MINERAL REPORT

Mineral Potential Report
For
The Vernal Planning Area

(Title)
Lands Involved

Vernal Planning Area
Vernal Field Office

Encompassing Approximately 5.1 million acres
Duchense, Dagget, Uintah and Grand Counties, Utah

Prepared by:

(Signature)
Subject Matter Expert
(Title)
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(Date)

Technical Approval:

(Signature)

(Title)

(Date)

Management Acknowledgment:

(Signature)

(Title)

(Date)

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SUMMARY AND CONCLUSIONS

This report assesses the mineral resource occurrence and development potential of the Vernal Planning Area (Planning Area). The conclusions regarding the mineral resources identified within the planning area are summarized as follows:

Oil and Gas

There is high and moderate potential for the occurrence of oil and gas resources in the Planning Area. There are established, currently economic operations for oil and gas in the Planning Area, and there will be continued exploration and development of these resources within the next 15 years.

Tar Sand

There is high potential for tar sand occurrence within the Planning Area. The potential for development of this resource, other than for asphalt paving, is anticipated to remain low over the next 15 years, although there are well established resources for tar sand in the Planning Area.

Gilsonite

There is high and moderate potential for gilsonite occurrence within the Planning Area. There are established, current economic operations for gilsonite in the Planning Area, and it is likely that there will be continued exploration and development of this resource within the next 15 years.

Oil Shale

There is high and moderate occurrence potential for oil shale within the Planning Area. There are well established resources for oil shale in the Planning Area and it is anticipated that one or two small-scale projects may be active over the next 15 years.

Phosphate

There is high and moderate phosphate occurrence potential within the Planning Area. There are established, current economic operations for phosphate in the Planning Area. Phosphate mining on private land is anticipated to continue over the next 15 years. There is some potential for exploration on Federal lands over the next 15 years.

Mineral Materials

There is high and moderate potential for the occurrence of mineral materials, including sand, gravel, and building stone, in the Planning Area. It is likely that exploration and development of these resources will continue to occur in the Planning Area over the next 15 years.

Locatable Minerals

There is moderate potential for the occurrence of locatable minerals within the Planning Area. Very little development activity for locatable minerals is anticipated over the next 15 years.

Coal

There is high potential for the occurrence of coal deposits within the Planning Area. It is unlikely that coal exploration or development will occur over the next 15 years.

INTRODUCTION

Purpose

The purpose of this mineral report is to assess the mineral resource occurrence and development potential within the Vernal Planning Area. The assessment of mineral resource occurrence and development potential involved reviewing published data and selecting pertinent data for use in the assessment. It did not include field studies. Identified mineral resources are classified according to the system of the U.S. Bureau of Land Management (BLM) found in BLM Manuals 3031 and 3060.

This report provides an intermediate level of detail for mineral assessment as prescribed in BLM Manual 3031 for planning documents. It has been prepared as a preliminary mineral assessment for use in preparing the Environmental Impact Statement (EIS) for the Vernal Planning Area Resource Management Plan (RMP), as required by the National Environmental Policy Act.

Lands Involved

The Vernal Planning Area is located in northeast Utah (Figure 1). It encompasses a total of approximately 5.5 million acres in Duchense, Dagget, Uintah and Grand Counties. Land ownership and administration in the Planning Area is summarized in Table 1 and Figure 2.

DESCRIPTION OF GEOLOGY

Regional Geology

Information pertaining to the geology of the Planning Area was obtained from the Book Cliffs Resource Area Resource Management Plan (BLM, 1983a). Diamond Mountain Resource Management Plan (BLM, 1990), Hintze (1988), and Stokes (1988). Most of the Planning Area lies in the broad features of the Uinta Basin and Mountains, with the most northwestern and northeastern corners of the Planning Area located within the Green River and Clay Basins, respectively (Figure 3).

A geologic map of the Planning Area and representative stratigraphic column of rock units are shown in Figure 4. The rocks in the area formed under a variety of depositional environments, such as marine, lacustrine, fluvial and aeolian, over a time span of at least 2.3 billion years. The changing depositional environments in the area over time have provided the vast array of mineral deposits present within the area. For example, shallow seas provided the phosphate deposits in the area, while lake sediments are sources of most hydrocarbons in the area. These depositional environments also influenced the rock composition and capability to hold fluids, which are characteristic for reservoir units of oil, gas, bitumen, and gilsonite. Specific rock units relevant to the mineral potential of the Planning Area are briefly discussed below.

Geologic Formations Containing Mineral Resources of Note

The geologic formations containing mineral resources of note are shown in Figures 4 and 5 (geologic map and lithologic column, respectively). These formations are discussed in the following paragraphs in order from most recently deposited (Quaternary) to oldest (Precambrian).

Quaternary alluvium deposits and piedmonts (mapping units Qa and Qao in Figure 4), particularly those deposited by streams sourced in the Proterozoic quartzites of the Uinta Mountain Group, are the primary sand and gravel deposits in the Planning Area. Quaternary surficial erosion of the older Jurassic Entrada Sandstone (mapping unit J1) and Navajo Sandstone (mapping unit Jg) created fine sand deposits in the vicinity of where these units crop out. (Hintze, 1988 and Stokes, 1988).

The Tertiary Duchense River Formation (mapping unit T3) consists of conglomerates, shales and red sandstone layers. These rocks were deposited in a fluvial environment and are reservoirs for hydrocarbons that originate in lower rock units. The Tertiary Late Eocene Uinta Formation (Uinta Formation - also mapping unit T3) consists of lacustrine shales and fluvial sandstones. The fluvial sandstone units within this formation become more prevalent in the southeastern section of the Uinta Basin, and are reservoirs for gilsonite veins. The Uinta Formation is also a source for the gas resource in the Planning Area. The Tertiary mid-Eocene Green

River Formation (mapping unit T2) contains lacustrine mudstones, thin bedded shales, and some sandstone layers. This formation contains some layers that are rich in bituminous material. The early-Eocene Wasatch Formation (mapping unit T1), sometimes considered part of the lower Green River Formation, consists of sandstones interbedded with shale and minor limestones. The sandstones are fluvial and can be bituminous. (Hintze, 1988 and Stokes, 1988).

The Cretaceous Mesaverde Group (mapping unit K3) contains two sandstone members, the Asphalt Ridge and Rim Rock sandstones. Both these sandstone members are marine and can be bituminous. The Mesaverde Group also contains organic rich shales, mudstones and coal beds that are hydrocarbon sources in much of the Uinta Basin (Hintze, 1988 and Stokes, 1988).

The Jurassic Entrada Sandstone (mapping unit J1) and Navajo Sandstone (mapping unit Jg) were deposited in fluvial and aeolian environments, respectively. These sandstones are sources of fine sand deposits in the Planning Area, as a result of Quaternary surficial erosion of formation outcrops.

The Triassic Moenkopi formation (mapping unit Tr1) formed in a broad coastal flood plain. This formation can be a source of gypsum in the Planning Area (Hintze, 1988 and Stokes, 1988).

The Permian Park City Formation (mapping unit P2) consists of an upper, middle, and lower unit, all of which are marine. The upper unit consists of light gray limestone and shale with a bed of tan to red sandstone. The middle unit contains interbedded limestone, concretionary shale, sandstone and chert. The lower unit contains gray fossiliferous cherty shale and phospherite, which thickens to the west. The Park City Formation is a source of phosphate in the Planning Area.

The Precambrian Uinta Mountain Group (mapping unit PCs) contains purple/red quartzites and is also a source of mineral materials in the planning area (Hintze, 1988 and Stokes, 1988).

Geological Structures

The dominant structures of the Planning Area are the broad asymmetrical syncline of the Uinta Basin and the Uinta Mountain Anticline. Both features trend east-west through the Planning Area, as shown in Figure 6. Numerous smaller-scale structures within the planning area are also identified in Figure 6.

DESCRIPTION OF MINERAL RESOURCES

Mineral Deposits

Mineral resources in the Planning Area include: (1) oil and gas, (2) tar sand, (3) gilsonite, (4) oil shale, (5) phosphate, (6) mineral materials, (7) locatable minerals, and (8) coal. Each of these resources is described below, starting with descriptions of known deposits, followed by discussion of historic and current exploration and production, and economic demand for the resource.

Oil and Gas

Oil and gas resources, which are also resources within the Planning Area, are discussed separately in Appendix A of this report.

Tar Sand

Tar sand contains heavy hydrocarbon residues such as bitumen, tar, or degraded oil that has lost its volatile components. Hydrocarbons can be liberated from tar sands by heating and other processes. Tar sand deposits in the Planning Area are generally located along the margin of the Uinta Basin, up dip from the basin axis. The bituminous substance in these sandstones is a tarry residuum of petroleum filling the porespace in coarse sandstones or forming a cement in loose unconsolidated sands. (Pruitt, 1961).

In the early 1980s, certain tar sand deposits in the Uinta Basin were divided into seven Special Tar Sand Areas (STSAs). These STSAs were designated by the USGS Conservation Division Classification Committee under direction from Congress pursuant to the Combined Hydrocarbon Leasing Act of 1981. These STSAs, which are shown in Figure 7, are: (1) Pariette, (2) Sunnyside, (3) Argyle Canyon B Willow Creek, (4) Asphalt Ridge B Whiterocks, (5) Hill Creek, (6) P.R. Spring, and (7) Raven Ridge B Rim Rock.

The Pariette STSA lies within the sandstone beds of the Uinta Formation. It is estimated to contain 12 to 15 million barrels of bitumen. The Sunnyside STSA is primarily contained within the upper sandstone beds of the Tertiary Wasatch Formation. This deposit is estimated to have 3.5 to 4 billion barrels of bitumen in place, only some of which lie within the Planning Area. The Argyle Canyon B Willow Creek STSA is located in the sandstone, siltstone and limestone beds of the Parachute Creek member of the Tertiary Green River Formation. This deposit is estimated to contain 60 to 90 million barrels of bitumen. The Asphalt Ridge - Whiterocks STSA is the second largest in the State of Utah. The reservoir units in this deposit are the Tertiary Duchense River/Uinta Formation, Jurassic Navajo Sandstone Formation, and Cretaceous Mesaverde Formation. This deposit is estimated to contain 1.2 to 1.3 billion barrels of bitumen. The Hill Creek STSA is also located in fluvial sandstones of the Green River Formation. It encompasses approximately 120 square miles with two pay zones. This deposit is estimated to contain 1.6 billion barrels of bitumen. The P.R. Spring STSA is located in the southeastern portion of the Uinta Basin in fluvial sandstones of the Tertiary Green River Formation. It is estimated to contain 4 to 4.5 billion barrels of bitumen. The Raven Ridge B Rim Rock STSA lies within the Parachute, Douglas, and Parachute Creek sandstone members of the Tertiary Green River Formation, as well as the basal unit of the Tertiary Uinta Formation. This deposit is estimated to contain 100 to 130 million barrels of bitumen. (Blackett, 1996).

Minor tar sand deposits delineated within the Planning Area are also shown in Figure 7. These deposits, some of which lie within STSAs, include: Chapita Wells (7.5 to 8 million barrels of bitumen), Cow Wash (1 to 1.2 million barrels of bitumen), Upper Kane Hollow (unestimated), Spring Branch (1.5 to 2 million barrels of bitumen), Tabiona (1.3 million barrels of bitumen), Lake Fork (6.5 -10 million barrels of bitumen), Split Mountain (unestimated), Nine Mile Canyon (unestimated), Minnie Maude Creek (10 to 15 million barrelsof bitumen), Little Water Hills (10 to 12 million barrels of bitumen), and Spring Hollow (unestimated). (Blackett, 1996).

Gilsonite

Gilsonite is a black, homogeneous, solid hydrocarbon that is lustrous when fresh but dull when weathered and that breaks with a pronounced conchoidal to hackly fracture (Verbeek and Grout, 1993). A characteristic of gilsonite is its softening-point temperature. Uses for gilsonite include high grade varnishes, laquers, paints, acid proofing, insulating plastics, inks, and mastic (Crawford, 1960). It is also used as a fluid-loss control agent in oil-base drilling muds and as a shale stabilizing additive in water-base muds. An example of typical gilsonite composition given by Pruitt (1961) is:

! Carbon 88.30%

! Hydrogen 9.96%

! Sulfur 1.32%

! Oxygen and Nitrogen 0.32%

! Ash 0.10%.

Gilsonite occurs in the Planning Area as vein-type deposits within the Tertiary sediments of the Uinta Basin (Figure 8). Gilsonite veins primarily occur within the coarser sandstones of the Tertiary Uinta Formation, but they are also known to occur within the Tertiary Duchense River and Green River Formations. The hydrocarbon source is assumed to be the oil shale beds of the Green River Formation. Veining is most extensive in the thickest sandstone units at the base of the Uinta Formation, which were deposited during the late Eocene waning of Lake Uinta (Verbeek and Grout, 1993). Individual sandstone units are 20 to 60 meters thick and are generally separated by thin (0.2 to 6 meters) marlstone and ash-fall tuff intervals (Cashion, 1967). Gilsonite veins are most abundant in the eastern area of the Uinta Basin, decreasing in abundance in the western portion of the basin as the host Uinta Formation becomes finer-grained (Verbeek and Grout, 1993). The gilsonite veins are primarily located in the southeastern portion of the Planning Area, in the Book Cliffs area east of the Green River. There are also some known veins of gilsonite located west of the Green River, such as those mapped south of Myton. However, these veins are less abundant than those in the Book Cliffs area.

Oil Shale

Oil shale is a popular term for sedimentary rock (e.g., marlstone) of the Tertiary Green River Formation that contain kerogen. Kerogen is a fossil organic material that can be converted to conventional oil through retorting or destructive distillation processes. Cashion (1967) characterizes oil shale as a marlstone that, when distilled, will yield 15 gallons or more of oil per ton of rock.

Oil shale occurs within the lower part of the Parachute Creek Member of the Green River Formation. The Mahagony Oil Shale Zone of the Parachute Creek Member is the most notable kerogen bearing unit of the Green River Formation (Sokolosky, 1995). It outcrops in the southern part of the planning area and dips north towards the synclinal axis of the Uinta Basin (Sokolosky, personal communication). The Mahogany Zone varies in thickness throughout the Uinta Basin, generally thickening and becoming less defined from East to West (Cashion, 1967). Figures 9 and 10 provide reported information on the thickness of overburden covering the Mahogany Zone in the Book Cliffs and Diamond Mountain areas, respectively, within the Planning Area. Figure 11 provides information on the average oil yield of the Mahogany Zone in the Diamond Mountain Area.

Phosphate

Phosphate deposits exist in the Uinta Basin within the Meade Peak Member of the Permian Park City Formation. The Meade Peak Member was deposited by upwelling currents in unusually deep water in the generally shallow seas occupying the area during Permian times. Phosphate ore is present in the form of P_2O_5 (Schillie, personal communication).

There are two designated phosphate fields within the planning area: (1) the Vernal Field and (2) the Flaming Gorge/Manila Field. As shown in Figure 12, Park City Formation outcrops are associated with each of these fields, which were probably first defined by geologist Harry Ratliff (Schillie, personal communication). The Vernal field is bounded to the East by the Island Park Fault and to the West by the Deep Creek Fault Zone (Figure 6). The Flaming Gorge/Manila Field is a complex structure of steeply dipping beds associated with the Uinta thrust system in the northeast corner of the Planning Area (Figure 6). The Park City Formation is also shown to outcrop in the Split Mountain area located east southeast of the Vernal

Field (Figure 4). However, Cheney (1957) does not show the Meade Peak Member of the Park City Formation present in this area, calling into question the presence of phosphate in this section of the formation.

Mineral Materials

Mineral material resources of fine sand, sand and gravel, and building stone exist within the Planning Area (Figure 13). Fine sand deposits (Mapping Unit Qfs) from the erosion of the Jurassic Entrada and Navajo Sandstones are located on the northern edge of Ashley Valley, that portion of the Uinta Basin lying between Asphalt Ridge and the Utah-Colorado state line. These fine sand deposits have been mapped as the outcrop of the Entrada and Navajo Sandstones along the southern flank of the Uinta mountains because they are known to exist in these areas (Sokolosky, personal communication). Moon lake reservoir and yellowstone reservoir, both on U.S. Forest Service land in the Uintas, are also known to have fine sand deposits (Todd, personal communication).

The primary sand and gravel deposits of economic significance are those that are sourced in the rocks of the Precambrian Uinta Mountain Group. Most of these deposits occur along the northern margin of the Uinta Basin, where it abuts the southern flank of the Uinta Mountains. These types of sand and gravel deposits occur in the upper sandstone units of the Tertiary Duchense River Formation, the Uinta Piedmont, and in Quaternary terrace/alluvial deposits in streams draining the Uinta Mountains (see mapping units Qa, Qao and T4 in Figure 13). Terrace deposits along the Green River are also a sand and gravel resource. The Mississippian Madison Limestone (Mapping Unit M1) outcrops along the south flank of the Uintas and could be crushed and used as an aggregate.

Building stone resources exist in the Parachute Creek Member of the Tertiary Green River Formation (Mapping Unit T2), particularly occurring as float material that has been eroded from outcrops along steep cliffs in the southern section of the Uinta Basin. (Sokolosky, personal communication)

Locatable Minerals

Minor deposits of locatable minerals associated with hydrothermal alteration and secondary mineral precipitation are known to exist within the Planning Area (Johnson, 1973). These include base metals, gold, gypsum, and uranium (Figure 14). The Precambrian Red Creek Quartzite has produced some lead, gold, copper, silver, iron and barium between Mountain Home and the Owiyukuts Plateau. The Mississippian carbonate rocks along the south flank of the Uintas have been known to contain some small iron deposits (Pruitt, 1961). The terrace deposits of the Green River also contain some fine grained placer gold (Pruitt, 1961). Uranium is known to exist in some sections of the carboniferous units of the Mesaverde and Uinta Formations (Chenoweth, 1992). Gypsum is also known to occur as an evaporative salt in the Jurassic Carmel and Triassic Moenkopi Formations. The Mississippian

Madison Limestone that crops out along the southern flank of the Unitas may have chemical qualities (e.g., may be used as a scrubber material) that would make it a locatable mineral.

Coal

Coal of commercial value exists in the coal unit of the Cretaceous Frontier Sandstone and the Mesaverde Group Formations (Pruitt, 1961). These formations, shown as mapping units K2 and K3, respectively, in Figure 4 are repeated in Figure 15. It is important to note that mapping unit K2 is representative of both the Cretaceous Frontier Sandstone and Mancos Shale Formations, which are undifferentiated.

The Frontier Sandstone is the most recognized coal bearing unit in the Vernal Field. The upper part of the Frontier can be divided into three divisions: 1) a lower thick, massive sandstone; 2) a coal zone 10 to 50 feet thick; and 3) a capping resistant sandstone. The upper sequence is thickest in the north and east parts of the Uinta Basin and thins to the south and west. (Doelling and Graham, 1972).

Most of the coal in the Mesaverde Formation lies within its upper member as lignitic coal seams. The quality of these coal beds improves in an easterly direction. (Doelling and Graham, 1972).

Mineral Exploration, Development, and Production History

Oil and Gas

Oil and gas exploration and production history in the Planning Area is discussed in Appendix A of this mineral report.

Tar Sand

Tar sand deposits have been mined for paving purposes since the 1920s. Material from the Asphalt Ridge B Whiterocks deposit was used to pave the streets of Vernal as early as the 1920s, and continues to be a source of road surfacing material for Uinta County Roads. Interest in development of the tar sand resource for oil has fluctuated since the 1950s, following trends in the conventional oil markets. Congress has also attempted to encourage the development of tar sand resources as an alternative to traditional oil deposits with passage of the Combined Hydrocarbon Leasing Act of 1981. While exploration and development research has been encouraged by state and federal governments, commercial extraction of oil from tar sand deposits has not yet occurred (Blackett, 1996). As of October 2001, there were four permitted tar sand surface mining operations in the Planning Area, all located in Uinta County. Available information regarding these permits/operations is summarized in Table 2. There are no approvals to mine-develop tar sands on any of the combined hydrocarbon leases (currently authorized or closed).

Gilsonite

Gilsonite mining has occurred in the Planning Area since the late 1800s. Gilsonite veins generally need to be 17-18 inches thick for mining techniques to be effective and economic gilsonite extraction feasible (Perks, personal communication). Gilsonite production is estimated to have peaked in the 1960s at around 400,000 tons per year. The market has since contracted, and production since the 1990s is estimated to be around 60,000 tons/year (Ziegler, personal communication). Authorized gilsonite lease/prospecting permit application areas are shown in Figure 16. Active gilsonite mine permits in the planning area as of October 2001 are summarized in Table 3.

Oil Shale

Known Oil Shale Lease Areas, oil shale tracts designated by the Department of the Interior, and oil shale mineral patent application areas are shown in Figure 17. The Known Oil Shale Lease Areas (KOSLAs), delineated by the BLM (1983b), have the following characteristics:

1) minimum 25 gallons/ton

2) minimum 25-foot thick Mahogany bed

3) maximum 3,000 feet of overburden

4) direct data point within three miles.

In April 1972, oil shale tracts Ua and Ub were designated for leasing by the Department of the Interior. These tracts were leased by three petroleum companies that sought to extract kerogen from the shale. The resulting White River Shale Oil Company subsequently mined declines and a vertical shaft into the Mahogany Oil Shale Zone on two leases. These mining operations did not result in any production, and operations on both tracts were terminated in February 1985. The leases were subsequently relinquished in October 1986. (Sokolosky, personal communication).

The areas of pending oil shale mineral patent application shown in Figure 17 are for mineral patent applications UTU 63241, 65275, and 65591 through 65598. Legal decisions declaring oil shale placer claims under these patent applications null and void and abandoned and void will probably remain in various forms of appeal throughout the planning period (Sokolosky, personal communication).

There is currently no extraction of oil shale or active mine permits in the Planning Area. There have been numerous pilot/small-scale oil shale retort and extraction projects in the Planning Area in the past. A small pilot-plant retort at the Rawhide mine east of Bonanza has utilized rock that was already extracted during past mining efforts and extracted oil from these deposits. Geokinetics also had a pilot project with in-situ extraction of oil from the Tertiary Green River Formation that was marginally successful on a small scale. This mine is now in the reclamation phase (Heberg, personal communication). Other proposed oil shale projects were the Magic Circle, Paraho-Ute, Syntana-Utah, and the Tosco oil shale production facilities (BLM, 1983c). None of these proposed projects ever went into production.

Phosphate

Although prospecting and leasing of public lands for phosphate production has occurred in the Planning Area, there has been no development of phosphate mines on public lands. Phosphate is, however, being mined on private lands within the Planning Area. Since 1985, approximately 45 million tons of phosphate ore used for fertilizer production has been extracted by Chevron and SF Phosphates on these private lands (Schillie, personal communication). As of October 2001, the only active mine permit for phosphate mining in the Planning Area is for SF Phosphates' Vernal phosphate operation, located approximately 2 miles north of Vernal. Approximately 3.6 million tons of phosphate were mined at this facility in 2001.

The Known Phosphate Lease Area (Ashley-Brush Creek KPLA), past and presently authorized federal phosphate lease areas and pending and closed prospecting permit areas are shown in Figure 18. There were no authorized prospecting permits in the Planning Area as of October 2001. However, as shown in Figure 18, there are two applications pending. Closed prospecting permit application areas shown in Figure 18 are those either rejected by the BLM or withdrawn by the applicant. The only phosphate exploration that has occurred on public lands in the Planning Area was in the 1960s, prior to issuance of the preference of right leases UT0149937-39 (Sokolosky, personal communication).

Mineral Materials

Disposal of mineral materials on public lands occurs in one of five ways: 1) exclusive mineral material contract sales (competitive and negotiated); 2) exclusive mineral material free use permits; 3) non-exclusive sales of sand and gravel from BLM designated community pits; 4) non-exclusive over the counter sales of stone from common use areas; and 5) mineral material right of ways (Sokolosky, personal communication). Mineral material extraction areas information is shown in Figure 19.

Table 4 shows cumulative production amounts (1982 through September 2001) from BLM lands for several categories of mineral materials in the Planning Area. The Forest Service has issued approximately 100 free use permits a year for mineral materials in the past, of which there is rarely more than a ton of material extracted per permit. The Forest Service usually issues one commercial dimension stone permit every three years. The State does not regulate the aggregate (e.g., sand and gravel) industry. Therefore, no permits are issued by the State for these activities. Mining Activities for materials such as limestone, clay and sandstone are, however, regulated by the State and, as of October 2001, there were three active minerals materials permits for operations in the Planning Area. Available information regarding these permits/operations is summarized in Table 5.

Locatable Minerals

A limestone mine operating on Forest Service lands has been extracting slightly over 30,000 tons of limestone a year for smokestack scrubbers at the Bonanza Power Plant and other general uses (Todd, personal communication). Copper mining has occurred in the Planning Area at the historic Dyer Mine located along the south flank of the Uintas. Over 600 tons of copper oxide was extracted and shipped from the mine, which was shut down permanently in 1941 after declining production. High grade lead carbonate minerals were also mined from the Madison Limestone at the historic Silver-King Mine (Pruitt, 1961). From 1949 to 1958, approximately 161 tons of ore, containing 649 pounds of uranium oxide averaging 0.2 percent U_3O_8, was also mined in the Planning Area (Chenoweth, 1992). Additional claims exist for iron, gold and manganese and evidence of prospecting exists in areas of these claims and other areas of known occurrence. (Pruitt, 1961)

The exploration and development of locatable minerals has been historically low in the Planning Area due to the majority of public lands withdrawn from mineral entry by Executive Order 5327 (April 15, 1930), as amended by Public Land Order 4522 (September 13, 1968). As provided by the BLM, mining claim densities for all locatables in the Planning Area are shown in Figure 20. As of October 2001, there were four active locatable mineral mining permits issued for operations in the Planning Area. Available information regarding these permits/operations is summarized in Table 6.

Coal

Coal mining has not occurred on public lands in the Planning Area due to lack of demand and the poor quality of the deposits. Coal extraction did occur in the first half of the 20th century at a few mines on private lands. Maximum coal production from the Planning Area (10,000 to 13,000 tons) occurred in 1903. By 1961, all coal mines in the Planning Area were idle (Pruitt, 1961). The total historic production from all mines in the Planning Area is estimated at 250,000 tons (Doelling and Graham, 1972).

POTENTIAL FOR OCCURRENCE AND REASONABLE FORESEEABLE DEVELOPMENT OF MINERAL RESOURCES

The mineral resource potential of the Planning Area is classified using the system set forth in BLM Manual 3031. Under this system, occurrence potential ratings are strictly based on the geologic likelihood of the mineral to be present in the area and do not address the economic feasibility of development of the resource. These ratings address the accumulation of mineral resources and certainty of data as follows:

Level of Potential Ratings:

O. The geologic environment, the inferred geologic processes, and the lack of mineral occurrences do not indicate potential for the accumulation of mineral resources.

L. The geologic environment and the inferred geologic processes indicate low potential of accumulation of mineral resources.

M. The geologic environment, the inferred geologic processes, and the reported mineral occurrences or valid geochemical/geophysical anomaly, and the known mines or deposits indicate moderate potential for accumulation of mineral resources.

H. The geologic environment, the inferred geologic processes, and the reported mineral occurrences or valid geochemical/geophysical anomaly, and the known mines or deposits indicate high potential for accumulation of mineral resources. The Aknown mines and deposits@ do not have to be within the area that is being classified, but have to be within the same type of geologic environment.

ND. Mineral potential not determined due to lack of useful data.

Level of Certainty Ratings:

A. The available data are insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within the respective area.

B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.

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

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

Development projections for mineral resources in the Planning Area are based on these ratings and communication with industry and BLM officials familiar with the specific resources and activities in the area. For the purposes of this report, these projections estimate a maximum reasonable foreseeable development of the mineral resource on BLM administered lands over a 15-year planning period. The occurrence and development potential for each mineral resource in the planning area are described in the following sections.

Oil and Gas

The potential for occurrence and reasonable foreseeable development for oil and gas is discussed in Appendix A of this report.

Tar Sand

Areas of H tar sand occurrence potential and D certainty are shown in Figure 21. These are the known tar sand fields that have been designated as STSAs, which, as previously described, include the Argyle Canyon B Willow Creek, Pariette, Asphalt Ridge B Whiterocks, P.R. Springs, Sunny Side, Hill Creek, and Raven Ridge B Rim Rock deposits (see Figure 7). The minor tar sand deposits described by Blackett (1996) and also shown in Figure 7 have also been classified as H occurrence potential and D certainty. Areas outside the previously mentioned locales, where little data exists, have been classified as ND occurrence potential and A certainty.

Because of higher production costs, at current oil and gas prices, extraction of oil from the bitumonous tar sands in the STSAs is not an economical use of this resource. A rise in the price of oil or improvement in extraction technology would be required to cause increased interest in these deposits for the extraction of fossil fuels. The remoteness of P.R. Springs, Hill Creek, Argyle-Willow Creek, and Sunnyside STSAs is another limiting factor for tar sand development in these areas (Sokolosky, personal communication).

The more likely use of tar sands from the Planning Area would be for asphalt paving. The Uintah County Road Department has actively used tar sand from an asphalt pit located on private land, and intends to continue to keep their agreement to mine tar sand from this area. Uintah County builds and repairs approximately 25 to 30 miles of road a year, which requires the extraction of approximately 70,000 tons of tar sand per year from the asphalt pit. The Uintah County Road Department foresees this use continuing throughout the first year planning period (McDonald, personal communication). By contrast, Duchense County does not currently use tar sand for asphalt It has been suggested that emphasis on performance standards for Federal highway construction and available deposits of tar sand in the Planning Area will increase the interest and likelihood of development of this resource over the planning period (Uintah County, 2001). Overall, the potential for development of tar sand in the planning area, other than for use for asphalt paving, is anticipated to remain low as industry continues to search for economically viable methods to extract oil from this resource. Nonetheless, interest in this resource continues, as evidenced by historical and current production.

<u>Gilsonite</u>

Gilsonite occurrence potential is mapped in Figure 22. Areas of H gilsonite occurrence potential and D certainty shown in Figure 22 are those where gilsonite veins (i.e., vertical dike systems) are known to occur at the surface (see Figure 8). Areas of M occurrence potential and B certainty shown in Figure 22 are those located within 1,000 feet down strike at each end of the mapped gilsonite veins. The classification of these M areas is supported by Verbeek and Grout (1993), who reported that gilsonite veins often continue below the surface along the same strike. Areas outside of the previously mentioned locales, where little data exists, are classified as ND occurrence potential and A certainty.

Approximately 30 percent of gilsonite produced in the Planning Area is estimated to be used as an additive to oil well drilling mud and cements (Uintah County, 2001). Therefore, gilsonite production and demand is to a degree tied to worldwide oil and gas production. Industry estimates are that the current rate of production of gilsonite in the planning area of approximately 60,000 tons per year will probably continue through the 15-year planning period (Zeigler, personal communication).

Depending on industry demand, it is anticipated that approximately ten public lands competitive lease sales will probably occur over the 15-year planning period, which will contribute to future gilsonite production. (Most pending prospecting permits (Figure 16) are expected to be in Known Gilsonite Leasing Areas [KGLAs], which are anticipated to be designated during the planning period. Gilsonite deposits in these areas will be subject to competitive leasing.) Currently approved mines will be in producing status during the next 15 years. Existing gilsonite leases that are not currently producing will have to go into production by the date these leases are up for renewal or they may be terminated by the Utah State Office - BLM. (Sokolosky, personal communication).

<u>Oil Shale</u>

Oil shale occurrence potential and certainty classifications are shown in Figure 23. Oil shale deposits underlie most of the Uinta Basin in the mahogany zone of the Green River Formation. The area in the southern portion of the Uinta Basin, north of where the Mahogany Zone outcrops to where the Tertiary Uinta Formation is mapped on the surface (see Figure 4) is classified H occurrence potential and D certainty. This classification was assigned based on the available information regarding oil shale occurrence in the area (e.g. Figures 9 and 10). Additionally, oil shale leasing tracts Ua and Ub and the known Oil Shale Leasing Areas (see Figure 16) are also classified H occurrence potential and D certainty based on available information used in establishing these tracts and areas. As the Mahogany Zone continues down dip toward the synclinal axis of the Uinta Basin, it is overlain by more overburden material. Less information regarding oil shale is reported for these areas, so the remainder of the Uinta Basin is classified as M occurrence potential and D certainty. Areas in the remainder of the Planning Area are classified as ND occurrence potential and A certainty.

Current technology does not allow for the economical extraction of kerogen from oil shale deposits in the Planning Area. To make these deposits economical to develop on a large-scale, an increase in the price of crude oil and/or improvements in the efficiency of extraction technology would probably be required. It is not anticipated that conditions will result in significant development of oil shale in the Planning Area over the 15-year planning period. However, experimentation in extractive processes continues, and increased activity in the development and demonstration of oil shale technology may be stimulated by any anticipated oil shortages and price increases. Further, the large acreage of oil shale lands in the Planning Area make some oil shale development likely within the planning period under such circumstances. In particular, the smaller scale projects of the past have appeared moderately successful, and it is anticipated that one to two small-scale projects may be active in the Planning Area over the planning period. These projects will probably occur on state or private land to simplify the permitting process (Hedberg, personal communication).

Phosphate

Phosphate occurrence and development potential exists within the Vernal and Manila Fields, which are located along the North and South flanks of the Uinta Mountains (see Figure 12). The Ashley-Brush Creek KPLA is encompassed within the Vernal Field. Areas within the Vernal and Manila fields where the Permian Park City Formation is mapped as outcropping are classified as H occurrence potential and D certainty (Figure 24). The remaining areas in the Vernal and Manila fields, down dip of the outcrop of the Park City Formation where it is covered by overburden and less information is known, have been classified as M occurrence potential and C certainty. The phosphatic member (Meade Peak Member) of the Park City Formation is believed to underlie Cretaceous, Jurassic and Triassic sedimentary rocks in these areas. There is little known of the phosphate that lies down dip under considerable overburden south of the Vernal Field and North of the Manila Field. Therefore, these areas and the remainder of the Planning Area are classified as ND occurrence potential and A certainty.

The phosphate resource is administered by the BLM in the same fashion as gilsonite, with prospecting permits and known leasing areas. There has not been any production of phosphate in the federal lease areas, and no lessees have indicated an intent to begin production anytime soon. There are two prospecting permit applications for federal and state land, so there is potential for exploration within the planning period (Sokolosky and Hedberg, personal communication). SF Phosphates will continue to produce phosphate and is anticipated to produce approximately 45 million tons of ore over the planning window, all from private land (Schillie, personal communication).

Mineral Materials

Sand and Gravel

Sand and gravel occurrence potential and certainty classifications are shown in Figure 25. Areas of H occurrence potential and D certainty include the alluvial deposits of the streams draining the Uinta Mountains and those of the Green River. The pediments coming off the Uintas are classified M potential and C certainty, because they are assumed to be more poorly sorted than the streambed deposits in the same area.

There will continue to be moderate demand for sand and gravel from the Planning Area throughout the 15-year planning period. The Green River and Wild Mountain community pits will continue to be active, and a third community pit in the Pleasant Valley area may be opened. Most of the demand for sand and gravel is anticipated to be for county road construction and maintenance in the Planning Area. Resource extraction for county road work will be governed by free use permit applications. Based on communication with county officials, no more than six new pit applications are anticipated over the planning period. It is also assumed that current free use permits that expire over the next 15 years will be renewed; those governmental entities that hold free use permits that expire may apply for another free use permit in the same area, if extraction of the mineral materials has not been completed. Additionally, industry representatives have inquired about the sale process for sand and gravel with the BLM, indicating that there is the potential for at least two contract sales for sand and gravel over the planning period (Sokolosky, personal communication).

Sand

Fine sand occurrence potential and certainty classifications are shown in Figure 26. These include the areas adjacent to outcrops of the Jurassic Entrada and Navajo Sandstones, which have been classified as H occurrence potential and D certainty for fine sand deposits. The fine sand deposits associated with the weathering of the Navajo Sandstone have been bought in the past, and demand for these fine sands is anticipated to continue over the planning period. At least three parties have inquired about future use of these fine sands over the planning period. (Sokolosky, personal communication).

Stone

The areas in the southeastern portion of the Uinta Basin where the Parachute Creek member of the Tertiary Green River Formation outcrops have been classified as H occurrence potential and D certainty for building stone occurrence (Figure 27). Current and past building stone extraction has occurred in these areas, as the potential for stone is well known here. The portion of the Green River Formation above the Mahogany Zone and below the contact with the Uinta Formation is classified as H occurrence potential and C certainty for building stone occurrence. This is the area where the steep cliffs of the Green River sandstones are abundant and ample float material should be present in this area (Sokolosky, personal communication). The Mississippian Madison Limestone Formation outcrops located along the northern edge of the Uinta Basin, have been classified as H occurrence potential and D certainty for limestone occurrence, based on available data.

It is anticipated that there will be continued interest in extracting small quantities of stone for non-commercial purposes from two existing common use areas. It is estimated that up to 60 tons per year could be extracted from both areas. There will also most likely be continued demand from commercial stone vendors within commercial sales tracts in the West Wrinkles Area or from other areas under applications for negotiated sale. During the next 15 years, it is estimated there may be as many as eight applications for sales of stone from commercial vendors. (Sokolosky, personal communication).

There is anticipated to be one commercial dimension stone permit issued every three years on Forest Service land. Approximately 30,000 tons per year of limestone is currently being extracted from a mine on Forest Service land, which extraction is anticipated to continue in the foreseeable future. (Todd, personal communication).

Locatable Minerals

Based on the known geology of the area, locatable minerals in the Planning Area have all been classified as M occurrence potential and D certainty (Figure 28). These include placer gold along the Green River terrace deposits and base metals in the Red Creek Quartzite in the Browns Park area (Pruitt, 1961); uranium in the outcrop of the Cretaceous Mesaverde Formation (Chenoweth, 1992); and gypsum in outcrops of the Jurassic Carmel and Triassic Moenkopi Formations.

There is a low potential for new mining claims to be issued over the planning window, as the geology of the area is not well suited for economic development of locatable mineral deposits. It is also anticipated that recent regulations requiring claimants to pay a $100 annual maintenance fee and that mandate that all notices submitted prior to January 20, 2001, be converted to plans of operation will cause many of these existing notices to be closed. Operations on public lands may possibly be limited to casual use or exploration (under notice) due to the more stringent requirements of the final surface management regulations under 43 CFR 3809. Due to regulatory requirements and low economic quality and quantity of deposits in the planning area, very little development activity for locatable minerals is anticipated over the 15-year planning period. (Sokolosky, personal communication).

Regarding current activities, SF Phosphate will continue to expand its tailings pond under plan of operation (UTU76097) on mill sites. Removal of uncommon variety stone under notice IUTU66378 may continue under an extension of the existing notice or may be converted to a plan of operation at the option of the operator. (Sokolosky, personal communication).

Coal

Coal occurrence rating in the Planning Area is shown in Figure 29. Outcrop of the Cretaceous Frontier Sandstone and Mesaverde Group Formations (see Figure 14) are rated as H Potential with C certainty for coal. It is highly unlikely that coal will be developed in the Planning Area in the foreseeable future because of the low-grade quality of the coal in the area and the high-grade abundant coal in nearby Colorado and Wyoming.

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GLOSSARY

Aeolian: Relating to, caused by, or carried by the wind

Alluvial: Pertaining to material that is carried and deposited by running water

Alluvium: Any sediment deposited by flowing water, as in a river bed, floodplain, or delta

Bitumen: Any of various flammable mixtures of hydrocarbons and other substances, occurring naturally or obtained by distillation from coal or petroleum, that are a component of asphalt and tar and are used for surfacing roads and for waterproofing

Cambrian: Of or belonging to the geologic time, system of rocks, or sedimentary deposits of the first period of the Paleozoic Era, characterized by desert land areas, warm seas, and rapid early diversification of marine life resulting in the rise of almost all modern animal phyla (500 to 570 million years before the present)

Casual Use: Mining activities that only negligibly disturb federal lands and resources. Casual use does not include the use of mechanized earth moving equipment or explosives or the use of motorized equipment in areas closed to off-road vehicles. Under casual use, operators do not have to notify BLM, and operations do not need to be approved. But operations are subject to monitoring by BLM to ensure that federal lands do not undergo unnecessary or undue degradation. Casual use operations must be reclaimed.

Chert: An impure, massive, flintlike quartz or hornstone, of a dull color
Concretion: A rounded mass of mineral matter found in sedimentary rock

Cretaceous: Of or belonging to the geologic time, system of rocks, and sedimentary deposits of the third and last period of the Mesozoic Era, characterized by the development of flowering plants and ending with the sudden extinction of the dinosaurs and many other forms of life (65 to 136 million years before present time)

Eocene: Of or belonging to the geologic time, rock series, or sedimentary deposits of the second epoch of the Tertiary Period, characterized by warm climates and the rise of most modern mammalian families (37 to 53 million years before present)

Facies: A rock or stratified body distinguished from others by its appearance or composition

Fault: A fracture in the continuity of a rock formation caused by a shifting or dislodging of the earth's crust, in which adjacent surfaces are displaced relative to one another and parallel to the plane of fracture

Formation: The primary unit of lithostratigraphy, consisting of a succession of strata useful for mapping or description

Fluvial: Pertaining to streams or produced by stream action

Fossiliferous: Containing or composed of fossils

Hydrocarbons: Any of a vast family of compounds containing carbon and hydrogen in various combinations, found especially in fossils fuels

In-Situ Mining: A method of extracting valuable minerals from ore by remobilizing or leaching them from where they occur in the ground

Jurassic: Of or belonging to the geologic time, rock series, or sedimentary deposits of the second period of the Mesozoic Era, in which dinosaurs continued to be the dominant land fauna and the earliest birds appeared (136 to 190 million years before the present)

Kerogen: A fossilized material in shale and other sedimentary rock that yields oil upon heating.

Lacustrine: Of or relating to lakes

Leasable Minerals: Minerals whose extraction from federal land requires a lease and the payment of royalties, including coal, oil and gas, oil shale and tar sands, potash, phosphate, sodium, and geothermal steam

Limestone: A common sedimentary rock consisting mostly of calcium carbonate, $CaCO_3$, used as a building stone and in the manufacture of lime, carbon dioxide, and cement

Locatable Minerals: Minerals that may be acquired under the Mining Law of 1872, as amended

Marine: Of or relating to the sea

Marlstone: A rock containing clay materials and calcium and magnesium carbonates

Mineral Materials: Materials such as common varieties of sand, stone, gravel, pumice, pumicite, and clay, that are not obtainable under the mining or leasing laws but that can be acquired under the Mineral Materials Act of 1947, as amended

Mississippian: Of or belonging to the geologic time, system of rocks, or sedimentary deposits of the fifth period of the Paleozoic Era, characterized by the submergence of extensive land areas under shallow seas (320 to 345 million years before the present)

Mud: The mixture of water or oil and clay, and sometimes other special materials, used as a drill circulation liquid in drilling a borehole

Mudstone: A fine-grained, dark gray sedimentary rock, formed from silt and clay and similar to shale but without laminations

Notice: The notification a mining operator must submit to BLM of the intention to begin an operation that will disturb 5 acres or less a year within a mining claim or project area

Overburden: All the earth and other materials that overlie a natural mineral deposit

Pennsylvanian: Of or belonging to the geologic time, system of rocks, or sedimentary deposits of the sixth period of the Paleozoic Era, characterized by the development of the amniotic egg, the diversification of amphibians, and widespread swamp forests (280 to 320 million years before the present)

Permian: Of or belonging to the geologic time, system of rocks, or sedimentary deposits of the seventh and last period of the Paleozoic Era, characterized by the formation of the supercontinent Pangaea, the rise of conifers, and the diversification of reptiles and ending with the largest known mass extinction in the history of life (225 to 280 million years before present)

Phospherite: A rock formed primarily of calcium phosphate and used for the manufacture of fertilizer, phosphoric acid and other phosphorous compounds

Piedmont: An area of land formed or lying at the foot of a mountain or mountain range

Placer: An alluvial deposit of sand and gravel containing valuable minerals such as gold

Precambrian: Of or belonging to the geologic time period between Hadean Time and the Cambrian Period, often subdivided into the Archean and Proterozoic eras, comprising most of the earth's history and marked by the appearance of primitive forms of life (greater than 570 million years before the present)

Proterozoic: Of or relating to the later of the two divisions of Precambrian time, from approximately 2.5 billion to 570 million years ago, marked by the buildup of oxygen and the appearance of the first multicellular eukaryotic life forms

Quartzite: A rock formed from the metamorphism of quartz sandstone

Quaternary: period of geologic time extending from the end of the tertiary period to the present (2 million years before to present time)

Sandstone: A sedimentary rock formed by the consolidation and compaction of sand and held together by a natural cement, such as silica

Shale: A fissile rock composed of layers of claylike, fine-grained sediments

Siltstone: A fine-grained rock of consolidated silt

Syncline: A fold in rocks in which the rock layers dip inward from both sides toward the axis

Tertiary: Of or belonging to the geologic time, system of rocks, or sedimentary deposits of the first period of the Cenozoic Era, characterized by the appearance of modern flora and of apes and other large mammals

Triassic: Of or belonging to the geologic time, system of rocks, or sedimentary deposits of the first period of the Mesozoic Era, characterized by the diversification of land life, the rise of dinosaurs, and the appearance of the earliest mammals (190 to 225 million years before present)

Vein: A well-defined, typically tabular zone or belt of mineral-bearing rock confined between nonmineralized rock