UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

OPEN-FILE REPORT 80-032

1985

FEDERAL COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SAMSON LAKE 7 1/2-MINUTE QUADRANGLE, McKINLEY COUNTY, NEW MEXICO

[Report includes 13 plates (14 sheets)]

Prepared by Berge Exploration, Inc.

SAMSON LAKE QUADRANGLE

CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (Continued)

TABLES

INTRODUCTION

Purpose

This text complements the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Samson Lake 7 ½ minute quadrangle, McKinley County, New Mexico. These maps and report are part of an evaluation of fifty-six 7 ½ minute quadrangles in northwestern New Mexico which were completed under U. S. Geological Survey Contract No. 14-08-0001-17459 (see figs. 1 and 2).

The purpose of this Coal Resource Occurrence-Coal Development Potential program, which was conceived by Congress as part of its Federal Coal Leasing Amendments Act of 1976, is to obtain coal resource information and to determine the geographical extent of Federal coal deposits. In addition, the program is intended to provide information on the amount of coal recoverable by various mining methods and to serve as a guide for land-use planning.

The U. S. Geological Survey initiated the program by identifying areas underlain by coal resources. These areas were designated Known Recoverable Coal Resource Areas based on the presence of minable coal thicknesses, adequate areal extent of these coal deposits, and the potential for developing commercial quantities of coal at minable depths.

This report is limited to coal resources which are 3,000 ft (914 m) or less below ground surface. Published and unpublished public information was used as the data base for this study. No new drilling or field mapping was performed as part of this study, nor were any confidential data used.

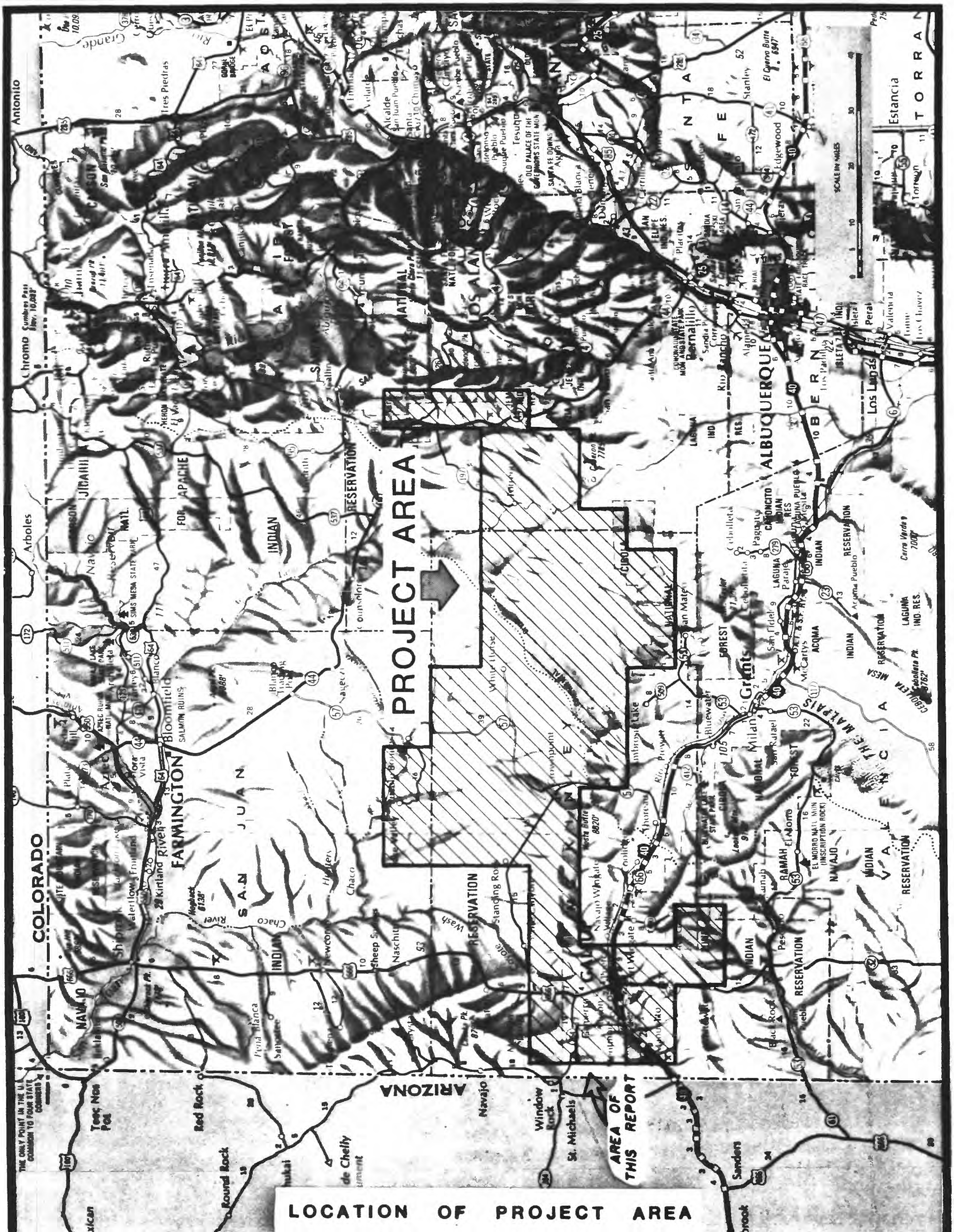
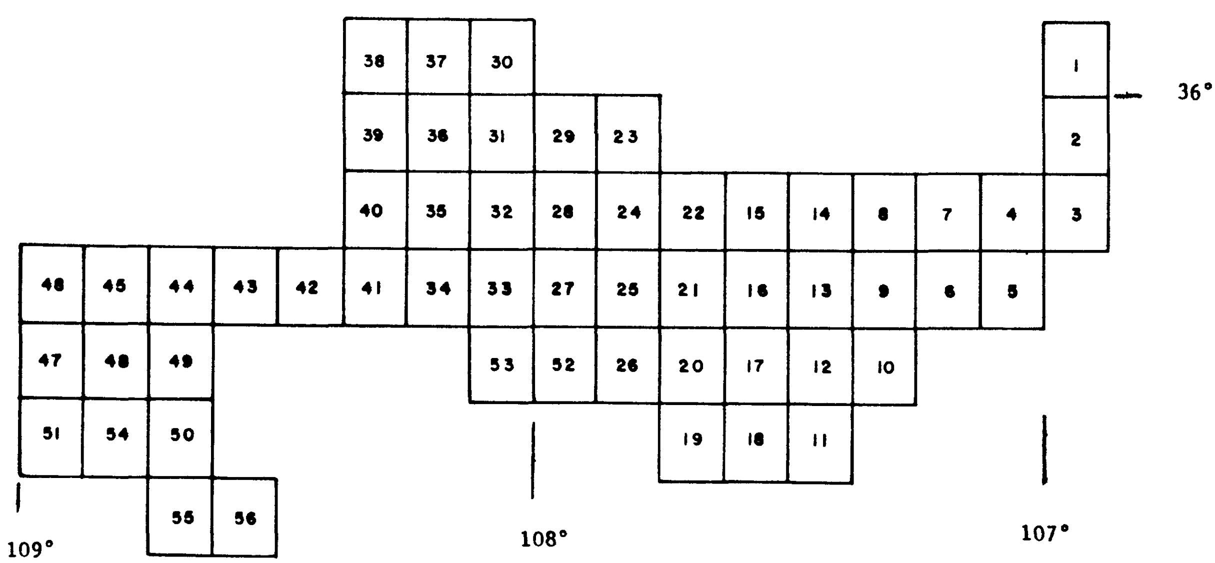

PROJECT AREA
AREA OF THIS REPORT
LOCATION OF PROJECT AREA
COLORADO
ARIZONA
FARMINGTON
ALBUQUERQUE
Grants
Bloomfield
Los Lunas
Estancia

FIGURE 1

FIGURE 2.--Index to USGS 7 1/2-minute quadrangles and coal resource occurrence/ coal development potential maps for the southern San Juan Basin area, New Mexico

Map No.	Quadrangle	Open-file report	Map No.	Quadrangle	Open-file report
1	Cuba	79- 623	31	Nose Rock	79- 641
2	San Pablo	79- 624	32	Becenti Lake	79-1124
3	La Ventana	79-1038	33	Heart Rock	79- 642
4	Headcut Reservoir	79-1043	34	Crownpoint	79-1125
5	San Luis	79-1044	35	Antelope Lookout Mesa	79-1376
6	Arroyo Empedrado	79-1045	36	Milk Lake	79-1377
7	Wolf Stand	79-1046	37	La Vida Mission	79-1378
8	Tinian	79- 625	38	The Pillar 3 SE	79-1379
9	Canada Calladita	79- 626	39	Red Lake Well	79-1380
10	Cerro Parido	79- 627	40	Standing Rock	79-1381
11	El Dado Mesa	79- 628	41	Dalton Pass	80- 026
12	Mesa Cortada	79- 629	42	Oak Spring	80- 027
13	Mesita del Gavilan	79- 630	43	Hard Ground Flats	80- 028
14	Rincon Marquez	79- 631	44	Big Rock Hill	80- 029
15	Whitehorse Rincon	79- 632	45	Twin Lakes	80- 030
16	Mesita Americana	79- 633	46	Tse Bonita School	80- 031
17	El Dado	79- 634	47	Samson Lake	80- 032
18	Cerro Alesna	79- 635	48	Gallup West	80- 033
19	San Lucas Dam	79- 636	49	Gallup East	80- 034
20	Piedra de la Aguila	79-1039	50	Bread Springs	80- 035
21	Hospah	79- 637	51	Manuelito	80- 036
22	Whitehorse	79-1040	52	Borrego Pass	80- 037
23	Seven Lakes NE	79- 638	53	Casamero Lake	80- 038
24	Kin Nahzin Ruins	79- 639	54	Twin Buttes	80- 039
25	Orphan Annie Rock	79-1041	55	Pinehaven	80- 040
26	Mesa de los Toros	79-1122	56	Upper Nutria	80- 041
27	Laguna Castillo	79- 640			
28	Seven Lakes	79-1042			
29	Seven Lakes NW	79-1123			
30	Kin Klizhin Ruins	79-1047			



Location

The Samson Lake 7½ minute quadrangle includes acreage in Tps. 15 and 16 N., Rs. 19 and 20 W. of the New Mexico Principal Meridian, McKinley County, northwestern New Mexico (see figs. 1 and 2).

Accessibility

U. S. Highway 68 (Highway 264 on fig. 1) passes through the extreme northern part of the Samson Lake quadrangle and provides access to U. S. Highway 666, 9 mi (14 km) northeast, and to the town of Window Rock, Arizona, 8 mi (13 km) northwest of the quadrangle. Light-duty maintained and unimproved dirt roads traverse most parts of the area. A spur line of the Atchison, Topeka, and Santa Fe Railroad line passes through the northern part of the quadrangle which provides railway services to Pittsburg and Midway's McKinley surface coal mine. The main line of the Atchison, Topeka, and Santa Fe Railroad passes through the southeast corner of the Samson Lake quadrangle (see fig. 1).

Physiography

The Samson Lake quadrangle is in the Navajo section of the southernmost part of the Colorado Plateau physiographic province (U. S. Geological Survey, 1965). The topography of the area is characterized by eroded mesas, alluvial valley floors, and rugged badlands. Torrivio Mesa is a prominent land form in the southeastern part of the quadrangle.

No perennial streams are present in the quadrangle. Local drainage is provided by the Puerco River and several intermittent arroyos. Samson Lake covers about 40 acres (16 ha) near the eastern quadrangle boundary. Elevations within the quadrangle range from less than 6,340 ft (1,932 m) in the southeast to 7,088 ft (2,160 m) in the northwest.

Climate

The climate of this area is semiarid to arid. The following temperature and precipitation data were reported by the National Oceanic and Atmospheric Administration for the Gallup 5E Station. The Samson Lake quadrangle is about 8 mi (13 km) W of the Gallup 5E Station. Average total annual precipitation for eleven of the previous fifteen years is 9.53 in. (24.21 cm). Intense thunderstorms in July, August, and September account for the majority of precipitation. The area is susceptible to flash flooding associated with these thunderstorms. Mean annual temperature for seven of the previous fifteen years is 48.8°F (9.3°C). The average daily temperatures in January and July are 29.0°F (-1.7°C) and 71.3°F (21.8°C), respectively.

Land status

The Federal Government holds coal rights to approximately 60 percent of the Samson Lake quadrangle. For the specific coal ownership boundaries, see plate 2. It is not within the scope of this report to provide detailed land-surface ownership. Most of the quadrangle is within the Gallup Known

Recoverable Coal Resource Area. About 2,800 acres (1,133 ha) in the northern part of the quadrangle are Federal coal lands leased by the Pittsburg and Midway Coal Mining Company.

GENERAL GEOLOGY

Previous work

Early reports on the area include that of Sears (1925) who mapped coal outcrops in the area, and reported thicknesses of Dilco Coal Member and the Gallup Sandstone coal beds along the eastern edge of the Samson Lake quadrangle. Dobbin (1932) mapped most of the quadrangle and reported numerous coals of the Gallup Sandstone, and Dilco and Gibson Coal Members. Shomaker, Beaumont, and Kottlowski (1971) estimated coal reserves of 250 million short tons (227 million t) within 10 to 150 ft (3 to 46 m) of the surface and 180 million short tons (163 million) from 150 to 250 ft (46 to 76 m) below the surface for a five township area which includes T. 16 N., R. 20 W. Portions of this area are within the Samson Lake quadrangle. They reported isolated areas of strippable coals from the Gallup Sandstone and Dilco and Gibson Coal Members. They also mentioned numerous deeply buried coals in the quadrangle but did not describe them further.

Stratigraphy

Within the San Juan Basin, the shoreline positions of the Cretaceous seaways changed innumerable times. The overall regional alignment of the shorelines trended N. 60° W. - S. 60° E. (Sears, Hunt, and Hendricks, 1941).

The transgressive and regressive shoreline migrations are evidenced by the intertonguing relationships of continental and marine facies. Rates of trough (geosynclinal) subsidence and availability of sediment supplies are the major factors that controlled the transgressive-regressive shoreline sequences.

Exposed rock units in the Samson Lake quadrangle include some of the sedimentary units of Upper Cretaceous age. There is Quaternary alluvium and terrace gravels along drainages in the area.

The "main body" of the Mancos Shale is stratigraphically the lowest exposed unit in the quadrangle and represents transgressive marine deposits. Light to dark gray, silty shales with interbedded brown, calcareous sandstones comprise the lithologies of the Mancos Shale. Thickness of the unit averages 550 ft (168 m) locally.

A major northeastward regression of the Cretaceous seaways followed, and resulted in deposition of the Gallup Sandstone in a beach or littoral environment. The Gallup Sandstone is composed of pink to gray, fine-to very coarse-grained, massive sandstone with interbedded gray shales, and coal beds. The unit averages 350 ft (107 m) thick locally. The Dilco Coal Member of the Crevasse Canyon Formation overlies the Gallup Sandstone and represents the continental sediments which were deposited inland from the beach area during deposition of the Gallup Sandstone. Medium to dark gray siltstone with interbedded medium-grained, tan sandstones, and coal beds comprise the lithologies of the Dilco Coal Member, which averages 250 ft (76 m) thick in the area.

Approximately 250 ft (76 m) of the Bartlett Barren Member overlies the Dilco Coal Member in this area. Yellowish-brown to olive-gray siltstone, light gray shales, white to brown locally calcareous sandstones, and thin local coal beds comprise the lithologies of the Bartlett Barren Member which represents flood plain deposits. The Crevasse Canyon Gibson-Menefee Cleary undifferentiated unit overlies the Bartlett Barren Member, and was combined based on similar lithologies and stratigraphic continuity representing essentially continuous continental deposition. Light to medium gray, carbonaceous siltstone with interbedded gray to tan sandstones, gray shales, and coal beds comprise the lithologies of the Crevasse Canyon Gibson-Menefee Cleary unit, which averages 540 ft (165 m) thick in this area.

Depositional environments

The Cretaceous System sedimentary units in the quadrangle represent transgressive and regressive depositional conditions. There were innumerable minor cycles of widely varying duration and extent within the major sedimentary sequences. The paucity of data in this quadrangle and the intended scope of this report permit only general interpretations of the depositional environments.

The Cretaceous coal deposits of the San Juan Basin are products of former coastal swamps and marshes. These swamps and marshes were supported by heavy precipitation and a climate conducive to rapid vegetal growth in moderately fresh water. Due to the relatively low sulfur contents of the San Juan Basin coals, Shomaker and Whyte (1977) suggest the coals formed in fresh water environments.

Most of the coal-bearing units were deposited in coastal plain environments. The majority of the peat deposits formed in a transition zone between lower and upper deltaic sediments during periods of relative shoreline stability. Coals also formed in lake margin swamps inland from the coastal area. Shoreline oscillations and the subsequent influx of continental or marine debris upon the peat accumulations produced the vertical buildup or "stacking" of peat deposits. This sediment debris is represented by variable ash contents, rock partings, and splits within the coal seams.

The peat accumulated in lenses or pods which were generally parallel to the ancient shorelines. The coals in the lower portions of the coal-bearing units represent regressive depositional conditions (Sears, Hunt, and Hendricks, 1941). The coals in the upper portions of these units are relatively sporodic in occurrence.

Structure

The Samson Lake quadrangle is in the Gallup Sag structural division in the southwestern portion of the structural depression known as the San Juan Basin (Kelley, 1950). The Torrivio Anticline and Syncline are present in the southeastern part of the quadrangle (Hackman and Olson, 1977). Hackman and Olson (1977) reported three low displacement faults in the eastern part of the area. Dips of the rock units range from 1^{o} to 4^{o} SE in the northern part of the area, and from 1^{o} NE to 14^{o} SW in the southern part of the quadrangle.

COAL GEOLOGY

In this quadrangle, the authors identified nine coal beds, three coal zones, and one local coal bed in an oil and gas well log and Sears'

(1925) and Dobbin's (1932) surface mapping. These coal beds and coal zones are here informally called the Gallup coal zone, Gallup No. 1 coal bed, Crevasse Canyon Dilco No. 2 coal bed, Crevasse Canyon Dilco coal zone, Crevasse Canyon Dilco No. 4, No. 7, and No. 8 coal beds, Local coal bed, Crevasse Canyon Gibson coal zone, and the Crevasse Canyon Gibson No. 5, No. 6, No. 7, and No. 8 coal beds.

Stratigraphically, the Gallup coal zone contains the lowest identified coal bed in the Samson Lake quadrangle. A single 3.0 ft (0.9 m) thick coal bed which occurs 88 ft (27 m) below the top of the Gallup Sandstone comprise the Gallup coal zone. The Gallup No. 1 coal bed occurs 75 ft (23 m) below the top of the Gallup Sandstone and is represented by 3.0 ft (0.9 m) of coal.

The Crevasse Canyon Dilco No. 2 coal bed is the lowest identified Dilco Coal Member bed. Thickness of the bed ranges from 1.0 to 3.5 ft (0.3 to 1.1 m) which occurs from 60 to 70 ft (18 to 21 m) above the top of the Gallup Sandstone in this quadrangle. Several coal beds which occur from 100 to 225 ft (30 to 69 m) above the top of the Gallup Sandstone comprise the Crevasse Canyon Dilco coal zone. These zone coals, as with all zone coals identified in this quadrangle, may be correlated for limited distances in portions of the area, but they lack sufficient continuity with poorly defined stratigraphic position and cannot be designated as persistent coal beds. The Crevasse Canyon Dilco No. 4, No. 7, and No. 8 coal beds occur 150 ft (46 m), 205 ft (62 m), and 245 ft (75 m) above the top of the Gallup Sandstone, respectively.

A local coal bed within the Bartlett Barren Member was identified in the oil and gas well log, occurring about 50 ft (15 m) below the top of the Bartlett Barren Member. The Crevasse Canyon Gibson coal zone contains up to three individual beds which occur from 40 to 185 ft (12 to 56 m) above the top of the Bartlett Barren Member. The Crevasse Canyon Gibson No. 5, No. 6, No. 7, and No. 8 coal beds are present 70 ft (21 m), 175 ft (53 m), 225 ft (69 m), and 265 ft (81 m) above the top of the Bartlett Barren Member. These coal beds, as with all numerically designated coal beds in this quadrangle, are inferred to be continuous, although they may be several individual coal beds that are stratigraphically equivalent.

A published coal quality analysis of Crevasse Canyon Gibson-Menefee Cleary coals from the McKinley mine in the northwestern part of the quadrangle has been reported by Shomaker, Beaumont, and Kottlowski (1971) and is shown in table 1 (sample 1). Three additional Gibson Coal Member mine samples from the abandoned Navajo No. 2 mine (Gibson No. 5 bed of Sears, 1925) sample 2, Heaton mine (Gibson No. 2 or Aztec bed of Sears, 1925) sample 3, and Navajo mine (Gibson No. 1 bed of Sears, 1925) sample 4, taken 6.5, 8.5, and 6.5 mi (10.5, 13.7, and 10.5 km), respectively, east of the quadrangle have been reported by the U. S. Bureau of Mines (1936) and are shown in table 1. Rank of the Gibson Coal Member beds is probably high volatile C bituminous in this area.

There are no known published coal quality analyses for Dilco Coal Member beds from the Samson Lake quadrangle. Analyses of Dilco Coal Member beds from the abandoned Otero mine (Otero bed of Sears, 1925) sample 1, Otero mine (Crownpoint bed of Sears, 1925) sample 2, and Dilco (Jones) mine (Dilco 1 or Defiance bed of Sears, 1925) sample 3, taken 8.8, 8.8, and 1.7 mi (14.2, 14.2, and 2.7 km), respectively, east of the quadrangle have been reported by the U. S. Bureau of Mines (1936) and are shown in table 2. The Dilco Coal Member beds analyzed are the author's Crevasse Canyon Dilco No. 4, No. 7, and No. 8 beds. Rank of the Dilco Coal Member beds is probably high volatile C bituminous in this area.

Table 1. - Analyses of coal samples from the Gibson Coal Member of the Crevasse Canyon Formation.

[Form of analysis: A, as received; B, moisture free; C, moisture and ash free]

Sample 1 from Shomaker, Beaumont, and Kottlowski, 1971

Samples 2, 3, and 4 from U. S. Bureau of Mines, 1936

Sample	Type of sample	Location Sec.	T. N.	R. W.	Form of analysis	Proximate analysis (percent) Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Heating value (Btu/lb)
1	tipple sample (McKinley mine)	(approximate) -	16	20	A	15.20	-	-	7.95	0.42	10,637
2	Composite mine sample (Navajo No. 2 mine)	SW¼ SE¼ 33	16	18	A	13.2	37.7	41.1	7.94	0.50	10,920
					B	-	43.5	47.4	9.15	0.58	12,580
					C	-	47.8	52.2	-	0.64	13,850
3	mine sample (Heaton mine)	NW¼ 35	16	18	A	15.2	38.2	42.1	4.50	0.41	11,070
					B	-	45.1	49.6	5.31	0.48	13,060
					C	-	47.6	52.4	-	0.51	13,790
4	mine sample (Navajo mine)	SE¼ 33	16	18	A	12.5	38.9	39.4	9.17	0.43	10,800
					B	-	44.4	45.1	10.49	0.49	12,350
					C	-	49.7	50.3	-	0.55	13,800

Remarks:
A moist, mineral-matter-free (MMMF) calculation using the Parr formula (American Society for Testing and Materials, 1973) yields heating values of 11,643 Btu/lb (27,082 kJ/kg; sample 1), 11,947 Btu/lb (27,789 kJ/kg; sample 2), 11,641 Btu/lb (27,077 kJ/kg; sample 3) and 11,995 Btu/lb (27,900 kJ/kg; sample 4). No agglomerating characteristics were included with the analyses.

Table 2. - Analyses of coal samples from the Dilco Coal Member of the Crevasse Canyon Formation.

[Form of analysis: A, as received; B, moisture free; C, moisture and ash free]

from U. S. Bureau of Mines, 1936

Sample	Type of sample	Location Sec.	T. N.	R. W.	Form of analysis	Proximate analysis (percent) Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Heating value (Btu/lb)
1	mine sample (Caretto mine)	NW¼ 14	15	18	A	10.6	40.6	44.4	4.40	0.59	12,100
					B	-	45.4	49.7	4.92	0.66	13,530
					C	-	47.7	52.3	-	0.69	14,230
2	mine sample (Otero mine)	NW¼ 14	15	18	A	9.1	40.8	40.2	9.9	1.27	-
					B	-	44.9	44.3	10.9	1.40	-
					C	-	50.3	49.7	-	1.57	-
3	mine sample (Dilco-Jones mine)	NW¼ 22	15	19	A	15.4	38.2	41.3	5.11	0.92	11,130
					B	-	45.1	48.9	6.04	1.09	13,160
					C	-	48.0	52.0	-	1.16	14,000

Remarks:
A moist, mineral-matter-free (MMMF) calculation using the Parr formula (American Society for Testing and Materials, 1973) yields heating values of 12,716 Btu/lb (29,577 kJ/kg; sample 1) and 11,795 Btu/lb (27,435 kJ/kg; sample 3). No agglomerating characteristics were included with the analyses.

Crevasse Canyon Gibson No. 8 coal bed

The Crevasse Canyon Gibson No. 8 coal bed was identified in seven outcrop measurements by Dobbin (1932). Thickness of the bed ranges from 1.0 to 6.5 ft (0.3 to 2.0 m). Because of limited coal bed measurements, the isopach, structure contour, and overburden isopach maps are included in this text as page-sized maps (figs. 3, 4, and 5). The mine sample from the Navajo mine (sample 4, table 1) is from the same coal bed as the author's Crevasse Canyon Gibson No. 8 coal bed.

Crevasse Canyon Gibson No. 7 coal bed

The Crevasse Canyon Gibson No. 7 coal bed was identified in seven outcrop measurements by Dobbin (1932). Thickness of the bed ranges from 1.0 to 5.5 ft (0.3 to 1.7 m). Because of limited data, the isopach, structure contour, and overburden isopach maps are included in this text as page-sized maps (figs. 6, 7, and 8). The bed is inferred to pinch out a short distance down dip from the outcrop (see figs. 6 and 7). The mine sample from the Heaton mine (sample 3, table 1) is from the same coal bed as the author's Crevasse Canyon Gibson No. 7 coal bed.

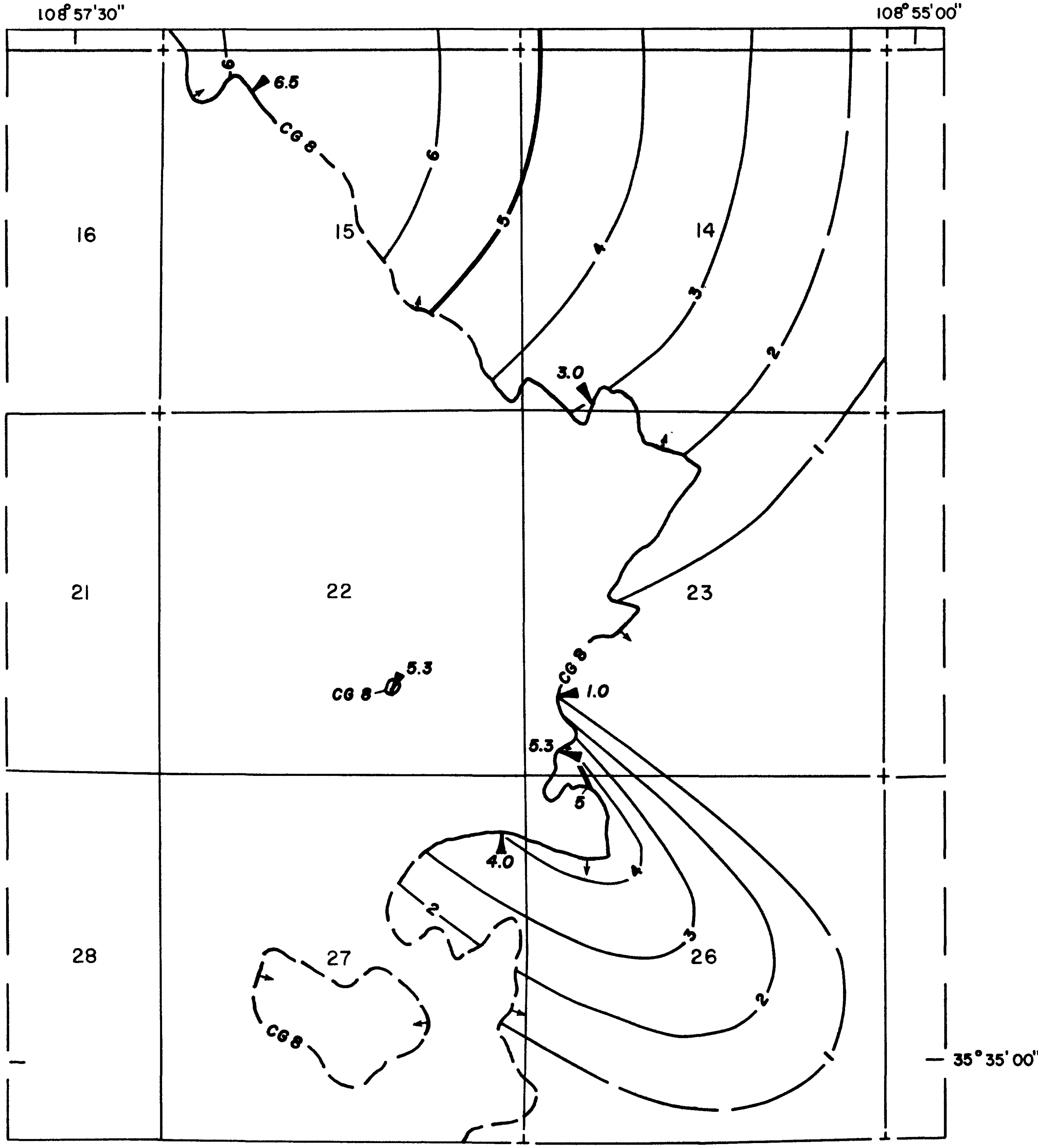
Crevasse Canyon Gibson No. 5 coal bed

The Crevasse Canyon Gibson No. 5 coal bed was identified in twelve outcrop measurements by Dobbin (1932). Thickness of the bed ranges from 0.8 to 7.7 ft (0.2 to 2.3 m). The bed crops out in the central and northern parts of the quadrangle. Existence and character of the bed are unknown in the northeastern part of the quadrangle because of insufficient data. The mine sample from the Navajo No. 2 mine (sample 2, table 1) is from the same coal bed as the author's Crevasse Canyon Gibson No. 5 coal bed.

Figure 3

ISOPACH MAP OF THE CREVASSE CANYON GIBSON NO.8 COAL BED

(See explanation p. 18)



SCALE 1:24,000

Figure 4

STRUCTURE CONTOUR MAP OF THE CREVASSE CANYON GIBSON NO.8 COAL BED

(See explanation p. 18)

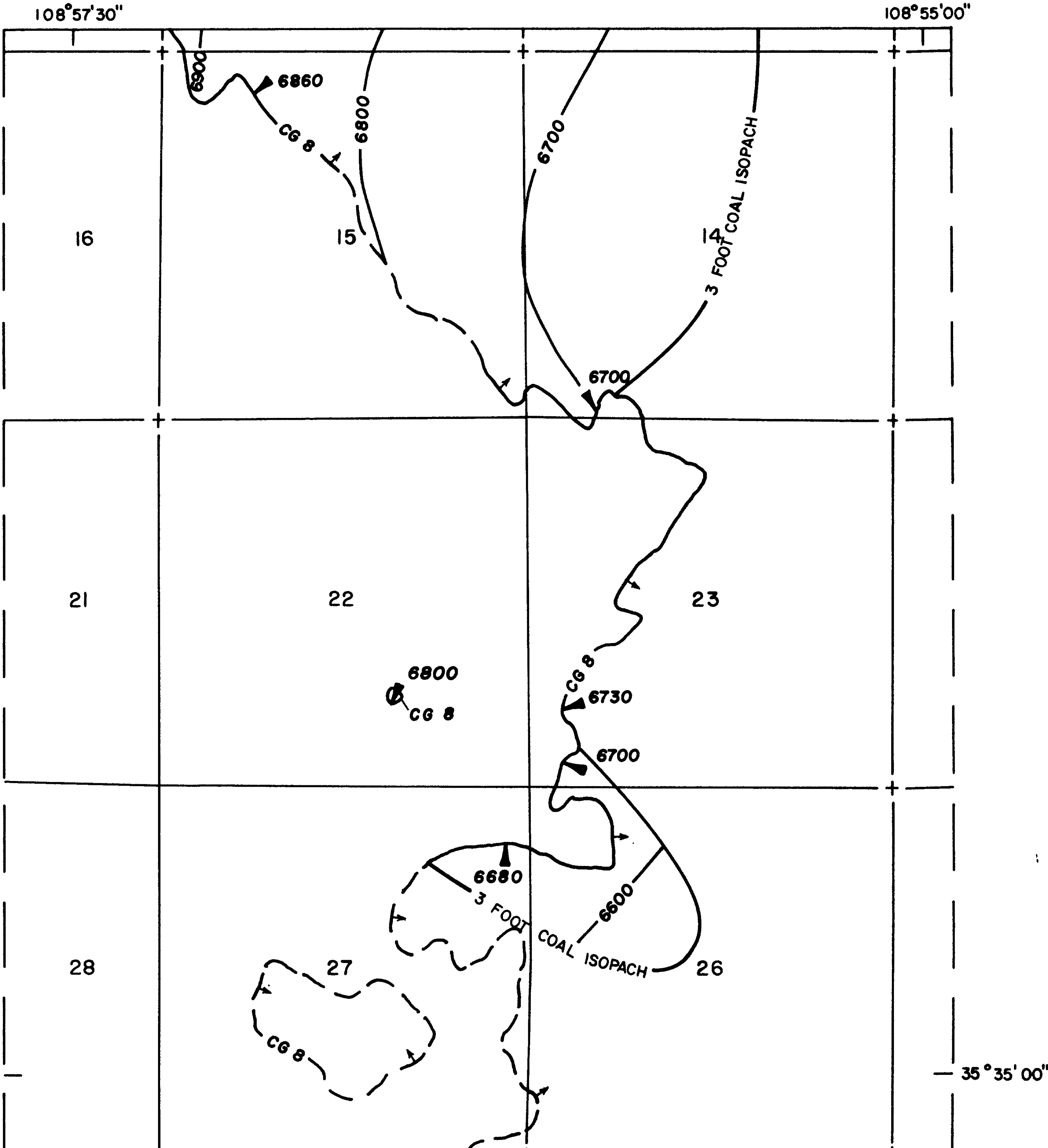


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Figure 5

ISOPACH MAP OF OVERBURDEN OF THE CREVASSE CANYON GIBSON NO.8 COAL BED

(See explanation p. 18)

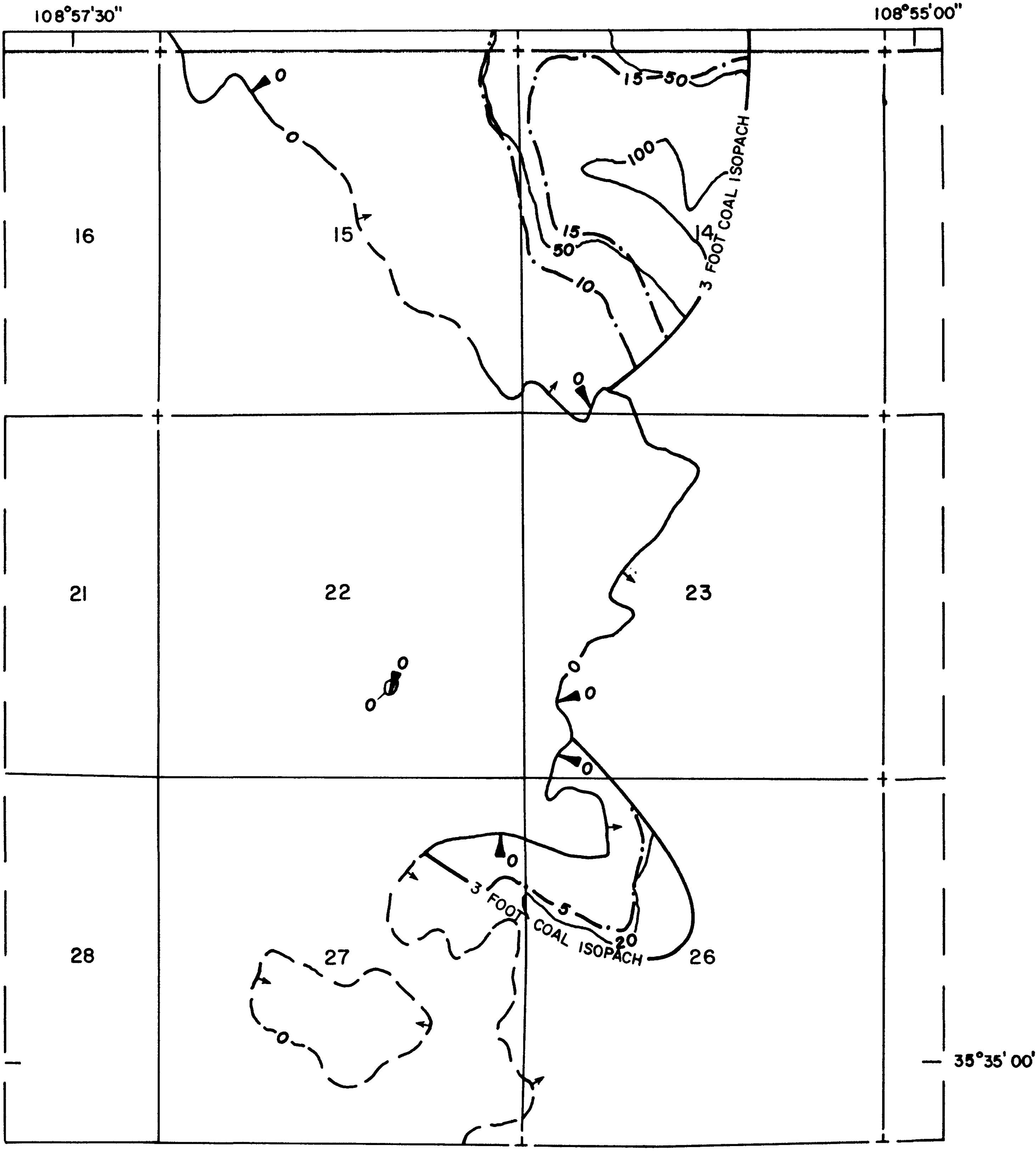

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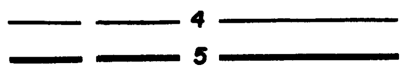
Figure 3

EXPLANATION



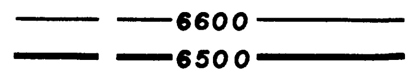
ISOPACHS OF THE CREVASSE CANYON GIBSON NO. 8 COAL BED-Showing thickness in feet. Isopach interval 1 foot (0.3 meter). Isopachs dashed where inferred.

TRACE OF COAL BED OUTCROP-Showing coal thickness, in feet, measured at triangle. Arrow points toward the coal-bearing area. Dashed line indicates inferred outcrop.

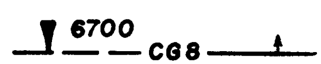
To convert feet to meters, multiply feet by 0.3048.

Figure 4

EXPLANATION



STRUCTURE CONTOURS-Drawn on top of the Crevasse Canyon Gibson No. 8 coal bed. Contour interval 100 feet (30.5 meters). Datum is mean sea level.



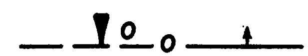
TRACE OF COAL BED OUTCROP-Showing altitude, in feet, measured at triangle. Arrow points toward the coal-bearing area. Dashed line indicates inferred outcrop.

To convert feet to meters, multiply feet by 0.3048.

Figure 5

EXPLANATION

OVERBURDEN ISOPACHS-Showing thickness of overburden, in feet, from the surface to the top of the Crevasse Canyon Gibson No. 8 coal bed. Isopach interval 50 feet (15.2 meters) with supplemental 20 ft (6.1 meter) isopach. Stripping limit is 200 feet (61 meters).



TRACE OF COAL BED OUTCROP-Showing no overburden at triangle. Arrow points toward the coal-bearing area. Dashed line indicates inferred outcrop.

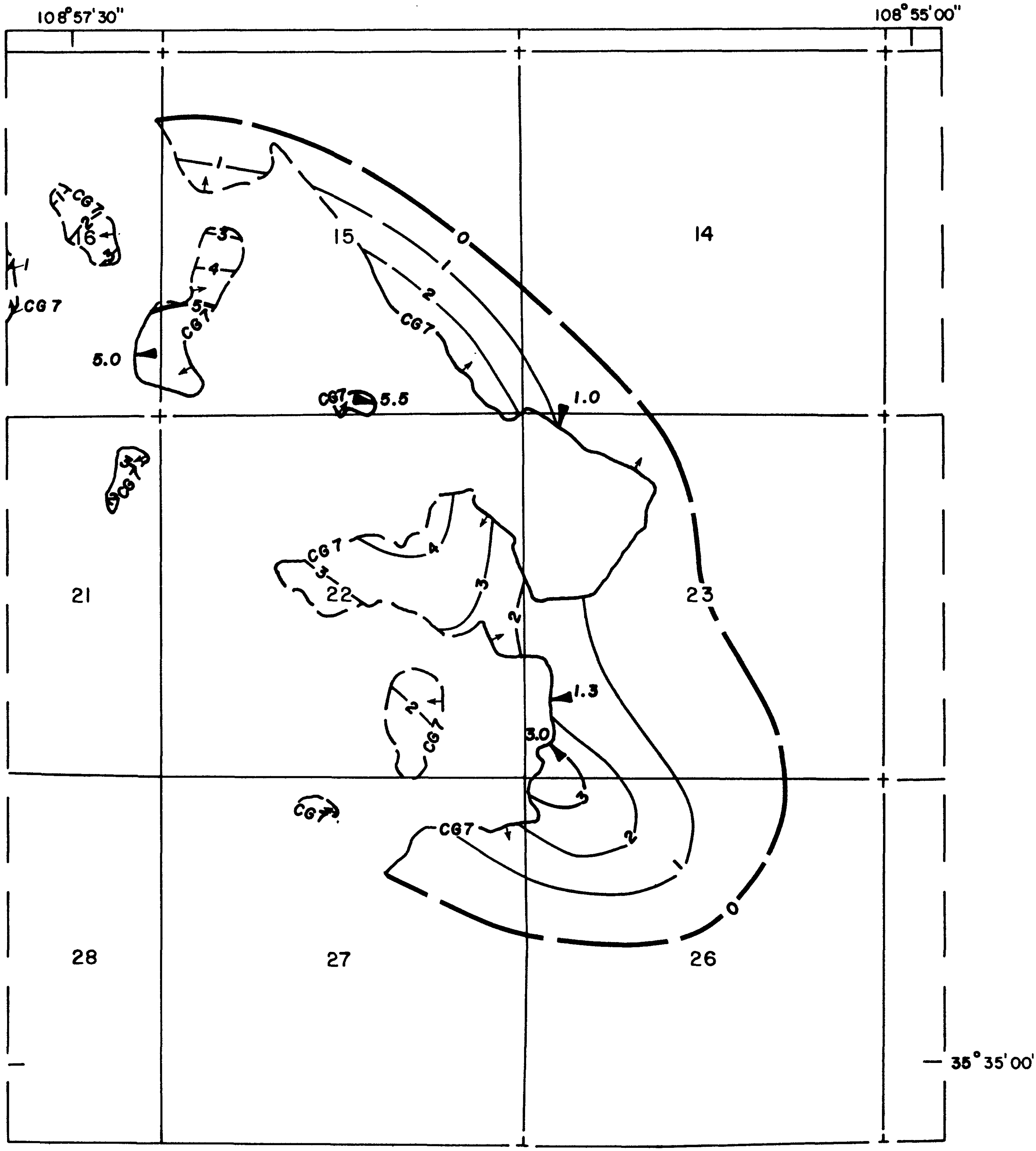
MINING RATIO CONTOUR FOR THE CREVASSE CANYON GIBSON NO. 8 COAL BED-Number indicates cubic yards of overburden per ton of recoverable coal by surface-mining methods. Contours shown only in areas suitable for surface mining within the stripping limit, less than 200 feet (61 meters) of overburden. Supplemental 5 mining ratio line included where necessary.

To convert feet to meters, multiply feet by 0.3048.

Figure 6

ISOPACH MAP OF THE CREVASSE CANYON GIBSON NO.7 COAL BED

(See explanation p. 22)

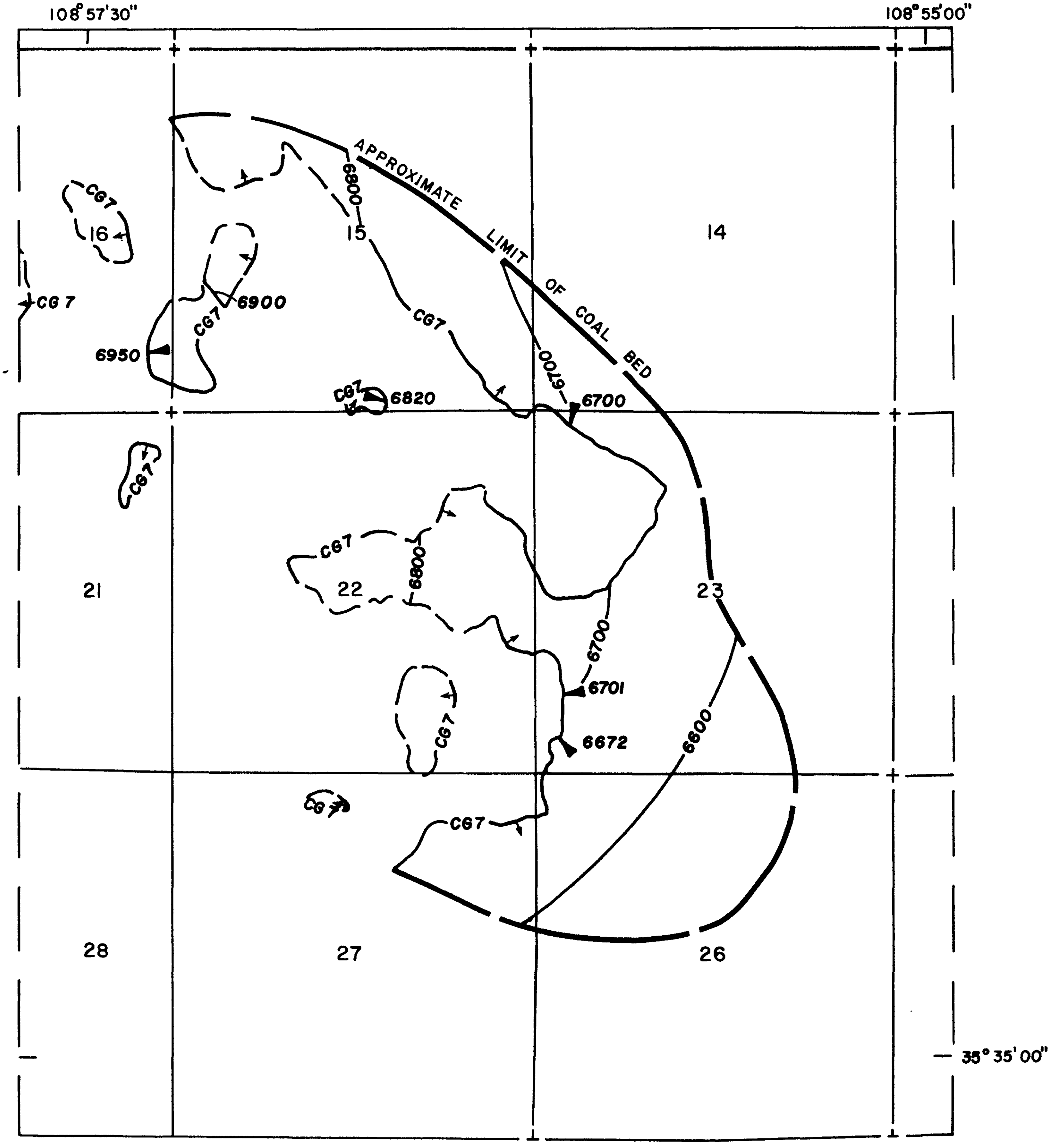


SCALE 1:24,000

Figure 7

STRUCTURE CONTOUR MAP OF THE CREVASSE CANYON GIBSON NO.7 COAL BED

(See explanation p. 22)

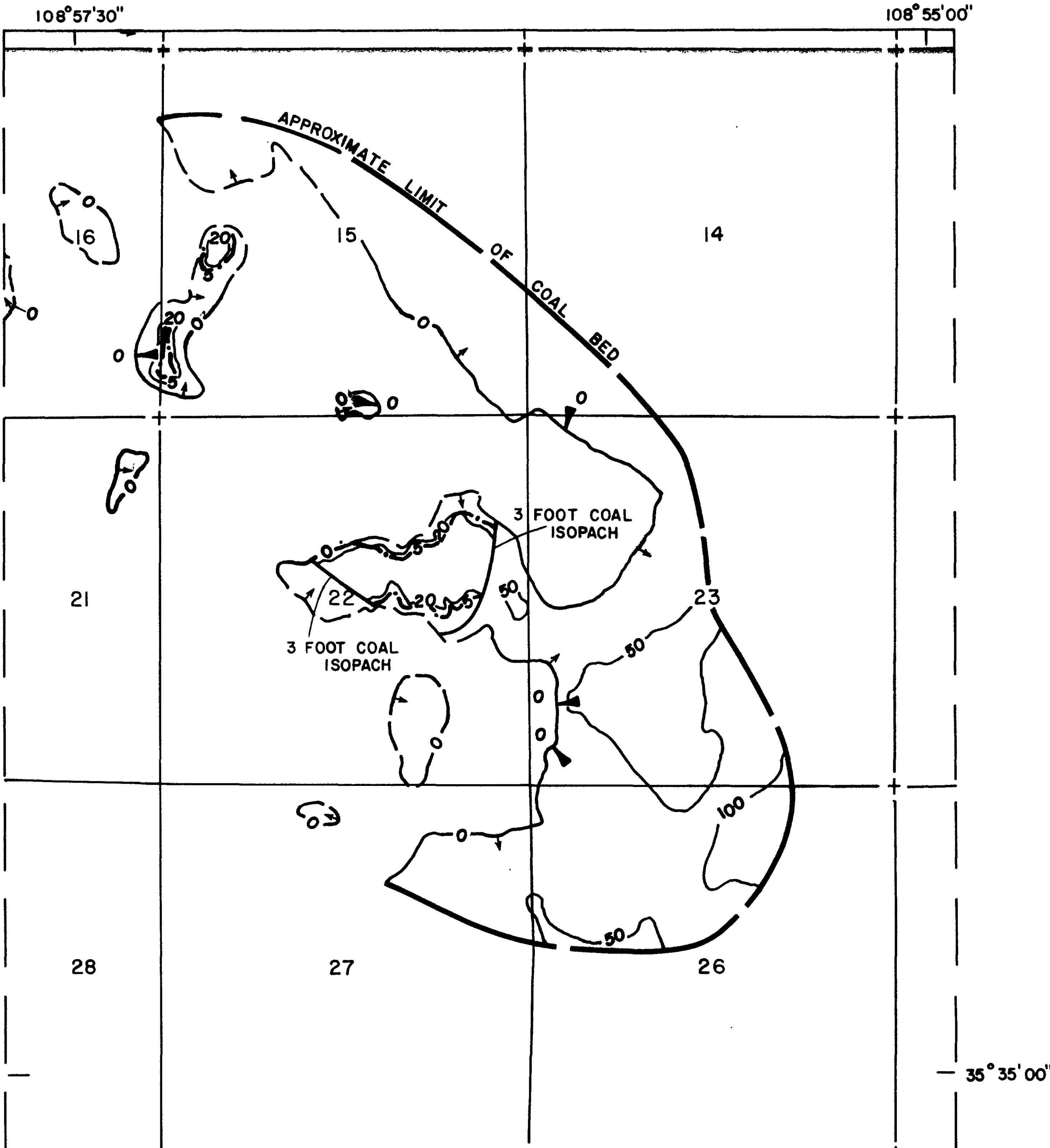


SCALE 1:24,000

Figure 8

ISOPACH MAP OF OVERBURDEN OF THE CREVASSE CANYON GIBSON NO.7 COAL BED

(See explanation p. 22)



SCALE 1:24,000

Figure 6

EXPLANATION

4

5

ISOPACHS OF THE CREVASSE CANYON GIBSON NO. 7 COAL BED-Showing thickness in feet. Isopach interval 1 foot (0.3 meter). Isopachs dashed where inferred.

3.0 CG 7

TRACE OF COAL BED OUTCROP-Showing coal thickness, in feet, measured at triangle. Arrow points toward the coal-bearing area. Dashed line indicates inferred outcrop.

To convert feet to meters, multiply feet by 0.3048.

Figure 7

EXPLANATION

6600

STRUCTURE CONTOURS-Drawn on top of the Crevasse Canyon-Gibson No. 7 coal bed. Contour interval 100 feet (30.5 meters). Datum is mean sea level.

6820 CG 7

TRACE OF COAL BED OUTCROP-Showing altitude, in feet, measured at triangle. Arrow points toward the coal-bearing area. Dashed line indicates inferred outcrop.

To convert feet to meters, multiply feet by 0.3048.

Figure 8

EXPLANATION

20

OVERBURDEN ISOPACHS-Showing thickness of overburden, in feet, from the surface to the top of the Crevasse Canyon Gibson No. 7 coal bed. Isopach interval 50 feet (15.2 meters) with supplemental 20 foot (6.1 meter) isopach. Stripping limit is 200 feet (61 meters).

0 0

TRACE OF COAL BED OUTCROP-Showing no overburden at triangle. Arrow points toward the coal-bearing area. Dashed line indicates inferred outcrop.

5

MINING RATIO CONTOUR FOR THE CREVASSE CANYON GIBSON NO. 7 COAL BED-Number indicates cubic yards of overburden per ton of recoverable coal by surface-mining methods. Contours shown only in areas suitable for surface mining within the stripping limit, less than 200 feet (61 meters) of overburden. Supplemental 5 mining ratio line included where necessary.

To convert feet to meters, multiply feet by 0.3048.

Crevasse Canyon Dilco No. 8 coal bed

The Crevasse Canyon Dilco No. 8 coal bed was identified in the oil and gas well log and ten outcrop measurements by Sears (1925) and Dobbin (1932). Thickness of the bed ranges from 1.0 to 7.3 ft (0.3 to 2.2 m). The bed crops out over most of the southern part of the quadrangle, and is displaced a short distance by a fault (see plate 7). Existence and character of the Crevasse Canyon Dilco No. 8 coal bed are unknown in the central and central northern parts of the quadrangle because of insufficient data. The mine sample from the Dilco (Jones) mine (sample 3, table 2) is from the same bed as the author's Crevasse Canyon Dilco No. 8 coal bed.

COAL RESOURCES

The U. S. Geological Survey requested resource evaluations of the Crevasse Canyon Gibson No. 5 coal bed and the Crevasse Canyon Dilco No. 8 coal bed where the beds are 3.0 ft (0.9 m) or more thick. The evaluation is restricted to Federal coal lands.

The following procedures were prescribed by the U. S. Geological Survey for the calculation of reserve base. Criteria established in U. S. Geological Survey Bulletin 1450-B were used to areally divide the beds into measured, indicated, and inferred reserve base categories. Reserve base was calculated for each category, by section, using data from the isopach and overburden maps (plates 4, 6, 7, and 9). The acreage in each category (measured by planimeter) multiplied by the average coal bed thickness and a bituminous coal conversion factor (1,800 tons of coal per acre-ft) yields the reserve base for that category. Coal beds with 3.0 ft (0.9 m) minimum thickness are included in reserve base and reserve data rather than the 28 in. (71 cm) minimum thickness prescribed in U. S. Geological Survey Bulletin 1450-B. Reserve figures are derived from reserve base totals by applying recovery factors of 85 percent and 50 percent for coal beds 0 to 200 ft (0 to 61 m) and 200 to 3,000 ft (61 to 914 in) deep, respectively. All reserve base and reserve values are rounded to the nearest 10,000 short tons (9,072 t).

Total reserve base data, which include all reserve base categories, are shown by section on plate 2. Reserve base and reserve data in the various categories are shown on plates 10 and 11.

COAL DEVELOPMENT POTENTIAL

The factors used to determine the development potential are the presence of a potentially coal bearing formation, and the thickness and overburden of correlative coal beds. The U. S. Geological Survey supplied the criteria to evaluate the coal development potential for Federal lands in this quadrangle. These criteria are based on current industry practice, U. S. Geological Survey Bulletin 1450-B, and anticipated technological advances. All available data were utilized for the surface and subsurface coal development potential evaluations.

Any area underlain by a potentially coal-bearing formation with 200 ft (61 m) or less of overburden has potential for surface mining. The U. S. Geological Survey designated the 200 ft (61 m) maximum depth as the stripping limit. Areas where a potentially coal-bearing formation is overlain by more than 200 ft (61 m) of overburden have no potential for surface mining. Areas with no correlative coal bed or a correlative coal bed less than 3.0 ft (0.9 m) in thickness and overlain by 200 ft (61 m) or less of overburden have unknown surface mining potential. Areas which have a correlative coal bed 3.0 ft (0.9 m) or more thick with surface mining potential are assigned a high, moderate or low development potential based on the mining ratio (cubic yards of overburden per short ton of recoverable coal). The formula used to calculate mining ratios is:

$$MR = \frac{t_o\,(C)}{t_c\,(Rf)}$$

Where MR= Mining ratio
t_o= Thickness of overburden in feet
t_c= Thickness of coal in feet
Rf= Recovery factor
C = Volume-weight conversion factor
(.896 yd^3/short ton for bituminous coal)
(.911 yd^3/short ton for subbituminous coal)

High, moderate, and low development potential areas have respective surface mining ratio values of 0 to 10, 10 to 15, and greater than 15.

Any area underlain by a potentially coal-bearing formation with 200 to 3,000 ft (61 to 914 m) of overburden has potential for subsurface mining. Areas where a potentially coal-bearing formation is overlain by more than 3,000 ft (914 m) of overburden have no subsurface mining potential. Development potential for subsurface mining is unknown where a potentially coal-bearing formation within 200 to 3,000 ft (61 to 914 m) of the surface contains no identified correlative coal bed or a correlative coal bed less than 3.0 ft (0.9 m) thick. High, moderate, and low development potential areas have respective overburden values of 200 to 1,000 ft (61 to 305 m), 1,000 to 2,000 ft (305 to 610 m), and 2,000 to 3,000 ft (610 to 914 m).

The no and unknown development potential boundaries for surface and subsurface mining methods (plates 12 and 13) are defined at the contact of the potentially coal-bearing Gallup Sandstone and the underlying noncoal-bearing Mancos Shale. These contacts are approximated due to the inaccuracies of adjusting old geologic maps to modern topographic bases.

Boundaries of coal development potential areas coincide with the boundaries of the smallest legal land subdivision (40 acres or lot). When a land subdivision contains areas with different development potentials, the potential shown on the map is that of the areally largest component area. When an area is underlain by more than one bed, the potential shown on the map is that of the bed with the highest potential.

Reserve base (in short tons) in the various development potential categories for surface and subsurface mining methods are shown in tables 3 and 4, respectively.

The coal development potential maps are subject to revision. Map boundary lines and reserve base values are based on coal resource occurrence map isopachs, overburden isopachs, and coal bed correlations that are interpretive and subject to change as additional coal information becomes available.

Development potential for surface mining methods

The coal development potential for surface mining methods in the Samson Lake quadrangle is shown on plate 12. Based on coal development potential criteria, all Federal coal lands in the Samson Lake quadrangle have high, moderate, low, unknown or no surface mining potentials. Refer to table 5 for reserves and planimetered acreage, by section, for Federal coal lands with surface mining potential.

Development potential for subsurface mining methods and in situ gasification

The coal development potential for subsurface mining methods in the Samson Lake quadrangle is shown on plate 13. Based on coal development criteria, all Federal coal lands in the Samson Lake quadrangle have high, unknown or no subsurface mining potentials. Refer to table 6 for reserves and planimetered acreage, by section, for Federal coal lands with subsurface mining potential.

In situ gasification of coal has not been done on a commercial scale in the United States and criteria for rating the development potential of this method are unknown.

Table 3.- Reserve base data (in short tons) for surface mining methods for Federal coal lands in the Samson Lake quadrangle, McKinley County, New Mexico.

[Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tonnes, multiply by 0.9072; to convert mining ratios in yds^3/ton coal to m^3/t, multiply by 0.842].

Coal Bed	High Development Potential (0-10 Mining Ratio)	Moderate Development Potential (10-15 Mining Ratio)	Low Development Potential (greater than 15 Mining Ratio)	Total
Crevasse Canyon Gibson No. 5	1,240,000	430,000	5,400,000	7,070,000
Crevasse Canyon Dilco No. 8	3,350,000	1,100,000	1,310,000	5,760,000
Total	4,590,000	1,530,000	6,710,000	12,830,000

Table 4.- Reserve base data (in short tons) for subsurface mining methods for Federal coal lands in the Samson Lake quadrangle, McKinley County, New Mexico.

[Development potentials are based on thickness of overburden. To convert short tons to metric tonnes, multiply by 0.9072].

Coal Bed	High Development Potential (200'-1,000' overburden)	Moderate Development Potential (1,000'-2,000' overburden)	Low Development Potential (2,000'-3,000' overburden)	Total
Crevasse Canyon Gibson No. 5	1,710,000	-	-	1,710,000
Total	1,710,000	-	-	1,710,000

Table 5.- Reserves and planimetered acreage, by section, for Federal coal lands in the Samson Lake quadrange with surface mining potential.

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes, multiply short tons by 0.9072].

Potential category	Coal bed	Sec.	T. N.	R. W.	Acres (planimetered)	Reserves (in short tons)
High	Crevasse Canyon Gibson No. 5	4	15	20	16.2	110,000
		3			10.6	50,000
		31	16	19	35.0	150,000
		28	16	20	86.1	720,000
	Crevasse Canyon Dilco No. 8	8	15	20	54.8	360,000
		15			54.7	350,000
		14			9.1	40,000
		6	15	19	44.1	270,000
		9	15	20	186.5	1,800,000
		10			2.0	less than 10,000
Moderate	Crevasse Canyon Gibson No. 5	4	15	20	13.5	80,000
		3			6.1	30,000
		28	16	20	25.6	170,000
		34			9.4	60,000
	Crevasse Canyon Dilco No. 8	6	15	19	28.8	170,000
		14	15	20	2.0	less than 10,000
		15			27.3	140,000
		8			7.6	40,000
		9			66.9	530,000
		10			1.0	less than 10,000
Low	Crevasse Canyon Gibson No. 5	4	15	20	75.5	440,000
		3			206.7	1,240,000
		28	16	20	24.2	140,000
		34			381.3	2,720,000
	Crevasse Canyon Dilco No. 8	6	15	19	56.3	310,000
		14	15	20	7.6	30,000
		15			63.8	380,000
		8			2.0	less than 10,000
		9			53.2	340,000
		10			1.5	less than 10,000

Table 6. - Reserves and planimetered acreage, by section, for Federal coal lands in the Samson Lake quadrangle with subsurface mining potential.

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes, multiply short tons by 0.9072].

Potential category	Coal bed	Sec.	T. N.	R. W.	Acres (planimetered)	Reserves (in short tons)
High	Crevasse Canyon	4	15	20	2.0	less than 10,000
	Gibson No. 5	3			155.1	500,000
		34	16	20	100.4	330,000

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#47

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GLOSSARY

coal bed--A stratified sequence of coal, composed of relatively homogeneous material, exhibiting some degree of lithologic unity and separated from the rocks above and below by physically rather well defined boundary planes.

coal bed separation line--A line on a map plate separating areas where different coal beds or zones are mapped.

coal bench--One of two or more divisions of a coal bed separated by rock.

coal conversion factor--A factor used to convert acre-feet of coal into short tons of coal; bituminous coal is 1800 tons/acre-ft; subbituminous coal is 1770 tons/acre-ft.

coal development potential--A subjective determination of the comparative potential of Federal coal lands for development of a commercially viable coal mining operation.

coal exploration license--An area of Federal coal lands in which the licensee is granted the right, after outlining the area and the probable methods of exploration, to investigate the coal resources. An exploration license has a term not to exceed 2 years and does not confer rights to a lease.

coal lease--An area of Federal coal lands in which the Federal Government has entered into a contractual agreement for development of the coal deposits.

coal split--A coal bed resulting from the occurrence of a noncoal parting within the parent coal bed which divides the single coal bed into two or more coal beds.

coal zone--A distinctive stratigraphic interval containing a sequence of alternating coal and noncoal layers in which the coal beds may so lack lateral persistence that correlating individual beds in the zone is not feasible.

Federal coal land--Land for which the Federal Government holds title to the coal mineral rights, without regard to surface ownership.

hypothetical resources--Undiscovered coal resources in beds that may reasonably be expected to exist in known mining districts under known geologic conditions. In general, hypothetical resources are in broad areas of coal fields where points of observation are absent and evidence is from distant outcrops, drill holes or wells. Exploration that confirms their presence and reveals quantity and quality will permit their reclassification as a Reserve or Identified Subeconomic Resource.

identified resources--Specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by engineering measurements.

indicated--Coal for which estimates for the rank, quality, and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections.

inferred--Coal in unexplored extensions of demonstrated resources for which estimates of the quality and quantity are based on geologic evidence and projections.

isopach--A line joining points of equal bed thickness.

Known Recoverable Coal Resource Area (KRCRA)--Formerly called Known Coal Leasing Area (KCLA). Area in which the Federal coal land is classified (1) as subject to the coal leasing provisions of the Mineral Leasing Act of 1920, as amended, and (2) by virtue of the available data being sufficient to permit evaluation as to extent, location, and potential for developing commercial quantities of coal.

measured--Coal for which estimates for rank, quality, and quantity can be computed, within a margin of error of less than 20 percent, from sample analyses and measurements from closely spaced and geologically well known sample sites.

mining ratio--A numerical ratio equating the in-place volumes, in cubic yards, of rocks that must be removed in order to recover 1 short ton of coal by surface mining.

overburden--A stratigraphic interval (composed of noncoal beds and coal beds) lying between the ground surface and the top of a coal bed. For coal zones, overburden is the stratigraphic interval lying between the ground surface and the structural datum used to map the zone.

parting--A noncoal layer occurring along a bedding plane within a coal bed.

Preference Right Lease Application (PRLA)--An area of Federal coal lands for which an application for a noncompetitive coal lease has been made as a result of exploration done under a coal prospecting permit. PRLA's are no longer obtainable.

quality or grade--Refers to measurements such as heat value; fixed carbon; moisture; ash; sulfur; phosphorus; major, minor, and trace elements; coking properties; petrologic properties; and particular organic constituents.

rank--The classification of coal relative to other coals, according to degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite (Classification of coals by rank, 1973, American Society for Testing and Materials, ASTM Designation D-388-66).

recovery factor--The percentage of total tons of coal estimated to be recoverable from a given area in relation to the total tonnage estimated to be in the Reserve Base in the ground.

reserve--That part of identified coal resource that can be economically mined at the time of determination. The reserve is derived by applying a recovery factor to that component of the identified coal resource designated as the reserve base.

reserve base--That part of identified coal resource from which Reserves are calculated.

stripping limit--A vertical depth, in feet, measured from the surface, reflecting the probable maximum, practical depth to which surface mining may be technologically feasible in the forseeable future. The rock interval, expressed in feet, above the stripping limit is the "strippable interval."

structure contour--A line joining points of equal elevation on a stratum or bed.