy Hanks was developed by a 300 foot long tunnel and two shafts (Schwochow, 1978). Copper production for the Unaweep District is not known.

The two known uranium-vanadium mines, the Flagstone and Rock Pit mines, are located in section 22, T14S, R100W and in section 6, T14S, R99W, respectively (Overlay B and Appendix B). Production for the Flagstone and Rock Pit Mines is not known.

Sand and gravel pits are located in the eastern half and northwestern portion of the GRA along the Gunnison River, Uncompaghre River, Dry Creek and East Creek (Overlay D). Production and current operating status are unknown.

The clay and limestone deposits are located in section 19, T15S, R96W and section 27 T14S, R98W, respectively (Overlay D). Production and current operating status are unknown. The Golden Stone construction stone and Mica View-quarries are both located in Mesa County in section 34, T14S, R101W and section 20, T14S, R100N, respectively. Fluorite ores have been mined from the Queen Beth mine in section 6, T14S, R99W, however, production is unknown. Amethyst has been produced from two

mines: the Amethyst mine, section 34 T14S, R101W and the Copper Queen mine in the Unaweep Mining District (Overlay D). The Copper Queen mine produced amethyst during 1964 and 1965 (Schwochow, 1978).

DOMINGUEZ CANYON WSA (CO-070-150 & CO-030-363)

There are no known mineral deposits in the Dominguez Canyon WSA.

ADOBE BADLANDS WSA (CO-030-370B)

There are no known mineral deposits in the Adobe Badlands WSA.

CAMEL BACK WSA (CO-030-353)

There are no known mineral deposits in the Camel Back WSA.

KNOWN PROSPECTS, MINERAL OCCURRENCES AND MINERALIZED AREAS

The known prospects, occurrences and mineralized areas in the Dominguez Canyon-Camel Back-Adobe Badlands GRA consist of coal, oil, gas, copper, uranium, industrial minerals and geothermal.

Oil and gas drilling has yielded 16 dry wells located in the northeastern and southeastern corners of the GRA (Overlay C).

Aerial photo interpretation and field examination has delineated a coal prospect in the Cretaceous Dakota formation in section 31, T14S, R98W (Appendix A, Dominguez Canyon).

In the GRA, there are 15 copper prospects, 10 copper occurrences, 2 uranium prospects and 1 uranium occurrence (Overlay B). With the exception of the uranium occurrence, the aforementioned prospects and occurrences are in the Unaweep and Dominguez Mining Districts. Amethyst occurs with the copper prospects in the Dominguez District Exploration drilling for uranium (?) or copper (?), in section 22, 23 and 26, T14S, R99W, which has been delineated through aerial photo interpretation (Appendix A, Dominguez Canyon).

Two fluorspar prospects are located in T14S, R100W (Overlay D). Fluorite occurs in many of the copper mines in the Unaweep Mining District (Schwochow, 1978).

Field examination has delineated a gypsum occurrence(s) in the Mancos shale in T14S, R96W (Appendix A, Adobe Badlands Field Notes).

Photo interpretation has delineated the occurrence of thermal springs near the Adobe Badlands WSA (Appendix A, Aerial Photographs and Topographic Maps).

DOMINGUEZ CANYON WSA (CO-070-150/CO-030-363)

The Dominguez Canyon WSA contains 1 coal prospect and 5 copper and/or amethyst prospects. These prospects are located in sections 22, 34 and 36, T14S, R99W and in

sections 5 and 7, T15S, R99W, Dominguez District (Overlay B and Appendix A, Dominguez Canyon, Aerial Photos).

ADOBE BADLANDS WSA (CO-030-370B)

Two occurrences in the WSA, have been noted through aerial photo interpretation and field examination. Thermal springs have been delineated on aerial photographs 1-5-192 and 1-29E-17 and on the topographic maps (Appendix A).

A gypsum occurrence(s) in the Mancos shale in T14S, R96W was defined through the field examination (Appendix A, Field Notes).

CAMEL BACK WSA (CO-030-353)

There are no known prospects in the Camel Back WSA.

MINING CLAIMS, LEASES AND MATERIAL SITES

In the Dominguez Canyon - Camel Back - Adobe Badlands GRA, there are 227 unpatented lode and 21 unpatented placer mining claims (Overlay A). The unpatented mining claims are primarily located in T14S, R98, 99 & 100W (6th P.M.); T15S, R97 & 98W (6th P.M.) and; T50N, R14W (N.M. P.M.). There are no major exploration companies with claim holdings in the GRA. The unpatented claim data was obtained from the Bureau of Land Management's June 14, 1982, Geographic Index (Appendix C).

In the GRA, there are 11 patented mining claims located in sections 9, 10 & 11, T14S, R100W (6th P.M.), Mesa County, Colorado (Overlay A). The patented claim locations were obtained from the BLM's Surface Management Quads and Master Title Plats (Appendix A).

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

DOMINGUEZ CANYON WSA (CO-070-150, CO-030-363)

There are 61 unpatented lode claims located within the WSA, in sectins 2, 10, 25, 26, 34 & 35, T15S, R98W and in sections 11, 24, 25 & 26, T14S, R99W (Overlay A). The unpatented claim data was obtained from the BLM's June 14, 1982, Geographic Index (Appendix C).

There are no patented claims in the Dominguez Canyon WSA .

For information on leases, please refer to the Oil and Gas Plats in Appendix A.

ADOBE BADLANDS WSA (CO-030-370B)

There are no unpatented or patented claims, leases or material sites located in the Adobe Badlands WSA.

CAMEL BACK WSA (CO-030-353)

There are no unpatented or patented claims located in the WSA. For information on leases, refer to the oil and gas plates in Appendix A.

MINERAL DEPOSIT TYPES

In the Dominguez Canyon - Camel Back GRA, the deposit types are categorized according to commodity produced. The GRA has yielded coal; copper with associated industrial minerals, gemstones, gold and silver; uranium-vanadium; and sand and gravel, clays and construction stone.

The known coal deposits are located at the extreme southern portion of the Grand Mesa Coal Field. The coal occurs in the Cretaceous Mesaverde Group, particularly, from youngest to oldest, in the Paonia Shale Member, the Bowie Shale member and the Rollins Sandstone Member. The Paonia Member is a fresh water facies lying unconformably on the Bowie, consisting of shale, some sandstone and coal. The Paonia coals contain up to eight persistent seams. The lower most seams are the most productive and persistent and attain a thickness of up to 7 feet. The Bowie Member is a marine - brackish - water facies composed of one coal bed, shales and massive sandstones. At the Rollins mine, the Rollins Sandstone is recognized as the base of the coal-bearing Mesaverde Group. The Rollins is a white cliff forming marine sandstone. Coal occurs above the Rollins Sandstone (Schwochow, 1978). Underlying the Rollins Sandstone unconformably, at the Rollins mine is a tongue of the Mancos Shale. The coal from the Grand Mesa Field is ranked as high-volatile C bituminous to subbituminous A.

Copper was deposited under two different structural and stratigraphic conditions. The first type of deposit consists of copper-silver-gold bearing quartz veins between diabase dikes and the intruded Precambrian granite. The veins are associated with northwest striking faults and associated joint systems (Gilmour, Personal Communication, 1982). The vein minerals consist of malachite and azurite, quartz, calcite and lesser amounts of chalcopyrite, galena, fluorite, barite, hematite and amethyst. The Precambrian sequence from oldest to youngest consists of complexly folded metamorphic schist and gneiss; granodiorite porphyry containing microcline - feldspar phenocrysts in a quartz - feldspar biotite ground mass; granite with inclusions of older rocks; and pegmatites and aplite dikes that cut the older igneous rocks in a northwest direction (Schwochow, 1978). The second type of copper mineralization occurs as copper, fluorite and gem-bearing quartz veins in the Triassic Chinle Formation. The Chinle consists of red shales, siltstones, mudstones and sandstones. Overlying the Chinle Formation is the Triassic Wingate Sandstone. Mineralization in the Chinle Formation occurs at or near the Chinle - Wingate contact (Schwochow, 1978; Gilmour, Personal Communication, 1982).

The uranium and vanadium deposits occur in the Jurassic Morrison formation and the Triassic Chinle 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 mineralization occurs in the Salt Wash Member and the 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 Member was formed in fluvial and lacustrine environments

with large amounts of clay (Craig et al, 1955). It is thought the introduction of the ore was done by mineral - bearing solutions that seeped through the permeable layers after sediments accumulated. The source of the primary minerals is currently under dispute (Craig et al, 1955). The Triassic Chinle Formation is composed of red and gray shales and siltstones; sandstone beds, which may be conglomeratic and thin layers of limestone and limestone conglomerate (Fisher, 1956). The Chinle Formation uranium deposits are primarily in the conglomeratic sandstone.

Construction stone has been produced from the upper Wingate Sandstone and the Salt Wash Member of the Morrison Formation. The Wingate Sandstone yielded a light reddish - brown, fine - grained, well cemented feldspathic sandstone. The Salt Wash Member has yielded thin beds of dense, crystalline gray limestone (Schwochow, 1978).

Clays are known to occur in the Brushy Basin member of the Morrison formation, the Dakota Sandstone and in the lower Mancos Shale. The Brushy Basin member has yielded bentonitic clays; the Dakota Sandstone and the Mancos Shale have yielded clays for nonrefractory uses.

Sand and gravel deposits found in the Unaweep Canyon area consist of coarse - grained sand and pebbles which are a result of disintegration of Precambrian granite. This area is composed of a series of alluvial fans composed of sandstones and Precambrian rocks (Schwochow, 19787). Other sand and gravel deposits are a result of drainage patterns along the Gunnison River and its' tributaries.

DOMINGUEZ CANYON WSA (CO-070-150/CO-030-363)

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

ADOBE BADLANDS (CO-030-370B)

There are no known deposits contained in the WSA.

CAMEL BACK WSA (CO-030-353)

There are no known deposits contained in the WSA.

MINERAL ECONOMICS

The inherent nature of discussing the economics of the minerals existing within the Dominguez Canyon/Adobe Badlands/Camel Back 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 in the GRA include coal, copper, gemstones, gold and silver, uranium and vanadium, sand and gravel, clays, and construction stone, and other industrial minerals.

Coal is produced from the Grand Mesa Field. The GRA contains three coal mines, from which production statistics are not available. 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).

Copper, gold, and silver (with associated industrial minerals such as fluorspar, mica, and gemstones) occur as vein deposits in various formations. Currently, a high demand for precious metals exists in Colorado and the U.S. due to high prices. Base metal production, however, is down from past production levels due to a general down-turn in the United States economy (Eng. & Ming. Journal, Dec. 1982). Commodities such as copper are not being currently produced at a substantial profit by any of the major mining operations in Colorado (Eng. & Ming. Journal, Dec. 1982; Carpenter, Personal Communication, 1982). The industrial minerals associated with these deposits are considered to have a "high unit value". "High unit value" minerals are of economic value wherever found as the commodity values exceed transportation costs (Eyde, 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 only two uranium-vanadium mines (Production statistics are not available). Future demand for uranium and vanadium is dependent on foreign production and the needs of the nuclear generating industry (Schwochow, 1978).

The remaining industrial minerals in the GRA can be placed into two groups. In the first, sand, gravel, and construction stone are considered to be "high place value" industrial minerals (Eyde, Personal Communication, 1982). These minerals are of economic value only when the deposits are readily accessible, and in close proximity to a market. In the second group, bentonitic clays are considered to have a "high unit value". Like the minerals discussed with the aforementioned base and precious metal deposits, these minerals are of economic value wherever found as the commodity values exceeds transportation costs.

The economic viability of the mineral resources in the WSA's in the Dominguez Canyon/Adobe Badlands/Camel Back GRA is summarized as follows:

WSA	Mineral Resources	Accessibility	Economic Potential[a]
Dominguez Canyon WSA (CO-070-150/ CO-030-363)	Base Metals*	Poor	Poor
	Coal*	Poor	Poor
Camel Back WSA (CO-030-353)	Base Metals**	Poor	Poor
Adobe Badlands WSA (CO-030-370B)	Oil & Gas**	Unknown	Unknown

* Occurs as prospects or mineralized area in WSA. No further information is known.

** No known prospects or occurrences. Refer to Section IV for an explanation of the economic potential.

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

SECTION IV

LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

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

The team or panel of geological experts was comprised of:

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

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

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

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

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

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

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

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

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

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

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

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

The WSA's, for the most part, are not well known geologically. For this reason, our expert team had to extrapolate geologic information from adjacent areas to make any sort of reasonable classification with some level of confidence. The following pages address those resources considered to be leasable, locatable and/or salable with associated maps locating the resource area (Figures IV-1 through 3):

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 in support or refute the possible existence of mineral resource.

LEASABLE RESOURCES

DOMINGUEZ CANYON WSA (CO-070-150/CO-030-363)

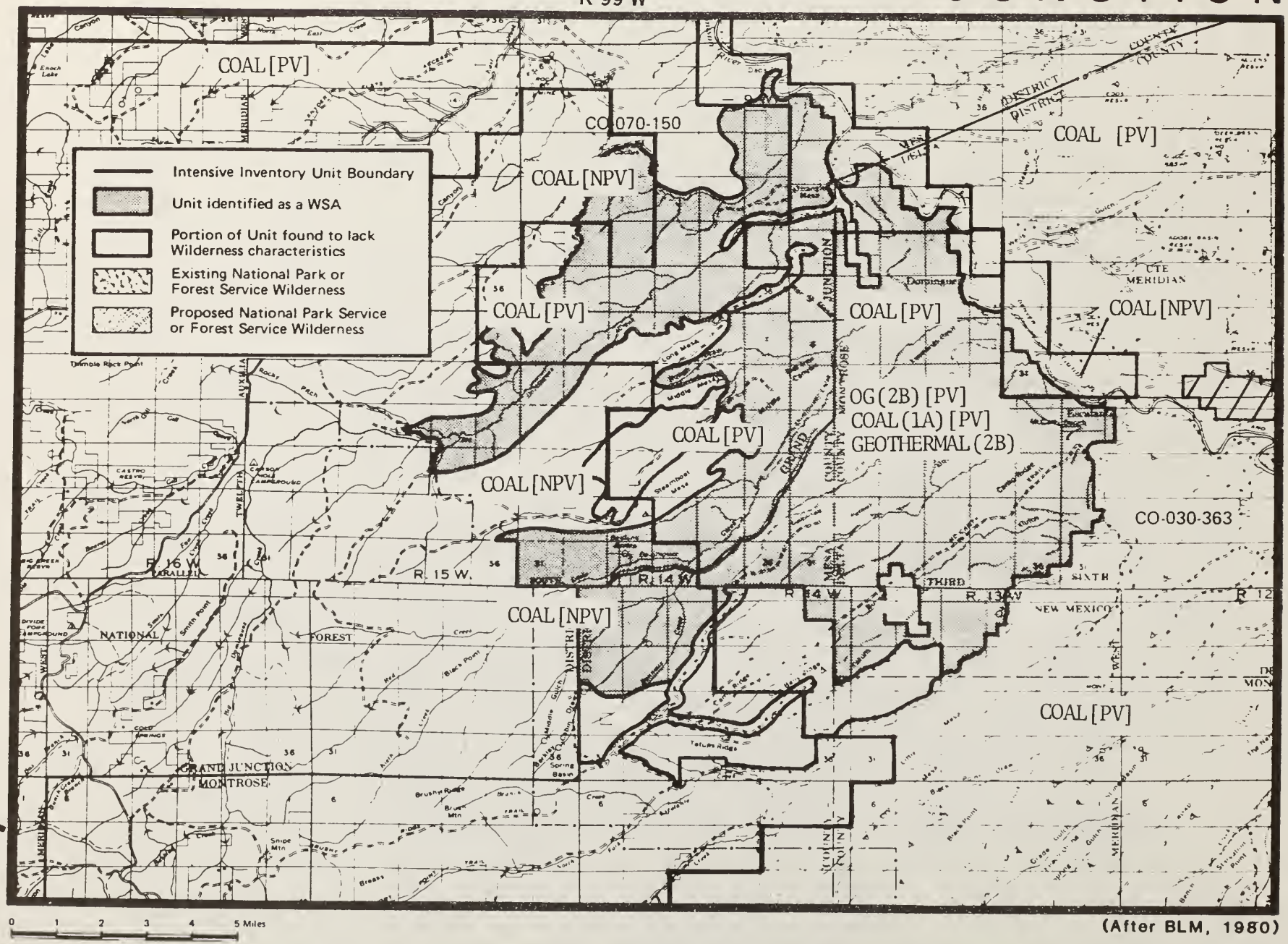
Resource	Classification	Comments
Oil & Gas	2B	The structure and stratigraphic section are not favorable for oil & gas accumulation.
Coal	1B	Lack of coal-bearing formations.
Geothermal	2B	Unknown potential

ADOBE BADLANDS WSA (CO-030-370B)

Resource	Classification	Comments
Oil & Gas	3C	The Cretaceous Mancos Shale has yielded production of oil and gas five miles east of the WSA. The Mancos Shale extends into the WSA. There are many possibilities for stratigraphic traps for oil and gas.
Coal	1A	Lack of coal-bearing formations.
Geothermal	3B	Obvious springs and mineral deposits with hydrothermal potential on NW and EW trending fault zones.

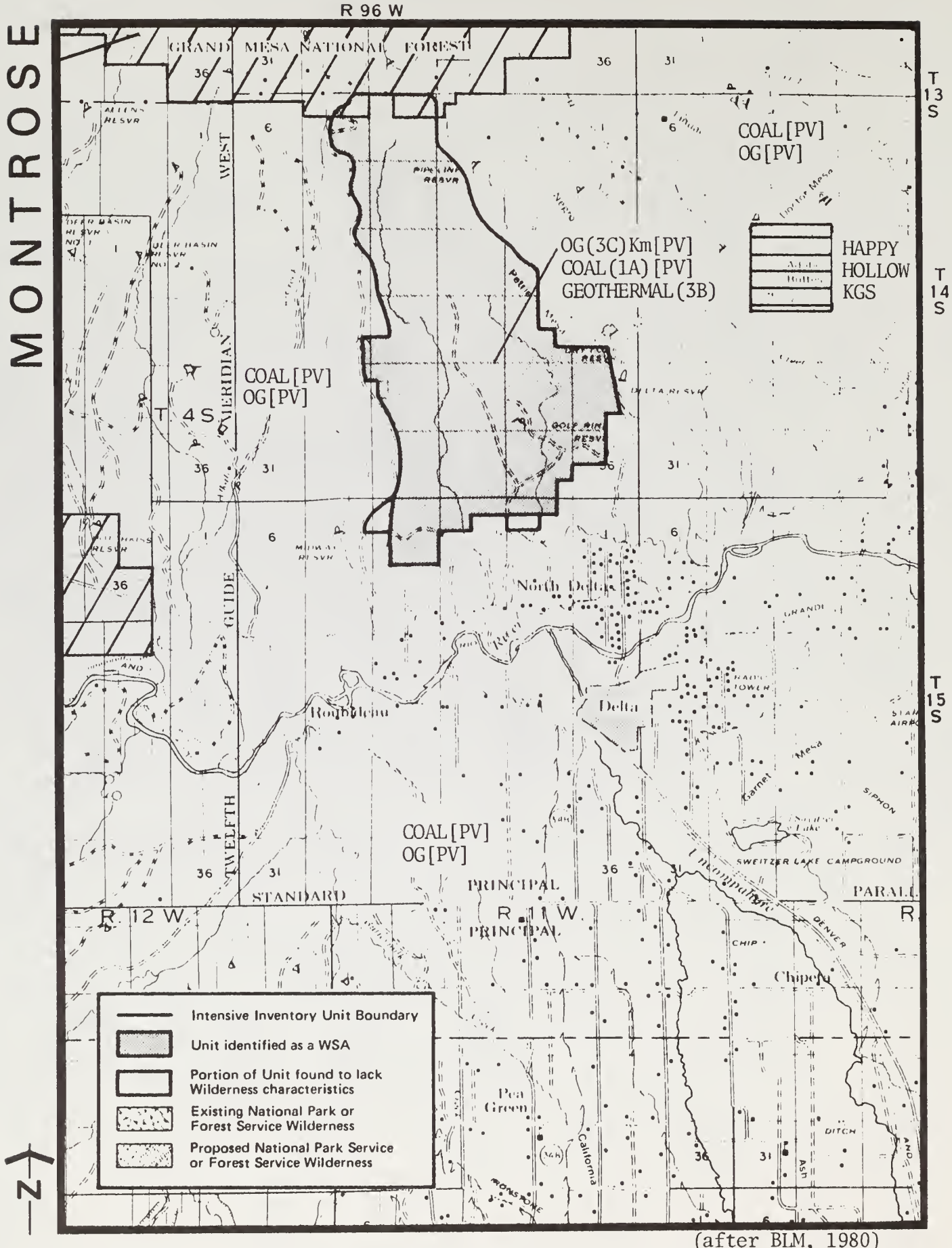
CAMELBACK WSA (CO-030-353)

Resource	Classification	Comments
Oil & Gas	2A	The WSA contains a limited favorable stratigraphic section, however, the structure is not favorable.
Coal	2B	The Cretaceous Dakota Formation is present.
Geothermal	2B	Unknown potential



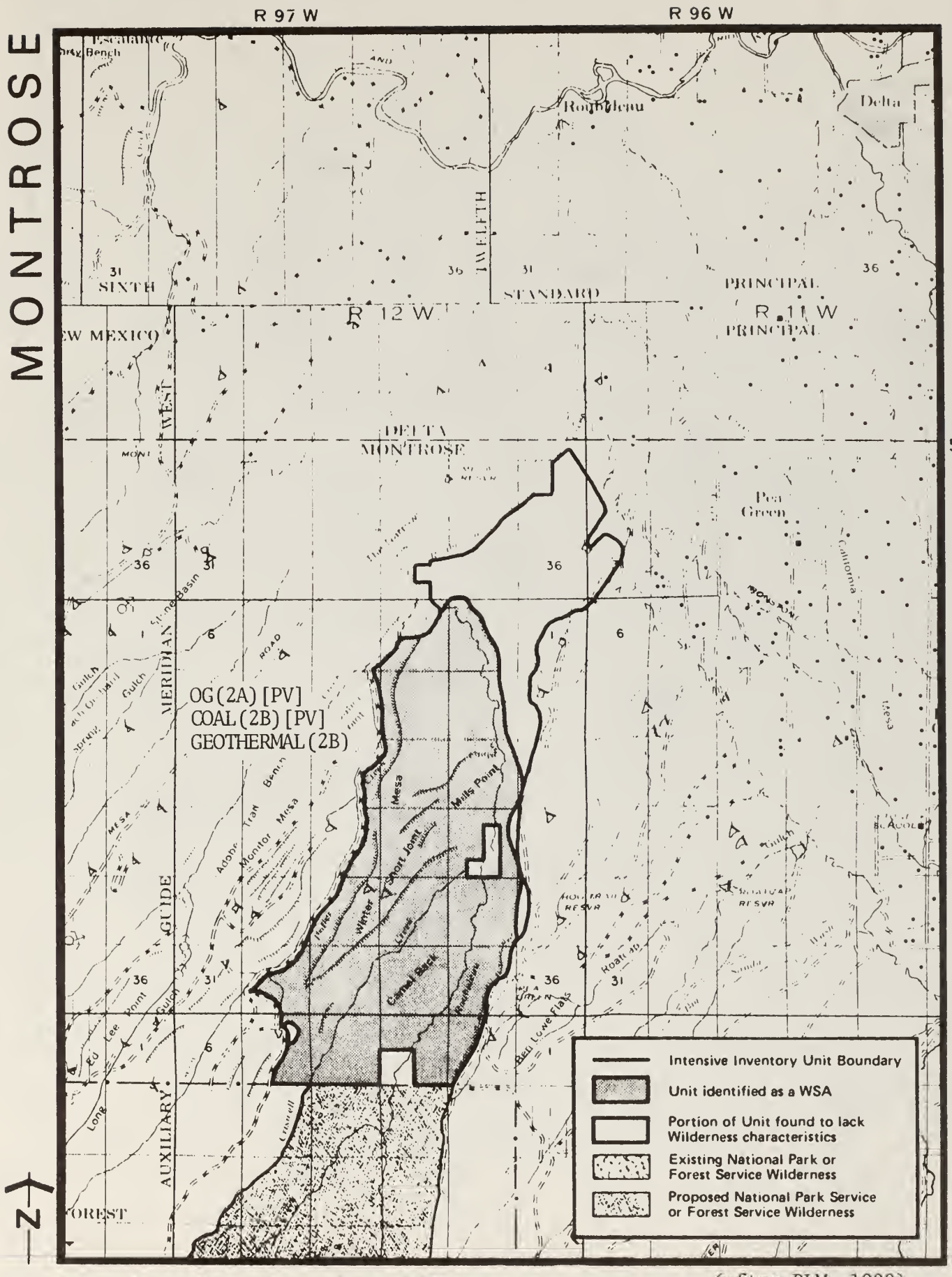
(After BLM, 1980)

MMS/LEASABLE RESOURCES
Figure IV-1a



(after BLM, 1980)

MMS/LEASABLE RESOURCES
Figure IV-1b

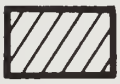


(after BLM, 1980)

MMS/LEASABLE RESOURCES
Figure IV-1c

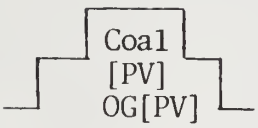
LEGEND FOR MINERALS MANAGEMENT SERVICE CLASSIFICATIONS

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

DOMINGUEZ CANYON WSA (CO-030-363 & CO-070-150)

Resource	Classification	Comments
Precious Metals	3C	Au, Ag mineralization potential in Precambrian felsic volcanics and sediments, past production, prospects.
	3C	Ag mineralization in Triassic Chinle and Wingate Formations, past production, prospects, mines.
Base Metals	3C	Cu, Pb, Zn mineralization potential in Precambrian felsic volcanics and sediments, past production, prospects.
	3C	Cu mineralization in Triassic Chinle and Wingate Formations past production, prospects, mines.
Locatable Energy Minerals	3C	Uranium-Vanadium mineralization in Jurassic Morrison Formation, prospects, current drilling activities.
Other Locatable Minerals		Unknown

ADOBE BADLANDS WSA (CO-030-370B)

Resource	Classification	Comments
Precious Metals	2A	Au, Ag mineralization potential in Precambrian felsic volcanics and sediments, favorable stratigraphy may exist at depth.
	2B	Ag mineralization potential in Triassic Chinle, and Wingate Sandstone Formations, favorable stratigraphy has been encountered in nearby drill holes.
Base Metals	2A	Cu, Pb, Zn mineralization potential in Precambrian felsic volcanics and sediments, favorable stratigraphy may exist at depth.
	2B	Ag mineralization potential in Triassic Chinle and Wingate Sandstone Formations, favorable stratigraphy has been encountered in nerby drill holes.
Locatable Energy Minerals	2B	Uranium-Vanadium mineralization potential in Jurassic Morrison Formation, thought to exist at depth.
Other Locatable Minerals	2B	Reported occurrences of gypsum in the Cretaceous Mancos Shale

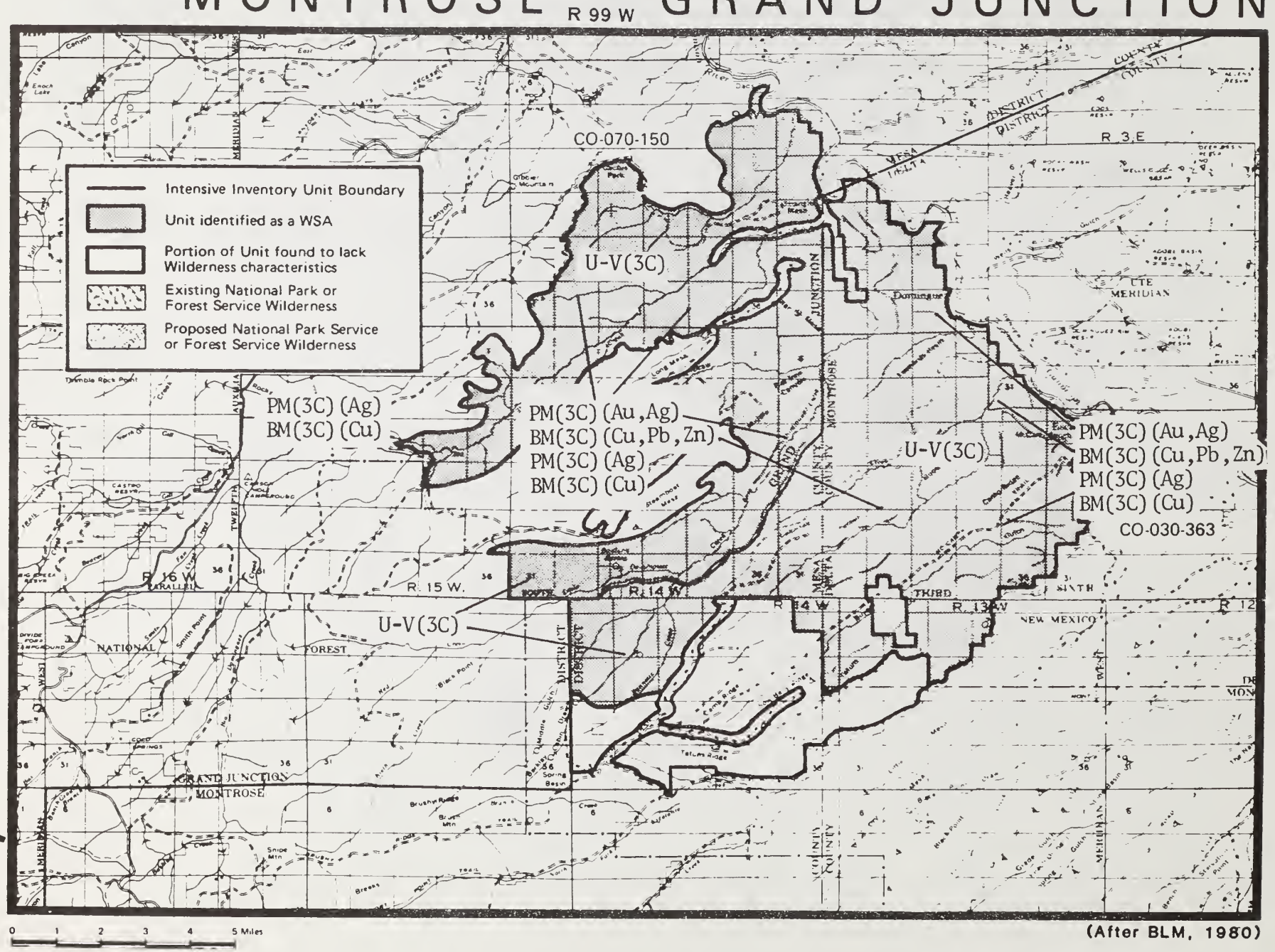
CAMEL BACK WSA (CO-030-353)

Resource	Classification	Comments
Precious Metals	2B	Rafinate Au, Ag mineralization potential in Precambrian felsic volcanics and sediments, favorable stratigraphy is known to outcrop nearby.
	2B	Ag mineralization potential in Triassic Chinle and Wingate Formations, favorable stratigraphy is known to outcrop nearby.
Base Metals	2B	Cu, Pb, Zn mineralization potential in Precambrian felsic volcanics and sediments, favorable stratigraphy is known to outcrop nearby.
	2B	Cu mineralization potential in Triassic Chinle and Wingate Formations favorable stratigraphy is known to outcrop nearby.
Locatable Energy	3B	Uranium-Vanadium mineralization potential in Jurassic Morrison Formation, occurrences of uranium mineralization in nearby area.
Other Locatable Minerals		Unknown

SALABLE RESOURCES

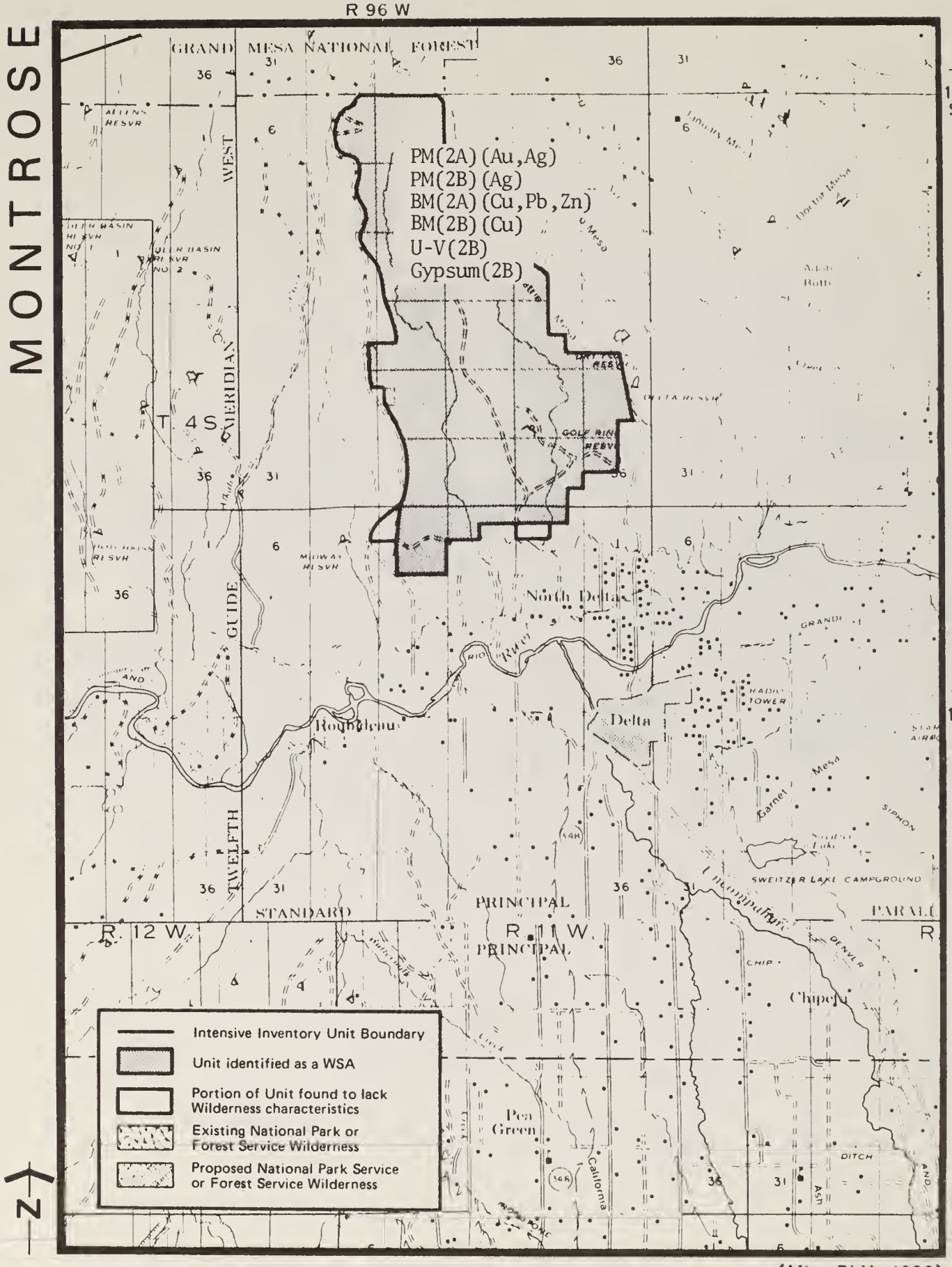
DOMINGUEZ CANYON WSA (CO-030-363/CO-070-150)

Resource	Classification	Comment
Quartz, Feldspar, Mica & Amethyst	3C	Derived from Precambrian pegmatities.
Dimension Stone	3C	The Wingate Sandstone may contain favorable beds for dimension stone. The economic potential is rated low.



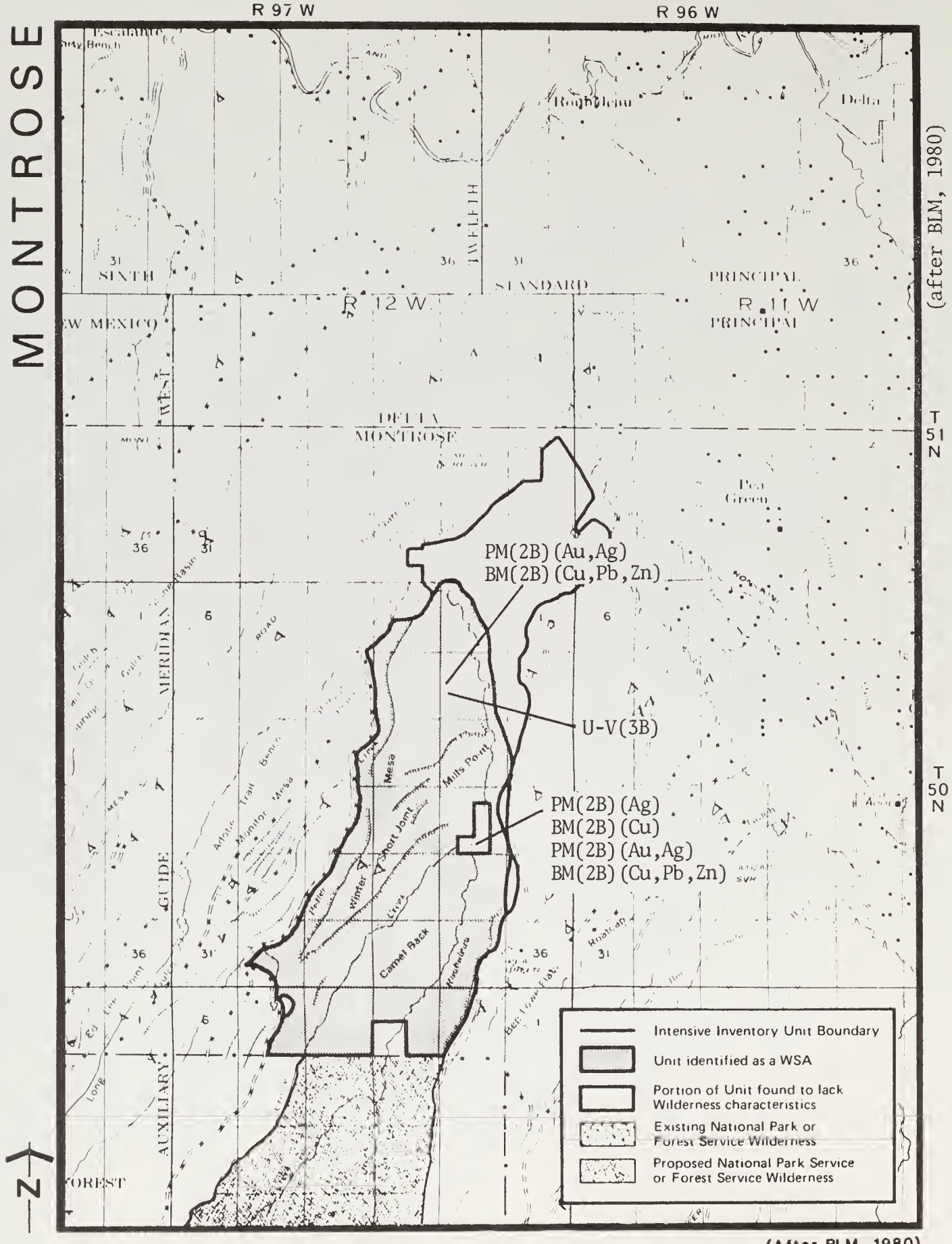
LOCATABLE RESOURCES
Figure IV-2a

Adobe Badlands



(After BLM, 1980)

LOCATABLE RESOURCES
Figure IV-2b



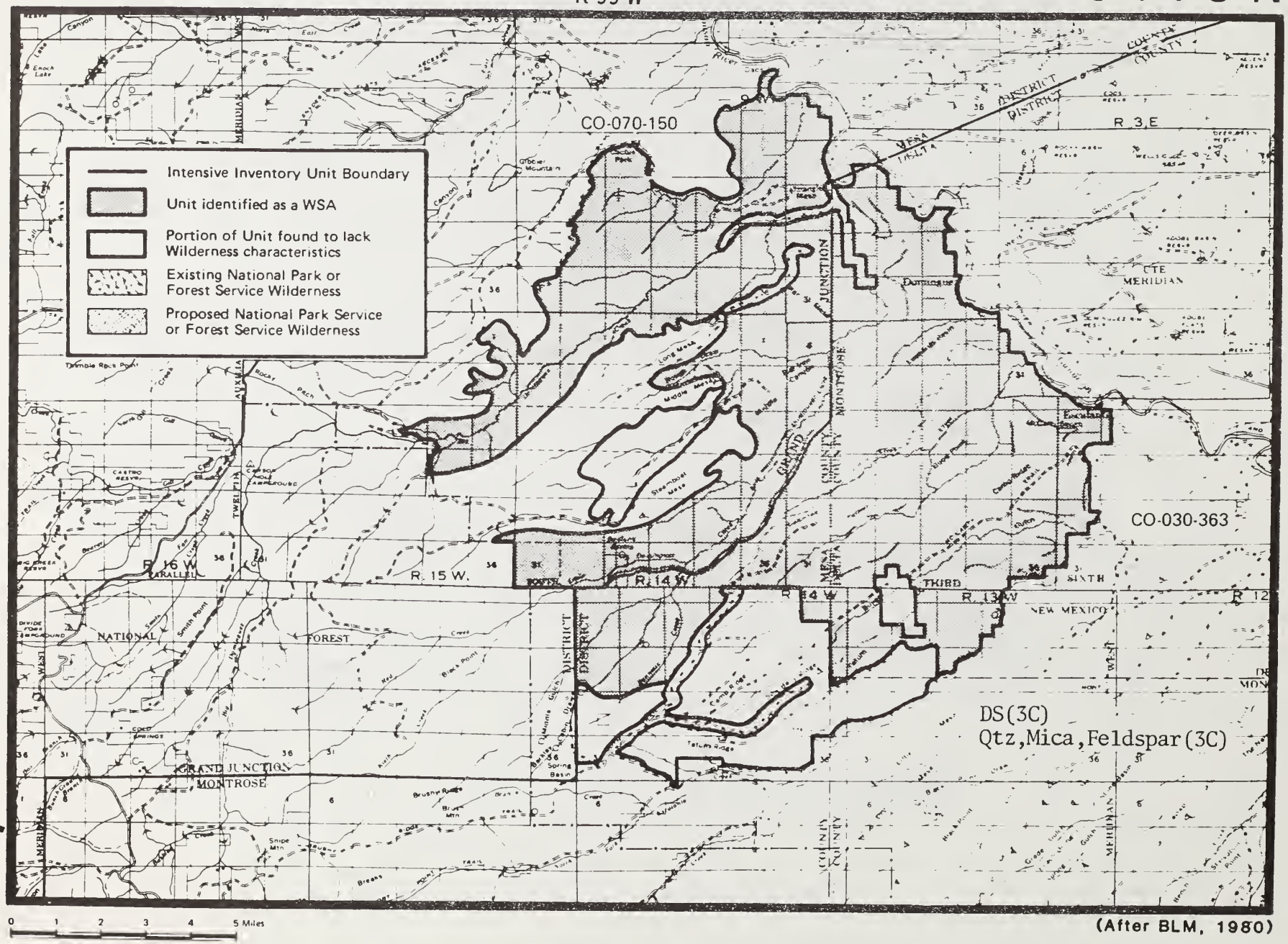
LOCATABLE RESOURCES
Figure IV-2c

ADOBE BADLANDS WSA (CO-030-370B)

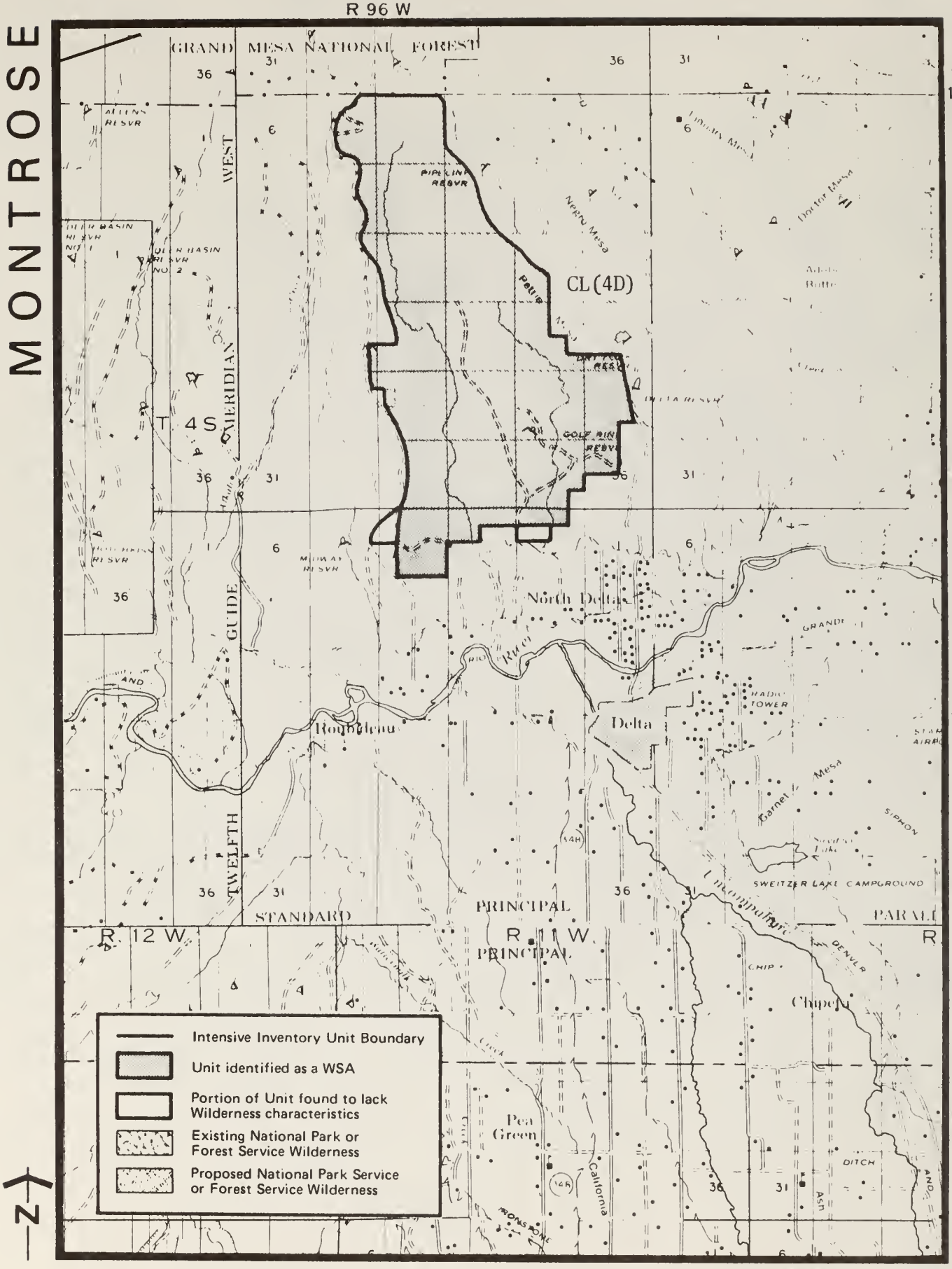
Resource	Classification	Comment
Specialty Clays	4D	These clays are derived from the Mancos Shale. The economic potential is rated as moderate to good.
Structural Clays	4D	
Bentonite	4D	
Clays	4D	The Morrison Formation may contain favorable units. The economic potential is rated as moderate to good.

CAMELBACK WSA (CO-030-353)

Resource	Classification	Comment
Dimension Stone	4D	The Wingate Sandstone contains favorable beds for dimension stone.

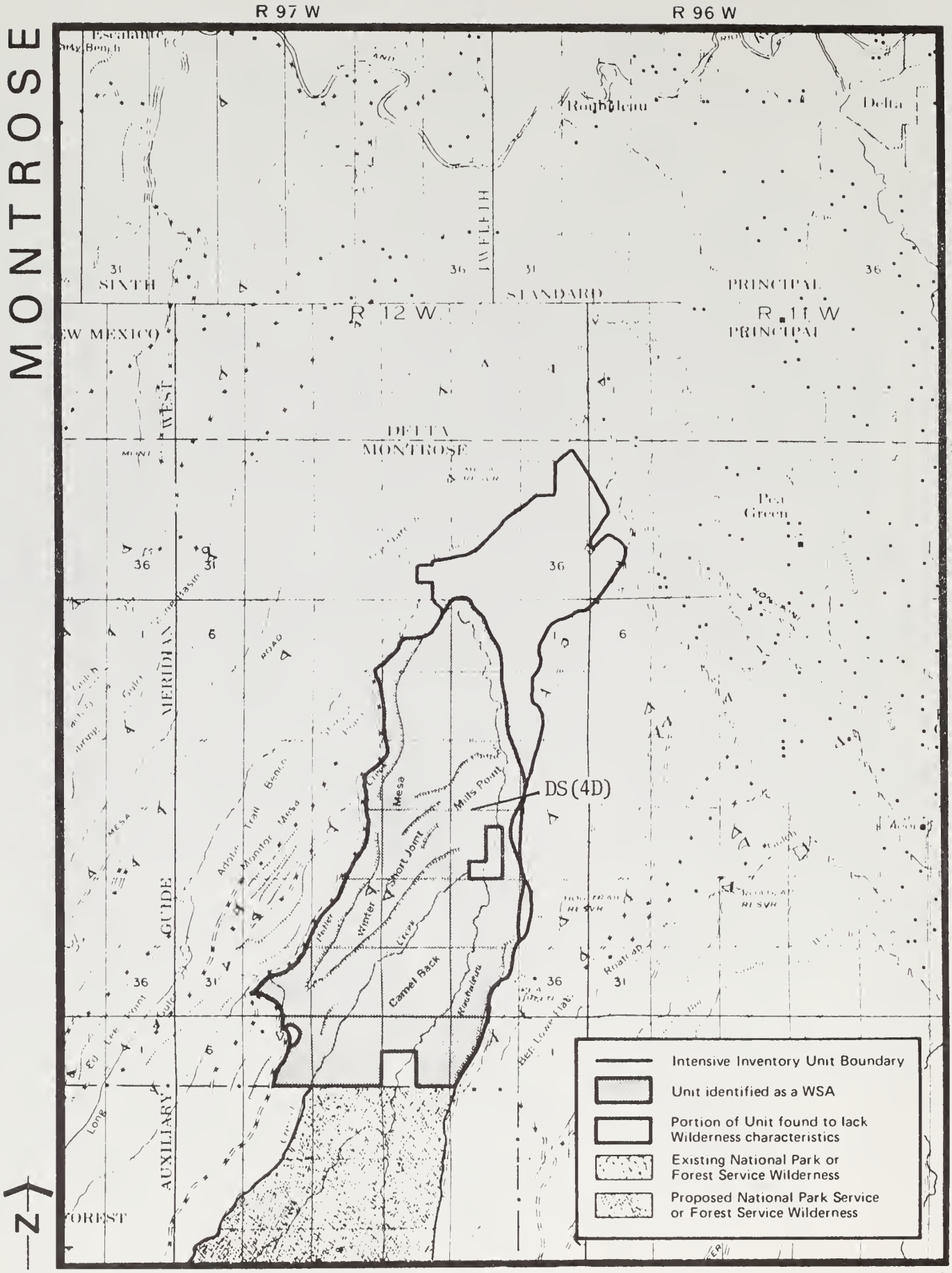


SALABLE RESOURCES
Figure IV-3a



(After BLM, 1980)

SALABLE RESOURCES
Figure IV-3b



SALABLE RESOURCES (After BLM, 1980)
Figure IV-3c

SECTION V

RECOMMENDATIONS FOR FURTHER STUDY

In the course of analyzing, assessing and evaluating each of the WSA's in the Dominguez Canyon/Adobe Badlands/Camel Back 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.

DOMINGUEZ CANYON WSA (CO-070-150 & CO-030-363)

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.

All existing mines, prospects and known mineral occurrences should be mapped and thoroughly sampled to delineate the full extent of the existing mineralization and the potential of the host lithologies. This is of particular importance in the determination of the copper-silver potential of the Triassic Chinle-Wingate Formations. 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 ot delineate any areas with anomalous values, ground radiometrics in conjunction with the geological-geochemical studies 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 information.

Since some of the Precambrian units have been used in the past as a source of local road building and dimension stone 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.

ADOBE BADLANDS WSA (CO-030-380B)

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

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

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

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

CAMEL BACK WSA (CO-030-353)

The GEMS potential of this area is essentially the same as the adjacent Black Ridge Canyon area. This being the case, it is recommended that the same sort of geological mapping and geochemical sampling program also be done in this area. Such a program should concentrate on the favorable sections of the Precambrian and Mesozoic lithologies and seek evidence of favorable environments for mineral deposition.

Of particular importance should be a detailed examination of the outcropping units of the Jurassic Morrison Formation and detailed mapping of the facies units within this generally favorable formation.

There are no known prospects or mineral occurrences within the WSA, and the area is known only generally from reconnaissance mapping of the area. This being the case, it appears that the potential for GEM resources in the area is largely unknown.

SECTION VI

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