Geology of the Cooper Ridge NE Quadrangle, Sweetwater County, Wyoming

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1065-B

Geology of the Cooper Ridge NE Quadrangle, Sweetwater County, Wyoming

By HENRY W. ROEHLER

GEOLOGY OF THE SOUTHEAST PART OF THE
ROCK SPRINGS UPLIFT, WYOMING

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Stratigraphy, structure, and energy resources, including coal, gas, oil, and shale oil

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1979

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, *Secretary*

GEOLOGICAL SURVEY

H. William Menard, *Director*

Library of Congress Cataloging in Publication Data
Roehler, Henry W.
Geology of the Cooper Ridge NE quadrangle, Sweetwater County, Wyoming.
(Geology of the southeast part of the Rock Springs uplift, Wyoming)
(Geological Survey Professional Paper 1065-B)
Bibliography: p. 16
1. Geology—Wyoming—Rock Springs region. 2. Mines and mineral resources—Wyoming—Rock Springs region.
I. Title. II. Series. III. Series: United States Geological Survey Professional Paper 1065-B.
QE182.R63R64 557.87'85 78-606142

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402
Stock Number 024-001-03183-3

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[Plates are in pocket]

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ENGLISH-METRIC CONVERSION

[The metric system is not currently used to compute coal, oil, and gas resources in the United States]

English unit			Metric unit
Short ton	=	0.907	Metric tonne
Mile	=	1.609	Kilometers
Square mile	=	2.59	Square kilometers
Acre	=	.4047	Hectare
Foot	=	.3048	Meter
Cubic foot	=	.0283	Cubic meter
Btu	=	.252	Kilogram calorie

ABBREVIATIONS

Am. .... American
Assoc. .... association
A.P.I. .... American Petroleum Institute
avg. .... average
B .... bottom
bbl .... barrel
bbl/mi² .... barrel per square mile
Btu .... British thermal unit
Bull .... bulletin
Bur. .... bureau
C .... celcius
cf. .... compare
Chapt. .... chapter
Circ. .... circular
Co. .... Company
commun. .... communication
Conf. .... conference
cm .... centimeter
do .... ditto
E .... east
ed. .... edition
F .... fahrenheit
Fed. .... federal
fig. .... figure
Fm .... formation
ft .... foot
ft³ .... cubic foot
gal .... gallon
gal/ton .... gallon per ton
Geog. .... geographical
Geol. .... geological
in. .... inch
Inc. .... incorporated
Inv. .... investigation
Jour. .... journal
km .... kilometer
km² .... square kilometer
m .... meter
MCF .... thousand cubic feet
mi .... mile
mi² .... square mile
mtg. .... meeting
N. .... north
NE .... northeast
No. (no.) .... number
NW .... northwest
p. .... page
pl. .... plate
Proc. .... proceedings
Phil. .... philosophical
Prof. .... professional
ppm .... parts per million
pt. .... part
R. .... range
ref. .... reference
Rept. .... report
SE .... southeast
sec. .... section
Soc. .... society
sp. .... species not determined
SS .... sandstone
SW .... southwest
t .... tonne
T. .... township
T .... top
TD .... total depth
Terr. .... territories
U.S. .... United States
USGS .... U.S. Geological Survey
Vol. (v) .... volume
W. .... west
Wyo. .... Wyoming

GEOLOGY AND MINERAL RESOURCES OF THE COOPER RIDGE NE QUADRANGLE, SWEETWATER COUNTY, WYOMING

By Henry W. Roehler

ABSTRACT

The Cooper Ridge NE 7½-minute quadrangle is 18 miles southeast of Rock Springs, Wyo., on the east flank of the Rock Springs uplift. Upper Cretaceous rocks composing the Rock Springs Formation, Ericson Sandstone, Almond Formation, Lewis Shale, Fox Hills Sandstone, and Lance Formation, Paleocene rocks composing the Fort Union Formation, and Eocene rocks composing the Wasatch Formation are exposed and dip 5°—8° southeast. Outcrops are unfaulted and generally homoclinal, but a minor cross-trending fold, the Jackknife Spring anticline, plunges southeastward and interrupts the northeast strike of beds. Older rocks in the subsurface are faulted and folded, especially near the Brady oil and gas field.

Coal beds are present in the Almond, Lance, and Fort Union Formations. Coal resources are estimated to be more than 762 million short tons in 16 beds more than 2.5 feet thick, under less than 3,000 ft of overburden. Nearly 166 million tons are under less than 200 ft of overburden and are recoverable by strip mining. Unknown quantities of oil and gas are present in the Cretaceous Rock Springs, Blair, and Dakota Formations, Jurassic sandstone (Entrada Sandstone of drillers), Jurassic(?) and Triassic(?) Nugget Sandstone, Permian Park City Formation, and Pennsylvanian and Permian Weber Sandstone at the Brady field, part of which is in the southeast corner of the quadrangle, and in the Dakota Sandstone at the Prenalta Corp. Bluewater 33-32 well near the northern edge of the quadrangle. Other minerals include uranium in the Almond Formation and titanium in the Rock Springs Formation.

INTRODUCTION

LOCATION AND EXTENT OF AREA

The Cooper Ridge NE 7½-minute quadrangle is an area of slightly more than 56 mi², 18 mi southeast of the city of Rock Springs, Wyo. (fig. 1). The quadrangle area is accessible by an improved gravel road that branches eastward from Wyoming Highway 15 mi southeast of Rock Springs. The gravel road enters the quadrangle east of Wyoming Highway 430, and crosses the quadrangle in a southeast direction, along Black Butte Creek.

SCOPE OF REPORT AND FIELDWORK

Fieldwork began in mid-June 1974 and lasted until mid-September 1974. A geologic map (Roehler, 1977) was prepared to illustrate rock-stratigraphic relationships, delineate coal beds, and locate the other mineral deposits. Mapping was done by planetable and alidade, and on aerial photographs. The geologic map was compiled from aerial photographs using a Kern PG-2 stereographic plotter.

Composite measured sections and detailed lithologic descriptions of exposed rocks are included in the report. A stratigraphic cross section was compiled from nearly 80 surface sections and 13 auger holes. The section shows the stratigraphic position of 35 coal beds that range in thickness from 1 to more than 14 ft. One hundred seventy-five detailed sections show coal thicknesses, parting relationships, and the lithologies of rocks adjacent to coal beds. Fourteen maps show the geographic distribution and resource data for 16 coal beds that are more than 2.5 ft thick. Five channel samples of coal-bed outcrops were analyzed for heating value and sulfur content. The composition of 25 channel samples of coal-bed outcrops was determined by geochemical analysis.

Fossils were collected to determine the age and environments of deposition of stratigraphic units. The geographic location and stratigraphic position of fossil sites are shown on the geologic map and on the stratigraphic cross-section. Fossil faunal and floral lists are included.

PREVIOUS INVESTIGATIONS

The area of the Cooper Ridge NE quadrangle was included on a geologic map of the southern part of the Rock Springs coal field that was prepared by Schultz (1910a, pl. 14). The map was published on a planimetric base at the scale of 1:250,000. Fifteen coal beds were mapped in the quadrangle area, but none of them was sampled and resources were not appraised.

Appraisals of coal resources in the Rock Springs coal field have been made by Berryhill, Brown, Brown, and Taylor (1950) and by Root, Glass, and Lane (1973).

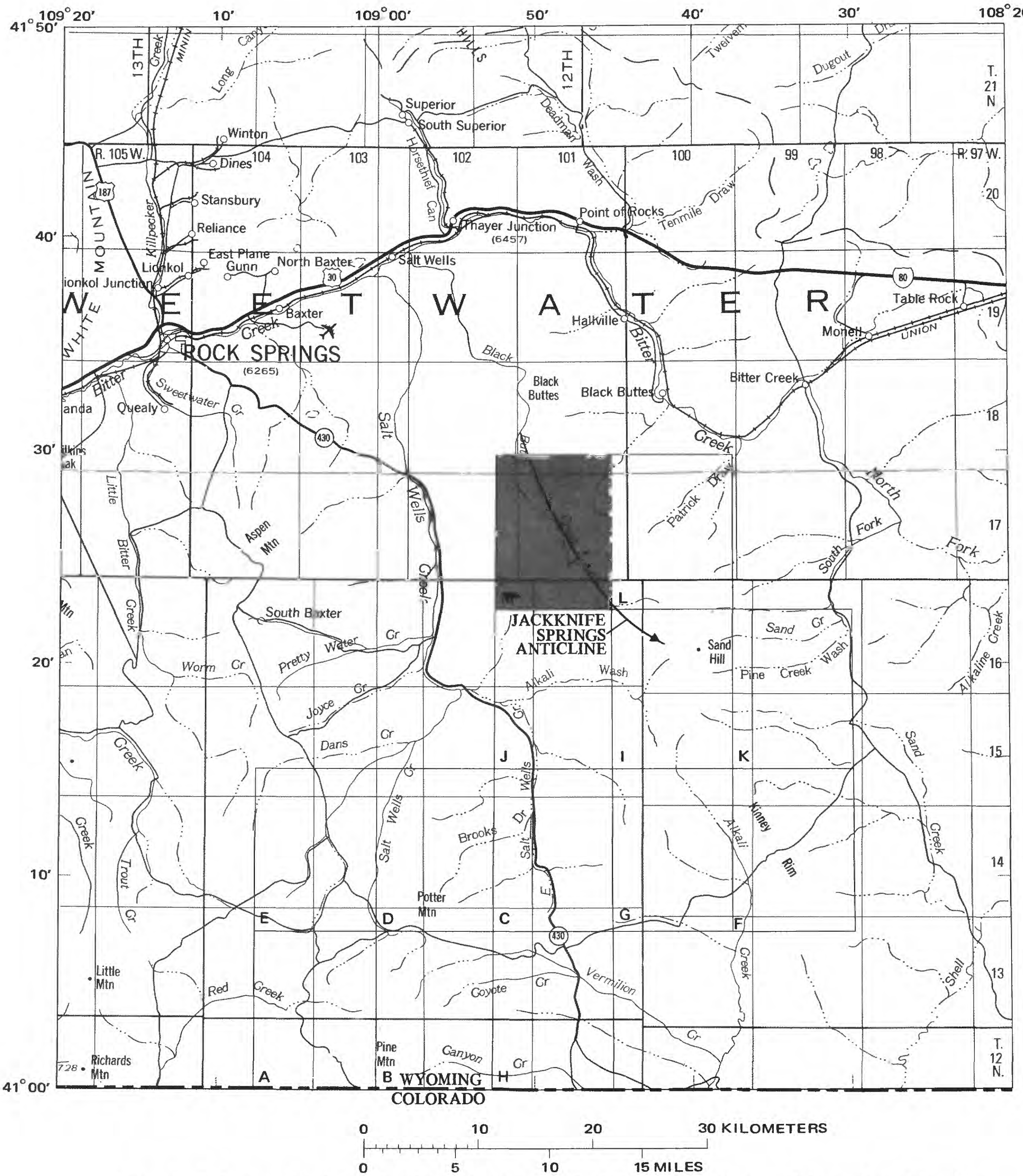

FIGURE 1.—Index map showing the location of the Cooper Ridge NE quadrangle (patterned) in southwest Wyoming.

Quadrangles shown in figure 1 and published in the Geological Survey Geologic Quadrangle map series

Index letter and quadrangle	GQ	Index letter and quadrangle	GQ
A. Red Creek Ranch	1001	H. Scrivner Butte	1166
B. Four J. Rim	1002	I. Pine Butte	1199
C. Erickson-Kent Ranch	1056	J. Burley Draw	1200
D. Potter Mountain	1082	K. Sand Butte Rim SE	1231
E. Titsworth Gap	1083	L. Sand Butte Rim NW	1362
F. Chicken Creek East	1128	M. Cooper Ridge NE	1363
G. Chicken Creek West	1139		

ACKNOWLEDGMENTS

T. K. Martin assisted the writer in the field and in the preparation of coal-resource data. The U.S. Bureau of Mines, Pittsburgh, Pa., prepared proximate, ultimate, Btu, and sulfur analyses of coal samples. Geochemical analyses of coal samples were prepared by Lorraine Lee, G. D. Shipley, E. J. Fennelly, Johnnie Gardner, Patricia Guest, J. A. Thomas, G. T. Burrow, Violet Merritt, and Claude Huffman, Jr. at the U. S. Geological Survey, Denver, Colo. Fossils were identified by W. A. Cobban and R. H. Tschudy. Champlin Petroleum Co., Mountain Fuel Supply Co., and Amoco Production Co. provided structural information and oil and gas analytical data for Brady oil and gas field.

STRATIGRAPHY

Formations exposed in the Cooper Ridge NE quadrangle include about 3,000 ft of rocks of Late Cretaceous age assigned in ascending order to the Rock Springs Formation, Ericson Sandstone, Almond Formation, Lewis Shale, Fox Hills Sandstone, and Lance Formation, and about 1,800 ft of rocks of early Tertiary age assigned to the Fort Union Formation and the overlying main body of the Wasatch Formation (fig. 2). The Ericson and Rock Springs Formations are divided into zones and tongues by minor lithologic changes.

Two unconformities are present in rocks exposed in the quadrangle area. An intraformational unconformity separates the Fort Union Formation into upper and lower parts that are of late and early Paleocene age, respectively. Little angular discordance in dips and no appreciable change in lithology is apparent in the two parts. Middle Paleocene rocks are missing by erosion. A major unconformity separates Tertiary rocks from Cretaceous Rocks; it relates to an upwarp and partial erosion of the Rock springs uplift associated with the Laramide revolution. There are 2°–3° of angular discordance in the dips of rocks above and below the unconformity. Late Cretaceous-pre-Tertiary erosion of the rocks underlying the unconformity truncated parts of the Lance Formation, Fox Hills Sandstone, and the Lewis Shale in a southwesterly direction across the quadrangle (fig. 2; pl. 1).

CRETACEOUS ROCKS

ROCK SPRINGS FORMATION

Outcrops in the Rock Springs Formation weather to northeast-trending brown ridges separated by drab-gray valleys in the northwest corner of the quadrangle. The formation is about 1,225 ft thick in adjacent areas and in the subsurface, but only the upper 750–800 ft crop out in the quadrangle area.

The Rock Springs Formation is divided into several tongues (Roehler, 1977). The Black Butte Tongue (Hale, 1950) is composed of shallow marine dark-gray shale having thin interbedded gray siltstone and gray very fine grained sandstone. Two persistent sandstone benches in the uppermost 300 ft of the formation were named by Smith (1961) the Brooks Tongue, about 65 ft thick, and the McCourt Tongue, 23-70 ft thick. These sandstones are the southeastward (seaward) parts of littoral deposits. A marine dark-gray shale and gray sandstone sequence between the McCourt Tongue and Brooks Tongue, nearly 85 ft thick, was named the Coulson Tongue by Smith (1961). A dark-gray carbonaceous shale and interbedded gray fine-grained sandstone sequence 30–50 ft thick, directly underlying the Ericson Sandstone was named the Gottsche Tongue by Smith (1965). The Gottsche Tongue was deposited in a paludal environment that was transitional between an underlying marine environment and overlying fluvial environment. Fossil worm borings and worm trails are common in thin siltstones in the Black Butte Tongue. A few *Ophiomorpha* sp. and large fish scales were observed in the Brooks Tongue in the NE¼NE¼ sec. 11, T. 17 N., R. 102 W.

ERICSON SANDSTONE

The Ericson Sandstone was divided into three zones by Smith (1961), who named the upper and lower, the Canyon Creek zone and Trail zone, respectively. The Canyon Creek and Trail zones are composed mostly of massive ridge-forming white fine- to coarse-grained highly crossbedded sandstone. The Canyon Creek zone is 350–400 ft thick; the Trail zone is 450–550 ft thick. Weathering of rocks between the Canyon Creek and the Trail zones has formed a shallow valley and the rocks are composed of partly hematitic gray fine- to medium-grained sandstone, gray siltstone, and gray shale. This stratigraphic sequence, about 300–325 ft thick, was named the Rusty zone by Smith (1961), because of an overall rust color imparted by iron-stained outcrops.

Rocks of the Ericson Sandstone were deposited in a low-relief fluvial environment where the load of sediments carried by streams exceeded the streams' carrying

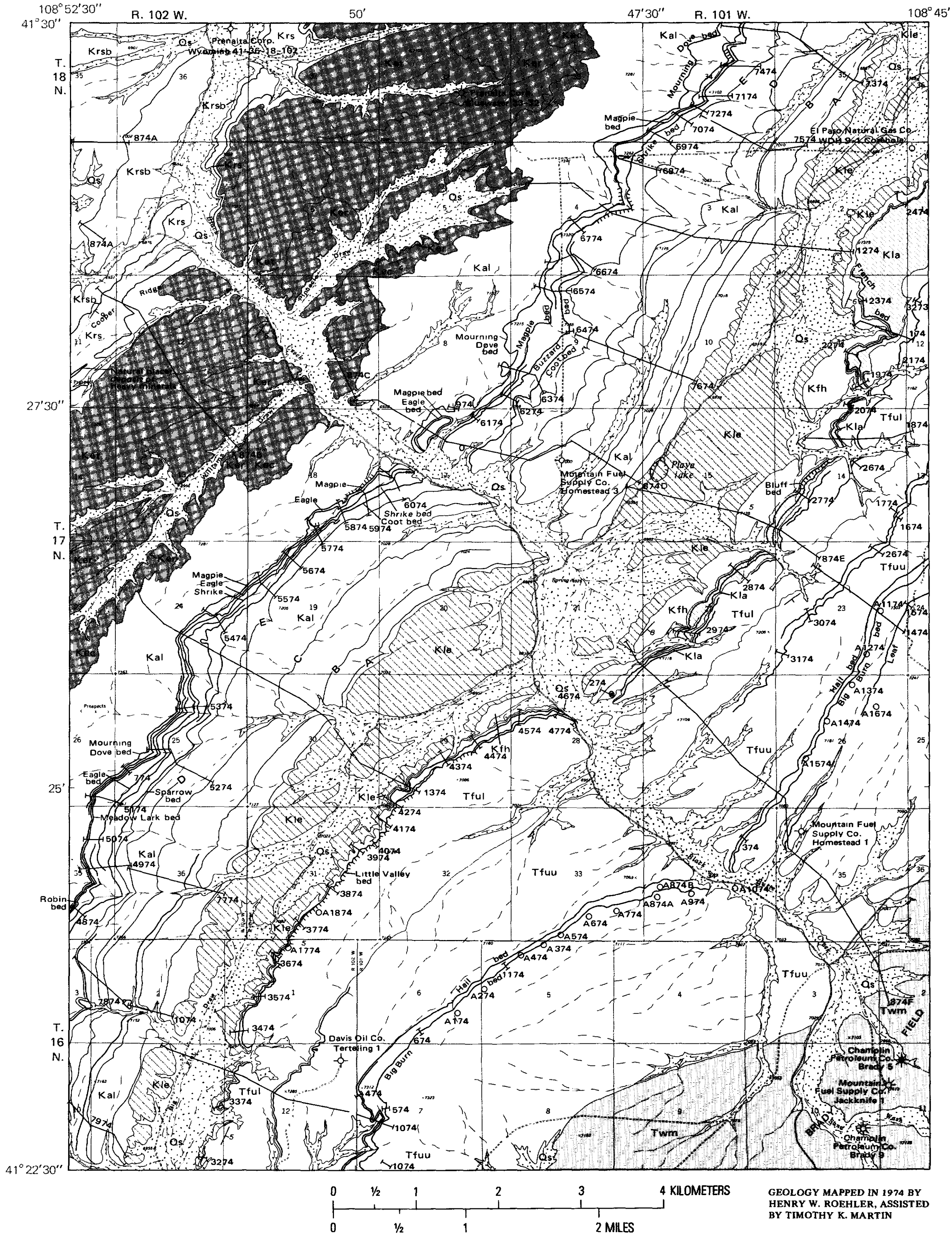

FIGURE 2 (above and facing page).—Geologic map of the Cooper Ridge NE quadrangle. Geology mapped by H. W. Roehler, assisted by T. K. Martin, 1974. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

EXPLANATION

QUATERNARY
- Qs — Surficial deposits (Holocene and (or) Pleistocene)

Unconformity

TERITIARY
- Twm — Wasatch Formation, main body (Eocene)
- Fort Union Formation (Paleocene)
  - Tfuu — Upper part
  - Tful — Lower part

Unconformity

CRETACEOUS
- Kla — Lance Formation (Upper Cretaceous)
- Kfh — Fox Hills Sandstone (Upper Cretaceous)
- Kle — Lewis Shale (Upper Cretaceous)
- Kal — Almond Formation (Upper Cretaceous)
- Ericson Sandstone (Upper Cretaceous)
  - Canyon Creek zone of Smith (1961)
  - Rusty zone of Smith (1961)
  - Trail zone of Smith (1961)
- Rock Springs Formation (Upper Cretaceous)
  - Krs — Rock Springs Formation above the base of Brooks Sandstone Tongue of Smith (1961)
  - —Krsm— McCourt Sandstone Tongue of Smith (1961)
  - —Krsk— Brooks Sandstone Tongue of Smith (1961)
  - Krsb — Black Butte Tongue of Hale (1950)

- Contact
- —c— Stratigraphic marker bed—Barrier-bar sandstones A–E in the Almond Formation, and unlabeled sandstone tongues in the Rock Springs Formation
- Anticline—Showing direction of plunge
- Little Valley — Coal bed and name
- Clinkered coal bed
- Gas well
- Dry hole
- Auger hole
- Mesozoic invertebrate fossil locality
- 1474 — Line and field reference number of measured stratigraphic section

capacity. Under these conditions braided streams developed. Truncated crossbedding suggests that the rocks were deposited by streams that scoured channels which were repeatedly filled and rescoured. The dips of crossbedding suggest that the streams flowed from west to east. No fossils were found in the Ericson.

ALMOND FORMATION

The Almond Formation weathers to drab dark-gray and dark-brown northeast-trending ridges and valleys in a band of outcrops 1.5–2.5 wide. The formation is about 600 ft thick in most parts of the quadrangle, but it is more than 900 ft thick along Black Butte Creek near the center of the quadrangle.

The formation can be divided stratigraphically into three parts on the basis of environments of deposition, and each part has a characteristic lithology. The lower part, 175–300 ft thick, was deposited in swamps. Rocks deposited in this environment are composed of dark-gray shale and interbedded dark-gray fine-grained sandstone. A few very thin beds of coal are present locally. No fossils were found in the lower Almond Formation, except for a few specimens of poorly preserved leaves and wood.

Rocks composing the middle part of the Almond Formation, 150–200 ft thick, were deposited in lagoons on the westward or landward side of a sequence of barrier bars. The barrier-bar sequence is not present in the quadrangle, but it is present in subsurface rocks east of the quadrangle. Lagoonal rocks of the middle part of the Almond Formation include dark-gray shale and interbedded gray siltstone, gray fine-grained sandstone, gray and brown carbonaceous shale, and coal. Brackish- and fresh-water fossils include a variety of pelecypods and gastropods; oysters are common (table 1).

The upper part of the Almond formation, 300–400 ft thick, was deposited in a shallow marine environment as shale, siltstone, and sandstone, and as barrier-bar (or barrier-island) sandstone. The shale is generally dark gray. The siltstone and sandstone are light gray; the sandstone is uniformly fine grained. The barrier-bar deposits form five distinct benches (fig. 2; pl. 1). The bars were deposited in a subtropical climate along the shores of the Lewis Sea which advanced northwestward across the quadrangle area in Late Cretaceous time. The landscape was similar to the present-day Gulf Coast area of Texas. Crossbedding and fossils were used to separate each barrier bar into lower shoreface zones, middle shoreface zones, upper shoreface zones and dune remnants. The seaward parts of the barrier bars have abundant crustacean borings and marine fossils such as shark teeth, clams, and cephalopods (pl. 1). The shoreward (lagoonal) parts have abundant brackish-water fossils, usually mollusks and commonly oysters (table 1).

LEWIS SHALE

The Lewis Shale weathers to a valley roughly 0.75 mi wide that is occasionally interrupted by low rounded hills and ridges. Outcrops uniformly weather to smooth rab dark-gray slopes.

The Lewis Shale has a persistent thickness of about 600 ft in most of the eastern part of the quadrangle. However, Laramide erosion at the Cretaceous-Tertiary boundary caused a thinning of the formation to about 350 ft in the southwest corner of the quadrangle (pl. 2). The Lewis Shale is mainly soft dark-gray shale containing some very thin interbedded gray dolomitic siltstone and tan lime-

TABLE 1.—*Mesozoic invertebrate fossils collected from the Almond Formation in the Cooper Ridge NE quadrangle*

[Identifications and remarks by W. C. Cobban]

USGS Mesozoic Fossil Invertebrate Locality No.	Geographic locality	Faunal list	Remarks
D9185	NE¼NW¼ sec. 9, T. 17 N., R. 101 W.	*Crassostrea wyomingensis*	These oysters contain numerous bryozoan borings. The oysters probably lived in the more saline part of a brackish-water environment.
D9186	SE¼SE¼ sec. 24, T. 17 N., R. 102 W.	*Crassostrea wyomingensis*	Extensive bryozoan borings.
D9187	SW¼SW¼ sec. 19, T. 17 N., R. 101 W.	*Anomia micronema* *Corbula perundata* Gastropods	The pelecypods seem to be a mixture of brackish-water species (*Anomia* and *Corbula*) and a wood-boring mollusk (*Terebrimya*) usually found in marine rocks.
D9190	SW¼SE¼ sec. 18, T. 17 N., R. 101 W.	*Crassostrea wyomingensis*	
D9191	SW¼SW¼ sec. 34, T. 18 N., R. 101 W.	*Glycymeris wyomingensis?* *Crassostrea* sp. *Cymbophora holmesi* *Hoploscaphites* sp. Internal molds of gastropods. Bored wood	This is a shallow-water marine assemblage; the brackish-water oysters were probably washed into it. Two internal molds suggest *Glycymeris wyomingensis*, a pelecypod known farther east in Wyoming from the zones of *Baculites eliasi* and *B. baculus* in the Lewis Shale. The ammonite is the inner septate whorls of a scaphite that has a row of small tubercles on each side of the venter. Scaphites that have the tubercles developed at this small diameter are not found below the zone of *Baculites reesidei*. Perhaps the collection is about the age of *B. eliasi*.
D9193	NW¼NW¼ sec. 16, T. 17 N., R. 101 W.	*Crassostrea wyomingensis* internal molds of a high-spired gastropod.	A brackish-water assemblage.

stone near the top and bottom. Rocks in the formation were deposited in a marine environment.

FOX HILLS SANDSTONE

The Fox Hills Sandstone weathers to massive brown ridges and ledges in most places in the quadrangle. In sec. 2, T. 17 N., R. 101 W., cliff-forming sandstone weathers to light-brown cuestas that stand nearly 500 ft above the adjacent valley to the west. Sandstone in the cliffs is 250 ft thick. It thins southwestward where it is partly replaced by shale and where the topographic relief on the formation lessens. The formation wedges out in surface rocks in sec. 29, T. 17 N., R. 101 W.

An anomalous lenticular sandstone is present above the Lewis Shale in the southwest part of sec. 29 and the northwest corner of sec. 32, T. 17 N., R. 101 W. No fossils were found in this white ledge-forming unit, and it was included in the overlying Fox Hills Sandstone for mapping purposes. This ledge-forming sandstone is overlain by a regolith that normally defines the top of Cretaceous rocks in this part of the section, but the sandstone nonetheless may be a disconnected part of the overlying Fort Union Formation of Paleocene age.

The Fox Hills Sandstone is mainly gray very fine grained sandstone and some interbedded dark-gray silty to sandy shale. Sandstone toward the base of the formation is very fine textured and interbedded with gray siltstone and gray shale. This sequence is replaced directly underneath by dark-gray shale. The contact between the Fox Hills Sandstone and the underlying Lewis Shale is placed at the base of the lowermost bench-forming sandstone in this transitional sandstone-to-shale sequence.

The Fox Hills Sandstone was deposited as barrier bars (or barrier islands) and as shallow marine sandstones. The sandstones deposited in these environments are lenticular; they rise stratigraphically in steplike fashion from west to east and reflect an eastward retreat of Late Cretaceous seas. Crossbedding and planar bedding are present in the sandstones. No fossils were collected from the Fox Hills Sandstone in the Cooper Ridger NE quadrangle.

LANCE FORMATION

Outcrops of the Lance Formation weather to northeast-trending ridges and valleys that are generally similar in appearance to those of the overlying Fort Union Formation. For this reason, the contact between the two formations is not readily apparent in many places. The two formations can be differentiated, however, by the overall color of weathered outcrops. Lance outcrops weather shades of dark gray and dark brown, whereas Fort Union outcrops weather shades of light gray and light brown. The contact is locally defined by a light-gray-weathering regolith that is nearly identical in appearance to the one that divides the Fort Union Formation into upper and lower parts.

The Lance Formation is about 100 ft thick in the northeast part of the quadrangle in sec. 1, T. 17 N., R. 101 W., but it thins rapidly southwestward and wedges out in outcrops near the southwest corner of sec. 22, T. 17 N., R. 101 W. (fig. 2; pl. 1). In the Mountain Fuel Supply Co. Homestead 1 drill hole in sec. 35, T. 17 N., R. 101 W., the Lance Formation is about 125 ft thick, and in the Mountain Fuel Supply Co. Jackknife Spring 1 well in sec. 11, T. 10 N., R. 101 W., it is about 90 ft thick; however, no Lance rocks are present in the Davis Oil Co. Terteling 1 drill hole in sec. 12, T. 16 N., R. 102 W. The approximate line of wedging out of the Lance Formation in the subsurface is shown in figure 7.

The Lance Formation is composed of dark-gray shale and interbedded gray very fine grained sandstone, dark-gray shale, and some coal and gray silty dolomite. The rocks were deposited in a subtropical climate in lagoons on the landward (westward) side of barrier bars that formed during a retreat of the Lewis Sea from the southwest Wyoming area during Late Cretaceous time. Fossil mollusks collected at USGS locality D9189 in the east center sec. 22, T. 17 N., R. 101 W., include *Leptesthes fracta, Tulotomops tompsoni, Campeloma multilineata,* and *Goniobasis* sp. The assemblage is a mixture of fresh-water and brackish-water forms, and suggests the rocks there were deposited in a lagoon. Fossils collected at USGS locality D9194 in the northeast part of sec. 22, T. 17 N., R. 101 W., include the mollusks *Tulotomops* sp. and *Goniobasis* sp. and abundant unidentified fossil leaves. The rocks there may have been deposited in a swamp or marsh adjacent to a lagoon.

PALEOCENE ROCKS

FORT UNION FORMATION

The Fort Union Formation crops out as a series of drab-brown- and drab-gray-weathering northeast-trending ridges and valleys. The formation has a fairly consistent thickness of about 1,300 ft. It is composed of gray shale and interbedded gray siltstone, gray very fine grained sandstone, gray and brown carbonaceous shale, and coal. Large brown-weathering gray dolomitic siltstone concretions cap some of the ridges. Coal-bearing sections are mostly present in the lower half of the formation (pl. 1).

The Fort Union Formation is divided into a lower part, about 300 ft thick, and an upper part, about 1,000 ft thick, by the above-mentioned intraformational unconformity. A regolith or fossil soil, as much as 10 ft thick, defines the level of erosion. The regolith is composed of gray calcareous siltstone and is easily recognized in outcrops because it weathers to a persistent light-gray ledge in adjacent slopes that weather drab brownish gray.

Fossil palynomorphs were used to establish the Paleocene age of the Fort Union Formation and to define the contact with underlying rocks of Cretaceous age. Taxa identified by R. H. Tschudy from samples collected in a stratigraphic section measured in the northeast part of the quadrangle are listed in figure 3.

EOCENE ROCKS

MAIN BODY OF WASATCH FORMATION

The main body of the Wasatch Formation is present in the southeast corner of the quadrangle. The main body is about 1,800 ft thick east of the quadrangle, but only the lower 500 ft are present in the mapped area. Areas underlain by the main body of the Wasatch Formation form rolling topography of drab-brown- and drab-gray-weathering minor ridges and valleys. Exposed rocks are composed of gray sandy mudstone and interbedded gray to gray-green silty shale and gray very fine to fine grained sandstone. No fossils were collected from the main body of the Wasatch Formation in the quadrangle area, but fossil mammals collected by the author from the Sand Butte Rim NW quadrangle, which borders the Cooper Ridge NE quadrangle to the east, suggest the formation was deposited in a warm-temperate climate in a fluvial environment of deposition.

STRUCTURE

JACKKNIFE SPRING ANTICLINE

Strata exposed in the Cooper Ridge NE quadrangle dip 5°–9° SE on the southeast flank of the Rock Springs uplift. A minor cross-trending fold, the Jackknife Spring anticline, interrupts the northeast strike of the beds (fig. 2). The anticline enters the northern edge of the quadrangle in sec. 32, T. 18 N., R. 101 W., plunges 3°–5°, SE, and leaves the quadrangle area at Brady field in sec. 11, T. 16 N., R. 101 W.

BRADY FAULT

A major fault in subsurface rocks, the Brady fault, bounds the northwest edge of Brady field. This high-angle reverse fault strikes N. 20° E. and dips 80°–85° SE. At a subsurface depth of 12,000 ft the fault crosses the center of sec. 10, the southeast part of sec. 3, and the northwest part of sec. 2, T. 16 N., R. 101 W. There are nearly 1,000 ft of structural closure along the southeast, upthrown, side of the fault across Brady field. The fault emanates from Precambrian basement rocks; it dies out upward in Cretaceous rocks, probably in the Baxter Shale, at a subsurface depth of about 5,000 ft.

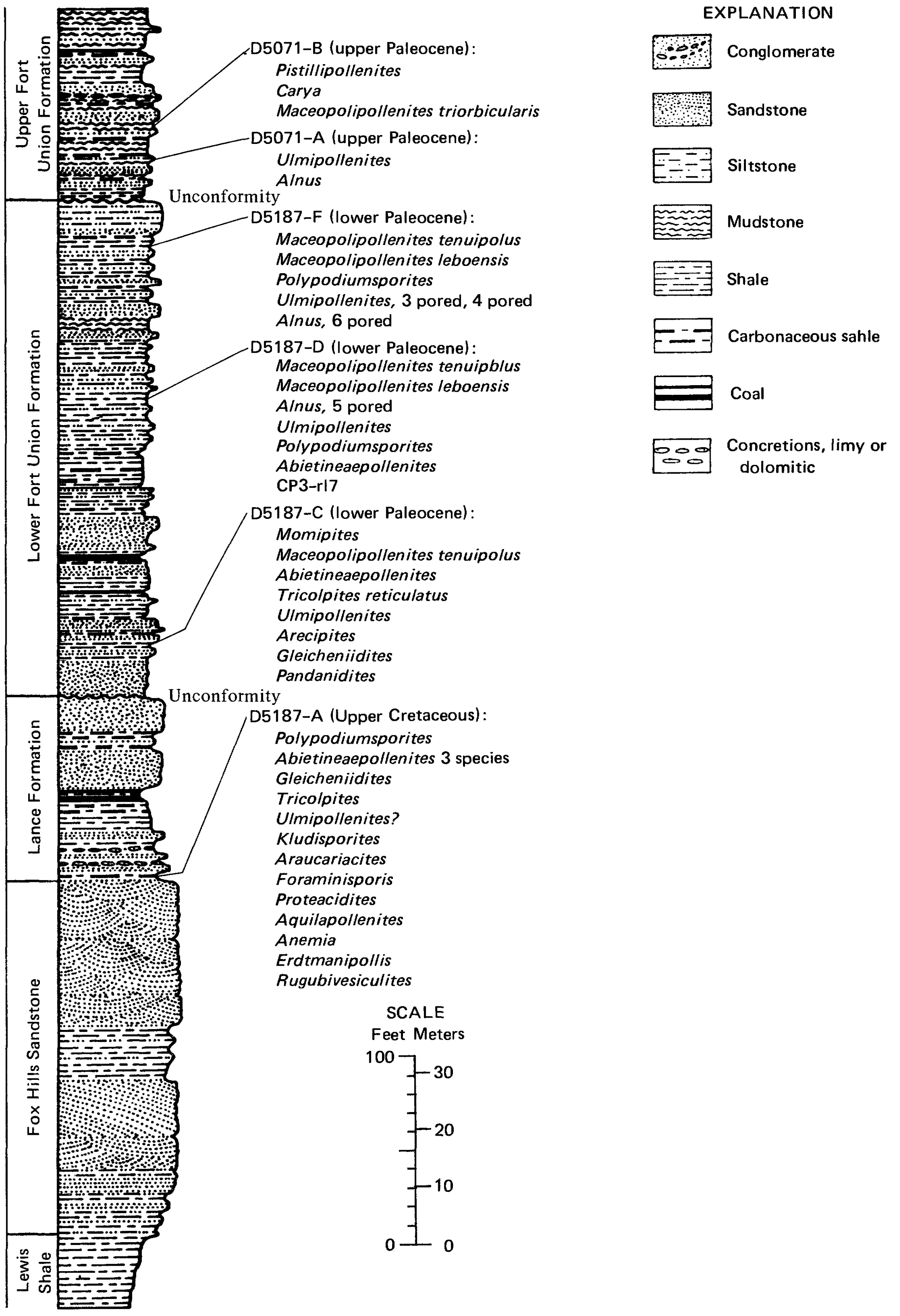

FIGURE 3.—Section showing the stratigraphic positions, USGS paleobotany locality numbers, age, and identifications of palynomorph specimens collected in the east center sec. 11, west center sec. 12, and NW¼ sec. 13, T. 17 N., R. 101 W.

ECONOMIC GEOLOGY

COAL

OUTCROPS

Coal beds mostly weather to narrow drab dark-gray poorly vegetated depressions in valleys, or to drab dark-gray bands in bald slopes below ridge-forming sandstones. The beds are generally covered by a veneer of soil or slope wash to depths ranging from a few inches to nearly 2 ft. The coal below the covered interval is bright, although it consists of small blocky fragments for several feet below outcrops. Minerals associated with weathering include selenite, limonite, and, in a few places, calcite. The coal and adjacent rocks are locally burned to orange-red clinker beds.

NAMES AND LOCATIONS OF COAL BEDS

The names of coal beds in the quadrangle were assigned by the author. There is no record that any of the beds have been named previously.

Three coal beds, the Leaf, Big Burn, and Hail, are within a 100 ft thick interval near the center of the upper part of the Fort Union Formation (pl. 2). Outcrops of the Big Burn and Hail coal beds trend northeast across the mapped area (pl. 1). The Leaf bed, generally less than 1.5 ft thick is present only in secs. 23, 24, and 26, T. 17 N., R. 101 W., and sec. 7, T. 16 N., R. 101 W. Two unnamed coal beds are present in the lower part of the upper part of the Fort Union Formation in secs. 13, 14, 22, 23 and 27, T. 17 N., R. 101 W., (pl. 1, 2). The Little Valley bed (actually a zone of coal beds) is within the lower 100 ft of the lower part of the Fort Union Formation. The Little Valley bed splits into upper, lower, and other parts that are lenticular and missing locally along outcrops. The Little Valley bed is burned where it is thickest in outcrops in secs. 29, 31, and 32, T. 17 N., R. 101 W., and sec. 1, T. 16 N., R. 102 W.

Two lenticular coal beds, the French and Bluff beds, are within the lower 60 ft of the Lance Formation. Both beds split and wedge out in places along outcrops (pl. 1). Where the Bluff bed is thickest in outcrops in sec. 14, T. 17 N., R. 101 W., it is burned to an orange-red clinker bed that overlies a small white bluff-forming sandstone.

The middle part of the Almond Formation has a 150-200-ft-thick interval that contains nine named and mapped, mostly lenticular coal beds. In descending order these are the Sparrow, Coot, Buzzard, Shrike, Eagle, Robin, Meadow Lark, Magpie, and Mourning Dove beds (pls. 1,2). Parts of the Magpie and Shrike beds are burned in outcrops in sec. 34, T. 18 N., R. 101 W., and in secs. 4 and 18, T. 17 N., R. 101 W. An isolated unnamed lenticular coal bed is also present in the upper part of the Almond Formation in sec. 36., T. 17 N., R. 102 W., and in secs. 2, 10, and 11, T. 16 N., R. 102 W.

HEATING VALUE, RANK, AND SULFUR ANALYSES

Channel samples of coal-bed outcrops of the Big Burn, Little Valley, Shrike, Meadow Lark, and Magpie beds were submitted to the U. S. Bureau of Mines for routine proximate, ultimate, Btu, and sulfur analyses. Results of these analyses are shown in table 2. The heating values on a moisture- and mineral-matter-free basis, determined by the Parr formula (American Society for Testing Materials, 1971, p. 59), are shown in table 3. The values range from 6,000 to 8,900 Btu/lb, which classifies them Lignite B, Lignite A, and Subbituminous C. Weathering has greatly reduced the heating value, however, and they should be ranked higher, possibly in the range from Lignite A to Subbituminous B. A study of the weathering effects on coal in the area was undertaken by Schultz (1910b, p. 282–296).

RESOURCES

Coal-resource tonnages were computed for beds that are more than 2.5 ft thick and which lie under less than 3,000 ft of overburden. Coal-resource categories reported are those based on the reliability of data (measured and indicated, and inferred), and on thickness of overburden (1 to 1,000 ft; 1,001 to 2,000 ft; and 2,001 to 3,000 ft). The combined measured and indicated categories include coal within 1.5 mi of measured outcrops and auger holes. The inferred category includes data from geophysical logs of oil and gas drill holes.

A six-step procedure was followed in calculating the resources of each coal bed. (1) Structure contours were drawn on the top of each coal bed. (2) 1,000, 2,000 and 3,000-ft overburden lines were drawn by subtracting structural elevations from topographic elevations. (3) The measured and indicated coal-resource-estimate categories were determined by plotting a line at 1.5-mile perpendicular distance from measured coal outcrops. The inferred category includes the area between this line and 3,000 ft of overburden. (4) The bed was isopached using measured outcrop thicknesses and the thicknesses indicated on geophysical logs (geophysical-log thicknesses were rounded to the closest one-half foot); 2.5 ft was the minimum thickness used for isopachs. (5) A programmed electronic computing planimeter was used to find the tonnage of coal in each section, or part thereof, in the quadrangle. The computer was programmed to use an average weight of 1,770 short tons of coal per acre-foot; a weighted average bed thickness was visually determined for each reporting category in each section by averaging maximum and minimum thicknesses, taking into account the geographic configuration of isopachs. (6) Tonnage corrections were applied to compensate for the dip of the bed. Each calculation was rounded to the closest 1,000 tons and recorded in millions of tons on tables of resources.

TABLE 2.—*Proximate, ultimate, Btu, and forms-of-sulfur analyses of five channel samples of coal outcrops in the Cooper Ridge NE quadrangle*

[Each sample represents the entire thickness of the bed. All analyses, except Btu, are in percent. Form of analysis: A, air dried; B, as received; C, moisture free; D, moisture and ash free; leaders (- -), no data. All analyses by Coal Analyses Section, U.S. Bureau of Mines, Pittsburgh, Pa.]

Sample No.			Proximate analysis				Ultimate analysis						Forms of sulfur		
USBM Lab. No.	USGS Field Ref. No.	Form of analysis	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Btu value	Sulfate	Pyritic	Organic
Big Burn bed, 8.6 feet thick, SW¼SE¼ sec. 6, T. 16 N., R. 101 W.															
K-48343	6742	A	12.6	37.9	32.5	17.0	4.2	45.1	1.4	31.8	0.5	6,960	----	----	----
		B	34.7	28.3	24.3	12.7	5.9	33.7	1.0	46.3	.4	5,200	0.01	0.03	0.37
		C	----	43.3	37.3	19.4	3.2	51.6	1.6	23.6	.6	7,960	.01	.05	.56
		D	----	53.8	46.2	----	3.9	64.0	2.0	29.3	.8	9,880	.01	.06	.70
Little Valley bed, 14.7 feet thick, SW¼SW¼ sec. 29, T. 17 N., R. 101 W.															
K-48344	137492	A	10.5	35.2	37.1	17.2	4.2	48.4	1.3	28.5	0.4	7,690	----	----	----
		B	24.3	29.8	31.3	14.6	5.3	41.0	1.1	37.7	.3	6,500	0.01	0.03	0.26
		C	----	39.3	41.5	19.2	3.4	54.1	1.5	21.4	.4	8,590	.01	.04	.35
		D	----	48.7	51.3	----	4.2	67.0	1.8	26.5	.5	10,630	.01	.06	.43
Shrike bed, 5.5 feet thick, NE¼NE¼ sec. 4, T. 17 N., R. 101 W.															
K-48347	68749	A	14.6	35.5	47.1	2.8	4.9	57.9	1.6	32.4	0.4	9,470	----	----	----
		B	23.9	31.6	42.0	2.5	5.6	51.6	1.5	38.4	.4	8,440	0.02	0.07	0.29
		C	----	41.6	55.1	3.3	3.9	67.8	1.9	22.6	.5	11,090	.02	.09	.37
		D	----	43.0	57.0	---	4.0	70.1	2.0	23.4	.5	11,470	.02	.10	.39
Meadow Lark bed, 9.3 feet thick, SE¼NE¼ sec. 35, T. 17 N., R. 102 W.															
K-48346	49744	A	14.7	36.4	44.0	4.9	5.1	56.4	1.4	31.9	0.3	9,210	----	----	----
		B	22.0	33.2	40.3	4.5	5.6	51.6	1.3	36.7	.3	8,420	0.01	0.01	0.25
		C	----	42.6	51.7	5.7	4.0	66.1	1.7	22.2	.3	10,800	.01	.01	.32
		D	----	45.2	54.8	---	4.3	70.2	1.8	23.3	.4	11,460	.01	.01	.34
Magpie bed, 11.6 feet thick, NE¼SE¼ sec. 4, T. 17 N., R. 101 W.															
K-48345	127420	A	13.2	36.8	42.0	8.0	4.4	53.2	1.4	32.8	0.2	8,260	----	----	----
		B	27.2	30.9	35.2	6.7	5.5	44.6	1.1	41.9	.2	6,930	0.01	0.01	0.18
		C	----	42.4	48.4	9.2	3.3	61.3	1.6	24.3	.3	9,520	.01	.01	.25
		D	----	46.8	53.2	---	3.7	67.5	1.7	26.8	.3	10,490	.01	.01	.28

TABLE 3.—*Heating value and rank of channel samples of coal outcrops in the Cooper Ridge NE quadrangle, as determined by the Parr Formula*

Coal bed	Geographic location	Btu/lb As received	Btu/lb Moisture and mineral-matter free[1]	Rank
Big Burn-------	SW¼SE¼ sec. 6, T. 16 N., R. 101 W.	5,200	6,018	Lignite B
Little Valley--	SW¼SW¼ sec. 29, T. 17 N., R. 101 W.	6,500	7,138	Lignite A
Shrike---------	NE¼NE¼ sec. 4, T. 17 N., R. 101 W.	8,440	8,673	Subbituminous C
Meadow Lark----	SE¼NE¼ sec. 35, T. 17 N., R. 102 W.	8,420	8,849	Subbituminous C
Magpie---------	SE¼NE¼ sec. 4, T. 17 N., R. 101 W.	6,930	7,469	Lignite A

[1] Parr formula, American Society for Testing Materials (1971, p. 59)

Calculated total minable resources of coal in all categories in the Cooper Ridge NE quadrangle are 762,855,000 tons. The geographic location, thickness, and resource data for 16 beds of coal are shown in figures 4–17 and the accompanying tables. Nearly 22 percent, 166,120,000 tons, is under less than 200 feet of overburden and is recoverable by strip mining (table 4). No coal has been mined in the Cooper Ridge NE quadrangle as of 1974.

TABLE 4.—*Strippable coal resources in millions of tons in the Cooper Ridge NE quadrangle*

Coal bed	Overburden 0-100 ft	Overburden 100-200 ft	Total
Bluff-------------------	3.768	3.184	6.952
Big Burn----------------	10.870	9.875	20.745
Little Valley-----------	7.756	11.865	19.621
Magpie------------------	23.862	30.139	54.001
Four beds that immediately overlie the Magpie[1] ------------	28.634	36.167	64.801
Total--			166.120

[1]Total resources of the four beds overlying the Magpie bed were estimated by using the arbitrary value of 1.2 times the resources calculated for the Magpie bed.

GEOCHEMICAL ANALYSES

Geochemical analyses were performed on 25 channel samples of coal collected from outcrops in the Fort Union, Lance, and Almond Formation. Four analytical methods were used: (1) Neutron activation of uranium and thorium on the coal as received; (2) X-ray fluorescence on the coal ash; (3) Semiquantitative spectrographic analysis on the coal ash; and (4) Quantitative chemical analyses of the coal as received and on the ash. Coal beds sampled are listed in table 5, and data obtained from geochemical analyses are presented in tables 6, 7, and 8. Geochemical analyses are variable and do not distinguish one bed from another; therefore, they cannot be used for the identification or stratigraphic correlation of coal beds. None of the coal analyses suggests that trace or minor elements in the coal are present in quantities large enough to be potentially hazardous to the environment if the coals are mined within the quadrangle.

OIL AND GAS

Parts of two oil and gas fields are within the Cooper Ridge NE quadrangle. The Brady field, in the southeast corner of the quadrangle, is operated by Champlin Pe-

TABLE 5.—*Coal samples analyzed in the Cooper Ridge NE quadrangle*

[Leaders (- - -), none]

USGS Lab. No. D1695-	USBM Lab. No.	USGS Ref. No.	Formation	Geographic locality		Bed name	Bed thickness (ft)
71	-------	4747	Fort Union--	NW¼SW¼NW¼	sec. 7, T. 16 N., R. 101 W.	Hail----------	2.1
72	-------	5742	-----do-----	SE¼SW¼NW¼	sec. 7, T. 16 N., R. 101 W.	Big Burn------	6.5
73	-------	874D37	Almond------	SW¼NE¼NW¼	sec.17, T. 17 N., R. 101 W.	Magpie--------	6.1
74	-------	874D40	-----do-----	SW¼NE¼NW¼	sec.17, T. 17 N., R. 101 W.	Eagle---------	2.5
75	-------	874D53	-----do-----	SW¼NW¼NE¼	sec.17, T. 17 N., R. 101 W.	Buzzard-------	2.0
76	-------	874E29	Lance-------	NE¼SE¼SE¼	sec.15, T. 17 N., R. 101 W.	Bluff---------	5.0
77	-------	874F108	Fort Union--	SE¼SE¼SE¼	sec.27, T. 17 N., R. 101 W.	Hail----------	3.9
78	-------	874F113	-----do-----	SE¼SE¼SE¼	sec.27, T. 17 N., R. 101 W.	Big Burn------	8.1
79	-------	10744	Almond------	SW¼NE¼SW¼	sec. 2, T. 16 N., R. 102 W.	Unnamed-------	4.2
80	-------	137419	-----do-----	SW¼NW¼SE¼	sec.24, T. 17 N., R. 102 W.	Magpie--------	3.4
81	-------	137423	-----do-----	SW¼NW¼SE¼	sec.24, T. 17 N., R. 102 W.	Eagle---------	3.4
82	-------	137429	-----do-----	SW¼NW¼SE¼	sec.24, T. 17 N., R. 102 W.	Shrike--------	2.2
83	-------	137432	-----do-----	SW¼NW¼SE¼	sec.24, T. 17 N., R. 102 W.	Coot----------	4.6
84	-------	137436	-----do-----	SE¼NW¼SE¼	sec.24, T. 17 N., R. 102 W.	Sparrow-------	2.5
85	-------	21743	Fort Union--	SE¼NE¼SE¼	sec.11, T. 17 N., R. 101 W.	Little Valley-	5.5
86	-------	29747	Lance-------	SW¼NE¼SW¼	sec.22, T. 17 N., R. 101 W.	Bluff---------	6.0
87	-------	297418	-----do-----	SW¼NE¼SW¼	sec.22, T. 17 N., R. 101 W.	French--------	4.7
88	-------	70748	Almond------	NE¼SW¼SW¼	sec.34, T. 18 N., R. 101 W.	Magpie--------	3.1
89	-------	707411	-----do-----	NE¼SW¼SW¼	sec.34, T. 18 N., R. 101 W.	Magpie--------	4.8
90	-------	707415	-----do-----	NE¼SW¼SW¼	sec.34, T. 18 N., R. 101 W.	Shrike--------	4.5
91	K-48343	6742	Fort Union--	NW¼SW¼SE¼	sec. 6, T. 16 N., R. 101 W.	Bug Burn------	8.6
92	K-48345	127420	Almond------	NW¼NE¼SE¼	sec. 4, T. 17 N., R. 101 W.	Magpie--------	11.6
93	K-48344	137492	Fort Union--	NE¼SW¼SW¼	sec.29, T. 17 N., R. 101 W.	Little Valley-	14.7
94	K-48346	49744	Almond------	SW¼SE¼NE¼	sec.35, T. 17 N., R. 102 W.	Meadow Lark---	9.3
95	K-48347	68749	-----do-----	NW¼NE¼NE¼	sec. 4, T. 17 N., R. 101 W.	Shrike--------	5.5

TABLE 6.—*Major and minor oxide and trace-element composition of the*

[Values are in percent (%) or parts per million (ppm). The coal was ashed at 525° F. Spectrographic results are to be identified with geometric brackets but are reported arbitrarily as midpoints of one bracket at 68 percent, or two brackets at 95 percent confidence. L, less than the value shown; N, not detected; B, not determined; S after element symbol, determined by semiquantitative

Sample	Ash %	SiO2 %	Al2O3 %	CaO %	MgO %	Na2O %	K2O %	Fe2O3 %	MnO %	TiO2 %
D169571	16.1	49	31	5.6	1.99	0.28	0.64	4.7	0.020L	0.65
D169572	13.9	39	20	6.6	1.79	.11	.62	20	.020L	.73
D169573	44.2	69	24	1.2	.95	.12	2.1	1.9	.020L	.63
D169574	6.9	22	25	16	10.5	1.24	.49	2.1	.077	.48
D169575	11.0	43	13	14	6.81	.24	.92	3.4	.032	.42
D169576	5.2	32	22	16	1.74	.11	.44	9.8	.020L	.63
D169577	25.6	55	25	2.6	.37	.23	.94	8.3	.020L	.80
D169578	27.0	65	18	2.7	.75	.16	1.1	6.6	.020L	1.0
D169579	6.5	28	15	9.2	4.35	.34	.26	20	.049	.53
D169580	35.0	70	18	3.2	2.09	.14	1.4	1.5	.020L	.73
D169581	9.9	39	27	14	3.04	.11	.79	3.5	.020L	.76
D169582	18.4	31	29	17	2.79	.23	.57	3.5	.020L	1.1
D169583	8.9	45	27	10	1.29	.09	1.1	4.4	.020L	.93
D169584	11.8	35	21	21	.90	.11	1.1	5.4	.020L	.58
D169585	14.0	56	22	4.9	1.84	.11	1.0	6.0	.020L	.92
D169586	6.7	39	20	12	1.24	.09	.85	10	.020L	.70
D169587	6.9	54	17	6.2	1.49	.08	.69	5.8	.027	.84
D169588	16.8	51	38	3.9	.70	.07	.79	3.3	.020L	.63
D169589	14.3	47	36	4.5	1.20	.08	.80	3.6	.020L	1.1
D169590	17.4	42	35	10	3.40	.18	.45	1.9	.020L	.91
D169591	18.4	47	31	5.1	.90	.20	1.0	7.7	.020L	.90
D169592	18.7	70	23	1.2	.70	.09	.80	2.6	.020L	1.1
D169593	7.6	37	28	19	4.40	.15	.36	3.3	.020L	.87
D169594	5.7	40	25	15	5.10	.15	.57	4.1	.020L	1.0
D169595	4.1	39	35	6.4	1.84	.08	.54	4.7	.020L	1.0

Sample	P2O5 %	SO3 %	Cl %	Cd ppm	Cu ppm	Li ppm	Pb ppm	Zn ppm	B ppm-S	Ba ppm-S
D169571	0.10 L	4.5	0.10 L	3.5	154	76	40	140	700	2000
D169572	.10 L	11	.10 L	2.5	126	38	35	102	100	1500
D169573	.21	1.1	.10 L	1.0L	28	56	30	73	100	700
D169574	4.4	13	.10 L	1.0L	56	42	35	84	1500	5000
D169575	.10 L	2.7	.10 L	3.0	40	30	25 L	330	200	700
D169576	.10 L	16	.10 L	3.5	78	10	40	248	700	1000
D169577	.25	4.3	1.3	1.5	138	80	30	73	150	3000
D169578	.36	4.0	.10 L	1.0L	80	28	25 L	44	150	3000
D169579	1.1	21	.10 L	1.0L	44	16	25 L	117	1000	1500
D169580	.10 L	2.2	.10 L	1.0L	42	60	25	66	150	500
D169581	3.5	8.5	.10 L	1.0	48	26	25	143	500	5000
D169582	6.8	3.3	.10 L	1.0L	34	20	35	76	150	10000
D169583	.43	9.6	.10 L	9.0	90	34	35	228	150	2000
D169584	.10 L	17	.10 L	2.0	52	20	30	122	70	20000
D169585	.10 L	5.1	.10 L	1.0	96	94	40	89	500	2000
D169586	.10 L	17	.10 L	10.5	64	20	30	157	500	2000
D169587	.76	9.7	.10 L	2.0	68	36	25	124	700	2000
D169588	.22	3.6	.10 L	3.5	40	74	40	89	100	1500
D169589	.64	.21	.10 L	1.0	48	84	40	152	150	1500
D169590	.68	4.5	.10 L	1.0	30	148	35	75	300	1500
D169591	.10 L	6.2	.10 L	1.5	168	42	40	113	300	3000
D169592	.10 L	2.4	.10 L	1.0L	86	96	35	44	200	1500
D169593	.49	8.1	.10 L	1.5	56	24	50	109	150	3000
D169594	.10 L	13	.10 L	1.5	78	58	35	140	700	1500
D169595	2.7	8.3	.10 L	1.0L	74	88	35	77	1000	3000

troleum Co., a subsidiary of the Union Pacific Railroad. An unnamed field was discovered in 1974 in sec. 32, T. 18 N., R. 101 W., by the Prenalta Corp.

Gas was discovered at the Brady field (formerly called the Jackknife Spring field) in 1960 in the Almond, Rock Springs, and Blair Formations in the Mountain Fuel Supply Co. Jackknife Spring 1 well in SW¼NW¼ sec. 11, T. 16 N., R. 101 W. The discovery well was completed in the Rock Springs and Blair Formations at depths between 5,335 and 6,336 ft and had initial flow potential of 7,220 MCF of gas per day. The Brady 1 discovery well, drilled in 1972 in the NE¼NW¼ sec. 11, T. 16 N., R. 101 W., was completed in the Weber Sandstone and had initial flow potential of 3,818 MCF of gas and 976 bbl of condensate per day. Hydrocarbons are structurally trapped at Brady field by closure against the southeast, upthrown, side of the Brady fault. The field is now capable of sustained production from the Rock Springs, Blair, Dakota, sandstone (Entrada of drillers), Nugget, Park City, and Weber Formation. Oil from the Nugget, Park City, and Weber Formations has American Petroleum Institute gravities ranging from 50 to 67 with pour points below 10° F. Gas in the Rock Springs, Blair, and Dakota Formations is less than 1 percent inert and has high heating value. Gas in the Nugget, Park City, and Weber Formations is 31–55 percent inert and has moderate heating value. Gas in the Park City Formation is composed of more than 30 percent hydrogen sulfide. Formation tops (in feet below ground level) in the Brady 1 well are as follows: the Cretaceous Almond, 2,701; Ericson, 3,153;

Laboratory ash of 25 coal samples from the Cooper Ridge NE quadrangle

those brackets, 1.0, 0.7, 0.5, whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, and so forth, 0.3, 0.2, 0.15, 0.1, and so forth. The precision of the spectrographic data is approximately spectrographic analysis. See table 5 for identification of samples by laboratory and field reference numbers, formation, geographic location bed name, and bed thickness]

Sample	Be ppm-S	Ce ppm-S	Co ppm-S	Cr ppm-S	Ga ppm-S	Ge ppm-S	La ppm-S	Mo ppm-S	Nb ppm-S	Nd ppm-S
D169571	10	N	20	100	30	N	70	15	20 L	N
D169572	N	N	15	70	30	N	70	10	N	N
D169573	N	N	10 L	70	15	N	N	N	20 L	B
D169574	5	N	10	30	15	N	70	7	N	N
D169575	20	N	30	50	15	20	N	N	20 L	B
D169576	5	N	20	70	20	N	70	N	20 L	N
D169577	3	500 L	15	70	20	N	100	15	20 L	150 L
D169578	N	N	10 L	70	15	N	70	10	20 L	N
D169579	5	N	15	30	20	20	70	N	20 L	N
D169580	3	N	N	70	15	N	N	N	N	B
D169581	7	N	10	50	30	N	70	N	N	N
D169582	N	N	10 L	30	30	N	70	N	N	N
D169583	10	N	30	100	30	N	70	N	N	N
D169584	10	N	15	70	30	N	N	7 L	N	B
D169585	3	N	10	70	30	N	70	7	20	N
D169586	5	N	20	70	20	N	70	7 L	N	150 L
D169587	3	N	15	70	15	N	70	7 L	20	N
D169588	10	N	15	70	50	N	70	N	20	N
D169589	3	500 L	15	50	50	N	100	N	20	150 L
D169590	3	N	15	30	30	N	70	N	20	N
D169591	3	N	15	100	30	N	70	15	20 L	150 L
D169592	N	N	N	50	20	N	70	7	20	N
D169593	7	500	15	70	30	N	300	10	20	200
D169594	10	N	15	70	30	N	70	7	N	N
D169595	15	500 L	15	50	30	20 L	100	7	20	150 L

Sample	Ni ppm-S	Sc ppm-S	Sn ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Yb ppm-S	Zr ppm-S
D169571	100	30	N	300	150	70	7	150
D169572	100	15	N	500	150	50	5	150
D169573	30	10	N	200	70	30	3	150
D169574	30	15	N	7000	70	50	3	150
D169575	70	30	N	300	70	70	7	150
D169576	100	15	N	500	70	70	5	150
D169577	70	20	N	300	100	50	5	150
D169578	20	15	N	500	70	30	3	200
D169579	150	20	N	3000	70	100	7	150
D169580	15	10	20 L	150	70	20	3	150
D169581	30	15	N	3000	70	30	3	150
D169582	10	10	N	10000	70	30	3	200
D169583	150	20	N	1000	100	70	5	150
D169584	100	30	N	1000	100	70	5	100
D169585	30	15	N	300	100	30	3	200
D169586	150	15	N	300	70	100	7	150
D169587	70	15	N	1500	100	70	5	200
D169588	70	15	N	500	100	70	7	200
D169589	30	15	N	1000	150	50	5	300
D169590	30	10	N	1500	100	30	3	200
D169591	70	20	N	500	150	50	5	100
D169592	10	10	N	200	70	30	3	300
D169593	70	30	N	3000	150	70	7	200
D169594	50	20	N	1000	70	70	7	200
D169595	50	30	N	3000	150	70	7	200

Rock Springs, 4,225; Blair, 5,425; Baxter, 7,120; Frontier, 10,280; Aspen, 10,615; and Dakota, 10,840; Jurassic Morrison, 11,030; Curtis of drillers, 11,387; sandstone (Entrada of drillers), 11,495; and Carmel of drillers, 11,580; Jurassic(?) and Triassic(?) Nugget, 11,650; Triassic Popo Agie, 12,194; Jelm, 12,340; and Red Peak, 12,530; Permian Park City, 13,353; Permian and Pennsylvanian Weber, 13,580; Pennsylvanian Amsden, 14,328; Mississippian Madison, 14,996; Cambrian Gros Ventre, 14,694; and Flathead, 16,140. The field is still being developed; by the end of 1974 nearly a dozen wells were in production.

The Bluewater 33-32 well, drilled by the Prenalta Corp. in sec. 32, T. 18 N., R. 101 W., discovered gas in the Dakota Sandstone at 7,274 feet. Initial flowing potential of the well was 191 bbl of condensate, 73 bbl of water, and 2,500 MCF of gas per day. Formation tops (in feet below ground surface) are as follows: Blair, 1,466; Baxter, 3,396; Frontier, 6,626; Aspen, 6,935; Dakota, 7,160; Curtis of drillers, 7,746; Entrada of drillers, 7,880; Carmel of drillers, 7,924; and Nugget, 7,996.

URANIUM

No uranium has been mined in the quadrangle, but a number of claims have been staked in the lower part of the Almond Formation in sec. 26, T. 17 N., R. 102 W. (pl. 1). The claims were staked in the period 1955–65; no recent assessment work has been done on them. The amount or value of the uranium present is unknown.

TABLE 8.—*Major, minor and trace-element composition of*

[Results are in percent (%) or parts per million (ppm). Al, Ca, Fe, Mg, Na, K, Si, Cl, Mn, P, Ti, Cd, Cu, Li, Pb, and Zn values were calculated from analyses of ash. As, F, Hg, Sb, Se, Th, and U values determined. See table 5 for identification of samples by laboratory and field

Sample	Si %	Al %	Ca %	Mg %	Na %	K %	Fe %	Mn ppm	Ti %	P ppm
D169571	3.7	2.6	0.65	0.193	0.034	0.086	0.52	25 L	0.063	70 L
D169572	2.5	1.5	.66	.150	.011	.072	1.9	22 L	.061	61 L
D169573	14	5.7	.38	.252	.040	.78	.57	68 L	.17	410
D169574	.71	.92	.77	.437	.063	.028	.10	41	.020	1300
D169575	2.2	.77	1.1	.451	.020	.085	.26	27	.028	48 L
D169576	.77	.60	.60	.055	.004	.019	.36	8.0L	.020	23 L
D169577	6.5	3.4	.48	.056	.044	.20	1.5	40 L	.12	280
D169578	8.2	2.6	.52	.121	.032	.25	1.2	42 L	.16	420
D169579	.86	.51	.43	.170	.016	.014	.91	25	.020	300
D169580	11	3.3	.80	.441	.035	.42	.36	54 L	.15	150 L
D169581	1.8	1.4	.98	.181	.008	.065	.24	15 L	.045	1400
D169582	2.7	2.9	2.2	.309	.031	.088	.45	28 L	.12	5400
D169583	1.9	1.3	.64	.069	.006	.079	.27	14 L	.050	170
D169584	1.9	1.3	1.7	.064	.009	.10	.44	18 L	.041	51 L
D169585	3.7	1.6	.49	.155	.011	.12	.59	22 L	.077	61 L
D169586	1.2	.71	.59	.050	.005	.048	.48	10 L	.028	29 L
D169587	1.7	.63	.31	.062	.004	.040	.28	15	.035	230
D169588	4.0	3.4	.46	.071	.008	.11	.39	26 L	.063	160
D169589	3.1	2.7	.46	.103	.009	.095	.36	22 L	.097	400
D169590	3.4	3.2	1.2	.357	.023	.065	.23	27 L	.095	520
D169591	4.0	3.0	.67	.099	.028	.16	1.0	28 L	.099	80 L
D169592	6.1	2.3	.16	.079	.013	.12	.34	29 L	.12	82 L
D169593	1.3	1.1	1.0	.201	.008	.023	.17	12 L	.040	160
D169594	1.1	.74	.62	.175	.006	.027	.16	8.8L	.036	25 L
D169595	.75	.75	.19	.046	.002	.018	.14	6.3L	.026	490

Sample	Cl %	As ppm	Cd ppm	Cu ppm	F ppm	Hg ppm	Li ppm	Pb ppm	Sb ppm	Se ppm
D169571	0.016L	4	0.56	24.8	90	0.09	12.2	6.4	0.9	2.1
D169572	.014L	30	.35	17.5	45	.18	5.3	4.9	.7	2.6
D169573	.044L	3	.44L	12.4	580	.07	24.8	13.3	1.0	.9
D169574	.007L	1 L	.07L	3.9	175	.03	2.9	2.4	.3	.6
D169575	.011L	1 L	.33	4.4	120	.03	3.3	2.8L	.6	.9
D169576	.005L	1 L	.18	4.1	50	.03	.5	2.1	.2	.9
D169577	.34	15	.38	35.3	135	.17	20.5	7.7	.9	4.0
D169578	.027L	15	.27L	21.6	230	.22	7.6	6.8L	.6	2.8
D169579	.006L	2	.07L	2.9	35	.07	1.0	1.6L	.3	1.1
D169580	.035L	1	.35L	14.7	230	.09	21.0	8.7	.5	1.1
D169581	.010L	1	.10	4.8	175	.03	2.6	2.5	.3	1.0
D169582	.018L	1	.18L	6.3	405	.04	3.7	6.4	.3	1.1
D169583	.009L	1	.80	8.0	115	.05	3.0	3.1	.4	1.2
D169584	.012L	1	.24	6.1	230	.14	2.4	3.5	.4	1.6
D169585	.014L	2	.14	13.4	70	.04	13.2	5.6	.5	.9
D169586	.007L	3	.70	4.3	55	.04	1.3	2.0	.3	1.0
D169587	.007L	1 L	.14	4.7	45	.03	2.5	1.7	.3	.8
D169588	.017L	1	.59	6.7	100	.04	12.4	6.7	.5	1.7
D169589	.014L	2	.14	6.9	190	.04	12.0	5.7	.5	1.3
D169590	.017L	1 L	.17	5.2	190	.06	25.8	6.1	.5	1.4
D169591	.018L	10	.28	30.9	105	.26	7.7	7.4	.5	3.0
D169592	.019L	2	.19L	16.1	90	.07	18.0	6.5	.5	1.4
D169593	.008L	1 L	.11	4.3	220	.05	1.8	3.8	.3	1.1
D169594	.006L	1	.09	4.4	80	.05	3.3	2.0	.2	.7
D169595	.004L	1 L	.04L	3.0	135	.04	3.6	1.4	.3	.4

Sample	Th ppm	U ppm	Zn ppm	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S	Cr ppm-S	Ga ppm-S
D169571	7.9	2.1	22.5	100	300	1.5	N	3	15	5
D169572	6.8	2.7	14.2	15	200	N	N	2	10	5
D169573	9.1	4.2	32.3	50	300	N	N	5 L	30	7
D169574	3.0L	1.0	5.8	100	300	.3	N	.7	2	1
D169575	3.0L	2.0	36.3	20	70	2	N	3	5	1.5
D169576	3.0L	.5	12.9	30	50	.2	N	1	3	1
D169577	10.9	4.1	18.7	50	700	.7	150 L	5	20	5
D169578	5.6	2.7	11.9	50	700	N	N	3 L	20	5
D169579	2.7	.4	7.6	70	100	.3	N	1	2	1.5
D169580	7.1	2.4	23.1	50	150	1	N	N	20	5
D169581	2.5	.9	14.2	50	500	.7	N	1	5	3
D169582	5.7	1.4	14.0	30	2000	N	N	2 L	5	5
D169583	3.2	.7	20.3	15	200	1	N	3	10	3
D169584	3.7	2.7	14.4	10	2000	1	N	1.5	10	3
D169585	4.0	1.4	12.5	70	300	.5	N	1.5	10	5
D169586	3.0L	.6	10.5	30	150	.3	N	1.5	5	1.5
D169587	2.0	.6	8.6	50	150	.2	N	1	5	1
D169588	6.6	3.3	15.0	15	200	1.5	N	2	10	10
D169589	6.2	1.3	21.7	20	200	.5	70 L	2	7	7
D169590	5.2	1.9	13.1	50	200	.5	N	2	5	5
D169591	9.0	2.5	20.8	50	500	.5	N	3	20	5
D169592	4.8	1.3	8.2	30	300	N	N	N	10	3
D169593	2.7	1.1	8.3	10	200	.5	30	1	5	2
D169594	2.4	.6	8.0	50	100	.7	N	1	5	1.5
D169595	3.0L	1.0	3.2	50	150	.7	20 L	.7	2	1.5

25 coal samples from the Cooper Ridge NE quadrangle

are from direct determinations on air-dried (32°F) coal. Remaining analyses were calculated from spectrographic determinations on ash. L, less than the value shown; n, not detected; b, not reference numbers, formation, geographic location, bed name, and thickness]

Sample	Ge ppm-S	La ppm-S	Mo ppm-S	Nb ppm-S	Nd ppm-S	Ni ppm-S	Sc ppm-S	Sn ppm-S	Sr ppm-S	V ppm-S
D169571	N	10	2	3 L	N	15	5	N	50	20
D169572	N	10	1.5	N	N	15	2	N	70	20
D169573	N	N	N	10 L	B	15	5	N	100	30
D169574	N	5	.5	N	N	2	1	N	500	5
D169575	2	N	N	2 L	B	7	3	N	30	7
D169576	N	3	N	1 L	N	5	.7	N	20	3
D169577	N	20	5	5 L	50 L	20	5	N	70	20
D169578	N	20	3	5 L	N	5	5	N	150	20
D169579	1.5	5	N	1.5 L	N	10	1.5	N	200	5
D169580	N	N	N	N	B	5	3	7 L	50	20
D169581	N	7	N	N	N	3	1.5	N	300	7
D169582	N	15	N	N	N	2	2	N	2000	15
D169583	N	7	N	N	N	15	2	N	100	10
D169584	N	N	1 L	N	B	10	3	N	100	10
D169585	N	10	1	3	N	5	2	N	50	15
D169586	N	5	.5 L	N	10 L	10	1	N	20	5
D169587	N	5	.5 L	1.5	N	5	1	N	100	7
D169588	N	10	N	3	N	10	2	N	100	15
D169589	N	15	N	3	20 L	5	2	N	150	20
D169590	N	15	N	3	N	5	1.5	N	200	15
D169591	N	15	3	3 L	30 L	15	3	N	100	30
D169592	N	15	1.5	3	N	2	2	N	30	15
D169593	N	20	.7	1.5	15	5	2	N	200	10
D169594	N	5	.5	N	N	3	1	N	70	5
D169595	.7 L	5	.3	.7	7 L	2	1.5	N	150	7

Sample	Y ppm-S	Yb ppm-S	Zr ppm-S
D169571	10	1	20
D169572	7	.7	20
D169573	15	1.5	70
D169574	3	.2	10
D169575	7	.7	15
D169576	3	.2	7
D169577	15	1.5	50
D169578	7	.7	50
D169579	7	.5	10
D169580	7	1	50
D169581	3	.3	15
D169582	5	.5	30
D169583	7	.5	15
D169584	10	.7	10
D169585	5	.5	30
D169586	7	.5	10
D169587	5	.3	15
D169588	10	1	30
D169589	7	.7	50
D169590	5	.5	30
D169591	10	1	20
D169592	5	.5	50
D169593	5	.5	15
D169594	5	.5	10
D169595	3	.3	7

TABLE 7.—*Content of seven trace elements in 25 coal samples from the Cooper Ridge NE quadrangle*

[Analyses on air-dried (32°C) coal. All values are in parts per million. L, less than the value shown; B, not determined. See table 5 for the identification of samples by laboratory and field reference numbers, geographical location, bed name and thickness]

USGS Lab. No. D1695-	As	F	Hg	Sb	Se	Th	U
71----	4	90	0.09	0.9	2.1	7.9	2.1
72----	30	45	.18	.7	2.6	6.8	2.7
73----	3	580	.07	1.0	.9	9.1	4.2
74----	1L	175	.03	.3	.6	B	1.0
75----	1L	120	.03	.6	.9	B	2.0
76----	1L	50	.03	.2	.9	B	.5
77----	15	135	.17	.9	4.0	10.9	4.1
78----	15	230	.22	.6	2.8	5.6	2.7
79----	2	35	.07	.3	1.1	2.7	.4
80----	1	230	.09	.5	1.1	7.1	2.4
81----	1	175	.03	.3	1.0	2.5	.9
82----	1	405	.04	.3	1.1	5.7	1.4
83----	1	115	.05	.4	1.2	3.2	.7
84----	1	230	.14	.4	1.6	3.7	2.7
85----	2	70	.04	.5	.9	4.0	1.4
86----	3	55	.04	.3	1.0	B	.6
87----	1L	45	.03	.3	.8	2.0	.6
88----	1	100	.04	.5	1.7	6.6	3.3
89----	2	190	.04	.5	1.3	6.2	1.3
90----	1L	190	.06	.5	1.4	5.2	1.9
91----	10	105	.26	.5	3.0	9.0	2.5
92----	2	90	.07	.5	1.4	4.8	1.3
93----	1L	220	.05	.3	1.1	2.7	1.1
94----	1	80	.05	.2	.7	2.4	.6
95----	1L	135	.04	.3	.4	B	1.0

TITANIUM

A littoral sandstone in the upper part of the Rock Springs Formation in SE¼ sec. 11, T. 17 N., R. 102 W., contains a natural placer deposit of titanium-bearing heavy minerals. No mining has been done, but outcrops there are covered by claims. The sandstone is dark gray but on exposure weathers red brown. The grain-size distribution is about 15 percent coarse, 30 percent medium, 20 percent fine, 20 percent very fine, and 15 percent silt and clay. Magnetic heavy-mineral fractions consisting of ilmenite and magnetite compose 50–55 percent of the sandstone. The nonmagnetic heavy-mineral fraction is more than 95 percent zircon and minor garnet and rutile. The titanium in the deposits is found mainly in ilmenite, which is composed of 52–68 percent titanium dioxide (Murphy and Houston, 1955, p. 193). The deposit is not presently of economic importance.

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FIGURES 4–17

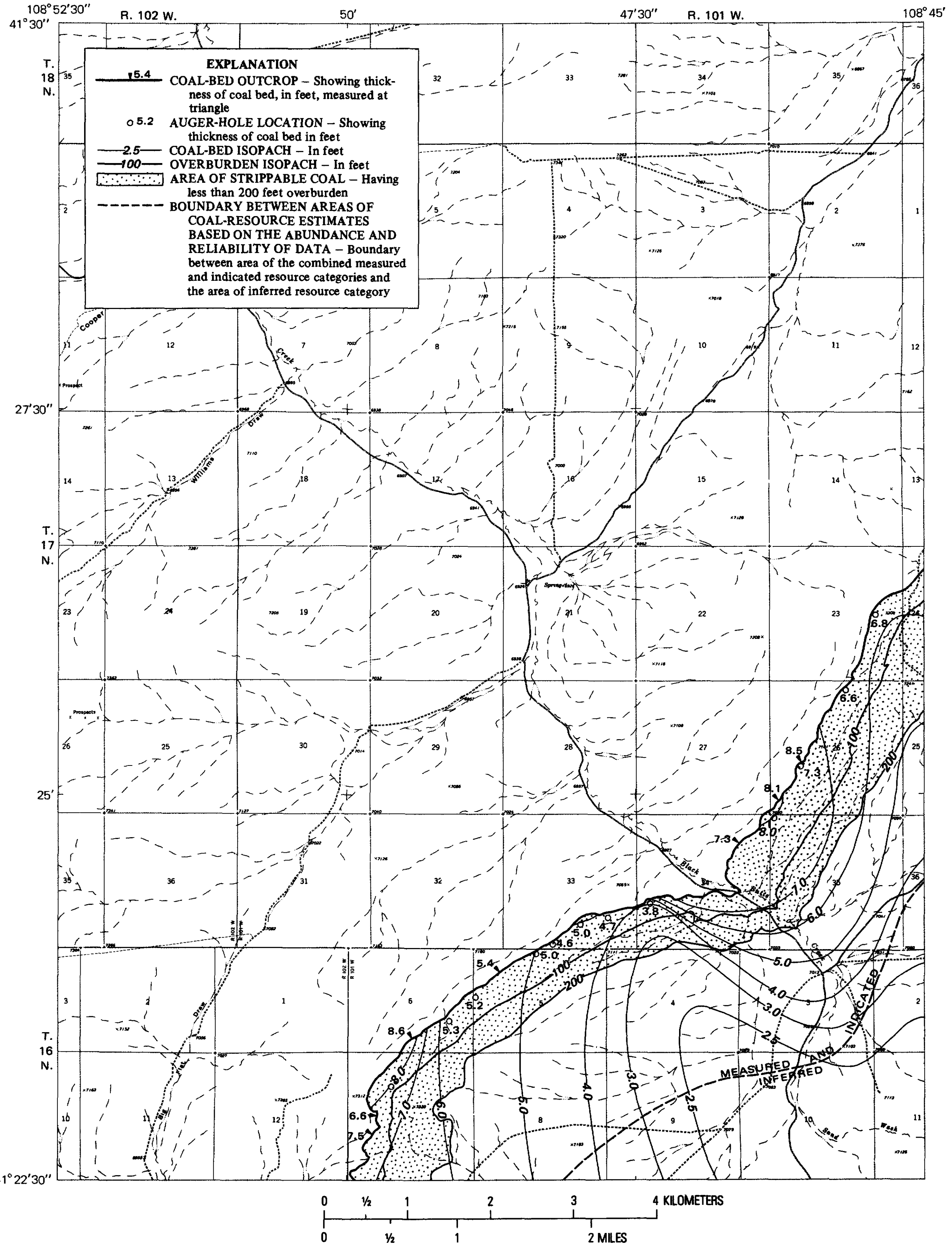

FIGURE 4.—Isopach map of the Big Burn coal bed, Fort Union Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Big Burn coal bed

[Leaders (- - -) indicate no resources]

Overburden thickness (in ft)---------	Measured and indicated resources 0-1,000		Inferred resources 0-1,000		Total coal reserves (million tons)	
	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
T. 17 N., R. 101 W.						
Sec. 23	6.0	1.228	--	--	1.228	
24	5.9	.796	--	--	.796	
25	4.7	.847	--	--	.847	
26	6.4	5.157	--	--	5.157	
27	8.1	.010	--	--	.010	
33	4.4	.758	--	--	.758	
34	7.5	4.532	--	--	4.532	
35	5.5	6.254	3.5	0.074	6.328	
36	4.3	.468	3.5	.256	.724	20.380
T. 16 N., R. 101 W.						
Sec. 2	3.8	0.068	2.9	0.725	0.793	
3	3.5	2.689	2.7	.158	2.847	
4	2.8	2.033	--	--	2.033	
5	4.8	3.836	--	--	3.836	
6	5.3	.897	--	--	.897	
7	6.5	5.406	--	--	5.406	
8	4.9	5.023	4.1	.193	5.216	
9	3.0	.945	3.0	1.189	2.134	
10	2.6	.030	2.6	.089	.119	
11	--	--	2.5	.002	.002	23.283

STRIPPABLE COAL RESOURCES

Overburden thickness (in ft) ------	0-100		100-200	
	Bed thickness (weighted avg. in ft)	Total (million tons)	Bed thickness (weighted avg. in ft)	Totsl (million tons)
T. 17 N., R. 101 W.				
Sec. 23	6.1	0.898	5.5	0.251
24	6.2	.256	5.5	.527
25	---	-----	5.5	.321
26	7.0	2.484	6.0	1.867
27	8.1	.020	---	-----
33	4.4	.607	3.6	.115
34	7.4	2.379	4.8	1.104
35	7.5	1.029	6.9	1.626
T. 16 N., R. 101 W.				
Sec 4	---	-----	3.5	0.120
5	5.1	.978	4.7	1.048
6	5.8	.713	5.7	.156
7	7.2	1.506	6.4	2.740
	Total----	10.870	Total-------	9.875

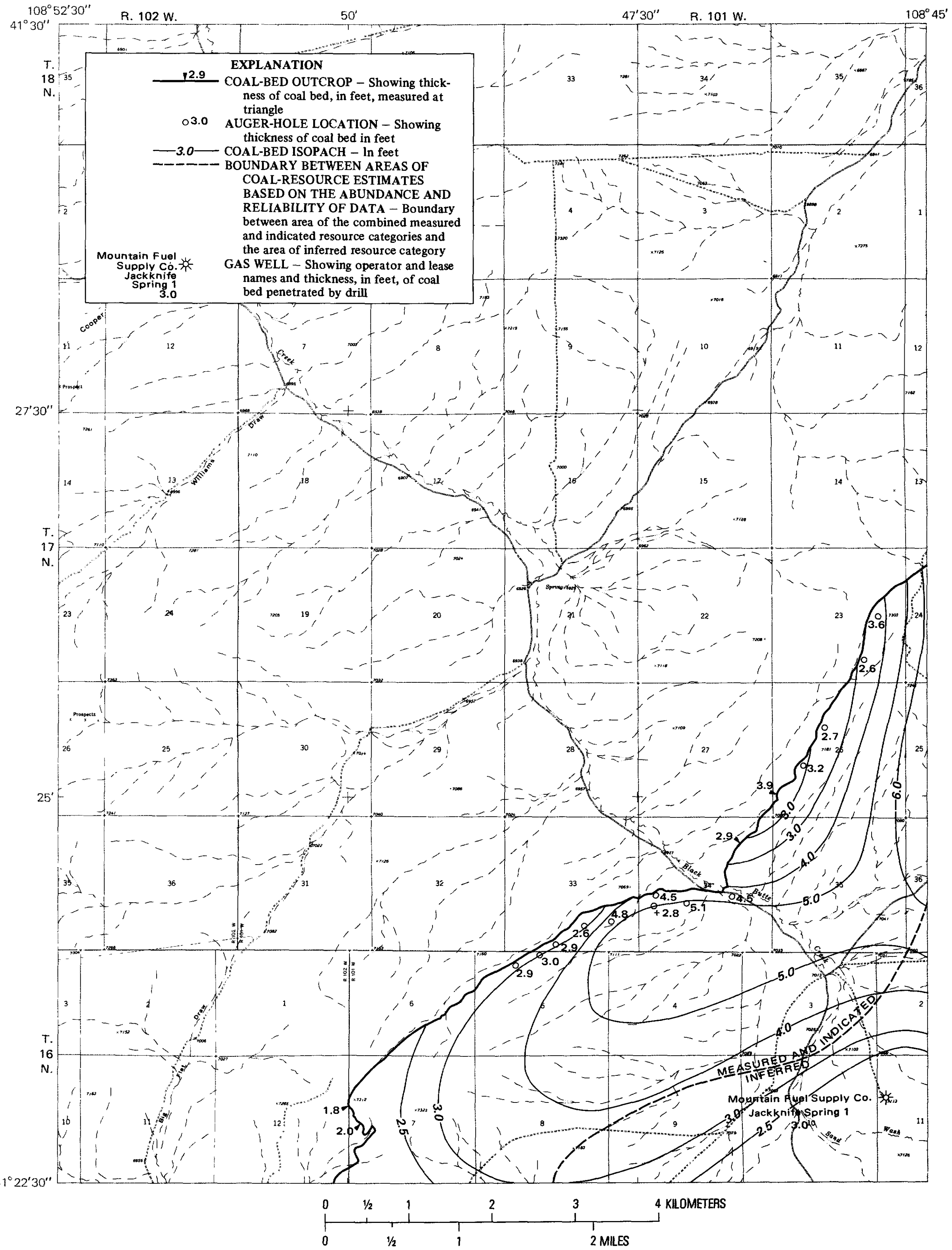

FIGURE 5.—Isopach map of the Hail coal bed, Fort Union Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Hail coal bed

[Leaders (- - -) indicate no resources for that category]

Overburden thickness (in ft)-------		Measured and indicated resources 0-1,000		Inferred resources 0-1,000		Total coal reserves (million tons)	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
T. 17 N., R. 101 W.							
Sec.	23	4.0	1.001	--	--	1.001	
	24	5.5	.813	--	--	.813	
	25	6.1	1.090	--	--	1.090	
	26	4.0	3.444	--	--	3.444	
	27	2.7	.015	--	--	.015	
	33	4.0	.890	--	--	.890	
	34	5.0	3.411	--	--	3.411	
	35	5.0	5.686	--	--	5.686	
	36	6.0	.906	5.5	.179	1.085	17.435
T. 16 N., R. 101 W.							
Sec.	2	4.5	0.219	3.5	0.955	1.174	
	3	4.5	3.509	3.0	.273	3.782	
	4	5.0	4.370	--	--	4.370	
	5	4.0	3.294	--	--	3.294	
	6	3.0	.487	--	--	.487	
	7	3.0	1.608	--	--	1.608	
	8	3.6	3.439	3.2	.390	3.829	
	9	4.1	1.372	3.0	2.027	3.399	
	10	3.5	.159	3.5	1.063	1.222	23.165

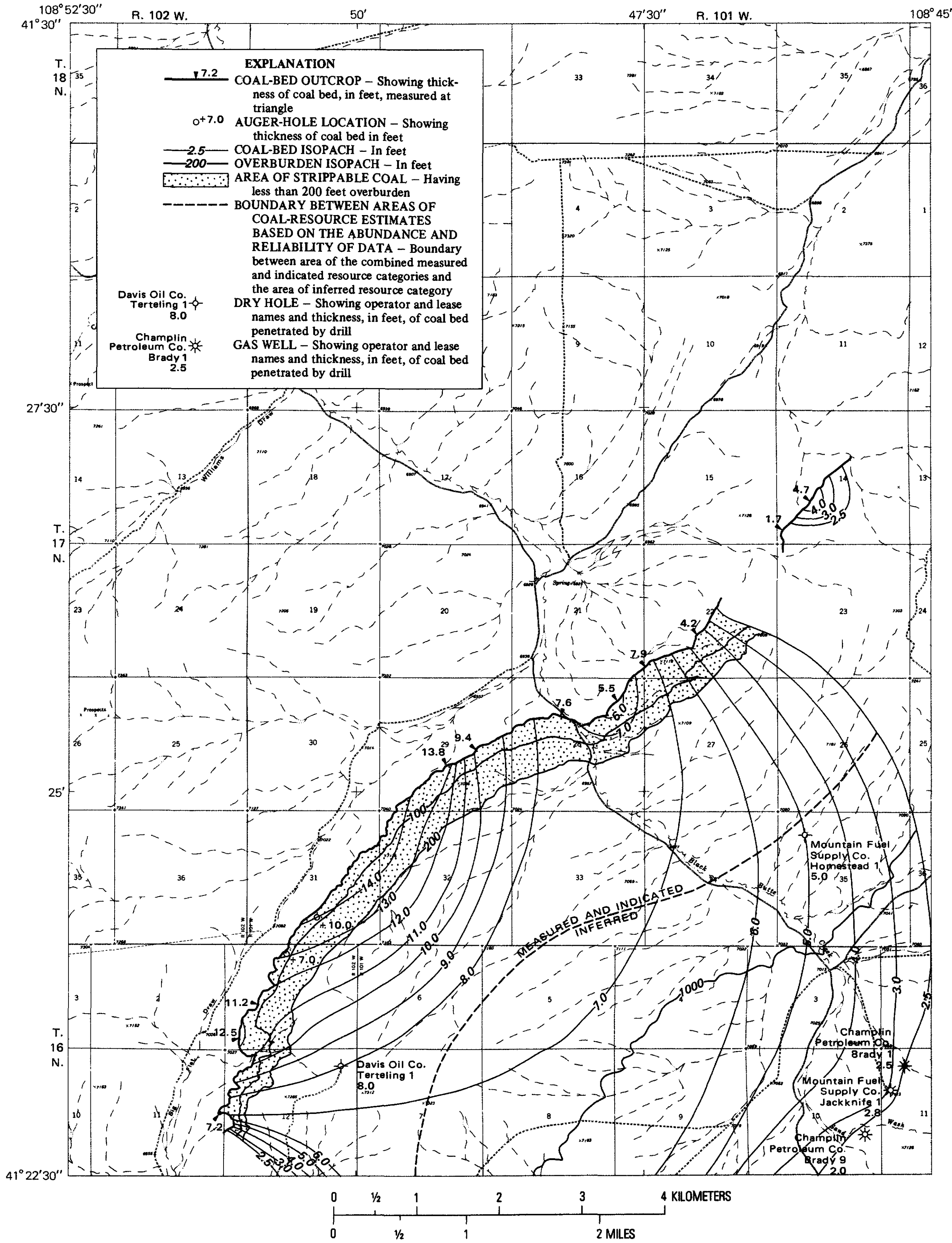

FIGURE 6.—Isopach map of the Little Valley coal bed, Fort Union Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Little Valley coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)---	---	Measured and indicated resources 0-1,000 Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Inferred resources 0-1,000 Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Inferred resources 1,000-2,000 Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Total coal reserves (million tons) For section	For township
				T. 17 N., R. 101 W.					
Sec.	14	3.0	0.380	--	--	--	--	0.380	
	21	7.0	.046	--	--	--	--	.046	
	22	4.3	1.495	--	--	--	--	1.495	
	23	2.8	.232	--	--	--	--	.232	
	26	3.7	2.338	3.0	0.780	--	--	3.118	
	27	6.2	7.121	--	--	--	--	7.121	
	28	7.5	6.396	--	--	--	--	6.396	
	29	11.0	3.770	--	--	--	--	3.770	
	31	13.5	4.386	--	--	--	--	4.386	
	32	11.0	12.330	--	--	--	--	12.330	
	33	7.6	7.445	7.2	1.158	--	--	8.603	
	34	6.6	3.742	6.3	3.643	--	--	7.385	
	35	5.1	.124	4.3	3.597	3.2	0.884	4.605	
	36	--	--	2.6	.017	2.6	.275	.292	60.159
				T. 16 N., R. 101 W.					
Sec.	2	--	--	--	--	2.9	0.829	0.829	
	3	--	--	5.4	0.270	4.7	3.917	4.187	
	4	--	--	6.6	3.206	6.3	2.466	5.672	
	5	7.8	0.735	7.1	5.582	--	--	6.317	
	6	8.9	6.911	7.5	.439	--	--	7.349	
	7	7.0	4.037	6.8	3.093	--	--	7.130	
	8	--	--	6.7	5.529	6.4	1.622	7.151	
	9	--	--	6.6	.107	6.0	6.384	6.491	
	10	--	--	--	--	3.6	3.398	3.398	
	11	--	--	--	--	3.0	.224	.224	48.748
				T. 16 N., R. 102 W.					
	1	11.0	7.237	--	--	--	--	7.237	
	11	7.1	.046	--	--	--	--	.046	
	12	7.0	6.482	--	--	--	--	6.482	13.765

STRIPPABLE COAL RESOURCES

Overburden thickness (in ft)------		0-100 Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	100-200 Bed thickness (weighted avg. in ft)	Coal reserves (million tons)
		T. 17 N., R. 101 W.			
Sec.	21	5.9	0.028	--	--
	22	5.0	.778	4.5	0.371
	27	7.1	.306	6.9	.487
	28	7.2	1.446	7.6	1.727
	29	12.0	1.586	10.0	1.741
	31	14.2	1.404	13.8	2.409
	32	14.2	.492	13.2	2.279
		T. 16 N., R. 102 W.			
Sec.	1	11.8	1.094	11.5	2.349
	11	7.1	.020	--	--
	12	8.0	.602	8.0	.502
		Total-----	7.756	Total----	11.865

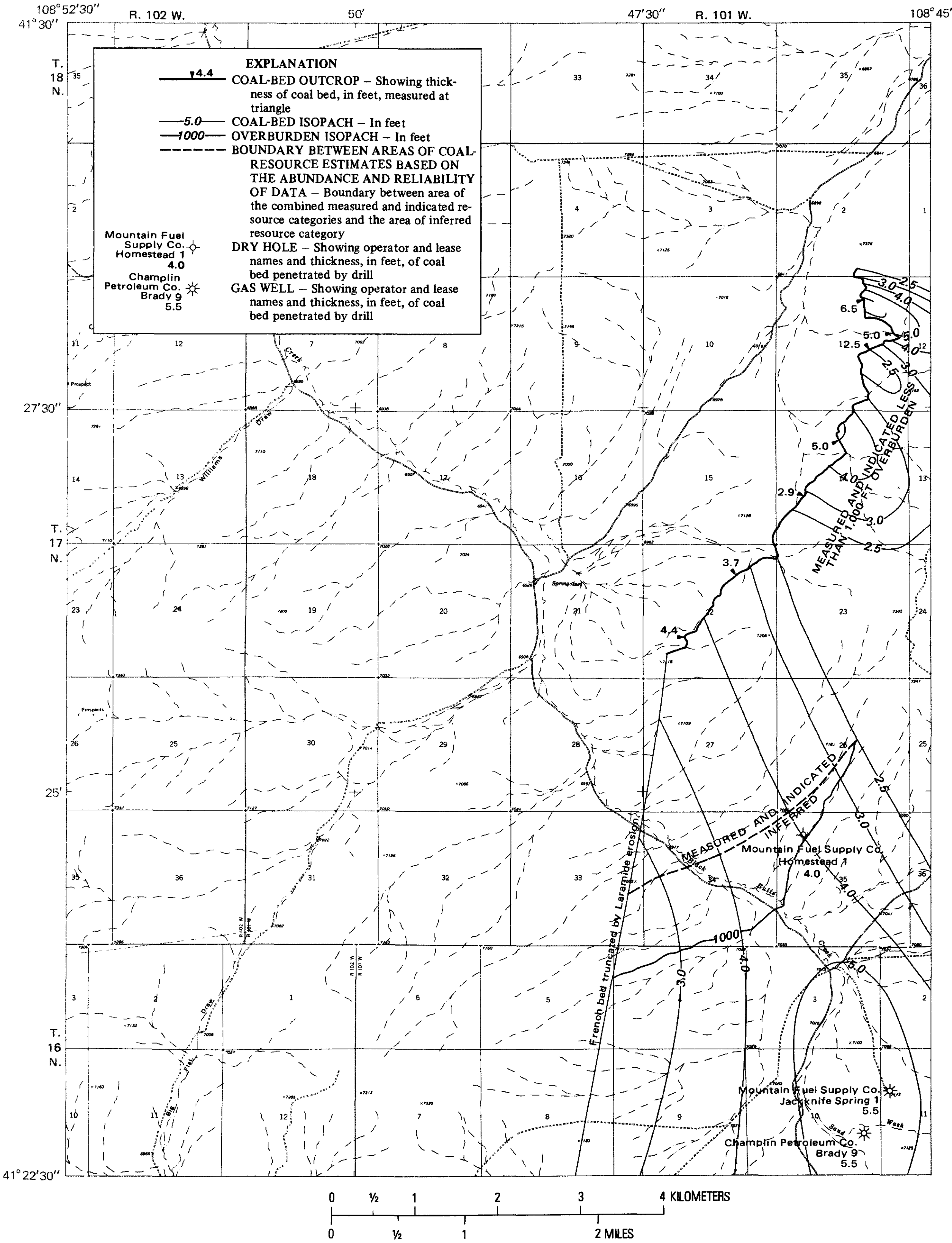

FIGURE 7.—Isopach map of the French coal bed, Lance Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the French coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)---------		Measured and indicated resources 0-1,000		Inferred resources 0-1,000		Inferred resources 1,000-2,000		Total coal reserves (million tons)	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For Township
T. 17 N., R. 101 W.									
Sec.	2	2.7	0.024	--	--	--	--	0.024	
	11	4.0	1.096	--	--	--	--	1.096	
	12	3.5	.613	--	--	--	--	.613	
	13	2.7	.463	--	--	--	--	.463	
	14	3.4	2.350	--	--	--	--	2.350	
	22	3.5	1.982	--	--	--	--	1.982	
	23	2.7	.557	--	--	--	--	.557	
	26	3.1	1.520	3.5	0.239	2.9	0.482	2.241	
	27	4.0	4.157	--	--	--	--	4.157	
	33	2.9	.097	2.8	.184	--	--	.281	
	34	3.8	1.440	3.9	2.675	4.0	.305	4.420	
	35	--	--	3.9	.504	4.0	4.002	4.506	
	36	--	--	--	--	2.9	.385	.385	23.075
T. 16 N., R. 101 W.									
Sec.	2	--	--	--	--	4.5	1.476	1.476	
	3	--	--	--	--	5.0	4.387	4.387	
	4	--	--	2.8	0.219	3.1	2.428	2.647	
	5	--	--	--	--	2.7	.078	.078	
	8	--	--	--	--	2.7	.573	.573	
	9	--	--	--	--	3.2	3.472	3.472	
	10	--	--	--	--	5.0	5.436	5.436	
	11	--	--	--	--	5.0	2.013	2.013	20.082

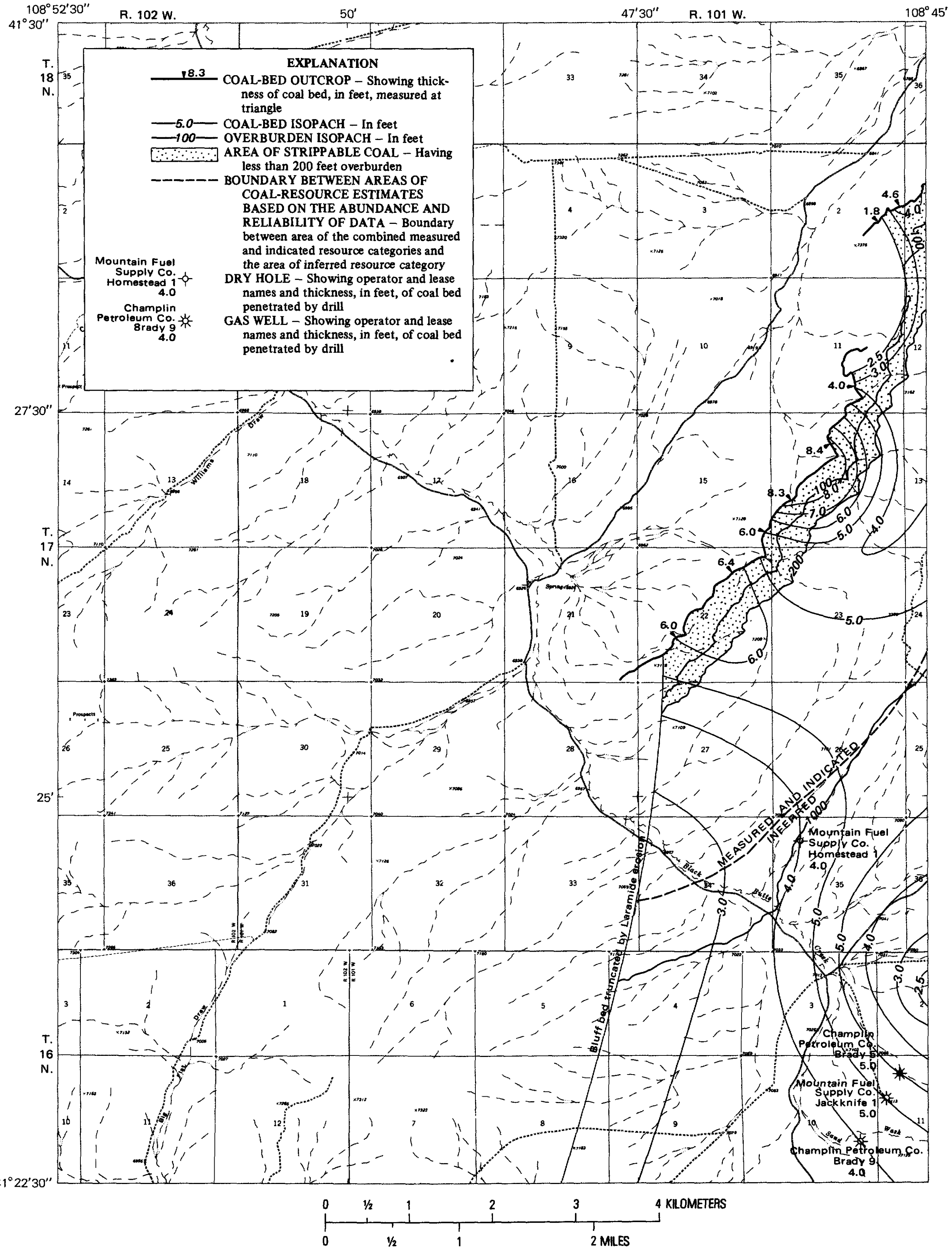

FIGURE 8.—Isopach map of the Bluff coal bed, Lance Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Bluff coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)------		Measured and indicated resources [1]0-1,000		Inferred resources 0-1,000		Inferred resources 1,000-2,000		Total coal reserves (million tons)	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
				T. 17 N., R. 101 W.					
Sec.	1	3.5	0.371	--	--	--	--	0.371	
	2	3.0	.127	--	--	--	--	.127	
	11	3.5	.687	--	--	--	--	.687	
	12	3.4	.642	--	--	--	--	.642	
	13	3.9	.756	--	--	--	--	.756	
	14	6.0	5.059	--	--	--	--	5.059	
	15	5.0	.053	--	--	--	--	.053	
	22	6.0	3.638	--	--	--	--	3.638	
	23	5.0	5.667	--	--	--	--	5.677	
	24	5.0	.841	5.0	0.049	5.0	0.025	.915	
	25	5.0	.015	5.0	.013	5.0	.894	.922	
	26	5.0	3.421	4.5	.367	5.0	1.883	5.671	
	27	3.9	3.766	--	--	--	--	3.766	
	34	2.9	1.300	3.0	1.743	3.6	.273	3.316	
	35	3.7	.016	3.9	.366	5.0	5.240	5.622	
	36	--	--	--	--	3.9	.685	.685	37.897
				T. 16 N., R. 101 W.					
Sec.	2	--	--	--	--	3.5	1.119	1.119	
	3	--	--	--	--	4.5	3.974	3.974	
	4	--	--	2.8	0.184	2.9	2.230	2.414	
	5	--	--	--	--	2.7	.027	.027	
	8	--	--	--	--	2.8	.601	.601	
	9	--	--	--	--	3.1	3.354	3.354	
	10	--	--	--	--	3.8	4.130	4.130	
	11	--	--	--	--	4.9	2.008	2.008	17.627

[1]Small insignificant areas on map in this category have overburden exceeding 1,000 feet.

STRIPPABLE COAL RESOURCES

Overburden thickness (in ft)------		0-100		100-200	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)
		T. 17 N., R. 101 W.			
Sec.	1	3.7	0.231	3.1	0.126
	2	2.7	.104	--	--
	11	3.3	.327	3.3	.236
	12	2.5	.015	3.0	.226
	14	7.5	1.433	6.2	1.285
	15	5.2	.055	--	--
	22	6.1	1.518	6.1	.935
	23	4.7	.055	4.7	.250
	27	4.6	.030	4.5	.126
		Total-------	3.768	Total-------	3.184

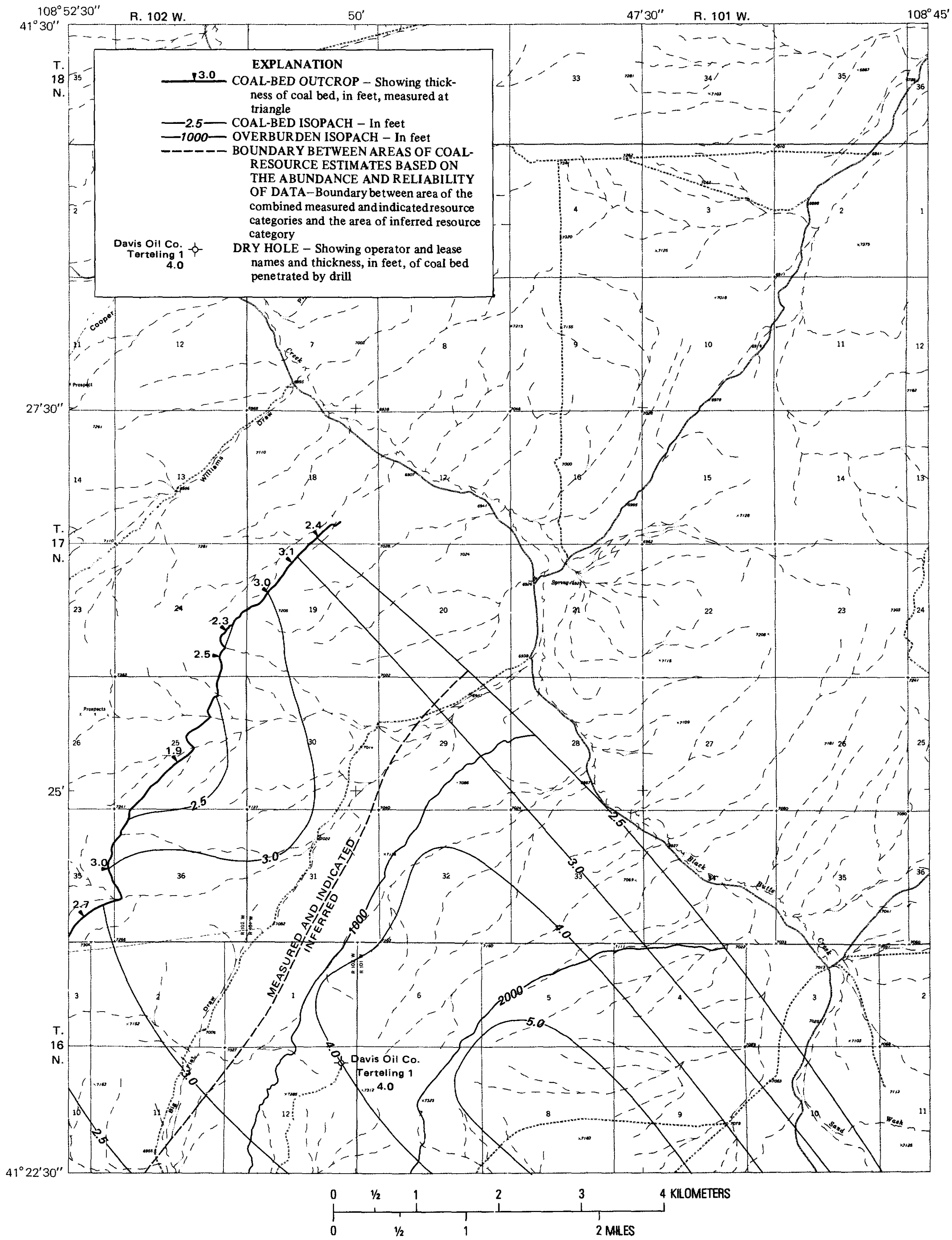

FIGURE 9.—Isopach map of the Sparrow coal bed, Almond Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Sparrow coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)--------		Measured and indicated resources 0-1,000		Inferred resources 0-1,000		Inferred resources 1,000-2,000		Inferred resources 2,000-3,000		Total coal reserves (million tons)	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
T. 17 N., R. 101 W.											
Sec.	18	2.5	0.009	--	--	--	--	--	--	0.009	
	19	3.0	2.740	--	--	--	--	--	--	2.740	
	20	2.8	.744	2.5	0.005	--	--	--	--	.749	
	28	--	--	2.6	.058	2.7	0.789	--	--	.847	
	29	3.1	.764	3.2	1.951	3.1	.709	--	--	3.424	
	30	3.1	3.484	3.5	.015	--	--	--	--	3.499	
	31	3.1	2.420	3.7	1.005	3.8	.236	--	--	3.661	
	32	--	--	3.7	.377	4.1	4.193	--	--	4.570	
	33	--	--	--	--	3.1	3.419	--	--	3.419	
	34	--	--	--	--	2.7	.628	--	--	.628	23.546
T. 17 N., R. 102 W.											
Sec.	24	2.6	0.211	--	--	--	--	--	--	0.211	
	25	2.6	.603	--	--	--	--	--	--	.603	
	35	2.7	.261	--	--	--	--	--	--	.261	
	36	3.1	3.424	--	--	--	--	--	--	3.424	4.499
T. 16 N., R. 101 W.											
Sec.	3	--	--	--	--	--	--	2.6	0.261	0.261	
	4	--	--	--	--	2.8	0.091	3.1	2.514	2.605	
	5	--	--	--	--	4.5	1.327	4.7	2.765	4.092	
	6	--	--	--	--	4.5	3.647	4.9	.106	3.753	
	7	--	--	--	--	4.2	2.412	4.8	2.127	4.539	
	8	--	--	--	--	--	--	5.3	5.636	5.636	
	9	--	--	--	--	--	--	4.4	4.746	4.746	
	10	--	--	--	--	--	--	2.9	2.142	2.142	27.774
T. 16 N., R. 102 W.											
Sec.	1	3.6	1.131	3.7	0.860	4.1	1.247	--	--	3.238	
	2	3.1	2.795	--	--	--	--	--	--	2.795	
	3	2.7	.407	--	--	--	--	--	--	.407	
	10	2.6	.226	--	--	--	--	--	--	.226	
	11	2.8	2.137	2.8	.721	--	--	--	--	2.858	
	12	3.3	.046	3.4	1.046	3.5	2.634	--	--	3.726	13.250

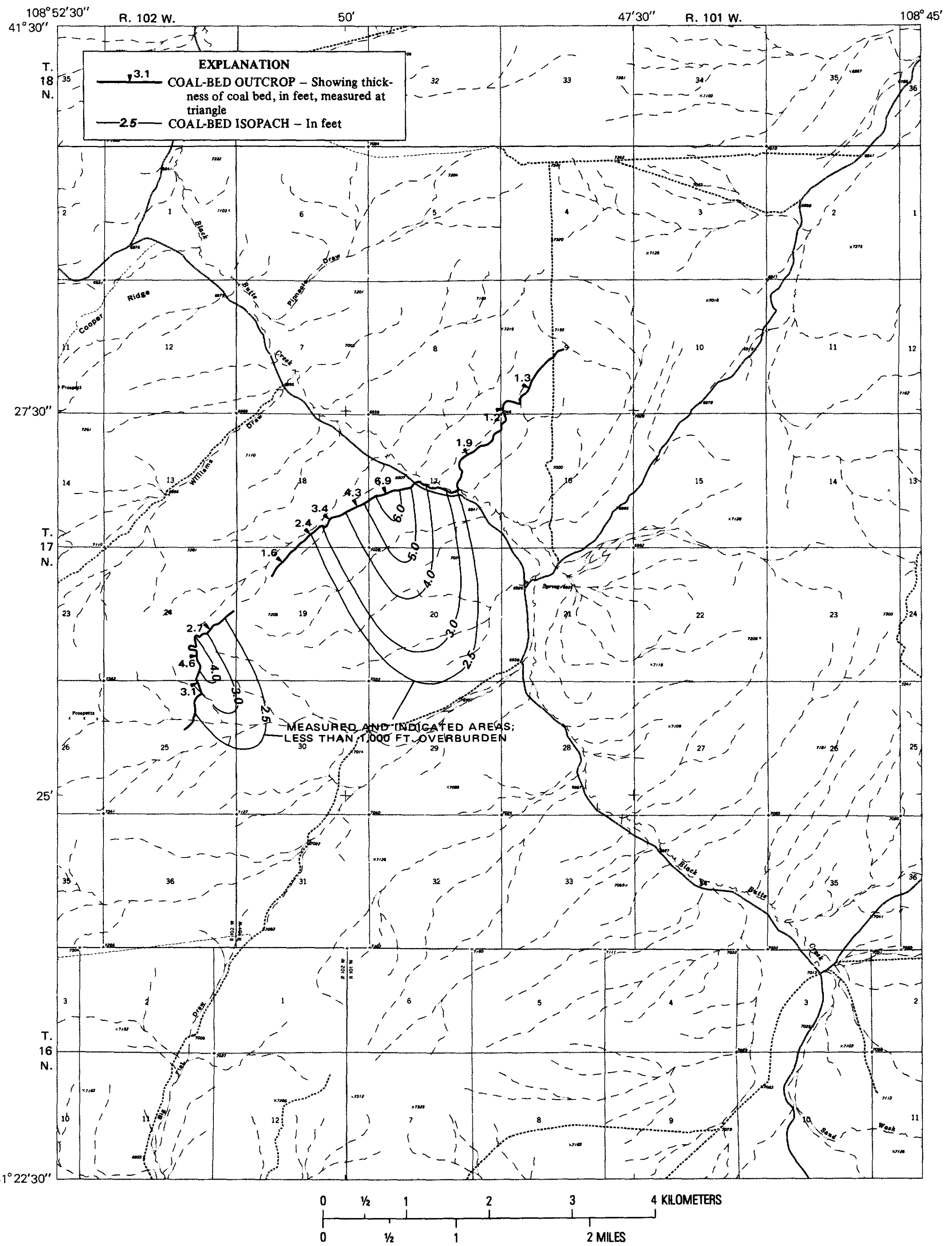

FIGURE 10.—Isopach map of the Coot coal bed, Almond Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Coot coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)-------	Measured and indicated resources 0-1,000 Bed thickness (weighted avg. in ft)	Measured and indicated resources 0-1,000 Coal reserves (million tons)	Total coal reserves (million tons) For section	Total coal reserves (million tons) For township
T. 17 N., R. 101 W.				
Sec. 17	5.0	1.810	1.810	
18	3.6	.407	.407	
19	2.8	.573	.573	
20	3.5	2.951	2.951	
29	2.5	.007	.007	
30	2.7	.314	.314	6.062
T. 17 N., R. 102 W.				
Sec. 24	3.1	0.412	0.412	
25	3.0	.407	.407	0.819

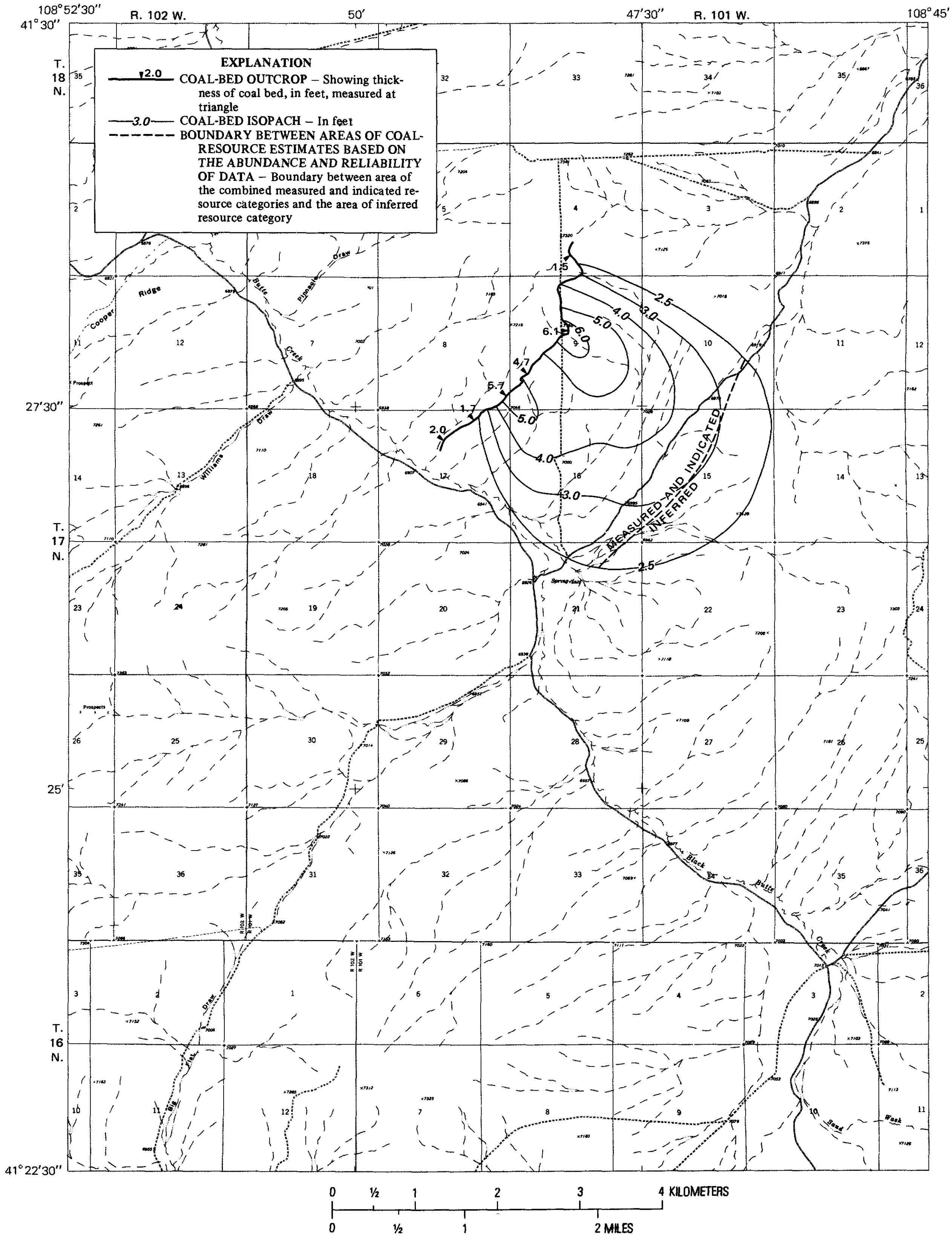

FIGURE 11.—Isopach map of the Buzzard coal bed, Almond Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Buzzard coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)-------	Measured and indicated resources 0-1,000		Inferred resources 0-1,000		Total coal reserves (million tons)	
	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
T. 17 N., R. 101 W.						
Sec. 4	2.6	0.046	--	--	0.046	
8	4.6	.043	--	--	.043	
9	5.0	4.173	--	--	4.173	
10	3.4	1.921	2.8	0.251	2.172	
15	3.5	1.337	2.8	1.627	2.964	
16	3.5	3.841	2.9	.020	3.861	
17	3.1	.412	--	--	.412	
21	2.7	.195	2.8	.151	.346	
22	--	--	2.7	.173	.173	14.190

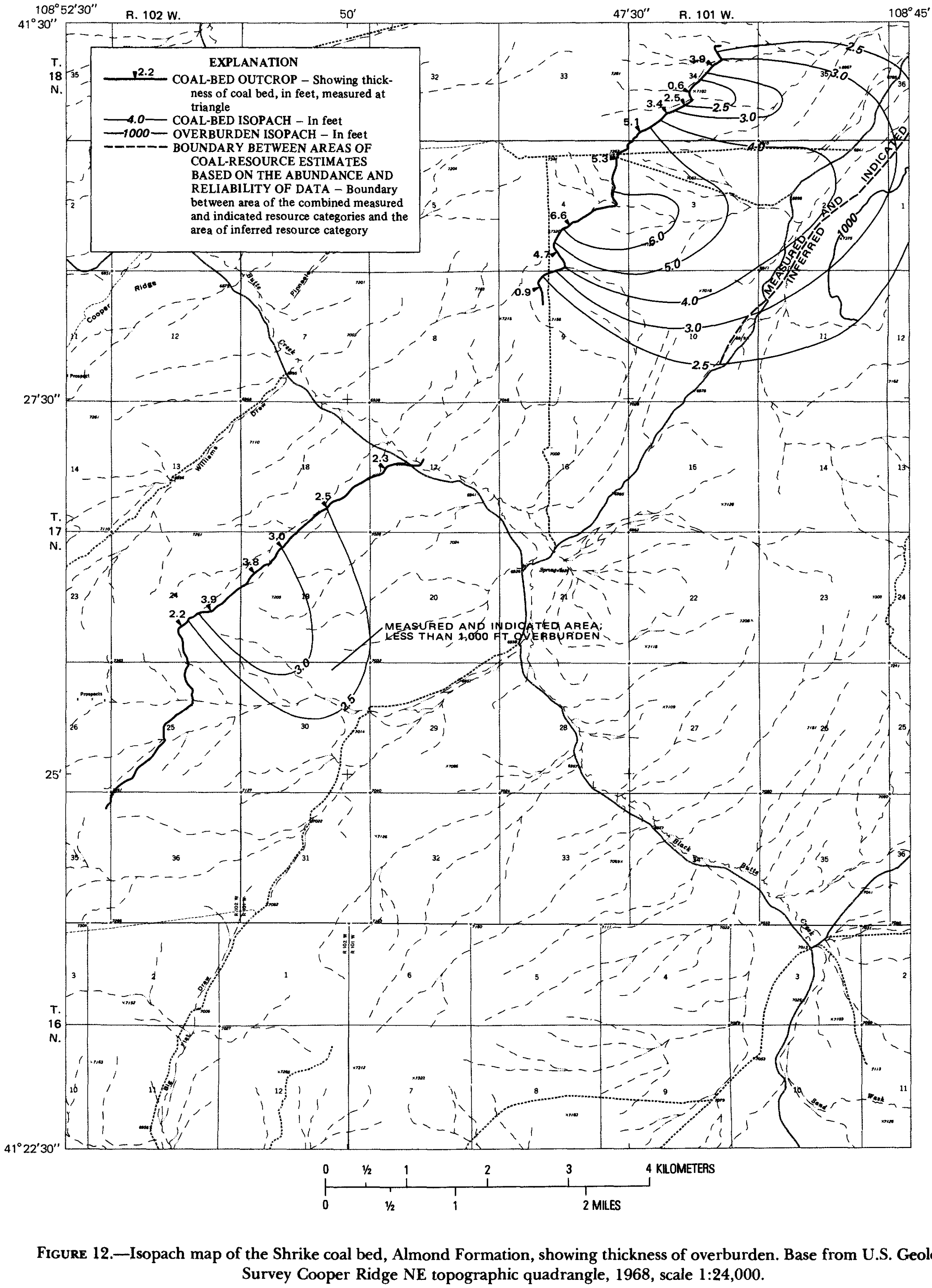

FIGURE 12.—Isopach map of the Shrike coal bed, Almond Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Shrike coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)---------		Measured and indicated resources 0-1,000		Inferred resources 0-1,000		Inferred resources 1,000-2,000		Total coal reserves (million tons)	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
				T. 18 N., R. 101 W.					
Sec.	34	3.0	1.166	--	--	--	--	1.166	
	35	3.2	2.599	--	--	--	--	2.599	
	36	2.7	.249	2.8	0.006	--	--	.255	4.020
				T. 17 N., R. 101 W.					
Sec.	1	3.0	0.029	2.9	0.141	2.7	0.279	.449	
	2	4.0	2.899	3.5	.631	2.9	.661	4.191	
	3	5.0	5.643	--	--	--	--	5.643	
	4	6.0	1.889	--	--	--	--	1.889	
	9	3.5	.855	--	--	--	--	.855	
	10	3.5	2.393	2.8	.242	--	--	2.635	
	11	3.6	.141	2.8	1.059	2.7	.390	1.590	
	12	--	--	--	--	2.5	.005	.005	
	18	2.7	.101	--	--	--	--	.101	
	19	2.9	2.700	--	--	--	--	2.700	
	30	2.8	.986	--	--	--	--	.986	21.044
				T. 17 N., R. 102 W.					
Sec.	24	3.1	0.442	--	--	--	--	0.442	
	25	2.7	.018	--	--	--	--	.018	.460

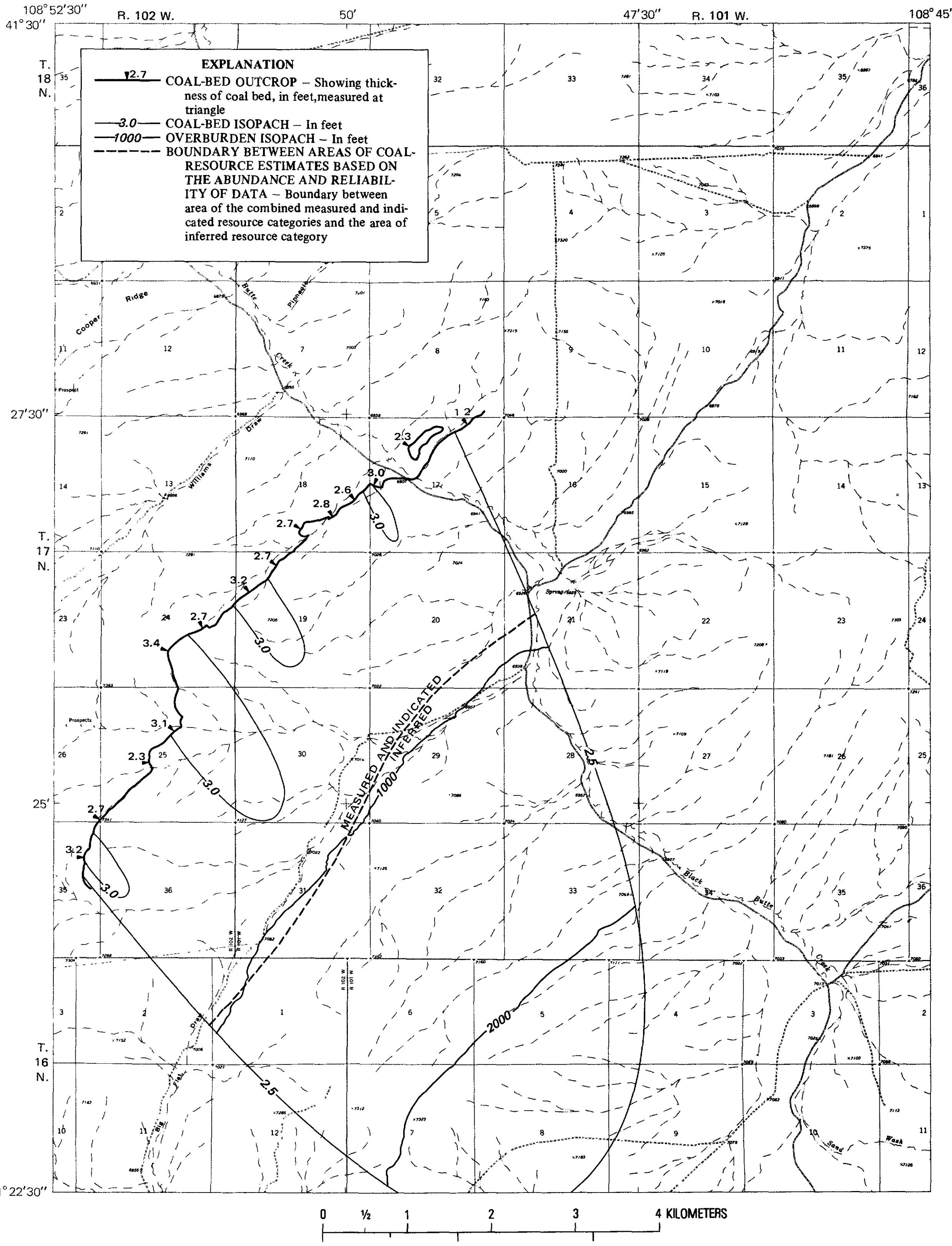

FIGURE 13.—Isopach map of the Eagle coal bed, Almond Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Eagle coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)--------	Measured and indicated resources		Inferred resources						Total coal reserves (million tons)	
	[1]0-1,000		0-1,000		1,000-2,000		2,000-3,000			
	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
				T. 17 N., R. 101 W.						
Sec. 16	2.5	0.002	--	--	--	--	--	--	0.002	
17	2.6	1.777	--	--	--	--	--	--	1.777	
18	2.7	.507	--	--	--	--	--	--	.507	
19	2.8	2.911	--	--	--	--	--	--	2.911	
20	2.7	2.710	2.7	.258	--	--	--	--	2.968	
21	2.6	.199	2.6	.183	2.6	.301	--	--	.683	
28	--	--	--	--	2.6	1.857	--	--	1.857	
29	2.7	.502	2.7	.504	2.7	2.018	--	--	3.024	
30	2.8	3.096	2.8	.030	2.8	.004	--	--	3.130	
31	2.7	1.752	2.8	.010	2.7	1.265	--	--	3.027	
32	--	--	--	--	2.7	3.044	--	--	3.044	
33	--	--	--	--	2.6	2.424	2.6	0.306	2.730	25.660
				T. 17 N., R. 102 W.						
Sec. 24	3.0	0.733	--	--	--	--	--	--	0.733	
25	2.9	2.052	--	--	--	--	--	--	2.052	
26	2.8	.001	--	--	--	--	--	--	.001	
35	2.9	.154	--	--	--	--	--	--	.154	
36	2.7	2.811	--	--	--	--	--	--	2.811	2.751
				T. 16 N., R. 101 W.						
Sec. 4	--	--	--	--	--	--	2.6	0.565	0.565	
5	--	--	--	--	2.7	0.634	2.6	1.646	2.280	
6	--	--	--	--	2.7	2.198	2.7	.038	2.236	
7	--	--	--	--	2.6	1.124	2.6	1.335	2.459	
8	--	--	--	--	--	--	2.6	2.620	2.620	
9	--	--	--	--	--	--	2.6	.239	.239	10.399
				T. 16 N., R. 102 W.						
Sec. 1	2.7	0.289	2.6	0.065	2.6	1.877	--	--	2.231	
2	2.6	.369	--	--	--	--	--	--	.369	
12	--	--	--	--	2.6	.803	--	--	.803	3.403

[1] Small insignificant areas on the map in this category have overburden exceeding 1,000 feet.

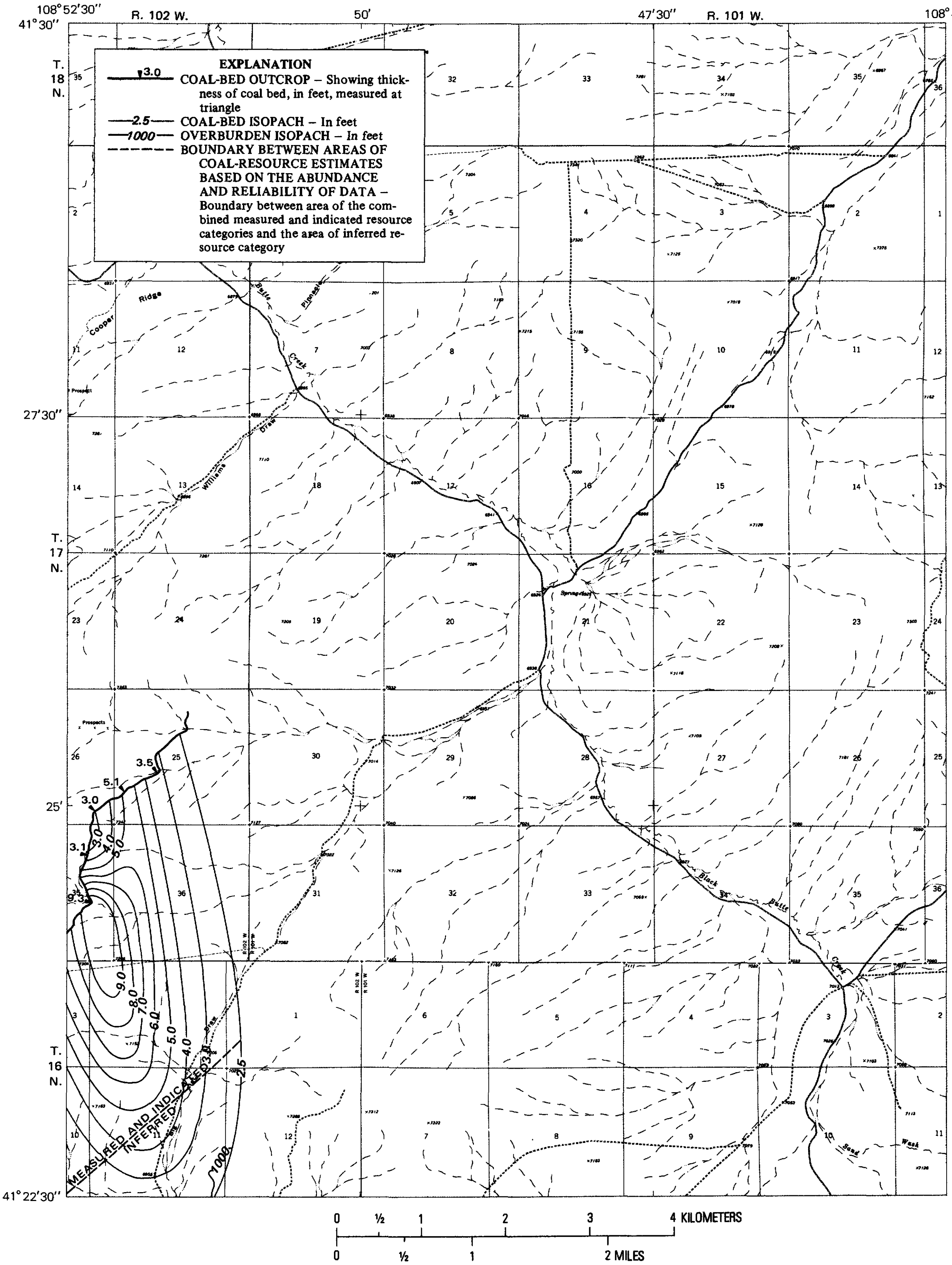

FIGURE 14.—Isopach map of the Meadow Lark coal bed, Almond Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Meadow Lark coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)-------		Measured and indicated resources 0-1,000		Inferred resources 0-1,000		Inferred resources 1,000-2,000		Total coal reserves (million tons)	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
				T. 17 N., R. 102 W.					
Sec.	25	4.0	1.146	--	--	--	--	1.146	
	26	3.5	.092	--	--	--	--	.092	
	35	7.0	1.961	--	--	--	--	1.961	
	36	4.5	3.901	--	--	--	--	3.901	7.100
				T. 16 N., R. 102 W.					
Sec.	1	2.6	0.149	2.6	0.047	--	--	0.196	
	2	5.5	4.907	2.7	.020	--	--	4.927	
	3	6.5	.940	--	--	--	--	.940	
	10	3.0	.480	2.7	.041	--	--	.521	
	11	4.9	2.061	2.8	1.792	2.5	.042	3.895	
	12	--	--	2.6	.156	2.5	.017	.173	10.652

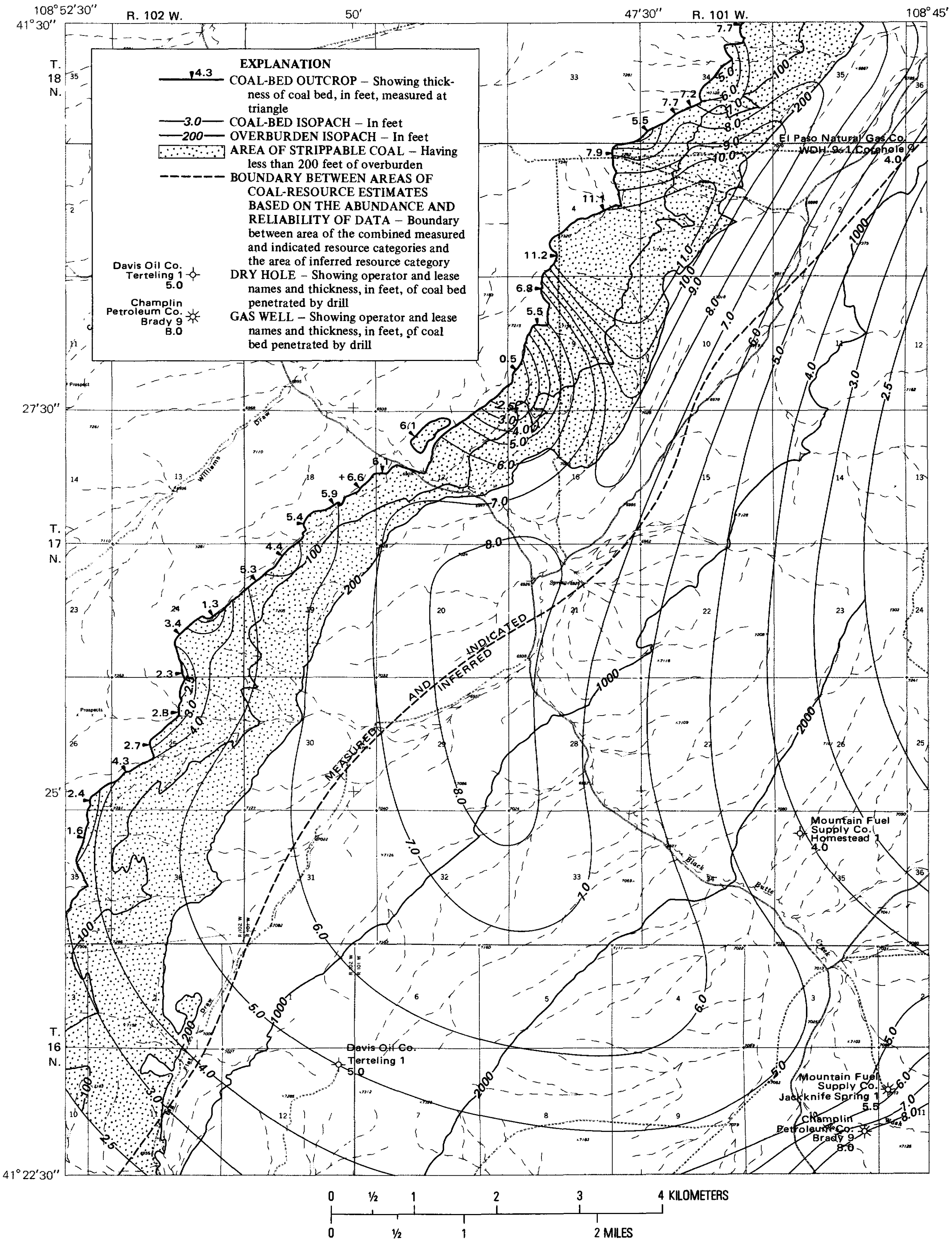

FIGURE 15.—Isopach map of the Magpie coal bed, Almond Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Magpie coal bed
[Leaders (- - -) indicate no data]

Overburden thickness (in ft)	Measured and indicated resources		Inferred resources						Total coal reserves (million tons)	
	0-1,000		0-1,000		1,000-2,000		2,000-3,000			
	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
T. 18 N., R. 101 W.										
Sec. 33	6.0	0.010	--	--	--	--	--	--	0.010	
34	7.5	4.082	--	--	--	--	--	--	4.082	
35	7.5	7.822	--	--	--	--	--	--	7.822	
36	5.1	.795	3.7	0.005	--	--	--	--	.800	12.714
T. 17 N., R. 101 W.										
Sec. 1	4.0	0.026	3.5	0.136	2.8	0.373	--	--	0.535	
2	6.0	4.367	4.1	.693	3.1	.745	--	--	5.805	
3	10.0	11.371	--	--	--	--	--	--	11.371	
4	11.0	4.968	--	--	--	--	--	--	4.968	
8	2.7	.035	--	--	--	--	--	--	.035	
9	8.0	7.486	--	--	--	--	--	--	7.486	
10	8.0	6.368	6.0	2.047	--	--	--	--	8.415	
11	4.9	.111	4.5	2.339	3.0	1.623	--	--	4.073	
12	--	--	--	--	2.6	.068	--	--	.068	
14	--	--	4.0	.539	3.0	2.115	--	--	2.654	
15	7.1	1.557	5.5	4.333	4.5	.607	--	--	6.497	
16	7.5	8.443	6.9	.056	--	--	--	--	8.499	
17	6.5	6.160	--	--	--	--	--	--	6.160	
18	6.0	1.238	--	--	--	--	--	--	1.238	
19	6.0	6.335	--	--	--	--	--	--	6.335	
20	8.0	8.330	8.3	.768	--	--	--	--	9.098	
21	8.0	3.093	7.2	5.240	6.3	.143	--	--	8.476	
22	--	--	6.0	1.511	5.0	4.500	--	--	6.011	
23	--	--	--	--	3.0	1.993	2.6	.351	2.344	
25	--	--	--	--	--	--	2.6	.118	.118	
26	--	--	--	--	3.4	.552	2.9	2.557	3.109	
27	--	--	--	--	5.0	5.499	4.3	.119	5.618	
28	--	--	7.7	1.976	7.0	6.140	--	--	8.116	
29	7.4	.962	8.0	7.629	8.2	.440	--	--	9.031	
30	6.1	6.045	6.6	.965	--	--	--	--	7.010	
31	5.7	1.731	6.2	5.137	--	--	--	--	6.868	
32	--	--	7.0	3.252	7.1	4.729	--	--	7.981	
33	--	--	--	--	7.0	7.892	6.5	.116	8.008	
34	--	--	--	--	5.7	3.130	5.2	3.083	6.213	
35	--	--	--	--	--	--	4.0	4.594	4.594	
36	--	--	--	--	--	--	3.0	.551	.551	167.296
T. 17 N., R. 102 W.										
Sec. 24	3.8	0.969	--	--	--	--	--	--	0.969	
25	4.6	3.699	--	--	--	--	--	--	3.699	
26	3.0	.083	--	--	--	--	--	--	.083	
35	3.9	1.115	--	--	--	--	--	--	1.115	
36	4.9	5.612	--	--	--	--	--	--	5.612	11.478
T. 17 N., R. 101 W.										
Sec. 2	--	--	--	--	--	--	4.8	1.606	1.606	
3	--	--	--	--	--	--	5.0	4.435	4.435	
4	--	--	--	--	--	--	6.1	5.341	5.341	
5	--	--	--	--	6.5	3.400	6.4	2.287	5.687	
6	--	--	--	--	6.1	5.113	--	--	5.113	
7	--	--	--	--	4.9	4.251	4.5	.738	4.989	
8	--	--	--	--	5.7	.222	5.2	5.440	5.662	
9	--	--	--	--	--	--	5.0	5.426	5.426	
10	--	--	--	--	--	--	5.5	5.995	5.995	
11	--	--	--	--	--	--	8.0	3.301	3.301	47.555
T. 17 N., R. 102 W.										
Sec. 1	5.1	0.282	5.2	2.441	5.4	2.009	--	--	4.732	
2	4.1	3.657	--	--	--	--	--	--	3.657	
3	2.9	.438	--	--	--	--	--	--	.438	
10	2.6	.211	--	--	--	--	--	--	.211	
11	2.9	1.557	3.0	1.058	3.0	.312	--	--	2.927	
12	--	--	4.3	.224	4.1	4.269	--	--	4.493	16.458

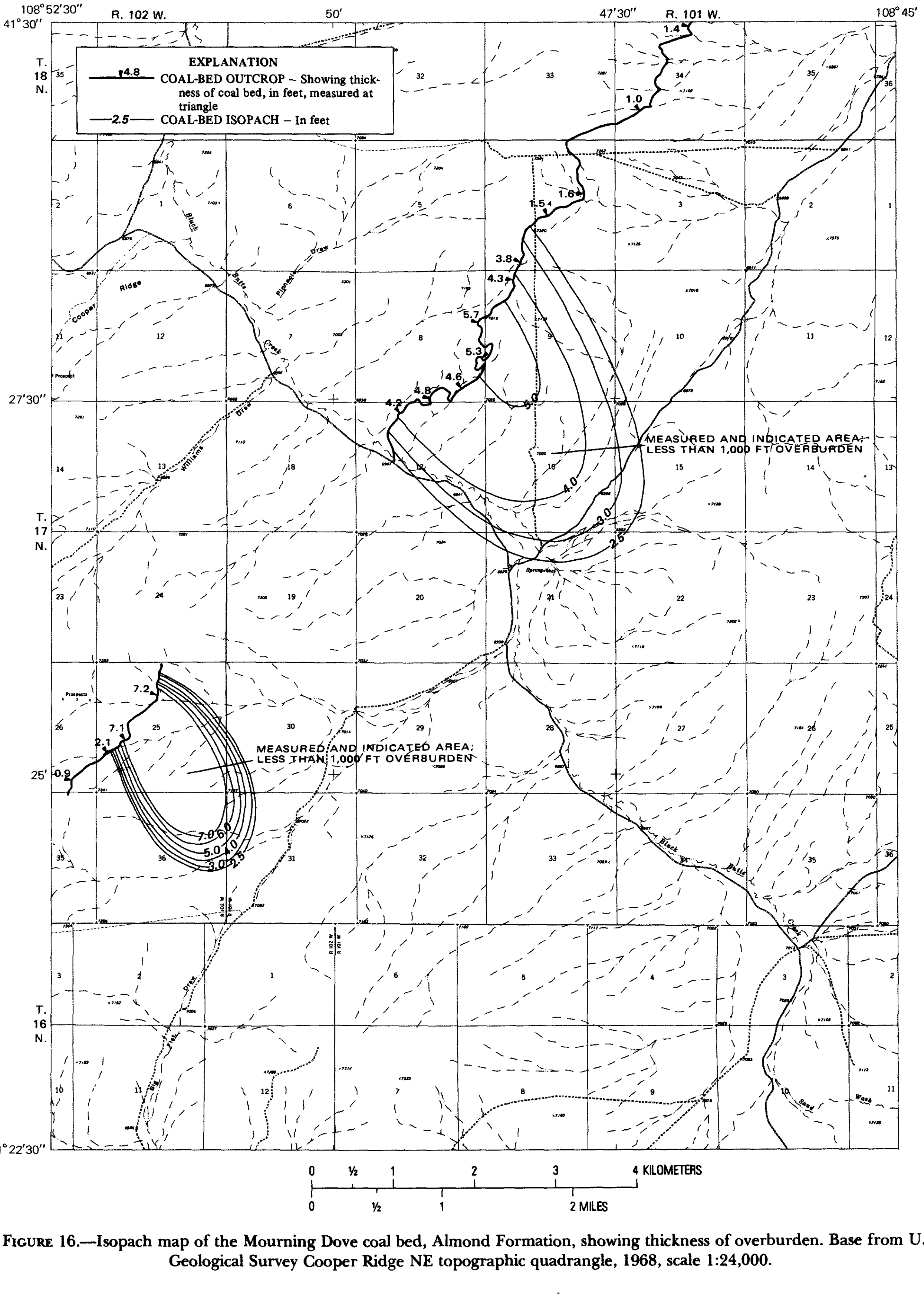

FIGURE 16.—Isopach map of the Mourning Dove coal bed, Almond Formation, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of the Magpie coal bed—Continued

STRIPPABLE COAL RESOURCES

Overburden (thickness in ft)-------		0-100		100-200	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	Bed thickness (weighted avg. in ft)	Coal reserves (million tons)
T. 18 N., R. 101 W.					
Sec.	33	6.5	0.045	--	--
	34	7.2	2.890	8.2	1.488
	35	7.3	.511	7.6	2.152
T. 17 N., R. 101 W.					
Sec.	3	10.0	1.960	10.0	5.113
	4	11.0	4.892	11.2	.126
	8	2.6	.025	--	--
	9	8.0	4.391	7.5	2.961
	10	--	--	10.5	1.355
	16	3.5	.070	6.5	2.108
	17	5.8	2.066	6.2	1.511
	18	6.0	.853	6.4	.442
	19	5.0	.813	5.9	3.262
	30	5.0	.128	5.5	1.415
T. 17 N., R. 102 W.					
Sec.	24	3.8	0.989	--	--
	25	4.4	2.244	5.0	1.395
	26	3.2	.092	--	--
	35	3.8	.929	3.8	.161
	36	4.3	.557	4.7	2.961
T. 16 N., R. 102 W.					
Sec.	2	3.0	0.050	3.8	2.106
	3	2.8	.241	2.9	.176
	10	2.6	.112	2.6	.087
	11	2.6	.004	2.7	1.320
		Total-----	23.862	Total----	30.139

Original coal resources of the Mourning Dove coal bed

Overburden thickness (in ft)--------		Measured and indicated resources 0-1,000		Total coal reserves (million tons)	
		Bed thickness weighted avg. in ft)	Coal reserves (million tons)	For section	For township
T. 17 N., R. 101 W.					
Sec.	4	2.9	0.201	0.201	
	8	4.6	.323	.323	
	9	4.0	3.635	3.635	
	10	2.6	.035	.035	
	15	2.7	.523	.523	
	16	3.9	4.394	4.394	
	17	4.0	2.324	2.324	
	20	2.5	.004	.004	
	21	2.7	.498	.498	
	22	2.5	.007	.007	
	30	4.2	.282	.282	
	31	4.0	.437	.437	12.663
T. 17 N., R. 102 W.					
	25	7.0	4.560	4.560	
	36	6.0	2.323	2.323	6.883

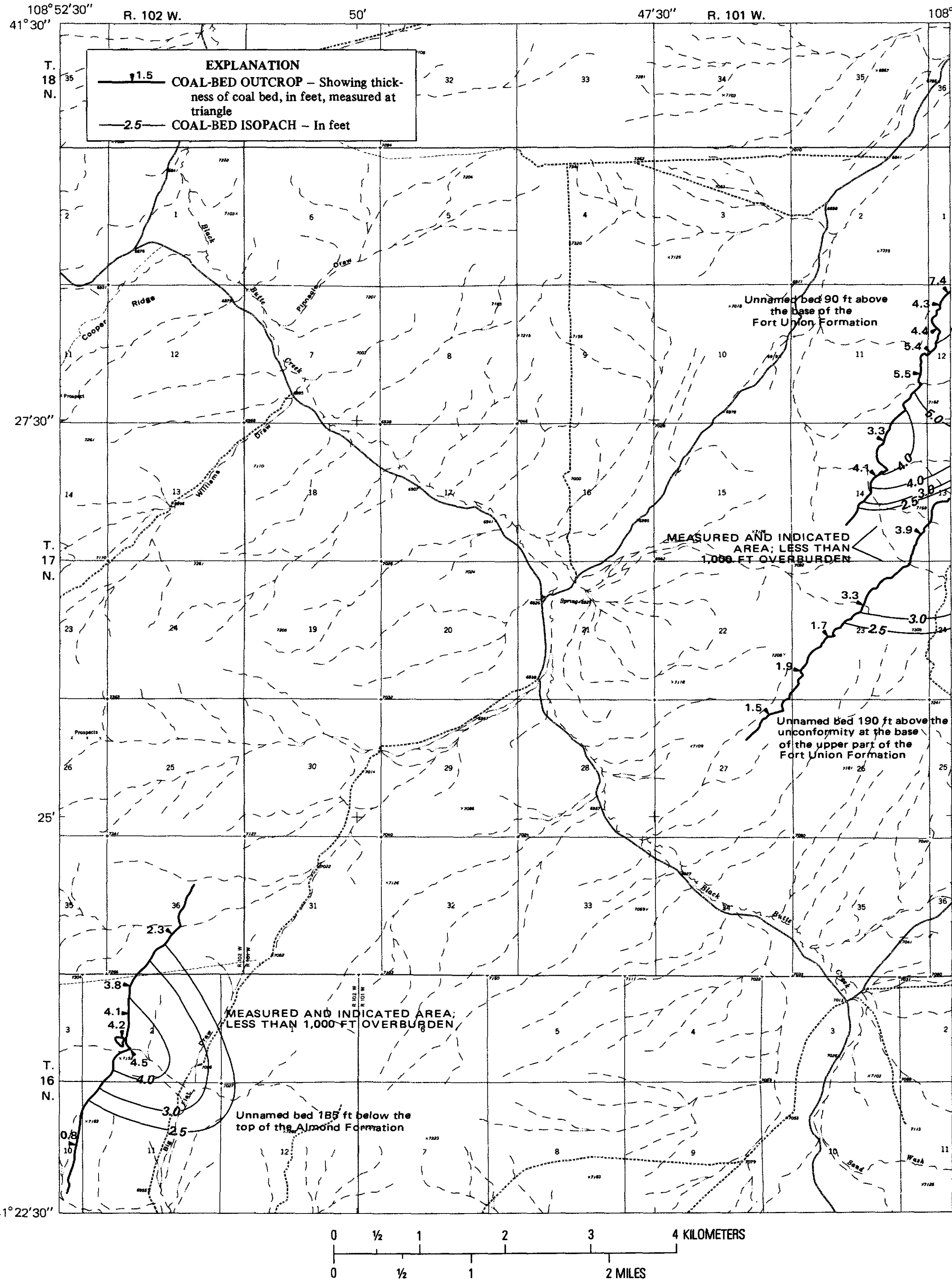

FIGURE 17.—Isopach map of unnamed coal beds having little lateral extent, Fort Union and Almond Formations, showing thickness of overburden. Base from U.S. Geological Survey Cooper Ridge NE topographic quadrangle, 1968, scale 1:24,000.

Original coal resources of unnamed coal beds with little lateral extent

Overburden thickness (in ft)-------		Measured and indicated resources 0-1,000		Total coal reserves (million tons)	
		Bed thickness (weighted avg. in ft)	Coal reserves (million tons)	For section	For township
BED 90 FEET ABOVE THE BASE OF THE FORT UNION FORMATION (LARAMIDE UNCOMFORMITY IN SECTION 1874) T. 17 N., R. 101 W.					
Sec.	11	4.8	0.266	0.266	
	12	5.0	.714	.714	
	13	4.2	.407	.407	
	14	3.9	1.000	1.000	2.387
BED 190 FEET ABOVE THE UNCONFORMITY AT THE BASE OF THE UPPER PART OF THE FORT UNION FORMATION (SECTION 1474) T. 17 N., R. 101 W.					
Sec.	13	3.5	0.266	0.266	
	14	3.7	.085	.085	
	23	3.2	.789	.789	
	24	3.4	.312	.312	1.452
BED 185 FEET BELOW THE TOP OF THE ALMOND FORMATION (SECTION 1074) T. 17 N., R. 102 W,					
Sec.	36	2.7	0.126	0.126	0.126
T. 16 N., R. 102 W.					
Sec.	1	2.6	0.070	0.070	
	2	3.6	2.086	2.086	
	11	3.0	.935	.935	
	12	2.6	.060	.060	3.151

*U.S. PRINTING OFFICE: 1979--0--677-026/43