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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE OAK CREEK QUADRANGLE, ROUTT COUNTY, COLORADO

[Report includes 23 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence and Coal Development Potential Maps of the Oak Creek quadrangle, Routt County, Colorado. This report was compiled to support the land planning work of the Bureau of Land Management (BLM) and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. This investigation was undertaken by Dames & Moore, Denver, Colorado, at the request of the U.S. Geological Survey under contract number 14-08-0001-15789. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1975 (P.L. 94-377). Published and unpublished public information available through April, 1978, was used as the data base for this study. No new drilling or field mapping was performed as part of this study, nor was any confidential data used.

Location

The Oak Creek quadrangle is located in south-central Routt County in northwestern Colorado, approximately 13 miles (21 km) south-southwest of Steamboat Springs and 7 miles (11 km) north of Yampa via Colorado Highway 131. With the exception of a few ranches and the small settlement of Park, the eastern and northern parts of the quadrangle are unpopulated. The towns of Oak Creek, Keystone, and Haybro are located in the southern and west-central parts of the quadrangle.

Accessibility

Colorado Highway 131 passes through the quadrangle from north to south along Oak Creek and joins U.S. Highway 40 approximately 5 miles (8 km) northeast of the Oak Creek quadrangle. The remainder of the quadrangle is accessible by several light-duty and unimproved dirt roads.

Railway service for the Oak Creek quadrangle is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig. The rail line follows Colorado Highway 131 across the quadrangle and is the major transportation route for coal shipped east from northwestern Colorado.

Physiography

The Oak Creek quadrangle lies in the southern part of the Wyoming Basin physiographic province as defined by Howard and Williams (1972). The quadrangle is approximately 8 miles (13 km) east of the Williams Fork Mountains and 15 miles (24 km) west of the Continental Divide.

Approximately 2,000 feet (610 m) of relief is present in the Oak Creek quadrangle. Altitudes range from approximately 9,000 feet (2,743 m) on Thorpe Mountain in the east-central part of the quadrangle to approximately 7,000 feet (2,134 m) along Oak Creek in the northeastern corner. The landscape in the eastern and southern parts of the quadrangle is dominated by moderate slopes and valleys which broaden and become more gentle in the northwestern part of the quadrangle.

Drainage in the Oak Creek area flows into the Yampa River, which flows east-northeastward across the southeastern corner of the Oak Creek quadrangle. Oak Creek, a tributary of the Yampa River, flows northeast and roughly bisects the quadangle. Oak Creek joins the Yampa River approximately 6 miles (10 km) north-northeast of the quadrangle. Another tributary of the Yampa River, Trout Creek, crosses the northwest corner of the quadrangle and flows northward. It joins the Yampa River approximately 8 miles (13 km) north-northwest of the quadrangle. Small intermittent creeks, which flow mainly in response to snowmelt in the spring, drain the remainder of the quadrangle.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail in the Oak Creek area, with daily temperatures varying from 0° to 35°F (-18° to 2°) in January to 42° to 80°F (6° to 27°C) in July. Annual precipitation in the area averages approximately 16 inches (41 cm). Snowfall during the winter months accounts for the major part of the precipitation in the area; however, rainfall from thundershowers during the summer months also contributes to the total. Winds, averaging 3 miles per hour (4.8 km per hour), are generally from the west, but wind directions and velocities vary greatly depending on the local terrain (U.S. Bureau of Land Management, 1977).

Open to very-dense stands of deciduous trees, often relatively small in size, occur at higher altitudes in the Oak Creek quadrangle where moisture and soil depth are adequate. At lower altitudes, the typical vegetation is sagebrush, grasses, and mountain shrubs which range from 2 to 8 feet (0.6 to 2.4 m) in height. The flatter areas in the northeastern portion of the quadrangle along Oak Creek are used as agricultural land (U.S. Bureau of Land Management, 1977).

Land Status

The Oak Creek quadrangle lies on the eastern boundary of the Yampa Known Recoverable Coal Resource Area (KRCRA). Approximately 50 percent of quadrangle lies within the KRCRA and the Federal government owns the coal rights for approximately 25 percent of this area as shown on plate 2. Four active coal leases are present within the KRCRA in this quadrangle.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Oak Creek quadrangle is located was published by Emmons (1877) as part of a Survey of the Fortieth Parallel. The decision to build a railroad into the region stimulated several investigations of coal between 1886 and 1905, including papers by Chisholm (1887), Hewett (1889), Hills (1893), Storrs (1902), and Parsons and Liddell (1903). Fenneman and Gale (1906) conducted geologic studies of the Yampa Coal Field and included a description of the geology and coal occurrence in the Oak Creek quadrangle in their report. In 1955, Bass and others expanded Fenneman and Gale's work in their report on the geology and mineral fuels of parts of Routt and Moffat Counties and this is the most comprehensive work on the area. In 1976, Tweto compiled a generalized regional geologic map which included this quadrangle. Reconnaissance drilling in the Yampa coal field by the U.S. Geological Survey was reported by Brownfield in 1978.

Stratigraphy

Rocks which crop out in the Oak Creek quadrangle range from Precambrian to Miocene in age. These include the Late Cretaceous-age, coal-bearing Iles and Williams Fork Formations of the Mesaverde Group; the underlying Late Cretaceous-age Mancos Shale; and the overlying Tertiary-age Browns Park Formation. The latter two formations are not known to contain coal in northwestern Colorado.

The Mancos Shale is exposed in the central third of the quadrangle. It is composed of gray to dark-gray marine shale, grading upwards with thin sandstone beds. According to Tweto (1976), the Mancos Shale is approximately 5,000 feet (1,524 m) thick in northwestern Colorado; however, its total thickness in the Oak Creek quadrangle is unknown.

The Mesaverde Group conformably overlies the Mancos Shale and contains two formations, the Iles and the Williams Fork. The Iles Formation, approximately 1,500 feet (457 m) thick in the Oak Creek area, is exposed in the southwestern quarter and along a north-south trending band through the middle of the quadrangle. The lower 1,400 feet (427 m) of the Iles Formation consists of thin beds of sandstone interbedded with sandy shale and shale. A coal-bearing sequence, approximately 450 feet (137 m) thick, occurs beginning approximately 200 feet (61 m) above the base of the formation. This sequence, designated as the Lower Coal Group, was first described by Fenneman and Gale (1906). The Trout Creek Sandstone Member overlies this sequence and the top of this member forms the contact between the Iles Formation and the conformably overlying Williams Fork Formation. This member consists of approximately 100 feet (30 m) of light tan to buff-colored, fine-grained massive sandstone.

According to Tweto (1976), the Williams Fork Formation ranges from 1,100 to 2,000 feet (335 to 610 m) in thickness, but only approximately

1,220 feet (372 m) of the formation crops out in the northwestern quarter of the Oak Creek quadrangle. The formation is generally divided into three units: a lower coal-bearing shale unit; the Twentymile Sandstone Member; and an upper transitional unit of sandstone and sandy shale.

The lower unit of the Williams Fork Formation extends from the top of the Trout Creek Sandstone Member of the Iles Formation to the base of the Twentymile Sandstone Member. In this quadrangle it is approximately 1,170 feet (357 m) thick and consists of thin sandstone interbedded with sandy shale, shale, and coal beds, grading upwards with interbedded dark-gray clay and light-colored sandstone. Fenneman and Gale (1906) have designated the coal in this sequence as the Middle Coal Group. Three major coal beds, the Wolf Creek, Wadge, and Lennox, are identified in the Middle Coal Group in this quadrangle. They are stratigraphically located approximately 75 feet (23 m), 210 feet (64 m), and 300 feet (91 m), respectively, above the top of the Trout Creek Sandstone Member.

The middle unit of the Williams Fork Formation is the Twentymile Sandstone Member, which is a massive, light-colored fine-grained sandstone. The Twentymile Sandstone Member has been mapped by Bass and others (1955) in the northwestern corner of the Oak Creek quadrangle and may be as much as 75 feet (23 m) thick.

The lower part of the upper transitional unit may be present in the extreme northwest corner of the quadrangle. This unit usually consists of sandstone, sandy shale, dark-gray shale, and may contain a few local coal beds designated as the Upper Coal Group (Fenneman and Gale, 1906).

A thin layer of Miocene-age Browns Park Formation rests unconformably on the Mancos Shale along the eastern edge of the quadrangle and on Thorpe Mountain in the east-central part (Tweto (1976). No information is available concerning the thickness or character of the Browns Park Formation in the quadrangle. However, according to Tweto (1976), the Browns Park Formation generally consists of light-colored loosely consolidated tuffaceous sandstone, fluvial siltstone, claystone, and basal conglomerate.

The Upper Cretaceous sedimentary rocks in the Oak Creek quadrangle accumulated close to the western edge of a Late Cretaceous-age epeirogenic seaway which covered part of the western interior of North America. Several transgressive-regressive cycles caused the deposition of a series of marine, near-shore marine, and non-marine sediments in the Oak Creek area.

The Mancos Shale was deposited in an offshore marine environment which existed east of the shifting strand line. Deposition of the Mancos Shale in the quadrangle area ended with the eastward migration of the shoreline, and the subsequent deposition of the Iles Formation.

The interbedded sandstone, shale, and coal of the Mesaverde Group were deposited as a result of minor changes in the position of the shoreline. During the deposition of the Iles and Williams Fork Formations, near-shore marine, littoral, brackish tidal, brackish and fresh water supratidal, and fluvial environments existed in the Yampa study area. The major sandstone members of the Iles and Williams Fork Formations, including the Trout Creek and Twentymile Sandstone Members, were deposited in shallow marine and near-shore marine environments. The major coal beds which have wide areal extent were deposited near the seaward margin of the non-marine environments, probably in large brackish-water lagoons or swamps. The slow migration of this depositional environment is responsible for the wide distribution of the Wolf Creek, Wadge, and Lennox coal beds in the Yampa study area. Coal beds of limited areal extent, including those in the Lower Coal Group, were generally deposited in environments associated with fluvial systems, such as back-levee and coastal plain swamps, interchannel basin areas, and abandoned channels.

The Miocene-age Browns Park Formation was deposited in the Oak Creek quadrangle after a long period of non-deposition and erosion. This is shown by the unconformable contact between the Upper Cretaceous-age sediments and the overlying Browns Park Formation. The coarse, conglomeratic nature of the base of the Browns Park Formation and the fine wind-blown tuffaceous sands of the upper part of the formation suggest that it was deposited during a time when the climate of the region was changing from one of relatively high rainfall to one of semi-aridity such as is found in the region today (Carey, 1955).

Structure

The Yampa KRCRA lies in the southern extension of the Washakie/Sand Wash structural basin of south-central Wyoming. The basin is bordered on the east by the Park Range, approximately 7 miles (11 km) northeast of the Oak Creek quadrangle, and on the southwest by the Axial Basin Anticline, which is approximately 35 miles (56 km) west of the quadrangle.

The Oak Creek quadrangle lies on the southeastern flank of the Twentymile Park Syncline. The syncline generally trends northwest, but in the western part of the Oak Creek quadrangle, it trends north-south. Dips of the Cretaceous rocks vary from approximately 5° west to 4° north in the northwestern corner of the quadrangle, and to as much as 30° west in some places along the southeastern edge of the Twentymile Park Syncline. A west-northwest-trending fault, shown on plate 1, offsets the Cretaceous rocks in the southwestern corner of the quadrangle (Bass and others, 1955).

The structure contour maps of the isopached coal beds are based on a regional structure map of the top of the Trout Creek Sandstone Member by Bass and others (1955), and it is assumed that the structure of the coal beds and zones duplicates that of the Trout Creek Sandstone Member. Modifications were made where necessary in accordance with outcrop and drill hole data. Drill holes from which the elevations of the tops of the coal beds could not be determined are not shown on the structure maps and were not used as data points in map construction.

COAL GEOLOGY

Several coal beds in the Lower and Middle Coal Groups of the Mesaverde Group have been identified in the Oak Creek quadrangle. The Lower Coal Group includes all coal beds in the Iles Formation below the Trout Creek Sandstone Member. The Middle Coal Group includes the coal beds in the lower coal-bearing zone of the Williams Fork Formation, between the Trout Creek Sandstone Member of the Iles Formation and the Twentymile Sandstone Member of the Williams Fork Formation. Coal beds of the Lower Coal Group tend to be lenticular and of limited areal extent, while coal beds of the Middle Coal Group characteristically persist over a large area.

Chemical analyses of coal.--Analyses of the coals in this area are listed in table 1.

In general, chemical analyses of coals in the Lower and Middle Coal Groups indicate that these coals are high-volatile C bituminous in rank on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Locations of coal samples tested in this quadrangle are shown in table 1 and include those for Zones 1 and 2 of the Middle Coal Group. Chemical analyses were not available in the Oak Creek quadrangle for coals from Zone 3 in the Lower Coal Group, or of the Wolf Creek coal bed in the Middle Creek Coal Group. However, it is believed that these coals are similar in rank to the Zone 3 and Wolf Creek coals mined, respectively, at the Nicholas Stein and Middle Creek mines in the Rattlesnake Butte quadrangle to the west.

Lower Coal Group

Coal beds in the Lower Coal Group have been projected to crop out in a general north-south-trending band in the western half of the Oak Creek quadrangle where the Lower Coal Group ranges in thickness from approximately 400 to 450 feet (122 to 137 m). Three coal zones within the Lower Coal Group were identified by Bass and others (1955) and each zone contains numerous coal beds. None of the coal beds are formally named, but where coal beds exceed Reserve Base thickness (5.0 feet or 1.5 meters), they have been given bracketed numbers for identification purposes in this quadrangle only.

In general, coal beds in Zones 1, 2, and 3 tend to be thin, lenticular and of limited areal extent. Relatively few of the coal beds exceeding Reserve Base thickness can be correlated between outcrops and/or drill holes. Because of the incomplete and discontinuous drill-hole data, structure contour maps could not be constructed on each separate bed. Therefore, structure contour maps of the top of each coal zone have been constructed. Where coal beds greater than Reserve Base thickness are encountered at only one location, they are treated as isolated data points (see Isolated Data Points section of this report). Also, where the inferred limit of influence from the isolated data point is entirely within non-Federal land areas or lands already leased for coal mining, isolated data point maps are not constructed for the coal bed.

Coal Zone 1

Zone 1 is located approximately 200 feet (61 m) above the base of the Iles Formation and ranges in thickness from approximately 45 to 75 feet (14 to 23 m). Many thin coal beds are present in this zone, but only three, the LG1[2], LG1[3] and LG1[4], exhibit sufficient thickness and lateral extent to warrant preparation of derivative maps. Three other coal beds of Reserve Base thickness, the LG1[15], LG1[16] and LG1[17], were encountered at only one location and have been treated as isolated data points. Dips of the isopached coal beds, as derived from the structure maps, range from approximately 30° west at the projected outcrops to 5° northwest in the subsurface.

The LG1[2] coal bed was penetrated in two drill holes in the northwestern part of the quadrangle as shown in figure 1 (all figures are attached at the end of this report). Measured thicknesses range from 7.4 to 8.2 feet (2.3 to 2.5 m), excluding the rock partings which vary in thickness from 1.7 to 2.6 feet (0.5 to 0.8 m), respectively.

Measured thicknesses of the LG1[3] coal bed range from 3.5 to 5.7 feet (1.1 to 1.7 m), the maximum being reported in sec. 31, T. 5 N., R. 85 W. (figure 4). The coal bed did not contain rock partings at this location.

The LG1[4] coal bed, identified in several drill holes and outcrops, ranges in thickness from 1.5 to 8.4 feet (0.5 to 2.6 m), the maximum thickness being reported in sec. 17, T. 4 N., R. 85 W. (plate 4). This coal bed generally occurs as a single bed, but local rock partings ranging from 2.0 to 3.0 feet (0.6 to 0.9 m) in thickness have been reported.

Isolated data point maps for the LG1[15], LG1[16] and LG1[17] coal beds are shown on plate 21.

Coal Zone 2

This coal zone is located approximately 90 feet (27 m) stratigraphically above the top of Zone 1 and ranges in thickness from approximately 40 to 110 feet (12 to 34 m). This coal zone contains numerous thin coal beds, but only the LG2[9] coal bed is mapped (plate 7) in the western part of the Oak Creek quadrangle. Four other coal beds, the LG2[26] through LG2[29], are treated as isolated data points and are shown on plate 21.

The LG2[9] coal bed has been identified in drill holes and outcrops, and has been mined locally in the SW 1/4 SW 1/4 sec. 36, T. 4 N., R. 86 W. This coal bed ranges in thickness from 4.5 to 13.6 feet (1.4 to 4.1 m), the maximum reported thickness being reported in a drill hole located in sec. 36, T. 4 N., R. 86 W. Usually the coal bed occurs as a bed of one single thickness, but thin rock partings varying from 0.3 to 0.7 feet (0.1 to 0.2 m) thick have been reported at four locations. The LG2[9] coal bed projects into the adjacent Rattlesnake Butte quadrangle to the west where it correlates with the LG2[3] coal bed in that quadrangle. The bed ranges in thickness from 5 to 11 feet (1.5 to 3.4 m) in the Rattlesnake Butte quadrangle. As calculated from plate 8, dips of the LG2[9] coal bed in the Oak Creek quadrangle are quite variable, ranging from approximately 20° to 5° west in the central part of the quadrangle to 7° north and 12° northeast in the southwest part of the quadrangle.

Coal Zone 3

Zone 3, ranging in thickness from approximately 50 to 110 feet (15 to 34 m), is stratigraphically above and separated from Zone 2 by approximately 140 feet of interbedded sandstone, sandy shale, and shale. Like Zones 1 and 2, this coal zone contains many thin, lenticular coal beds and only two coal beds, the LG3[11] and LG3[13], are mapped in this quadrangle. Two other coal beds, the LG3[45] and LG3[46] are treated as isolated data points.

The LG3[11] coal bed was penetrated in two drill holes in the northwestern part of the quadrangle as shown in figure 7. Measured thicknesses were 1.3 and 5.7 feet (0.4 and 1.7 m), the maximum being recorded in sec. 7, T. 4 N., R. 85 W. Rock partings were not reported in either drill hole. The coal bed dips to the west from approximately 30° near the projected outcrop to 8° in the subsurface, as calculated from figure 7. Overburden thicknesses increase in the same direction.

The LG3[13] coal bed was identified in several drill holes and an outcrop in the western part of the quadrangle (plate 10). Measured thicknesses range from 3.5 to 7.0 feet (1.1 to 2.1 m), the maximum thickness being recorded in sec. 17, T. 4 N., R. 85 W., and in sec. 26, T. 4 N., R. 86 W. Rock partings have been recorded at several locations, ranging in thickness from 0.3 to 7.0 feet (0.1 to 2.1 m). As calculated from plate 11, dips of this coal bed vary considerably, ranging from approximately 30° west near the projected outcrop to 6° west and 7° northwest in the subsurface in the central part of the quadrangle, to approximately 11° northeast in the subsurface in the southwestern part of the quadrangle. Based on drill hole data, the LG3[13] coal bed extends into the Rattlesnake Butte quadrangle to the west. However, the Lower Coal Group, Zone 3, is mapped as a zone in that quadrangle and the LG3[13] coal bed is included in the zone map.

Undifferentiated Lower Group Coal Bed

One coal bed of Reserve Base thickness, the LG[18] coal bed, could not be placed within a specific coal zone because of incomplete geologic data and has been treated as an isolated data point.

Middle Coal Group

The Middle Coal Group is located between the Trout Creek and Twentymile Sandstone Members and contains the Wolf Creek and Wadge coal beds. These two major coal beds are separated stratigraphically by approximately 120 to 160 feet (37 to 49 m) of interbedded sandstone and shale. The Lennox coal bed is located approximately 50 feet (145 m) above the Wadge coal bed, and although it has been mined with the Wadge coal bed in the Edna mine, the Lennox coal bed is not known to exceed Reserve Base thickness outside of the mined area.

Wolf Creek Coal Bed

The Wolf Creek coal bed has been identified throughout the northwestern quarter of the quadrangle from both outcrops and drill holes, and is located approximately 75 feet (23 m) stratigraphically above the Trout Creek Sandstone Member. According to Bass and others (1955), the Wolf Creek coal bed splits and, in places, contains as much as 45 feet (13.7 m) of interburden. Only the upper limb is known to exceed Reserve Base thickness in the area. This limb varies in thickness from 3.3 to 11.0 feet (1.0 to 3.4 m), reaching its maximum thickness in sec. 14, T. 4 N., R. 86 W. (plate 13). Where the Wolf Creek coal bed is greater than Reserve Base thickness, it dips approximately 4° to 5° to the west-northwest, as derived from plate 14. In the Cow Creek quadrangle to the north, the upper limb of the Wolf Creek coal bed ranges from 4.3 to 5.0 feet (1.3 to 1.5 m) in thickness. In the Rattlesnake Butte quadrangle to the west of the Oak Creek quadrangle, the Wolf Creek coal bed thickens to 14.7 feet (4.5 m) in sec. 10, T. 4 N., R. 86 W., and to 21.5 feet (6.6 m) in sec. 23, T. 4 N., R. 87 W.

Wadge Coal Bed

The Wadge coal bed is recognized throughout the northwestern quarter of the quadrangle and has been mined extensively. This coal bed lies approximately 210 feet (64 m) above the Trout Creek Sandstone Member. Bass and others (1955) indicate that the Wadge coal bed splits and contains as much as 17 feet (5.2 m) of interburden. In this quadrangle, only the upper limb exceeds Reserve Base thickness. This limb varies in thickness from 2.7 to 8.0 feet (0.8 to 2.4 m), reaching its maximum thickness in secs. 23, 24, 25, and 26, T. 5 N., R. 86 W. (plate 17). The dip of the Wadge coal bed, calculated from plate 18, ranges from approximately 13° near the outcrop to less than 5° in the subsurface.

To the north in the Cow Creek quadrangle, the upper limb thickens to 10.0 feet (3.0 m) in sec. 1, T. 5 N., R. 86 W., and sec. 7, T. 5 N., R. 85 W. In the Rattlesnake Butte quadrangle to the west, the Wadge coal bed appears not to be split and reaches a maximum reported thickness of 13.0 feet (4.0 m) in sec. 18, T. 4 N., R. 86 W.

Isolated Data Points

In instances where isolated measurements of coal beds thicker than 5.0 feet (1.5 m) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these coal beds limits the extent to which they can be reasonably projected in any direction and usually precludes correlations with other, better known coal beds. For this reason, isolated data points are included on a separate plate for non-isopached coal beds (plate 21). Coal beds identified by bracketed numbers are not formally named but are used for identification purposes in this quadrangle only.

COAL RESOURCES

Data from drill holes, mine measured sections, and outcrop measurements were used to construct outcrop, isopach, structure contour, and overburden isopach maps of the coal beds in the Oak Creek quadrangle. Where coal beds of Reserve Base thickness exist entirely on non-Federal lands or on lands already leased for coal mining, areal distribution and identified resources (ADIR) maps are not constructed and Reserve Base tonnages are not calculated.

Coal resources for Federal land were calculated using data obtained from the coal isopach maps (plates 13 and 17) and the ADIR maps (plates 16, 20, and 21). The coal bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed and by a conversion factor of 1,800 short tons of coal per acre-foot (13,238 metric tons per hectare-meter) for bituminous coal, yields the coal resources in short tons of coal for each coal bed.

Reserve Base and Reserve tonnages for the Wolf Creek, Wadge, and non-isopached coal beds are shown on plates 16, 20, and 21, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Coal beds of Reserve Base thickness (5 feet or 1.5 meters) or greater that lie less than 3,000 feet (914 m) below the ground surface are included. These criteria differ somewhat from those stated in U.S. Geological Survey Bulletin 1450-B which call for a minimum thickness of 28 inches (70 cm) and a maximum depth of 1,000 feet (305 m) for bituminous coal. Only Reserve Base tonnages (designated as inferred resources) are calculated for areas influenced by the isolated data points.

Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 29.99 million short tons (27.21 million metric tons) for the entire quadrangle, including the tonnages for the isolated data points. Reserve Base tonnages in the various development potential categories for surface and subsurface mining methods are shown in tables 2 and 3. The source of each indexed data point shown on plate 1 is listed in table 4.

Dames & Moore has not made any determination of economic recoverability for any of the coal beds described in this report.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-ha) parcels have been used to show the limits of the high, moderate, or low development potentials.

A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-ha) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 ha) within a parcel meet criteria for a high development potential; 25 acres (10 ha), a moderate development potential; and 10 acres (4 ha), a low development potential; then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Surface Mining Methods

Areas where the coal beds of Reserve Base thickness are overlain by 200 feet (61 m) or less of overburden are considered to have potential for surface mining and can be assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for surface mining of coal is as follows:

$$MR = \frac{t_o \, (cf)}{t_c \, (rf)}$$

where MR = mining ratio

t_o = thickness of overburden in feet

t_c = thickness of coal in feet

rf = recovery factor (85 percent for this quadrangle)

cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:
0.911 for subbituminous coal
0.896 for bituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential for surface mining methods are defined as areas underlain by coal beds having less than 200 feet (61 m) of overburden and respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15. These mining ratio values for each development potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey.

Areas where the coal data is absent or extremely limited between the 200-foot (61-m) overburden line and the outcrop are assigned unknown development potential for surface mining methods. This applies to areas where no coal beds 5 feet (1.5 m) or more thick are known to occur and to those areas influenced by isolated data points. Limited knowledge pertaining to the areal distribution, thickness, depth, and attitude of the coal beds prevents accurate evaluation of development potential in the high, moderate, and low categories. The areas influenced by isolated data points in this quadrangle total approximately 1.51 million short tons (1.37 millon metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 22. All of the Federal land areas having a known development potential for surface mining are rated high. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for surface mining methods.

Development Potential for Subsurface and In-Situ Mining Methods

Areas considered to have a development potential for conventional subsurface mining methods include those areas where coal beds of Reserve Base thickness are between 200 and 3,000 feet (61 and 914 m) below the ground surface which have dips of 15° or less. Coal beds lying between 200 and 3,000 feet (61 and 914 m) below the ground surface, dipping greater than 15°, are considered to have development potential for in-situ mining methods.

Areas of high, moderate, and low development potential for conventional subsurface mining are defined as areas underlain by coal beds of Reserve Base thickness at depths ranging from 200 to 1,000 feet (61 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m) below the ground surface, respectively.

Areas where the coal data is absent or extremely limited between 200 and 3,000 feet (61 and 914 m) below the ground surface are assigned unknown development potentials. This applies to those areas influenced by isolated data points and areas where coal beds of Reserve Base thickness are not known to occur. The areas influenced by isolated data points in this quadrangle contain approximately 3.96 million short tons (3.59 million metric tons) of coal available for subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 23. All of the Federal land areas classified as having known development potential for conventional subsurface mining methods are rated high. The remaining Federal land within the KRCRA boundary is classified as having unknown development potential for conventional subsurface mining methods.

Coal beds of Reserve Base thickness dipping in excess of 15° are not known to occur on unleased Federal lands within the KRCRA boundary in this quadrangle. Therefore, all of these Federal lands have been rated as having an unknown development potential for in-situ mining methods.

Table 1. -- Chemical analyses of coals in the Oak Creek quadrangle, Routt County, Colorado

Location	COAL BED NAME	Form of Analysis	Proximate				Ultimate					Heating Value	
			Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	Btu/Lb
S½ sec. 30, T. 4 N., R. 85 W., Old Schuster Mine (Campbell, 1923)	Lower Group, coal zone 1	A	8.8	36.1	50.2	4.90	1.51	5.69	68.59	1.54	17.77	--	12,160
		B	--	39.6	55.0	5.38	1.66	5.17	75.25	1.69	10.85	--	13,340
		C	--	41.8	58.2	--	1.75	5.46	79.52	1.79	11.48	--	14,100
NW¼ sec. 31, T. 4 N., R. 85 W., Argo Mine (Hancock, 1925)	Lower Group, coal zone 2	A	8.6	39.1	48.0	4.25	0.41	5.75	69.41	1.50	18.68	6,790	12,220
		B	5.3	40.5	49.8	4.40	0.43	5.56	71.93	1.55	16.13	7,035	12,660
		C	--	42.8	52.6	4.65	0.45	5.24	75.96	1.64	12.06	7,430	13,370
SW ¼ NE¼ sec. 23, T. 4 N., R. 86 W., Nicholas Stein Mine (Rattlesnake Butte quadrangle) (Fieldner and others, 1937)	Lower Group, coal zone 3	A	9.0	36.2	49.4	5.4	0.5	5.6	68.3	1.4	18.8	6,650	11,970
		B	--	39.8	54.2	6.0	0.5	5.0	75.0	1.6	11.9	7,306	13,150
		C	--	42.3	57.7	--	0.6	5.3	79.8	1.6	12.7	7,772	13,990
NW¼ sec. 10, T. 4 N., R. 86 W., Middle Creek Mine (Rattlesnake Butte quadrangle) (Bass and others, 1955)	Middle Group, Wolf Creek coal bed	A	7.7	40.9	45.3	6.1	0.6	5.7	67.4	1.5	18.7	--	11,940
		B	5.2	42.0	46.5	6.3	0.6	5.5	69.3	1.5	16.8	--	12,270
		C	--	44.3	49.0	6.7	0.6	5.2	73.1	1.6	12.8	--	12,940
secs. 7, 18, and 19, T. 4 N., R. 85 W.; secs. 12, 13, 14, and 24, T. 4 N., R. 86 W.; Edna Strip Mine (Bass and others, 1955)	Middle Group, Wadge coal bed	A	11.0	36.5	47.7	4.8	0.5	5.9	65.8	1.3	21.7	--	11,640
		B	6.0	38.6	50.3	5.1	0.5	5.6	69.5	1.4	17.9	--	12,290
		C	--	4.0	53.6	5.4	0.6	5.2	73.9	1.5	13.4	--	13,070
sec. 31, T. 5 N., R. 85 W., Moffat "B" Strip Mine (Jones and Murray, 1977)	Middle Group Lennox coal bed	A	11.4	42.7	52.3	5.0	0.7	--	--	--	--	--	11,620

Form of Analysis: A, as received
B, air dried
C, moisture free

Note: To convert Btu/pound to kilojoules/kilogram, multiply by 2.326

Table 2.--Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Oak Creek quadrangle, Routt County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Wolf Creek	50,000	-	-	-	50,000
Isolated data points	-	-	-	1,510,000	1,510,000
Totals	50,000	-	-	1,510,000	1,560,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 3.--Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Oak Creek quadrangle, Routt County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Wadge	10,340,000	-	-	-	10,340,000
Wolf Creek	13,690,000	440,000	-	-	14,130,000
Isolated data points	-	-	-	3,960,000	3,960,000
Totals	24,030,000	440,000	-	3,960,000	28,430,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 4. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	Bass, N. W., and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 22	Measured Section No. B33
2		Measured Section No. B34
3		Measured Section No. B38
4		Measured Section No. B1
5		Measured Section No. B2
6	U.S. Geological Survey, 1969, Inactive Coal Lease File Appeal No. Colorado 794, Pittsburg and Midway Coal Company	Drill hole No. MC-18
7	Bass, N. W., and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 22	Measured Section No. B6
8		Measured Section No. B5
9		Measured Section No. B3
10		Measured Section No. B4
11		Measured Section No. B7
12		Measured Section No. B12
13		Measured Section No. B10
14		Measured Section No. B9
15		Measured Section No. B11
16		Measured Section No. B14
17		Measured Section No. B13

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
18	Bass, N. W., and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 22	Measured Section No. B15
19		Measured Section No. B8
20		Measured Section No. B16
21		Measured Section No. B17
22		Measured Section No. B18
23		Measured Section No. B19
24		Measured Section No. B20
25		Measured Section No. B21
26		Measured Section No. B47
27		Measured Section No. B57b
28		Measured Section No. B57
29		Measured Section No. B61
30		Measured Section No. B60
31		Measured Section No. B59
32		Measured Section No. B77
33		Measured Section No. B75
34		Measured Section No. B58
35		Measured Section No. B72
36		Measured Section No. B76
37		Measured Section No. B74
38		Measured Section No. B77a

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
39	Bass, N. W., and others, 1955 U.S. Geological Survey Bulletin 1027-D, pl. 22	Measured Section No. B77c
40		Measured Section No. B77b
41		Measured Section No. B79
42		Measured Section No. B81
43		Measured Section No. B78
44		Measured Section No. B80
45	Bass, N. W., and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 23	Measured Section No. B30
46	Bass, N. W., 1955, U.S. Geological Survey, unpublished field notes, Moffat Coal Company	Drill hole No. 2-E1
47		Drill hole No. 2-E2
48	Bass, N. W., and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 23	Measured Section No. B31
49		Measured Section No. B32
50		Measured Section No. B93
51	U.S. Geological Survey, 1969, Inactive Coal Lease File Appeal No. Colorado 794, Pittsburg and Midway Coal Company	Drill hole No. MC-17
52		Drill hole No. MC-14
53		Drill hole No. MC-15

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
54	Bass, N. W., and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 23	Measured Section No. B112
55	Brownfield, M. E., 1978, U.S. Geological Open-File Report 78-365	Drill hole No. OC-3
56	↓	Drill hole No. OC-2
57	↓	Drill hole No. OC-1

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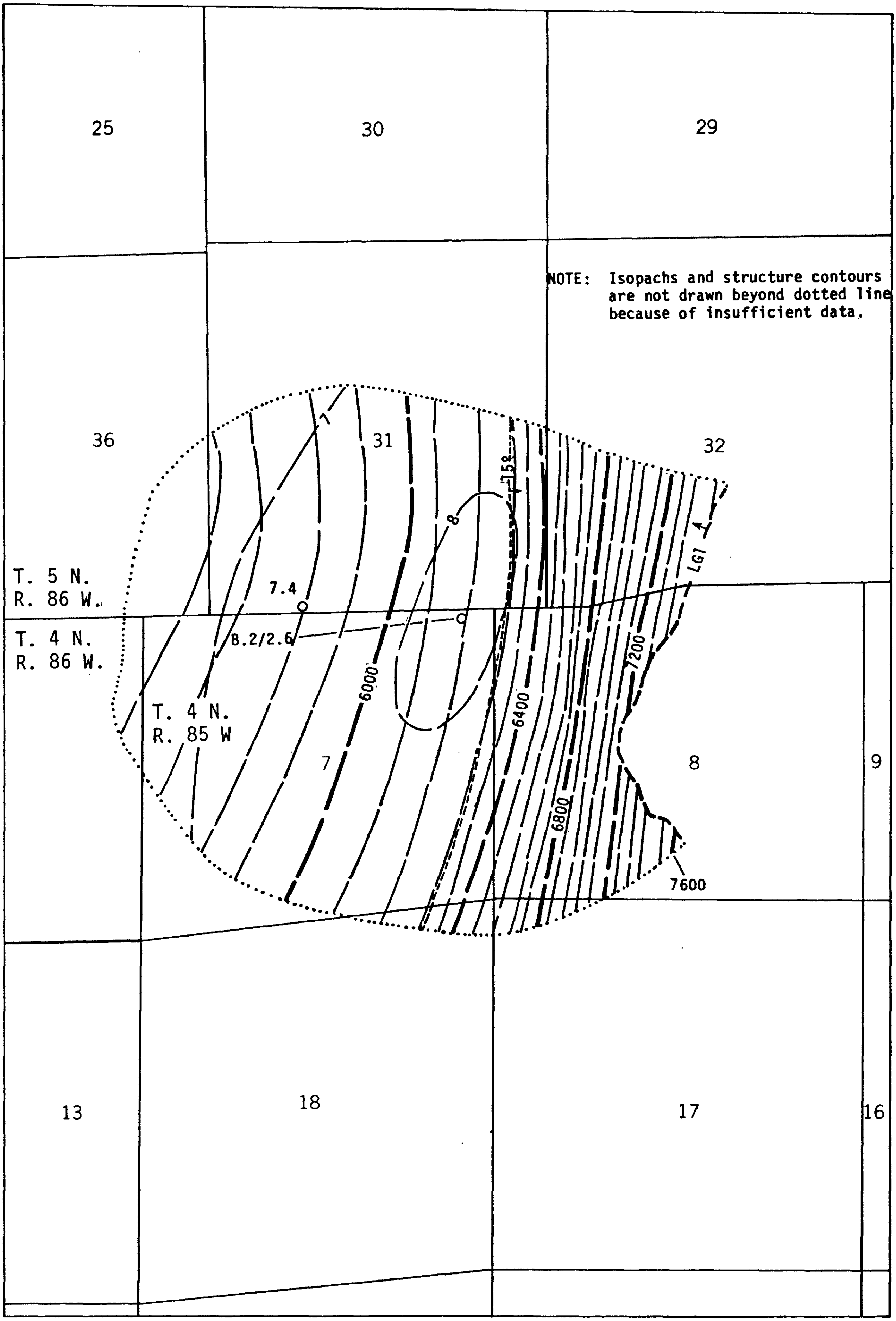

FIGURE 1. — Isopach map of the Lower Group, Coal Zone 1, Coal Bed [2] and structure contour map of the Lower Group, Coal Zone 1.

EXPLANATION

7

ISOPACHS - Showing thickness of coal, in feet. Long dashed where inferred. Isopach interval 1 foot.

6400

STRUCTURE CONTOURS - Drawn on top of coal zone. Long dashed where vertical accuracy possibly not within 40 feet. Contour interval 80 feet (24 m). Datum is mean sea level.

o 7.4

DRILL HOLE - Showing thickness of coal, in feet.

8.2/2.6

INTERBEDDED COAL AND ROCK - Showing total coal thickness/total rock thickness.

LG1 - Lower Coal Group, zone 1

COAL ZONE SYMBOL AND NAME

LG1

TRACE OF COAL ZONE OUTCROP - Showing symbol of name of coal zone as listed above. Arrow points toward coal-bearing area. Short dashed where inferred by present authors.

15°

SUBSURFACE MINING LIMIT - Showing areas where dips of coal beds are greater than 15° and subsurface mining by conventional methods is not considered feasible. Reserve Base tonnages are calculated beyond limit; Reserve tonnages are not. Arrow points toward area where dips are greater than 15°.

To convert feet to meters, multiply feet by 0.3048.

Figure 1. — Continued.

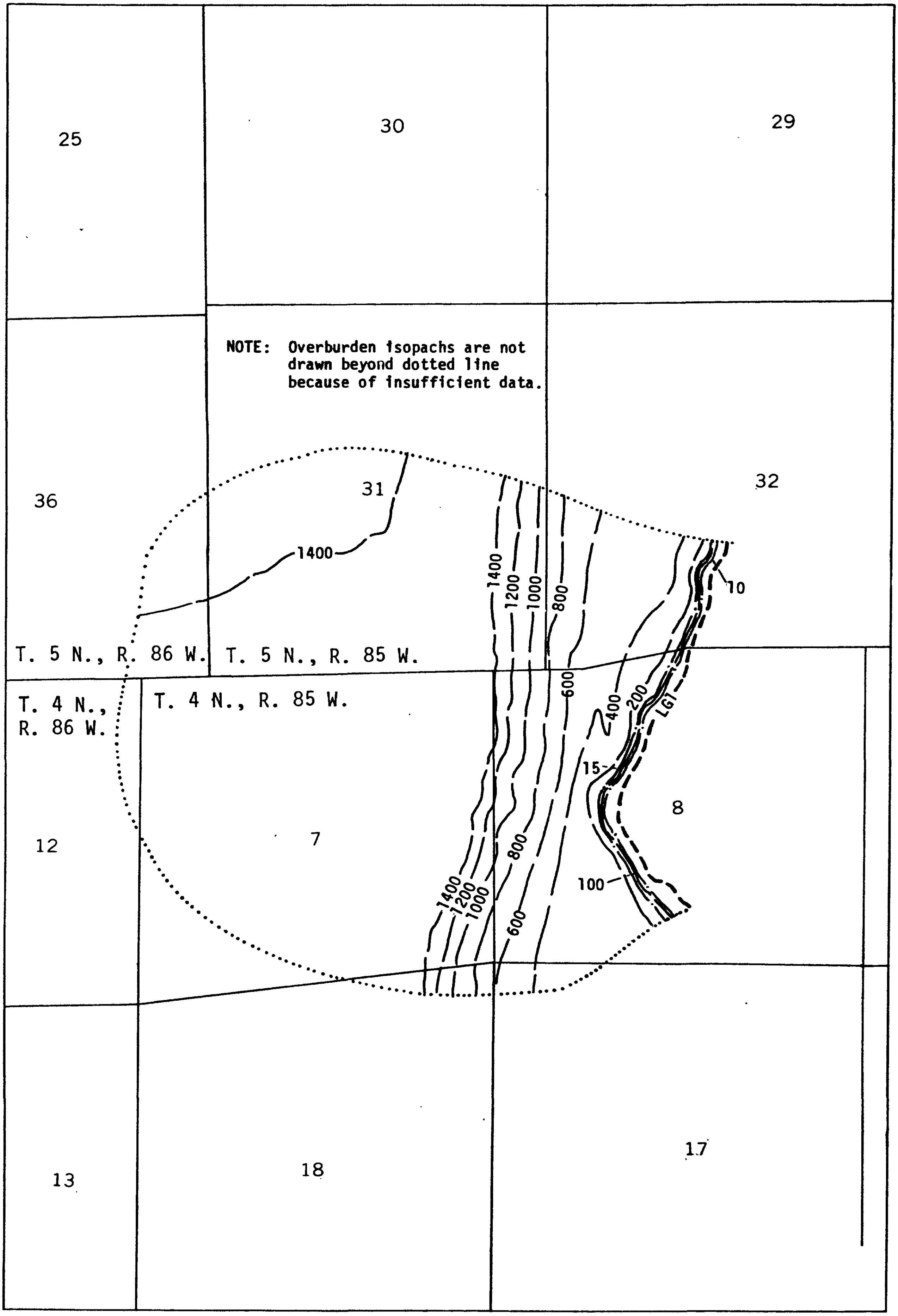

FIGURE 2. — Overburden isopach map of the Lower Group, Coal Zone 1 and mining ratio map of the Lower Group, Coal Zone 1 Coal Bed [2].

EXPLANATION

——— ——— 400 ——— ———

OVERBURDEN ISOPACHS - Showing thickness of overburden, in feet, from surface to top of coal zone. Dashed where vertical accuracy possibly not within 40 feet. Isopach interval is 100 feet (31 m) over strippable coal and 200 feet (61 m) beyond the stripping-limit line.

——— · ———15——— · ———

MINING-RATIO CONTOUR - Number indicates cubic yards of overburden per ton of recoverable coal by surface mining methods. Contours shown only in areas underlain by coal of Reserve Base thickness within the stripping-limit (in this quadrangle, the 200-foot-overburden isopach). To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply mining ratio by 0.8428.

LG1 - Lower Coal Group, zone 1

COAL ZONE SYMBOL AND NAME

— — — — — —LG1— — — — — —

TRACE OF COAL ZONE OUTCROP - Showing symbol of name of coal zone as listed above. Short dashed where inferred by present authors.

To convert feet to meters, multiply feet by 0.3048.

Figure 2. — Continued.

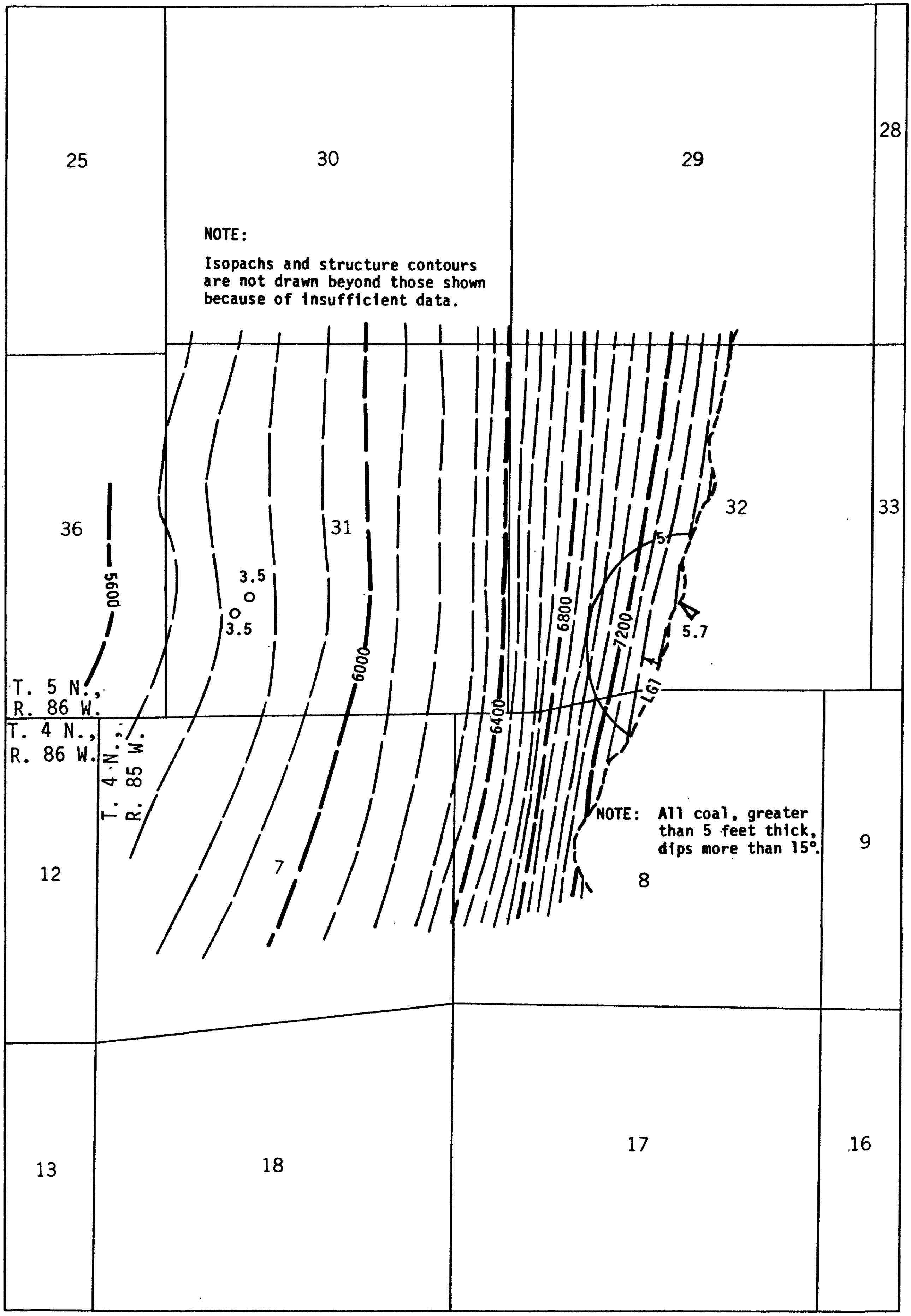

FIGURE 3. — Isopach map of the Lower Group, Coal Zone 1, Coal Bed [3] and structure contour map of the Lower Group, Coal Zone 1.

EXPLANATION

5

ISOPACHS - Showing thickness of coal, in feet. Long dashed where inferred. Isopach interval 1 foot.

6400

STRUCTURE CONTOURS - Drawn on top of coal zone. Long dashed where vertical accuracy possibly not within 40 feet. Contour interval 80 feet (24 m). Datum is mean sea level.

o 3.5

DRILL HOLE - Showing thickness of coal, in feet.

Δ 5.7

PROJECTED POINT OF MEASUREMENT - Showing thickness of coal bed, in feet. Because of an interval of no record in the measured section, exact location and altitude of coal bed is unknown and point has been projected to the outcrop of the zone.

LG1 - Lower Coal Group, zone 1

COAL ZONE SYMBOL AND NAME

LG1

TRACE OF COAL ZONE OUTCROP - Showing symbol of name of coal zone as listed above. Arrow points toward coal-bearing area. Short dashed where inferred by present authors.

To convert feet to meters, multiply feet by 0.3048.

FIGURE 3. — Continued.

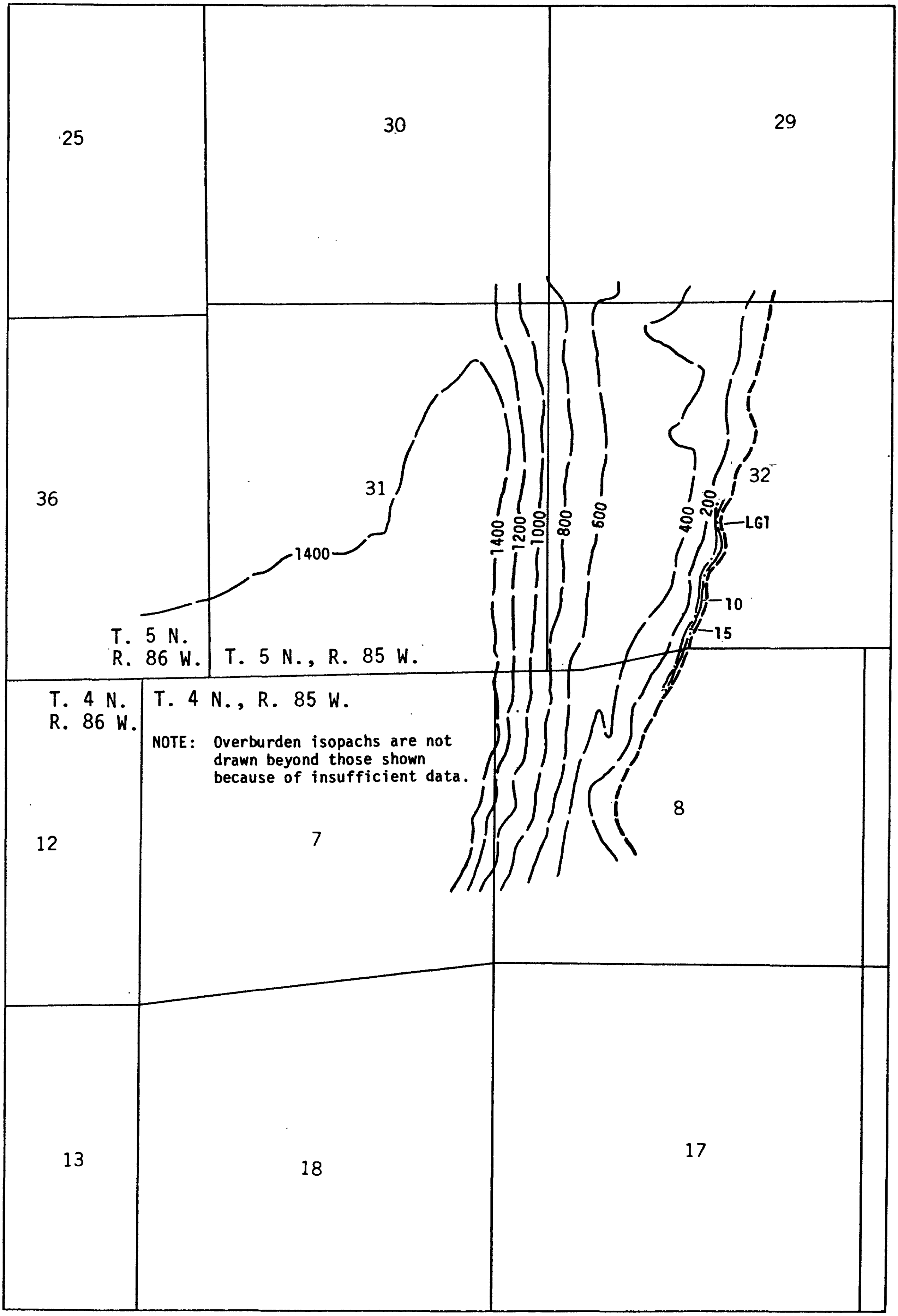

FIGURE 4. — Overburden isopach map of the Lower Group, Coal Zone 1 and mining ratio map of the Lower Group, Coal Zone 1 Coal Bed [3].

EXPLANATION

——— ———400——— ———

OVERBURDEN ISOPACHS - Showing thickness of overburden, in feet, from surface to top of coal zone. Dashed where vertical accuracy possibly not within 100 feet. Isopach interval is 200 feet (61 m) over strippable coal and 200 feet (61 m) beyond the stripping-limit line.

———·———15———·———

MINING-RATIO CONTOUR - Number indicates cubic yards of overburden per ton of recoverable coal by surface mining methods. Contours shown only in areas underlain by coal of Reserve Base thickness within the stripping-limit (in this quadrangle, the 200-foot-overburden isopach). To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply mining ratio by 0.8428.

LG1 - Lower Coal Group, zone 1

COAL ZONE SYMBOL AND NAME

— — — — — —LG1— — — — — —

TRACE OF COAL ZONE OUTCROP - Showing symbol of name of coal zone as listed above. Short dashed where inferred by present authors.

To convert feet to meters, multiply feet by 0.3048.

Figure 4. — Continued.

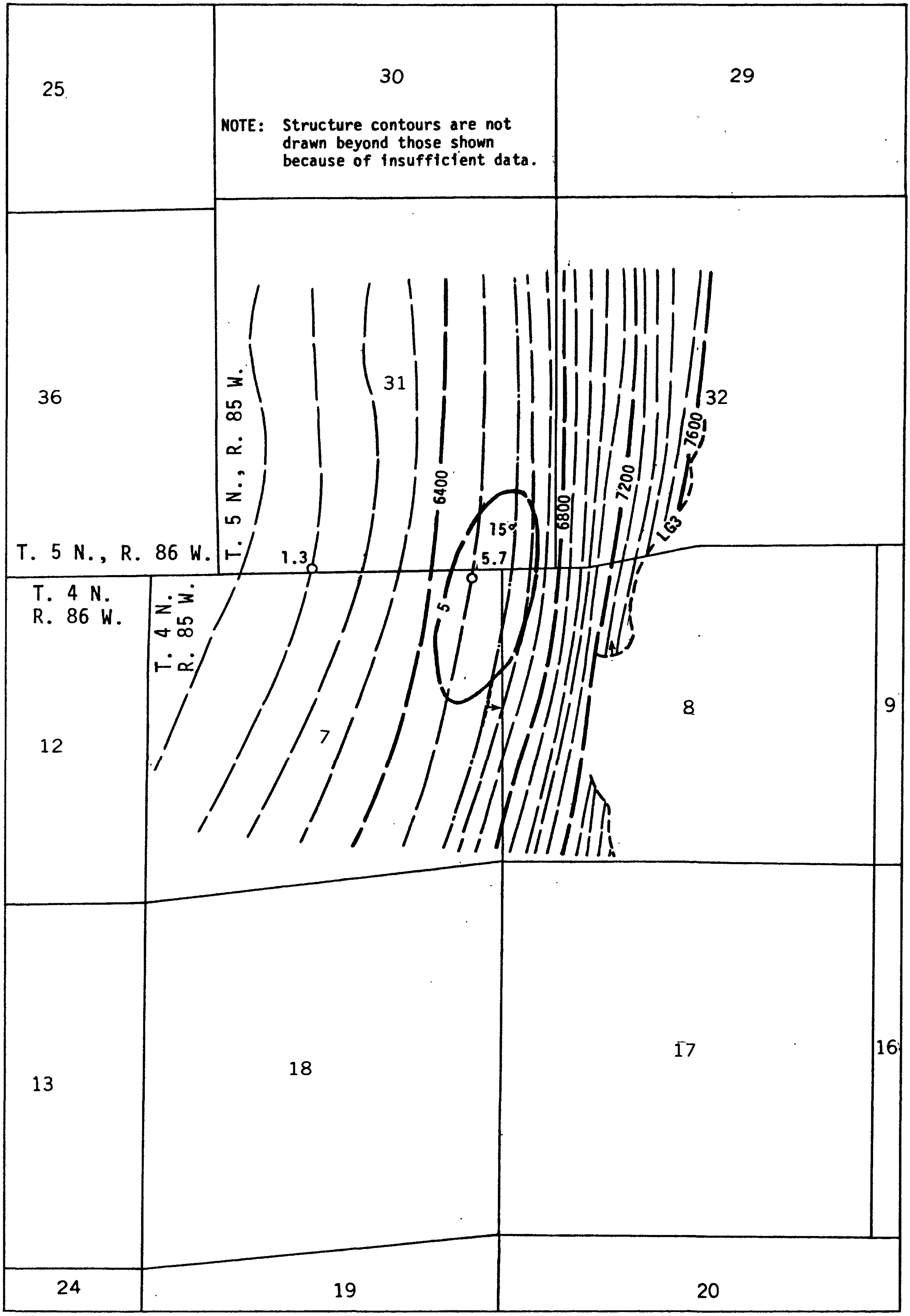

FIGURE 5. — Isopach map of the Lower Group, Coal Zone 3, Coal Bed [11] and structure contour map of the Lower Group, Coal Zone 3.

EXPLANATION

5

ISOPACHS - Showing thickness of coal, in feet. Long dashed where inferred. Isopach interval 1 foot.

6400

STRUCTURE CONTOURS - Drawn on top of coal zone. Long dashed where vertical accuracy possibly not within 40 feet. Contour interval 80 feet (24 m). Datum is mean sea level.

o 5.7

DRILL HOLE - Showing thickness of coal, in feet.

LG3 - Lower Coal Group, zone 3

COAL ZONE SYMBOL AND NAME

LG3

TRACE OF COAL ZONE OUTCROP - Showing symbol of name of coal zone as listed above. Arrow points toward coal-bearing area. Short dashed where inferred by present authors.

15°

SUBSURFACE MINING LIMIT - Showing areas where dips of coal beds are greater than 15° and subsurface mining by conventional methods is not considered feasible. Reserve Base tonnages are calculated beyond limit; Reserve tonnages are not. Arrow points toward area where dips are greater than 15°.

To convert feet to meters, multiply feet by 0.3048.

Figure 5. — Continued.

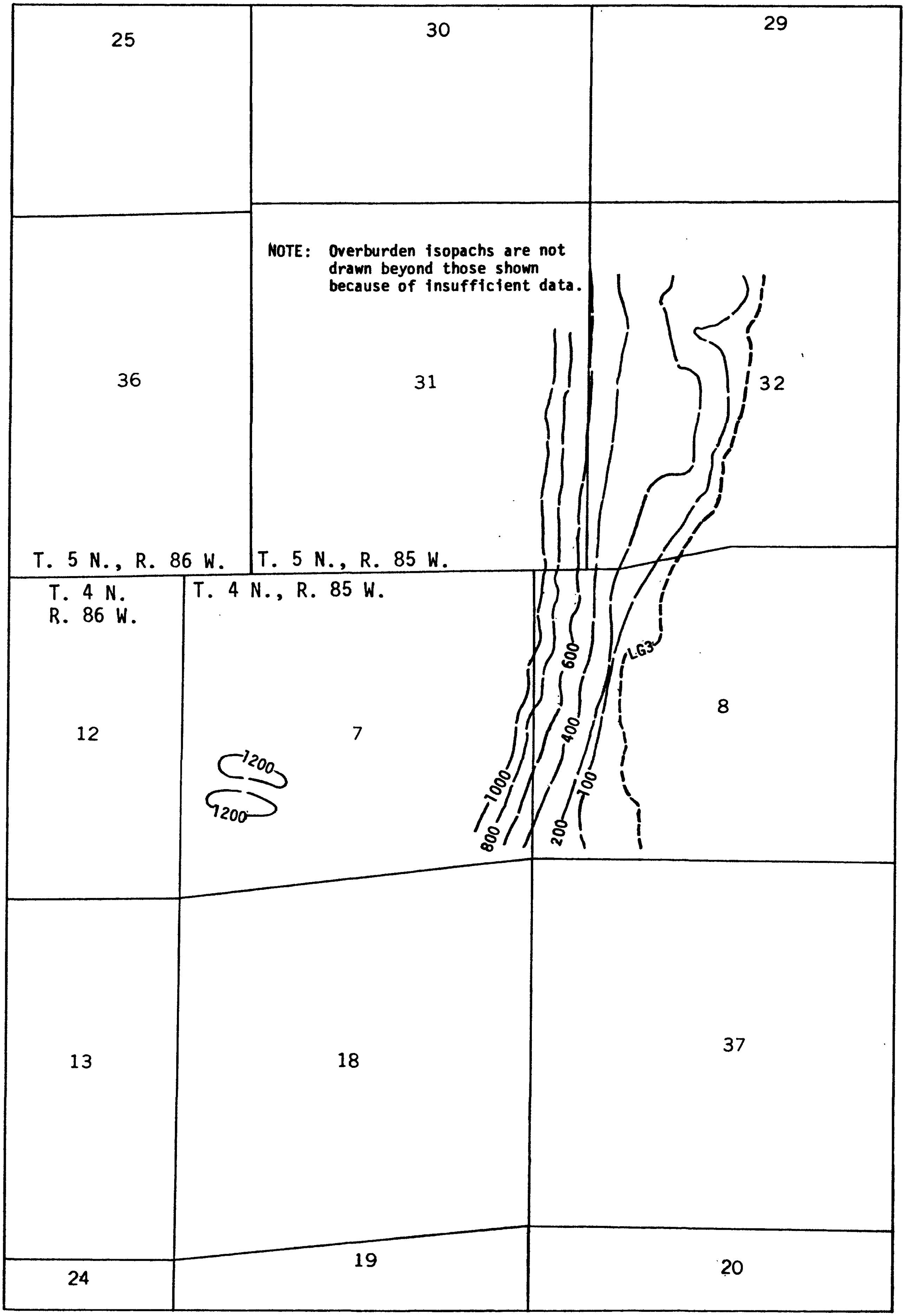

FIGURE 6. — Overburden isopach map of the Lower Group, Coal Zone 3.

EXPLANATION

——— ———400——— ———

OVERBURDEN ISOPACHS - Showing thickness of overburden, in feet, from surface to top of coal zone. Dashed where vertical accuracy possibly not within 40 feet. Isopach interval is 100 feet (31 m) over strippable coal and 200 feet (61 m) beyond the stripping-limit line.

LG3 - Lower Coal Group, zone 3

COAL ZONE SYMBOL AND NAME

— — — — — — LG3 — — — — — —

TRACE OF COAL ZONE OUTCROP - Showing symbol of name of coal zone as listed above. Short dashed where inferred by present authors.

To convert feet to meters, multiply feet by 0.3048.

Figure 6. — Continued.