UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral resource potential of the Bisti (NM-010-057), De-na-zin (NM-010-004), and Ah-shi-sle-pah (NM-010-009) Wilderness Study Areas, San Juan County, New Mexico

By

Alan M. Bielski[1], Janet L. Brown[2], and Jerry R. Hassemer[2],

Open-File Report 83-889
1983

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

[1]U.S. Bureau of Mines
Denver, Colorado

[2]Denver, Colorado

STUDIES RELATED TO WILDERNESS

The U.S. Geological Survey and the U.S. Bureau of Mines are required by the Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) to conduct mineral surveys within wilderness study areas designated by the Bureau of Land Management to determine their mineral resource potential. The results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the Bisti (NM-010-057), De-na-zin (NM-010-004), and Ah-shi-sle-pah (NM-010-009) Wilderness Study Areas, San Juan County, New Mexico.

CONTENTS

FIGURE

TABLES

SUMMARY

The noncontiguous Bisti, De-na-zin, and Ah-shi-sle-pah Wilderness Study Areas (WSAs) are in the San Juan Basin of northwestern New Mexico. Each of the three areas has a high resource potential for coal, a high resource potential for oil and gas, and an unknown potential for uranium. Identified resources (includes demonstrated and inferred reserves) of low-sulfur subbituminous coal that can be mined by surface or underground methods occur in the Upper Cretaceous Fruitland Formation in all three study areas; the identified resources of coal in the Bisti area are 186 million tons, in the De-na-zin area 440.7 million tons, and in the Ah-shi-sle-pah area 399.4 million tons. Royalties due the Federal Government, if coal is produced, are expected to be $396 million, $213 million, and $510 million, respectively. Coal also occurs in the deeper Upper Cretaceous Menefee Formation in the three areas, but reserve estimates for this coal cannot be made because of inadequate information.

Cretaceous and older sedimentary rocks that produce large quantities of oil and gas in nearby parts of the San Juan Basin also underlie each of the Wilderness Study Areas. Drilling has not adequately tested these rocks in all the study areas, but production and shows of oil and gas from some wells and the projected stratigraphic distribution of producing sandstone lenses indicate that all the areas have a high resource potential for oil and gas.

The Morrison Formation of Jurassic age, which has the rich sandstone-type uranium deposits in the Grants, New Mexico, area to the south, occurs at a depth of about 5,000 ft in the study areas. Because of the lack of exploratory drilling information on the possible uranium-bearing rocks, the Wilderness Study Areas are classified as having an unknown mineral resource potential for uranium.

INTRODUCTION

The Bisti, De-na-zin, and Ah-shi-sle-pah Wilderness Study Areas (WSAs) are noncontiguous areas 5 to 15 mi apart, and consist of 3,968, 18,554, and 6,563 acres, respectively. The WSAs are located in T. 22-25 N., R. 10-13 W., in the southwestern part of San Juan County in northwestern New Mexico (fig. 1). Farmington, New Mexico, the nearest major population center, is 20 to 40 mi north of the WSAs.

The WSAs, which are within the Colorado Plateau Province, are on a gently westward-sloping tableland that has been dissected by entrenched, intermittent streams. Stream channels within the WSAs have formed badland topography at some localities. Drainage within the WSAs flows in a southwest direction, eventually reaching the intermittent Chaco River, and then flows northward to the San Juan River. Uplands are blanketed by fields of stabilized sand dunes.

Altitudes range from a maximum of 6,860 ft in the De-na-zin WSA to a minimum of 5,780 ft in the Bisti WSA. Topographic relief is 240 ft in the Bisti WSA, 900 ft in the De-na-zin WSA, and 380 ft in the Ah-shi-sle-pah WSA.

Access to the vicinity of the WSAs is provided on the east by paved New Mexico State Highway 44, on the south by unpaved New Mexico State Highway 57, and on the west by partly paved New Mexico State Highway 371. East-west access between the WSAs is by several unpaved roads that connect New Mexico State Highway 44 near Huerfano Trading Post with New Mexico State Highway 371 near Bisti Trading Post. Sparse vegetation and moderate local relief within the WSAs allow easy access on foot.

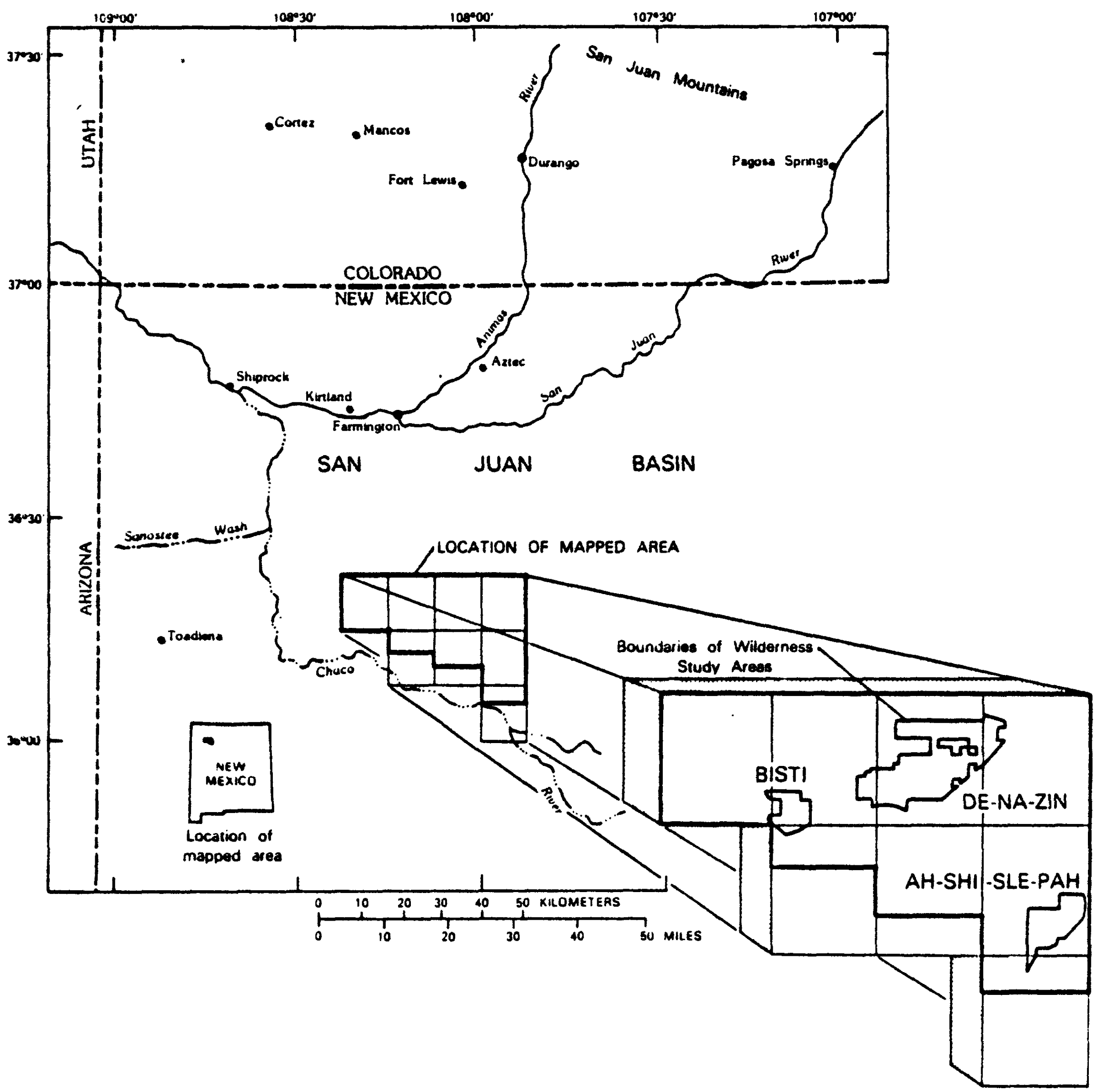

Figure 1.--Index map showing the location of the Bisti (NM-010-057), De-na-zin (NM-010-004), and Ah-shi-sle-pah (NM-010-009) Wilderness Study Areas, San Juan County, New Mexico.

Present investigation

To evaluate the mineral resource potential of the WSAs, the U.S. Geological Survey and the U.S. Bureau of Mines conducted field studies and investigated various sources of minerals information. Reports produced specifically for this investigation of the WSAs are the geologic map and related data by Brown (1983), the results of geochemical sampling and analyses by Hassemer and others (in press), and the report on mineral occurrences, leasing, and mining activity by Bielski and Zelten (in press).

Published literature was reviewed, and lessees, mine operators, and government employees having knowledge of mineral occurrences and geology in and near the WSAs were interviewed. Records at the San Juan County Courthouse and the offices of the U.S. Bureau of Land Management (BLM) were examined to provide map locations of mining claims and mineral leases. Some published and all proprietary subsurface coal data were obtained from the District Mining Office, Minerals Management Service (MMS) in Farmington. (MMS was created from the reorganization of the U.S. Geological Survey's Conservation Division in January 1982; however, the functions of the MMS District Mining Office were transferred to the BLM in December 1982.)

Previous investigations

Since first described by Bauer and Reeside (1921), the geology and distribution of coal in and near the WSAs have been the subject of many regional investigations. Recent publications dealing with the geology and coal resources in the Fruitland and Menefee Formations include those by Fassett and Hinds (1971), Shomaker and others (1971), and Shomaker and Whyte (1977). Studies specific to the WSAs that provide subsurface coal information are by Wilson and Jentgen (1980), Schneider and others (1979), Flores and Erpenbeck (1982), and Mytton (1983). The coal resource occurrence and coal development potential (CRO/CDP) maps of the topographic quadrangles in which the WSAs are located show areas of Federal coal deposits (Dames and Moore, 1979a-g).

The geology and production of oil and gas in the vicinity of the WSAs have been discussed by Fassett (1978) and Ryder (1983).

Uranium occurrences and deposits in northwestern New Mexico have been described by Hilpert (1969), Chenoweth (1977), and Green (1982a, b).

GEOLOGIC SETTING

The three WSAs are located in the west-central part of the San Juan Basin, which is an asymmetric northwest-trending structural basin that extends over an area of about 7,500 mi^2 of northwestern New Mexico and southwestern Colorado. The basin contains sedimentary rocks that range in age from Cambrian to Holocene and that total as much as 14,000 ft thick. The Upper Cretaceous rocks, which contain the abundant coal resources and have produced most of the large quantities of oil and gas from the San Juan Basin, are about 6,000 ft thick. The Upper Jurassic Morrison Formation, which directly underlies the Upper Cretaceous rocks in the basin and which contains abundant uranium resources along the southern edge of the basin, is about 1,000 ft thick and about 5,000 ft below the surface in the area of the WSAs.

The Upper Cretaceous rocks in and near the vicinity of the WSAs include, from oldest to youngest: the Dakota Sandstone; the Mancos Shale, including the Gallup Sandstone; the Mesaverde Group, which includes the Point Lookout Sandstone, the coal-bearing Menefee Formation, and the uppermost formation in the group, the Cliff House Sandstone; Lewis Shale; Pictured Cliffs Sandstone;

the Fruitland Formation, which is the most important coal-bearing formation in the basin; the Kirtland Shale; Ojo Alamo Sandstone; and possibly the Nacimiento Formation, which may be only in part Late Cretaceous in age. These Upper Cretaceous rocks consist of intertonguing marine and nonmarine sedimentary units that were deposited on the western margin of a vast epeiric seaway during four basin-wide transgressive-regressive cycles (Sears and others, 1941; Fassett and Hinds, 1971).

The Dakota Sandstone, the Gallup Sandstone, and younger sandstone lenses in the Mancos Shale are significant reservoir rocks for oil and gas in the San Juan Basin. These reservoir rocks are at the general depth range of 5,000 to 8,000 ft in the three WSAs. The Dakota Sandstone is a marine transgressive deposit comprised mainly of shallow-marine sandstone tongues, intercalated with the Mancos Shale in its upper part (Molenaar, 1977, p. 161). The Dakota interval represents southwesterly directed transgressions of marine and associated shoreline and coastal-plain depositional environments. The Gallup Sandstone is part of a regressive marine strandline and strandplain sequence that intertongues seaward to the northeast with prodelta and deep marine shales of the Mancos Shale (Molenaar, 1973; Fassett, 1978). The younger sandstone lenses and tongues are part of the succeeding transgressive sequence and are stratigraphic traps that formed in the barrier-bar complexes.

The Point Lookout Sandstone consists of littoral marine sandstone units that are overlain by the Menefee Formation of nonmarine origin. The Menefee is mainly sandstone, shale, and coal formed in floodplain, swamp, and lagoonal environments. The marine Cliff House Sandstone, which overlies the Menefee and is the oldest formation exposed in the vicinity of the WSAs, was deposited during the last major transgression of the Cretaceous sea in the San Juan Basin area. The overlying Lewis Shale is an offshore marine deposit laid down in the expanded seaway. The combined thickness of the four formations in the Point Lookout-Lewis sequence is about 2,000 ft.

The final regression or contraction of the Cretaceous sea resulted in the beach deposits of the Pictured Cliffs Sandstone, which is 200 to 300 ft thick. The nonmarine Fruitland and younger Cretaceous formations overlying the Pictured Cliffs Sandstone are composed mostly of interbedded paludal and fluvial sandstone, siltstone, and shale that, in the WSAs, have an aggregate thickness of about 1,800 ft.

The Fruitland Formation, which contains most of the coal resources of the WSAs and is at or near the surface over much of the WSAs, consists of a variable and intertonguing sequence of sandstone, siltstone, mudstone, and coal. The formation is 250 to 300 ft thick and contains several coal beds that range from a few to 20 ft thick, but which rarely total more than 30 ft in the vicinity of the WSAs. The coal beds are discontinuous, and generally appear in northwest-trending belts rarely more than a few miles wide; in areas where the aggregate coal is thickest, the beds commonly appear in two or three thick beds and a few thin beds in the lower part of the formation.

All of the formations in the west-central part of the San Juan Basin are nearly horizontal, dipping at most about 1° to the north or north-northeast. Because the shorelines of the transgressing-regressing Cretaceous sea had a northwest trend, most bodies of sediment such as beach sands and belts of coal reflect this trend of environments of deposition. This trend and the intertonguing and pinching out of different types of sedimentary units in places suggest a more complex structural setting, but except for widespread regional uplift typical of most of the Colorado Plateau the tectonic history of this part of the San Juan Basin is comparatively very simple.

MINERAL OCCURRENCES

Energy minerals that occur in or near the WSAs are coal, petroleum, and, possibly, uranium. The Fruitland Formation is the only one of several coal-bearing stratigraphic units underlying the WSAs for which available information is sufficient to define the quantity and quality of the coal resources. Clinker and humates may be coproducts recoverable during coal mining, and aluminum metal may be a recoverable byproduct derived from coal ash. Oil and gas are produced and shows are common in wells in and near the WSAs. Uranium occurrences may be present beneath the WSAs where the favorable host rocks are 5,000 ft or more below the surface.

Coal and byproducts of coal mining

Coal-bearing units within the sequence of Cretaceous rocks beneath the WSAs are, in ascending stratigraphic position, the Dakota Sandstone, several units of the Mesaverde Group, and the Fruitland Formation. Information is not sufficient, however, to determine the thickness and distribution of the deeply buried coal within the Dakota Sandstone or the coal beds in and below the Menefee Formation within the Mesaverde Group. Limited subsurface data allow for some general description of coal within the Menefee Formation, and there is sufficient subsurface information available to determine the quantity and quality of coal in the Fruitland Formation.

Within the Menefee Formation, two zones, each of which contains several coal beds that have individual thicknesses of about 3 ft, occur near the top and bottom of a 1,500-ft interval. The uppermost zone of coal beds occurs at minimum depths of about 1,300 ft in all three WSAs. The depths to the uppermost coal beds increase to the northeast to a maximum of about 3,000 ft in the De-na-zin WSA (Dames and Moore, 1979a-g).

Coal beds in the Fruitland Formation crop out in and near the WSAs, and are interbedded with sandstone, siltstone, shale, and carbonaceous shale. Some individual coal beds split or pinch out within short distances, but zones of nearly continuous coal may persist within a given stratigraphic interval for distances of several miles. Many coal beds of more limited areal extent lie between the major coal zones.

All coal in the Fruitland Formation of the WSAs is considered to be low-sulfur subbituminous coal. On an as-received basis, heating values of coal samples taken in and near the Bisti and Ah-shi-sle-pah WSAs range from 6,620 to 10,920 Btu/lb, with an average of 8,890 Btu/lb; average ash content is about 22.4 percent, and sulfur averages 0.6 percent (Schneider and others, 1979; Wilson and Jentgen, 1980).

In the Bisti and Ah-shi-sle-pah WSAs, coal in the Fruitland is at the surface and extends to depths of about 300 ft and 600 ft, respectively. In the De-na-zin WSA, the depth to Fruitland coal ranges from about 250 to 1,400 ft.

Clinker and humates are possible coproducts during coal mining, and aluminum is a possible product recoverable from the ash of Fruitland coal combusted in power plants. Clinker, which is locally abundant along coal outcrops in the WSAs, is baked rock that surrounds burned parts of coal beds; it is commonly used in road building. Humates occur as organic-rich rock material associated with coal seams; humates are used for agricultural purposes as a soil conditioner. No humate occurrences have been documented within the WSAs; however, deposits may be uncovered if coal is mined. The occurrence and production of humates in the San Juan Basin were discussed by Shomaker and Hiss (1974). Aluminum compounds (alumina) and, ultimately, aluminum metal can be extracted from fly ash of burned Fruitland coal (Torrey, 1978).

Oil and gas

A significant amount of oil and gas has been produced from fields that adjoin the De-na-zin WSA on the northeast; the oil is from the Bisti Lower Gallup Oil Field (Bisti Field), and gas is from the Basin Dakota Gas Field (Basin Dakota). The wells are producing in the same geographic area, but the producing interval of the Bisti Field is vertically and stratigraphically above that of the Basin Dakota Field. Deeper formations that produce oil and gas in the southwestern part of the San Juan Basin are, for the most part, untested in the vicinity of the WSAs. Three Known Geologic Structures (KGSs) lie in the De-na-zin WSA.

The Bisti Field was discovered in 1955 and is one of the larger fields in the San Juan Basin. The field is about 3 mi wide, 30 mi long, and trends northwest. The southwestern limit of production may extend into the De-na-zin WSA. The producing interval has been given several stratigraphic names. The term "Gallup" is used by the oil industry, and the term "Gallup lenses" is used in this report; the name refers to all Niobrara age, transgressive sandstone lenses in the Mancos Shale (Fassett, 1978, p. 54). Within the producing interval, oil occurs in stratigraphic traps consisting of marine sandstone lenses that were deposited as offshore bars and enclosed by deposits of fine-grained sediments within the Mancos Shale. The shape of the sandstone lenses is elongate to the northwest in proportion to width and thickness. The geology and production of the Bisti Field have been described by Sabins (1978), and Molenaar (1973) provided a regional stratigraphic description of the "Gallup lenses" in northwestern New Mexico.

The WSAs are almost entirely southwest of the productive "Gallup lenses" of the Bisti Field; however, "Gallup lenses", stratigraphically similar to those of the Bisti Field, occur in the vicinity of the WSAs, as Molenaar (1973, p. 99) has shown in cross section. "Gallup lenses" in the De-na-zin WSA are petroleum bearing, as indicated by some wells that have oil and gas shows or production. The distribution of these productive wells among dry and abandoned wells suggests that the productive "Gallup lenses" in the vicinity of the WSAs are smaller than the lenses of the Bisti Field, and, therefore, were intersected less frequently by test wells.

The Basin Dakota Field is a major producer of gas and some oil in the San Juan Basin. The discovery well was drilled in 1947 about 30 mi north of the WSAs. Production is from an area several hundred thousand acres in size, but areal limits of the Basin Dakota production have yet to be established. Within the producing interval, petroleum occurs in stratigraphic traps formed by marine beach and offshore sandstone bodies in the Dakota Sandstone and the Mancos Shale (Dakota interval). The geology and production of the Basin Dakota have been described by Deischl (1973) and Hoppe (1978).

The WSAs overlie an area where the productive marine sandstones of the Dakota interval thin to the southwest (Hoppe, 1978, p. 205). Most of the Basin Dakota wells are north and east of the WSAs, although one well, about 4 mi east of the De-na-zin WSA, had initial oil production from the Dakota interval. Several other wells in the vicinity of the WSAs showed gas in the Dakota interval.

In the vicinity of the WSAs, just one well has penetrated possibly productive formations below the Cretaceous sequence. These formations include rocks of Jurassic, Pennsylvanian, Mississippian, and Devonian ages. The well, which is just a few tenths of a mile south of the Bisti WSA, bottomed at a depth of about 10,000 ft in Mississippian rocks. The well was dry and abandoned after down-hole tests were conducted on the lowermost Cretaceous interval.

The location and more detailed description of wells in and near the WSAs are given in the report by Bielski and Zelten (1983).

Uranium

No near-surface uranium occurrences are known within the WSAs; however, uranium is reported to occur at the surface in the Ojo Alamo Sandstone, about 1 mi northeast of the Ah-shi-sle-pah WSA, in E1/2 sec. 26, T. 23 N., R. 10 W. The occurrence could not be located during this investigation but was described by Hilpert (1969, p. 50).

The WSAs are within part of an area investigated by the Department of Energy during the National Uranium Resource Evaluation (NURE) program. The results of the NURE investigation show that the Bisti, Ah-shi-sle-pah, and the southern extreme of the De-na-zin WSA are within an area favorable for sandstone-type uranium deposits in the Brushy Basin and Westwater Canyon Members of the Morrison Formation (Green, 1982a, 1982b). The Brushy Basin and Westwater Canyon Members are considered favorable for uranium occurrences because these stratigraphic units host many significant deposits in the Grants Uranium Belt, about 50 mi south of the WSAs. The favorable area is defined as south of, and therefore above, the approximate 5,000-ft depth contour at the base of the Westwater Canyon Member of the Morrison Formation. The contour trends in a northwest direction, just north of the Bisti and Ah-shi-sle-pah WSAs, and crosses the southern extreme of the De-na-zin WSA. Thus, uranium deposits may occur at a depth of about 5,000 ft in the WSAs. The uranium occurrence in the Ojo Alamo Sandstone, east of the Ah-shi-sle-pah WSA, was not corroborated by the NURE investigators; nor were any stratigraphic units other than those within the Morrison Formation considered favorable for uranium deposits in or near the WSAs.

Other possible mineral occurrences

A geochemical survey was conducted in order to evaluate the possibilities for other, previously undiscovered minerals in the area of the WSAs. During this survey, 59 stream-sediment samples were collected, 59 heavy-mineral concentrates from the sediment samples, 121 soil-gas helium samples, and a few rock and water samples. All of the samples, except for the soil samples, were chemically analyzed using spectrographic and atomic-absorption methods to determine anomalously high contents of metals or other elements that would indicate concentrations of important minerals. Anomalously high helium in soil samples could indicate either concentrations of uranium minerals or helium-bearing oil or gas accumulations at depth. The analyses and detailed description of the geochemical survey are presented by Hassemer and others (in press).

In general, the results of the geochemical survey indicate no significant enrichment in metals or other possibly important elements in or near the WSAs. Iron, copper, cobalt, and molybdenum are slightly and uniformly enriched in the heavy-mineral concentrates in all three WSAs, but the low level of enrichment and the lack of "hot spots" does not suggest the presence of metalliferous deposits in the study areas.

The regional median value of soil-gas helium was determined to be 60 ppb (parts per billion). A somewhat higher helium value of about 100 ppb was observed in much of the Bisti WSA, but this anomaly could not be related to any observed or reported mineralization, any fracturing or faulting, or to any other geologic features recorded during this study.

A few thin beds of sedimentary manganese were observed in rocks exposed in the Ah-shi-sle-pah and De-na-zin WSAs, and a few small transported barite nodules were observed in a stream drainage near the northeastern corner of the De-na-zin WSA. These mineral occurrences are not especially uncommon in areas of Cretaceous sedimentary rocks, and, with the overall negative results of the geochemical survey, the conclusion is that there is no positive evidence for occurrences of mineral deposits in the WSAs other than coal, oil and gas, and possibly uranium.

MINING AND LEASING ACTIVITY

Mineral leases and (or) mining claims cover nearly the entire surface area of each WSA. The lands in and near the WSAs have undergone considerable exploration for coal and petroleum. Many boreholes have been drilled to determine the quantity of coal, and many test wells have been drilled in attempts to discover oil and gas in the underlying sedimentary rocks. Mineral leases, mining claims, drill holes, wells, coal mines, and other areas of Federal minerals interest in the vicinity of the WSAs are described in detail in the report by Bielski and Zelten (1983). The report also reviews the history of exploration and classification of Federal lands, such as under Preference Right Lease Applications (PRLAs), Known Recoverable Coal Resource Areas (KRCRAs), and Known Geologic Structures (KGSs, for oil or gas).

In 1983, coal was being mined from the Fruitland Formation on New Mexico-owned land in the vicinity of the WSAs. The De-na-zin Coal Mine, located about 0.5 mi south of the Bisti WSA, is operated by the Sunbelt Mining Company, a subsidiary of the Public Service Company of New Mexico. Coal production was also begun on a test scale at the Gateway Coal Mine, also operated by Sunbelt, that is adjacent to the Bisti WSA on the west and partly encompassed by the Bisti WSA. The coal is produced by surface-mining methods.

Nearly all of the Federal oil and gas rights have been leased in the WSAs. Some drilling has taken place in and near the WSAs, but wells in the WSAs were, with one exception, plugged and abandoned as incapable of commercial production of oil or gas. The exception is a well in the De-na-zin WSA, completed in April 1983, that is shut in until pumping equipment is installed (Richard Wilson, BLM-Farmington, oral commun., 1983).

Since 1977, mining claims have been staked in the vicinity of the WSAs for aluminum and uranium. Claims for aluminum overlie coal leases in the Bisti WSA, for the recovery of aluminum from the fly ash produced by the burning of Fruitland coal at a power plant. Claims located for uranium cover about two-thirds of the Ah-shi-sle-pah WSA, but no current uranium claims exist in the other WSAs; direct evidence for uranium at depth in the area of the WSAs by drilling is not known.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The mineral resources and mineral resource potential of each of the three WSAs have been assessed, based on the investigations and evaluations outlined above. Identified resources are specific bodies of mineralized rock whose location, quality, and quantity have been measured. Mineral resource potential is the characteristic attributed to a geologic terrane that indicates or suggests the possible presence of resources. The resource potential of an area for a commodity is rated as low, moderate, or high; if data are too meager or if no resources are indicated by geologic factors, an area is rated as having an unknown mineral resource potential for a commodity.

In summary, each of the Bisti, De-na-zin, and Ah-shi-sle-pah WSAs has a high resource potential for coal, a high potential for gas and oil (Ryder, 1983, p. I-27, map), and an unknown potential for uranium. Because of inadequate information, each area has an unknown resource potential for other mineral commodities such as clinker, humates, and aluminum.

The identified resources (Wood and others, fig. 2, 1983) of coal for each WSA are given below; these resources and the tonnages minable by surface or underground methods are listed by Bielski and Zelten (1983). In their report, and in the tables below, "reserve base" is equivalent to "identified resources", the "minable reserve base" is that part of the reserve base that meets certain depth and thickness criteria as defined for each of the WSAs in their report, and "recoverable reserves" are equivalent to "demonstrated reserves."

Bisti Wilderness Study Area

The entire Bisti WSA is underlain by the Fruitland Formation, which has identified resources (includes demonstrated and inferred reserves) of 186 million tons of low-sulfur subbituminous coal minable by surface methods (table 1). The market value of the demonstrated reserves in the WSA are estimated at $3.2 billion and would generate an estimated $396 million in Federal royalties (James Edwards, Minerals Management Service, written commun., Sept. 1982). The WSA has a high resource potential for coal in the Fruitland, and coal also may exist at depths greater than 1,300 ft in the Menefee Formation.

No oil and gas wells have been drilled in the WSA, but a well adjacent to the WSA on the southwest had gas shows in the Dakota interval, and several wells as near as 5 mi north-northeast of the WSA had initial production of oil and gas from "Gallup lenses" in the Mancos Shale. These nearby occurrences of oil and gas indicate that the Bisti WSA has a high resource potential for oil and gas in the Upper Cretaceous sandstone units (Ryder, 1983). One well, a few tenths of a mile south of the Bisti WSA, was drilled through the Cretaceous rocks to bottom in Mississippian rocks, but the well was dry and abandoned. This information, however, is considered insufficient for suggesting the presence or absence of oil or gas resources in the pre-Cretaceous rocks of the Bisti WSA.

No uranium occurrences are known to exist near the surface of the WSA. Sandstone-type uranium deposits, like those in the Grants Uranium Belt, 50 mi to the south, may occur in the Brushy Basin and Westwater Canyon Members of the Morrison Formation at a depth of about 5,000 ft in the WSA (Green, 1982a, 1982b). The existence of uranium deposits in the WSA is dependent upon the assumed continuation, downdip and to the north, of mineralized areas present in the Grants Uranium Belt. Because of the lack of exploratory drilling information on the possible uranium-bearing rocks, the WSA is classified as having an unknown mineral resource potential for uranium.

De-na-zin Wilderness Study Area

The identified resources of low-sulfur subbituminous coal in the WSA are 440.7 million tons, minable by underground methods (table 2); the identified resources could not be estimated for the central part of the WSA because of insufficient subsurface information, but this part is also underlain by the coal-bearing Fruitland Formation. The demonstrated reserves within this WSA are expected to have a market value of $2.6 billion and to generate Federal royalties of $213 million (James Edwards, Minerals Management Service, written

Table 1.--Coal reserve base and reserves, Fruitland Formation coal, Bisti Wilderness Study Area (from Bielski and Zelten, 1983)

[All values reported in short tons; all coal considered subbituminous in rank and has an estimated weight of 1,770 tons per acre-foot; estimates of reserves, based on 85 percent recovery of the minable reserve base, were provided by James Edwards, Minerals Management Service (MMS). Sources of subsurface coal information: Wilson and Jentgen (1980); Kinark Corp., Public Service Coal Co., Sunbelt Mining Co. (proprietary information on file at the District Mining Office of MMS, Farmington, N. Mex.)]

Surface minable coal		
	Demonstrated reserve base[1]	
Reserve classification	Size (acres)	Coal quantity (million tons)
Reserve base	3,892	186
Minable reserve base	3,892	186
Recoverable reserves	3,892	158

[1]Includes total inferred reserve base of 285,000 tons of coal within a 3.5 acre area. The WSA, as a Logical Mining Unit, is capable of supporting a 4 million ton per year surface mine for 40 years (James Edwards, Minerals Management Service, written commun., 1982).

Table 2.--Coal reserve base and reserves, Fruitland Formation coal, De-na-zin Wilderness Study Area (from Bielski and Zelten, 1983)

[All values reported in short tons; all coal considered subbituminous in rank and has an estimated weight of 1,770 tons per acre-foot; ND, not determined. Estimates of reserves, based on 65 percent recovery of coal seams 5.0 to 12.0 ft thick (minable reserve base), were provided by James Edwards, Minerals Management Service (MMS). Sources of subsurface coal information: Dames and Moore (1979a, b, and d); Western Associated Coal Corp. (proprietary information on file at the District Mining Office, MMS, Farmington, N. Mex.)]

	Coal Area A[1] Underground minable coal				Coal Area B[2] Underground minable coal				Coal Area C[3] Underground minable coal	
	Demonstrated reserve base		Inferred reserve base		Demonstrated reserve base		Inferred reserve base		Reserve base	
Reserve classification	Size (acres)	Coal quantity (million tons)	Size (acres)	Coal quantity (million tons)	Size (acres)	Coal quantity (million tons)	Size (acres)	Coal quantity (million tons)	Size (acres)	Coal quantity (million tons)
Reserve base	7,269	307	1,505	42.9	1,560	40.7	1,948	50.1	6,982	ND
Minable reserve base	7,269	149	ND	ND	1,560	29.4	ND	ND	ND	ND
Recoverable reserves	7,269	89.5	ND	ND	1,560	17.6	ND	ND	ND	ND

[1]Coal Area A: Coal seams in the southern extreme of Coal Area A are less than 350 ft deep, but are considered to be minable by underground methods because of the geographic relationship of this part of the WSA to projected stripping areas to the south. It was not considered practical to initiate an operation to strip 250+ ft of overburden within the southern part of the WSA to recover a relatively small amount of coal.

In the southern extreme of Coal Area A, quantities of coal from seams in several stratigraphic zones are included in the reserve base estimates. Underground mining of more than one coal zone was not considered practicable because the separation between the zones was less than 100 ft.

Coal Area A is bounded on the northeast by a line that approximates the 5.0 ft thickness contour on the coal isopachous map used to derive the reserve base estimates.

[2]Coal Area B: State-owned coal in the southern part of Coal Area B was not included in the reserve base estimates.

Coal Area B is bounded on the southwest by a line that approximates the 5.0 ft thickness contour on the coal isopachous map used to derive the reserve base estimates.

[3]Coal Area C: Information is insufficient to estimate the quantity of coal in Coal Area C; therefore, the reserve base category of Coal Area C is undefined.

Coal Area C is bounded on the southwest and the northeast by lines that approximate the 5.0 ft thickness contour on the coal isopachous map used to derive the reserve base estimates. The lines were interpolated from coal seam thicknesses at drill hole locations in Coal Areas A and B. The coal seams appear to be thinning from the southwest (Coal Area A) as well as from the northeast (Coal Area B) to less than 5.0 ft in thickness in Coal Area C. Additional drilling is needed to determine the actual coal thickness and quantity in Coal Area C.

An entire section of state-owned minerals is within the northwestern part of Coal Area C.

commun., Sept. 1982). The De-na-zin WSA has a high resource potential for coal in the Fruitland and coal also may be present at depths greater than 1,300 ft in the Menefee Formation.

Three wells drilled in the WSA have intersected petroleum-bearing "Gallup lenses" in the Mancos Shale. One of these wells, which was completed in April 1983, is expected to produce small, but commercial, quantities of oil and gas when pumping equipment is installed. Many other oil and gas wells near the WSA have had shows or production of oil or gas in the Dakota interval or in "Gallup lenses" and the Bisti Oil Field and Basin Dakota Gas Field adjoin to the northeast, so the De-na-zin WSA is rated as having a high resource potential for oil and gas in the Upper Cretaceous units (Ryder, 1983). Insufficient information is available to suggest that oil and gas resources exist in the pre-Cretaceous sedimentary rocks underlying the WSA.

Following the criteria used for the Bisti WSA, the De-na-zin WSA is classified as having an unknown mineral resource potential for uranium in the subsurface Morrison Formation.

Ah-shi-sle-pah Wilderness Study Area

The entire WSA also is underlain by the Fruitland Formation, and has identified resources of low-sulfur subbituminous coal of 399.4 million tons (table 3), most of which is minable by surface methods. The demonstrated reserves within the WSA are expected to have a market value of $4.1 billion and to generate Federal royalties of $510 million (James Edwards, Minerals Management Service, written commun., Sept. 1982). The WSA has a high resource potential for coal, mainly in the Fruitland Formation; some coal resources also may exist at depths greater than 1,300 ft in the Menefee Formation.

The only well in the WSA did not discover oil, but a producing well 4 mi north and scattered wells in the vicinity of the WSA that had shows of oil and gas all indicate that the Ah-shi-sle-pah WSA has a high potential for oil and gas in the Dakota interval and the "Gallup lenses" in the Mancos Shale (Ryder, 1983). Information is not sufficient to suggest that oil and gas resources exist in the pre-Cretaceous sedimentary rocks underlying the WSA.

The Ah-shi-sle-pah WSA is classified as having an unknown mineral resource potential for uranium in the subsurface Morrison Formation, following the same criteria applicable to the Bisti WSA.

Table 3.--Coal reserve base and reserves, Fruitland Formation coal, Ah-shi-sle-pah Wilderness Study Area (from Bielski and Zelten, 1983)

[All values reported in short tons; all coal considered subbituminous in rank and has an estimated weight of 1,770 tons per acre-foot; ND, not determined. Estimates of reserves, based on 85 percent recovery of the minable reserve base, provided by James Edwards, Minerals Management Service. Source of subsurface coal information: Schneider, Hildebrand, and Affolter (1979)]

	Coal Area A Surface minable coal				Coal Area B[1] Surface minable coal		Coal Area C[2] Underground minable coal	
	Demonstrated reserve base		Inferred reserve base		Inferred reserve base		Inferred reserve base	
Reserve classification	Size (acres)	Coal quantity (million tons)	Size (acres)	Coal quantity (million tons)	Size (acres)	Coal quantity (million tons)	Size (acres)	Coal quantity (million tons)
Reserve base	3,523	240	494	28.6	866	39.3	1,616	91.5
Minable reserve base	3,523	240	ND	ND	ND	ND	ND	ND
Recoverable reserves	3,523	204	ND	ND	ND	ND	ND	ND

[1]Coal Area B: Coal estimates in Area B are based on the assumed continuation of the seams present at drill hole locations in Coal Area A and are, therefore, inferred. Coal Area B is bounded on the southwest by a line that represents where the projected depth of the lowermost coal seam in Coal Area A is greater than 350 ft. The northeastern boundary of Coal Area B is a line that represents where the projected depth of the uppermost coal seam of Coal Area A is greater than 350 ft. None of the seams in Coal Area B that are at depths greater than 350 ft are minable by underground methods because the separation between surface minable and deeper seams is less than 100 ft.

[2]Coal Area C: Coal estimates in Coal Area C are based on the assumed continuation of one major seam (average thickness of 32 ft) from Coal Area A and are, therefore, inferred.

REFERENCES

Bauer, C. M., and Reeside, J. B., Jr., 1921, Coal in the middle and eastern parts of San Juan County, New Mexico: U.S. Geological Survey Bulletin 716-G, p. 155-237.

Bielski, A. M., and Zelten, J. E., in press, Mine and prospect map of the Bisti, De-na-zin, and Ah-shi-sle-pah Wilderness Study Areas: U.S. Geological Survey Miscellaneous Field Studies Map MF-1508-C, scale 1:50,000.

______1983, Mineral investigation of the Ah-shi-sle-pah, Bisti, and De-na-zin, Wilderness Study Areas, San Juan County, New Mexico: U.S. Bureau of Mines Open-File Report 40-83, 46 p., 3 pls.

Brown, J. L., 1983, Geologic and isopach maps of the Bisti, De-na-zin, and Ah-she-sle-pah [Ah-shi-sle-pah] Wilderness Study Areas, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1508-A, scale 1:50,000.

Chenoweth, W. L., 1977, Uranium in the San Juan Basin--an overview, in Fassett, J. E., ed., San Juan Basin III, Northwestern New Mexico: New Mexico Geological Society Guidebook, 28th Field Conference, p. 257-262.

Dames and Moore, 1979a, Coal resource occurrence and coal development potential maps of the Alamo Mesa East Quadrangle, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 79-0603, scale 1:24,000, 24 p.

______1979b, Coal resource occurrence and coal development potential maps of the Alamo Mesa West Quadrangle, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 79-0602, scale 1:24,000, 30 p.

______1979c, Coal resource occurrence and coal development potential maps of the Bisti Trading Post Quadrangle, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 79-0601, scale 1:24,000, 23 p.

______1979d, Coal resource occurrence and coal development potential maps of the Huerfano Trading Post SW Quadrangle, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 79-0152, scale 1:24,000, 23 p.

______1979e, Coal resource occurrence and coal development potential maps of the Pueblo Bonito Quadrangle, San Juan and McKinley Counties, New Mexico: U.S. Geological Survey Open-File Report 79-0156, scale 1:24,000, 16 p.

______1979f, Coal resource occurrence and coal development potential maps of the Pueblo Bonito NW Quadrangle, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 79-0154, scale 1:24,000, 27 p.

______1979g, Coal resource occurrence and coal development potential maps of the Tanner Lake Quadrangle, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 79-0605, scale 1:24,000, 30 p.

Deischl, D. G., 1973, The characteristics, history, and development of the Basin Dakota Gas Field, San Juan Basin, New Mexico, in Fassett, J. E., ed., Cretaceous and Tertiary rocks of the southern Colorado Plateau: Four Corners Geological Society Memoir, p. 168-173.

Fassett, J. E., ed., 1978, Oil and gas fields of the Four Corners Area, 2 v.: Four Corners Geological Society, 727 p.

Fassett, J. E., and Hinds, J. S., 1971, Geology and fuel resources of the Fruitland Formation and the Kirtland Shale of the San Juan Basin, New Mexico and Colorado: U.S. Geological Survey Professional Paper 676, 76 p.

Flores, R. M., and Erpenbeck, M. F., 1982, Stratigraphic framework and coal correlation of the Upper Cretaceous Fruitland Formation, Bisti-Ah-Shi-Sle-Pah area, San Juan Basin, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1390, scale 1:24,000.

Green, M. W., principal investigator, 1982a, Uranium resource evaluation of the Aztec 1° x 2° NTMS Quadrangle, New Mexico, and Colorado (preliminary file): U.S. Department of Energy PGJ/F-012(82).

______principal investigator, 1982b, Uranium resource evaluation of the Shiprock 1° x 2° NTMS Quadrangle, Arizona, New Mexico, Colorado, and Utah (preliminary file): U.S. Department of Energy PGJ/F-024(82).

Hassemer, J. R., Erickson, M. S., and Been, J. M., in press, Methodology, statistical summary, and listing of analyses of geochemical samples, Bisti, De-na-zin, and Ah-shi-sle-pah Wilderness Study Areas, San Juan County, New Mexico: U.S. Geological Survey Open-File Report ___, 26 p., 8 tables.

Hilpert, L. S., 1969, Uranium resources of northwestern New Mexico: U.S. Geological Survey Professional Paper 603, 166 p.

Hoppe, W. F., 1978, Basin Dakota (gas field), in Fassett, J. E., ed., Oil and gas fields of the Four Corners Area, v. 2 of 2: Four Corners Geological Society, p. 204-206.

Molenaar, C. M., 1973, Sedimentary facies and correlation of the Gallup Sandstone and associated formations, northwestern New Mexico, in Fassett, J. E., ed., Cretaceous and Tertiary rocks of the southern Colorado Plateau: Four Corners Geological Society Memoir, p. 85-110.

______1977, Stratigraphy and depositional history of upper Cretaceous rocks of the San Juan Basin area, New Mexico and Colorado, with a note on economic resources: New Mexico Geological Society Guidebook, 28th Field Conference, San Juan Basin III, 1977, p. 159-166.

Mytton, J. W., 1983, Geologic map of the Chaco Canyon 30′ x 60′ quadrangle, showing coal zones of the Fruitland Formation, San Juan, Rio Arriba and Sandoval Counties, New Mexico: U.S. Geological Survey Coal Investigations Map C-92-A, scale 1:100,000.

Ryder, R. T., 1983, Petroleum potential of wilderness lands in New Mexico: U.S. Geological Survey Miscellaneous Investigations Map I-1543, scale 1:1,000,000.

Sabins, F. F., 1978, Bisti Lower Gallup (oil field), in Fassett, J. E., ed., Oil and gas fields of the Four Corners Area v. 2 of 2: Four Corners Geological Society, p. 213-215.

Schneider, G. B., Hildebrand, R. T., and Affolter, R. H., 1979, Geology, coal resources, and chemical analyses of coal from the Fruitland Formation, Kimbeto EMRIA study site, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 79-1090, 37 p.

Sears, J. D., Hunt, C. B., and Hendricks, T. A., 1941, Transgressive and regressive Cretaceous deposits in southern San Juan Basin, New Mexico: U.S. Geological Survey Professional Paper 193-F, p. 110-121.

Shomaker, J. W., Beaumont, E. C., and Kottlowski, F. E., compilers and eds., 1971, Strippable low sulfur coal resources of the San Juan Basin in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Memoir 25, 189 p.

Shomaker, J. W., and Hiss, W. L., 1974, Humate mining in northwestern New Mexico, in Siemers, C. T., ed., Guidebook to Ghost Ranch (central-northern New Mexico): New Mexico Geological Society, 25th Field Conference, p. 333-336.

Shomaker, J. W., and Whyte, M. R., 1977, Geological appraisal of deep coals, San Juan Basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 155, 39 p.

Torrey, S., ed., 1978, Coal ash utilization--fly ash, bottom ash, and slag, in Pollution Technology Review No. 48: Park Ridge, New Jersey, Noyes Data Corp., p. 308-318.

Wilson, R. W., and Jentgen, R. W., 1980, Coal test drilling in the De-na-zin Bisti area, San Juan County, New Mexico: U.S. Geological Survey Open-File Report 80-1289, 111 p.

Wood, G. H., Jr., Kehn, T. M., Carter, M. D., and Culbertson, W. D., 1983, Coal resource classification system of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p.