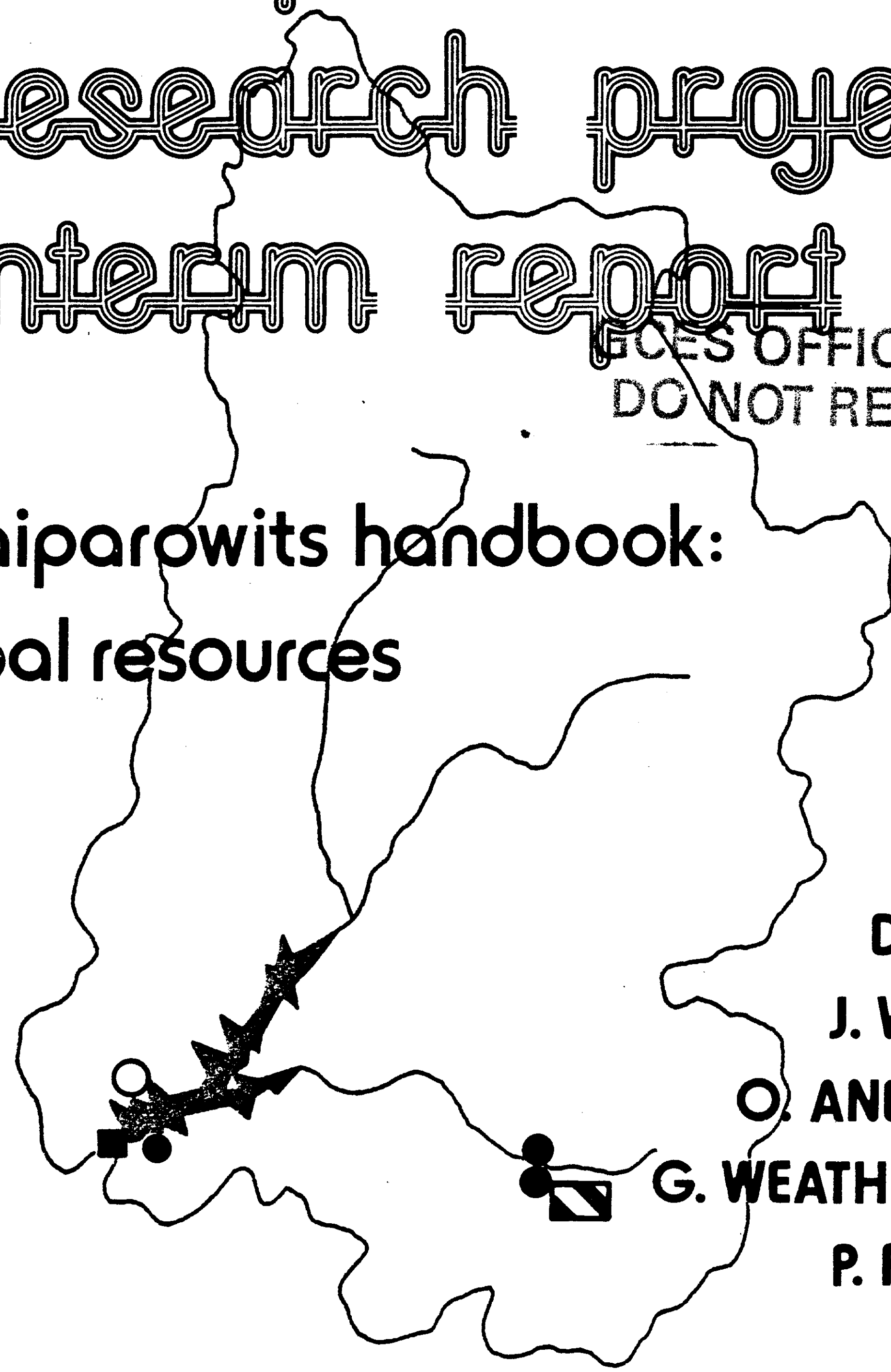
lake powell research project interim report

kaiparowits handbook: coal resources



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Research Applied to National Needs

This Lake Powell Research Project Interim Report is a preliminary version of a chapter in the _Kaiparowits Handbook_, a looseleaf data book about the natural and human resources of the Kaiparowits region. Work on the _Handbook_ is currently in progress. A similar chapter on water resources will be released in the summer of 1975.

Additional copies and further information about the work of the Kaiparowits Resources subproject of the Lake Powell Research Project may be obtained from:

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Los Angeles, California 90024

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LAKE POWELL RESEARCH PROJECT
INTERIM REPORT

KAIPAROWITS HANDBOOK: COAL RESOURCES

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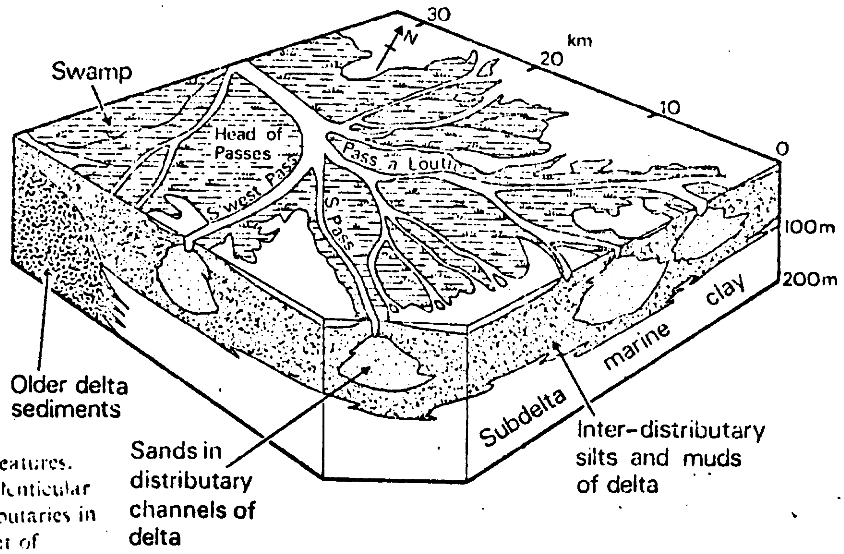
A. COAL RESOURCES OF THE KAIPAROWITS REGION

1. Introduction

a. Origin of Coal

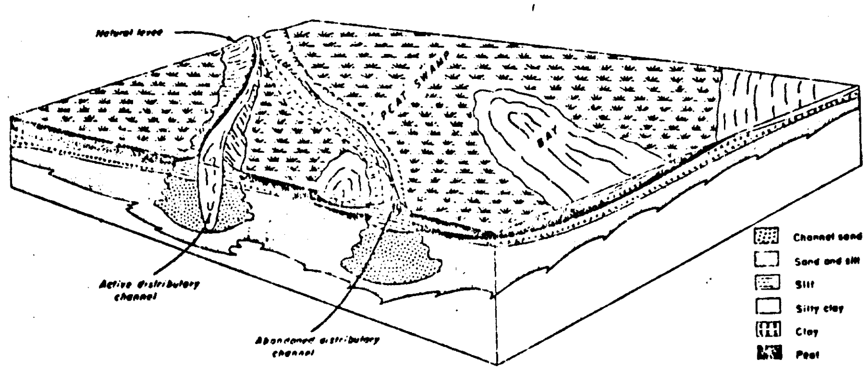
Coal is composed of the fragments of ancient plants that grew in swamps, marshes, or lagoons, or that were transported to and deposited in such environments by erosional processes. Two things are thus necessary to form a coal deposit: a warm, humid environment which produces a great abundance of plant life, and a basin of some sort in which the remains of the plants are accumulated. Figure 1 illustrates a swamp environment which would be favorable for the deposition of plant material and the eventual formation of coal. As the plant remains continue to collect year after year in a swamp (especially one that is slowly sinking), the fragments lowest down are compacted and eventually are turned into peat.[1] The greater the amount of plant remains deposited in the swamp, the thicker the peat bed, or the eventual coal bed, will be. In time, environmental conditions change, and the swamp disappears, perhaps flooded by the sea and covered by marine sands, or buried by continental deposits of sand and gravel brought down by streams. It may even be eroded away if the area experiences uplift. If the deposit is continually buried by successive layers of sediment, the peat is further compacted by the weight of the overlying material, and very slowly, over millions of years, the earth's internal heat and the pressure of the overlying rocks may turn the peat into coal.

(a)



· Mississippi delta features. The diagram shows elongate lenticular sand bodies formed by distributaries in the inter-distributary sediment of carbonaceous silts and muds. The vertical scale is exaggerated 30 times.

(b)



Block diagram showing peat accumulation and related sediments on a portion of a large delta.

Figure 1. Sample geologic environments favorable for the accumulation of peat which may later turn to coal.

Reproduced from (a) Open University Course Team, 1974, The Earth's Physical Resources, Block 2: Energy Resources, Open University Press, p. 26, Figure 17; and (b) Simon, Jack A., and M. E. Hopkins, 1973, "Geology of Coal," in Elements of Practical Coal Mining, S. M. Cassidy, ed., Society of Mining Engineers, New York, p. 15, Figure 3.

Coalification is the process by which compacted vegetable matter, or peat, becomes coal, and the term is thus used to describe all the physical and chemical changes that occur while peat is changing to coal. Basically, there is a reduction in the moisture and volatile matter,[2] and an increase in density, fixed carbon, and heating value.[3]

b. Ranks and Uses of Coal

Coal is ranked according to its content of these components, as can be seen in Figure 2.[4] The terms "lignite," "sub-bituminous," "bituminous," and anthracite" describe coal in increasing stages of coalification. Thus, to a great degree the rank of the coal, as measured by these variables, depends upon the depth to which the material was buried within the earth and the length of time it spent there. In general, the greater the depth of burial of the peat within the earth, the hotter the temperature, and the more compacted and "cooked" the peat becomes.[5]

The basic reason for the difference between most coals in the eastern United States (bituminous and anthracite) and those found west of the Mississippi River (primarily lignite, sub-bituminous, and high-volatile bituminous) is the age, or duration and depth of burial within the earth. Eastern coals are of Pennsylvanian age (the period from 270 to 305 million years ago), whereas western coals are Cretaceous in age (70 to 135 million years ago).

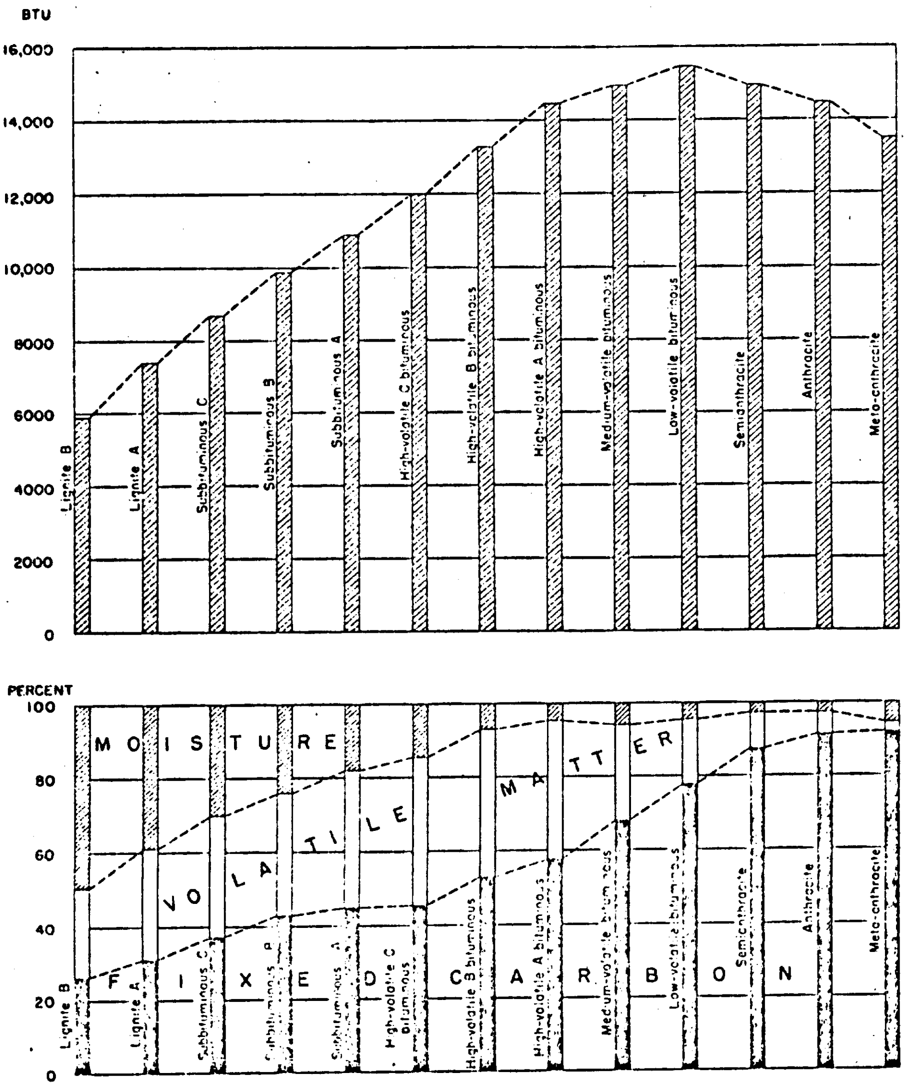


Figure 2. Variation of moisture, fixed carbon, volatile matter, and heat content in coals of different rank.

Reproduced from U. S. Department of the Interior, Bureau of Land Management, 1974, Draft Environmental Impact Statement: Proposed Federal Coal Leasing Program, Volume 1, U.S. Government Printing Office, Washington, p. I-42.

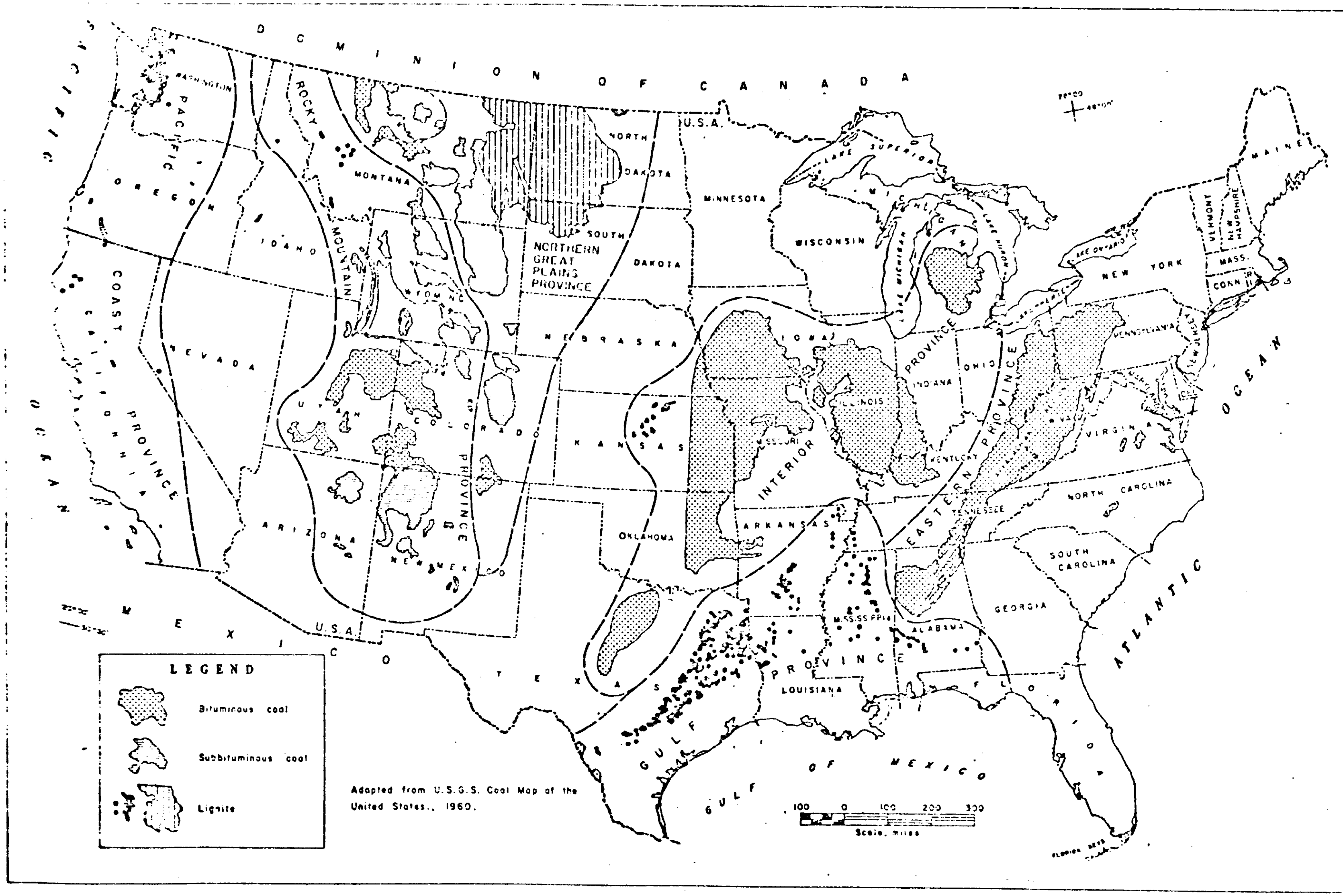


Figure 3. Coal provinces of the United States.

Reproduced from U. S. Department of the Interior, Bureau of Land Management, 1974, Draft Environmental Impact Statement: Proposed Federal Coal Leasing Program, Volume 1, U. S. Government Printing Office, Washington, p. I-47.

The need for increasing the production of coal for electric power generation is well recognized. The conversion of coal by gasification to supplement natural gas and by liquefication to supplant the use of petroleum in transportation is now established as a national goal. Emphasis on research in coal technology will certainly increase the demand for coal in the future. At present, however, the two largest users of coal in the United States are the metals industry and the electric power utilities. The metals industry, which includes steel and iron producers, uses coal both to fire furnaces and to reduce iron ores to metallic iron. For these purposes, they require the higher quality coals (anthracite and bituminous) and those bituminous coals that will coke. Electric power utilities are usually concerned only with the unit cost of the coal per Btu, and therefore most often use the lower grade coals.[6]

c. Coal Provinces

The United States has been divided into six coal provinces on the basis of the geologic age, geologic structural setting, quality, and location of the coal (Figure 3). The Kaiparowits coalfield is contained within the Rocky Mountain Coal Province, which extends from northern Idaho and Montana to southern Arizona and New Mexico. Coal-bearing rocks range in age from Cretaceous to Miocene (from about 135 to 35 million years in age) within the Rocky Mountain Province. The Province contains coal of all ranks, ranging from lignite to anthracite. Figure 4 shows the Kaiparowits Plateau field in relation to other southern Utah coalfields.

2. Geologic History of the Kaiparowits Region

The geologic history of the Kaiparowits Plateau coal-field has been reconstructed by scientific interpretation of the record preserved in the rocks of southern Utah (Figure 5). We begin our description of the geologists' reconstruction of this history by considering a time before the coal was deposited. The rocks which now form the walls of the Grand Canyon were deposited before the end of the Paleozoic era. Most of the rocks which we see today in the Kaiparowits region are younger. Our story begins at the start of the Mesozoic era, 225 million years ago. During the first half of the Mesozoic era (in Triassic and Jurassic time, 225 to 135 million years ago), thick layers of continental sediments (those deposited on land rather than in the ocean) were formed. Because the land was slowly but steadily sinking in this region, material eroded from the highlands to the south and west was washed down and deposited in stream channels, valleys, sand dunes, and lakes. The environment of deposition was quite similar to that in deserts of the Southwest today. In Mesozoic times, however, an ocean covered what is now the State of Nevada. Occasionally a tongue of the sea made its way into the area from the ocean, depositing some marine sedimentary rocks. The period of time during which these processes took place (Triassic and Jurassic) was 90 million years long, so it is not at all surprising to find that the shoreline moved back and forth across a distance of several hundred miles during so long a time. The Triassic Moenkopi Formation and the Jurassic Carmel Formation in southern Utah were deposited by some of these marine invasions. Also formed during this period were the great desert sand dunes which

Figure 4. Coalfields of southern Utah.

Reproduced from Bureau of Economic and Business Research, University of Utah, 1973, Utah! Facts: An Introductory Handbook to the Industrial Development Information System, Arrow Press, Salt Lake City, Utah, Section V., Figure A-3.

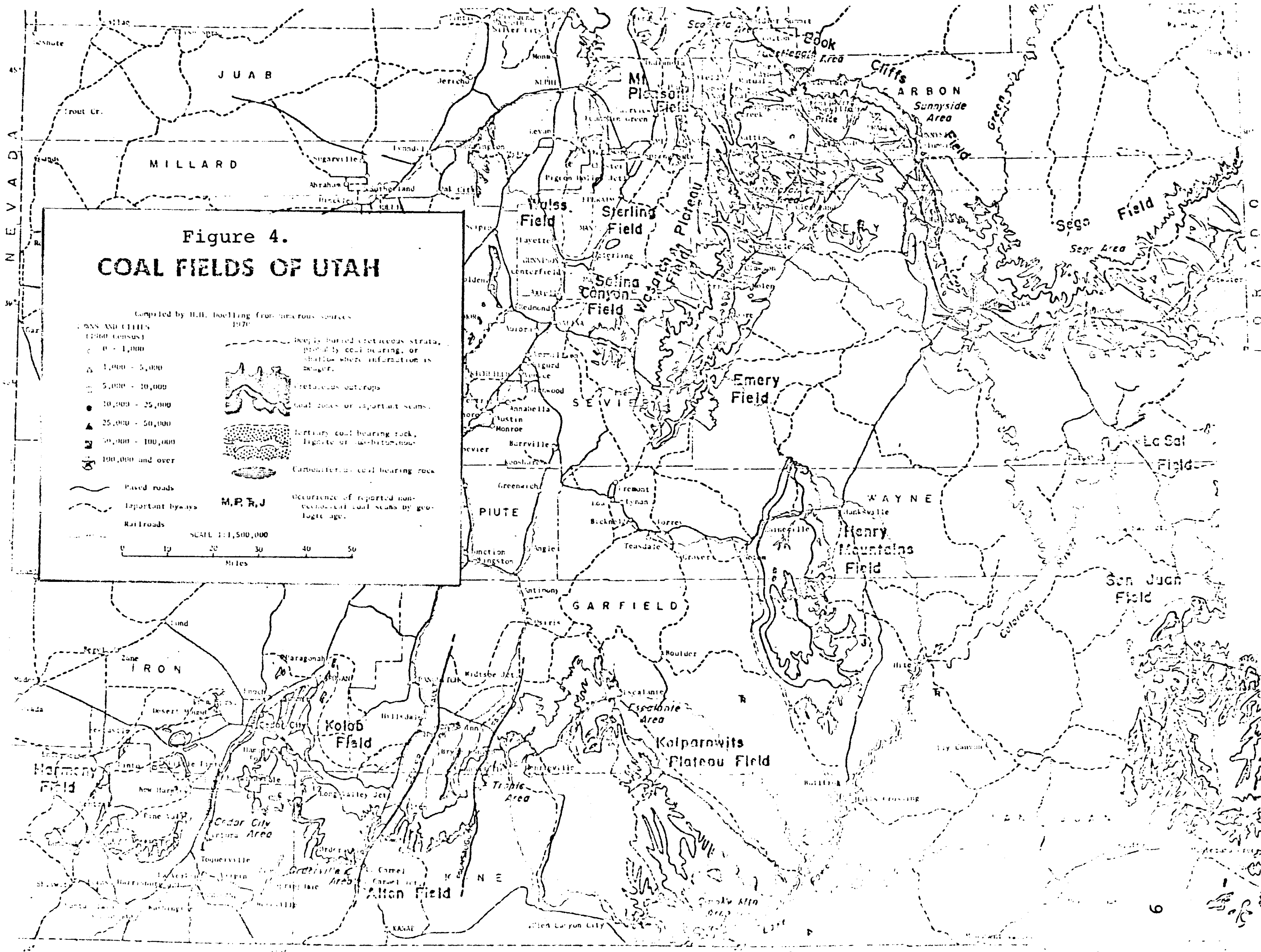


Figure 4.
COAL FIELDS OF UTAH
Compiled by H.H. Doelling from numerous sources
1970
TOWNS AND CITIES
(1960 Census)
0 - 1,000
1,000 - 5,000
5,000 - 10,000
10,000 - 25,000
25,000 - 50,000
50,000 - 100,000
100,000 and over
Paved roads
Important byways
Railroads
Deeply buried cretaceous strata, probably coal bearing, or shallow where information is meager.
Cretaceous outcrops
Coal zones or important seams.
Tertiary coal bearing rock, lignite or subbituminous
Carboniferous coal bearing rock
M,P,Tr,J
Occurrence of reported non-economical coal seams by geologic age.
SCALE 1:1,500,000
0
10
20
30
40
50
Miles
JUAB
MILLARD
NEVADA
CARBON
GRAND
WAYNE
GARFIELD
PIUTE
IRON
ARIZONA
Book Cliffs Field
Sunnyside Area
Sego Field
Sego Area
Wasatch Plateau Field
Sterling Field
Salina Canyon Field
Emery Field
La Sal Field
Henry Mountains Field
San Juan Field
Kolob Field
Harmony Field
Cedar City Area
Alton Field
Kaiparowits Plateau Field
Escalante Area
Tropic Area
Green
Colorado

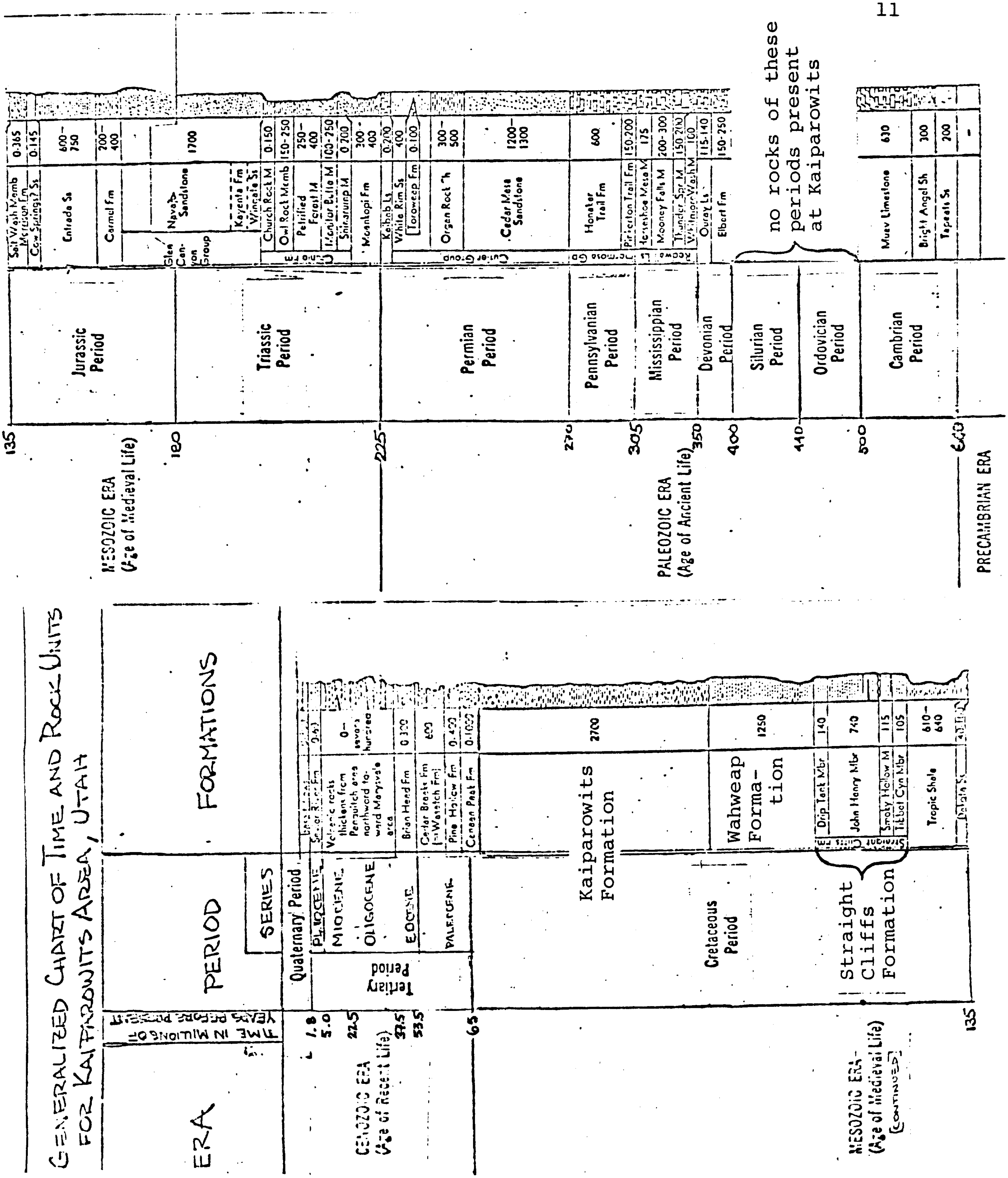
Figure 5. Generalized chart of time and rock units of the Kaiparowits region, Utah

Adapted from: Hintze, Lehi F., 1973, Geologic History of Utah, Brigham Young University Geology Studies, 20, pp. 77, 160-161, Charts 43 and 44; Newman, William L., 1974, Geologic Time, U. S. Geological Survey Information Circular, pp. 6-7; Oetking, P., et al., 1967, Geological Highway Map of the Southern Rocky Mountain Region, Map No. 2, American Association of Petroleum Geologists.

Thickness of the Straight Cliffs Formation at the type locality is:

Drip Tank member 140-220 feet
John Henry member 740 to 900 feet
Smokey Hollow Member 115 to 280 feet
Tibbet Canyon member 90 to 110 feet

(Howard D. Zeller, personal communication, 2/10/75)



GENERALIZED CHART OF TIME AND ROCK UNITS FOR KAIPAROWITS AREA, UTAH
ERA
TIME IN MILLIONS OF YEARS BEFORE PRESENT
PERIOD
SERIES
FORMATIONS
CENOZOIC ERA (Age of Recent Life)
Quaternary Period
Tertiary Period
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
1.8
5.0
22.5
37.5
53.5
65
Volcanic rocks thickens from Panguitch area northward toward Marysvale area
0–several hundred
Brian Head Fm
Cedar Breaks Fm (=Wasatch Fm)
600
Pine Hollow Fm
Canaan Peak Fm
Kaiparowits Formation
2700
Cretaceous Period
Wahweap Formation
1250
Straight Cliffs Formation
Drip Tank Mbr
140
John Henry Mbr
740
Smoky Hollow M
115
Tibbet Cyn Mbr
105
Tropic Shale
610–640
Dakota Ss
135
MESOZOIC ERA (Age of Medieval Life) [CONTINUED]
MESOZOIC ERA (Age of Medieval Life)
135
Jurassic Period
Salt Wash Memb Morrison Fm
0.365
Cow Springs? Ss
0.145
Entrada Ss
600–750
Carmel Fm
200–400
180
Glen Canyon Group
Navajo Sandstone
1700
Kayenta Fm
Wingate Ss
Triassic Period
Chinle Fm
Church Rock M
0.150
Owl Rock Memb
150-250
Petrified Forest M
250–400
Monitor Butte M
100-250
Shinarump M
0.200
Moenkopi Fm
300–400
225
Permian Period
Cutler Group
Kaibab Ls
0.200
White Rim Ss
400
Toroweep Fm
0.100
Organ Rock Sh
300–500
Cedar Mesa Sandstone
1200–1300
270
Pennsylvanian Period
Hermosa Gp
Honaker Trail Fm
600
Pinkerton Trail Fm
150-200
305
PALEOZOIC ERA (Age of Ancient Life)
Mississippian Period
Redwall Ls
Horseshoe Mesa M
175
Mooney Falls M
200-300
Thunder Spr M
150-200
Whitmore Wash M
100
350
Devonian Period
Ouray Ls
115-140
Elbert Fm
150-250
400
Silurian Period
440
Ordovician Period
no rocks of these periods present at Kaiparowits
500
Cambrian Period
Muav Limestone
630
Bright Angel Sh
300
Tapeats Ss
200
600
PRECAMBRIAN ERA

Figure 5.

later were turned into the sandstones of the Navajo Formation (well-exposed today in the cliffs of Zion National Park), and the uranium-rich sands of both the Shinarump member of the Chinle Formation and the Morrison Formation. Toward the end of the Jurassic, a broad uplift of the land raised these sediments and tilted them to the east, thus stopping deposition and starting a period of erosion. This period of erosion, during which some of the previously deposited sediments were completely eroded away, lasted until the latest Lower Cretaceous time (about 110 million years ago) when the land once again began to sink and new sediments were deposited.

This renewed period of subsidence was the time during which the Kaiparowits coal was deposited. At first, rivers and streams transported sand and mud from the rising highlands to the southwest, depositing it in broad plains at the base of the hills. Also, during this time, movement first began along the lines that now mark the axes, or "backbones," of the folds that we see in the rocks today. During long periods when there was not too much material being eroded from the hills and deposited on the floodplains, these low areas became swampy, and thus an environment favorable for the accumulation of peat came into being. This was the time during which the Dakota Formation was deposited. As the land subsided, the sea began slowly to flood the area, moving inland from the direction of the present Gulf of Mexico, and also possibly down from the Arctic, forming the so-called Western Interior Cretaceous Seaway (Figure 6). As the shallow sea began to inundate the continent (that is, as subsidence of the land continued), the area changed from a terrain of streams and plains to one with many lagoons. The lagoons were succeeded by beaches and finally were covered by marine waters as the sea advanced over the land. In the new marine environment, the muds which later were lithified to become the Tropic Shale were deposited.[7]

After the maximum advance of the inland sea, the shoreline began to retreat slowly. Folding of the rocks continued, at irregular intervals, creating local uplifts and depressions which collected material eroded from the highlands. Although the sea continued to retreat gradually to the east, the shoreline repeatedly fluctuated back and forth across the eastern half of the area which is now the Kaiparowits Plateau. At that time, the Kaiparowits area was a basin in which sediments were accumulating. Most of the time, the ancient shoreline was approximately parallel to the present-day northwest-southeast trend of the Straight Cliffs. This was the period of deposition of the Straight Cliffs Formation. Marine sands were deposited offshore parallel to the beaches, and long lines of sandy barrier islands protected swampy inland lagoons from the ocean waves. Landward from the broad swampy lagoons, in which the material of the coal slowly accumulated, lay the alluvial plains which were occasionally overrun by streams bringing sand and mud down from the highlands. This ancient pattern of depositional environments probably closely resembled the present-day east coast of Florida, where Daytona Beach protects the great expanse of the swampy Everglades from the sea.

Figure 6. Geological reconstruction of the ancient geography of the Kaiparowits region during the Cretaceous. The position of the Western Interior Seaway is shown during the time of deposition of peat which eventually became the Christensen coal zone.

Reproduced from Doelling, H.H., and R. L. Graham, 1972, "Kaiparowits Plateau Coal Field, in H.H. Doelling and R. L. Graham, Southwestern Utah Coal Fields: Alton, Kaiparowits Plateau and Kolob-Harmony, Utah Geologica and Mineralogical Survey Monograph Series No p. 90, Figure 11, modified from Peterson, Fred, 1969, Cretaceous Sedimentation and Tectonism in the Southeastern Kaiparowits Region, Utah, U.S. Geological Survey Open File Report, p. 193.

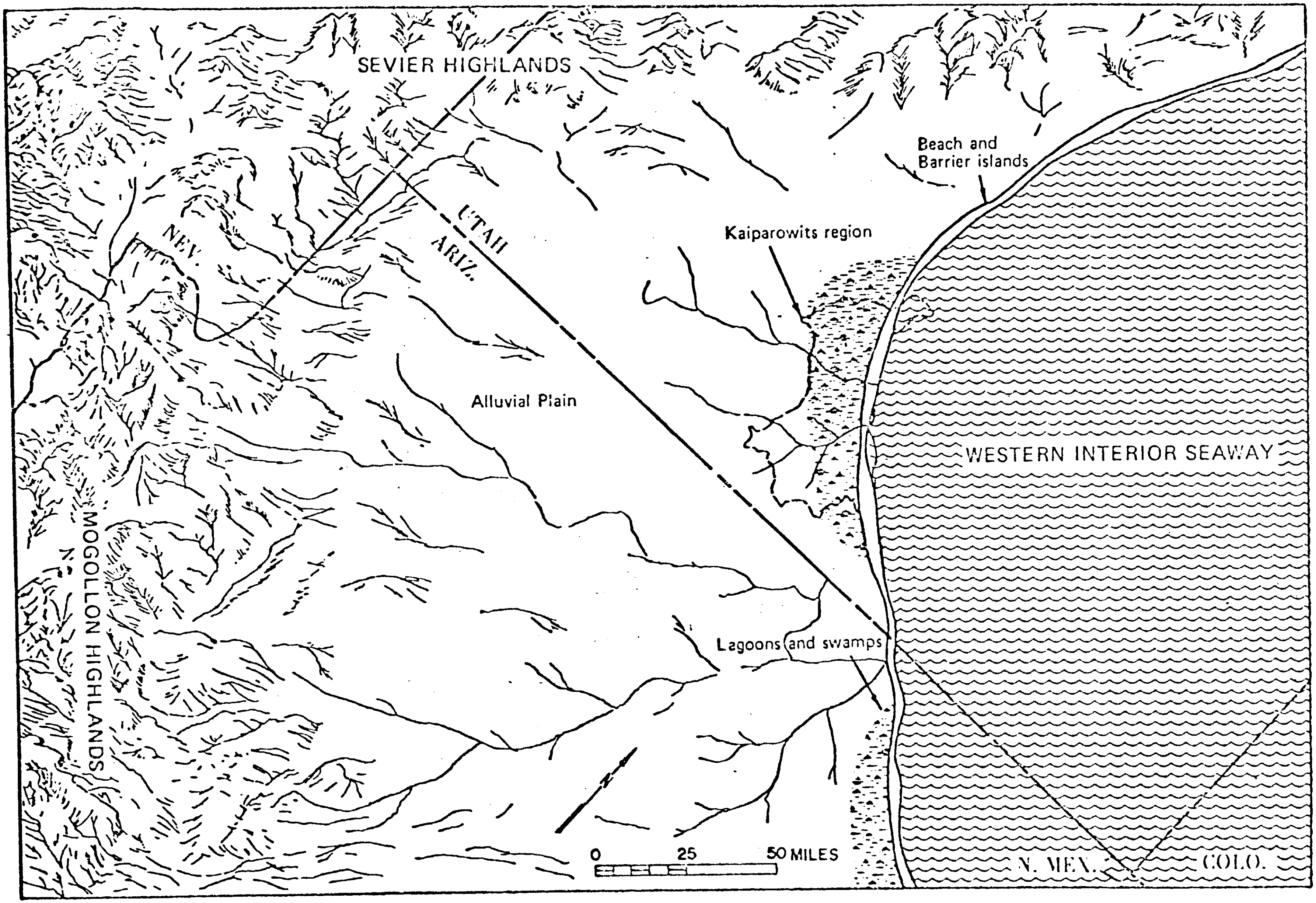

SEVIER HIGHLANDS
NEV.
UTAH
ARIZ.
Beach and
Barrier islands
Kaiparowits region
Alluvial Plain
WESTERN INTERIOR SEAWAY
MOGOLLON HIGHLANDS
N
Lagoons and swamps
0
25
50 MILES
N. MEX.
COLO.

Figure 6.

As the sea continued to retreat during the Upper Cretaceous, continental deposits now known as the Wahweap and Kaiparowits Formations buried the older marine and lagoonal deposits. Both coarse and fine sediments were laid down, sometimes simultaneously and sometimes in alternating sequences. This was also a time when dinosaurs roamed the area, for numerous fossil reptile bones are found at certain places in the Wahweap and Kaiparowits Formations. Following the accumulation of these thick continental sediments (in late Upper Cretaceous time, about 75 million years ago), the entire area was again uplifted and subjected to erosion.[8] During the latest Cretaceous and early Tertiary periods (about 75 to 40 million years ago), the land in the Kaiparowits region was alternately uplifted, tilted, eroded and downdropped. During various depositional periods, additional continental and lacustrine beds were deposited, such as the Wasatch Formation, which forms the Pink Cliffs and delicate pinnacles of Bryce Canyon. Folding continued to deform the rocks of the Kaiparowits region, and molten rock began to pour out over the surface of the land from numerous vents and fissures. This volcanic activity occurred in mid-Tertiary time (about 40 million years ago). The rocks capping Boulder Mountain belong to this group. Some geologists think that the Paunsagunt Fault (east of Bryce Canyon) and the East Kaibab Monocline ("The Cockscomb") became active at this time. Possibly faulting and earthquake activity were genetically related to the volcanism which was present at the same time.

Since mid-Tertiary time, uplift and erosion have dominated the geologic history of the Kaiparowits region, and they have given the finishing touches to the physiography of the Kaiparowits Plateau (Figure 7).

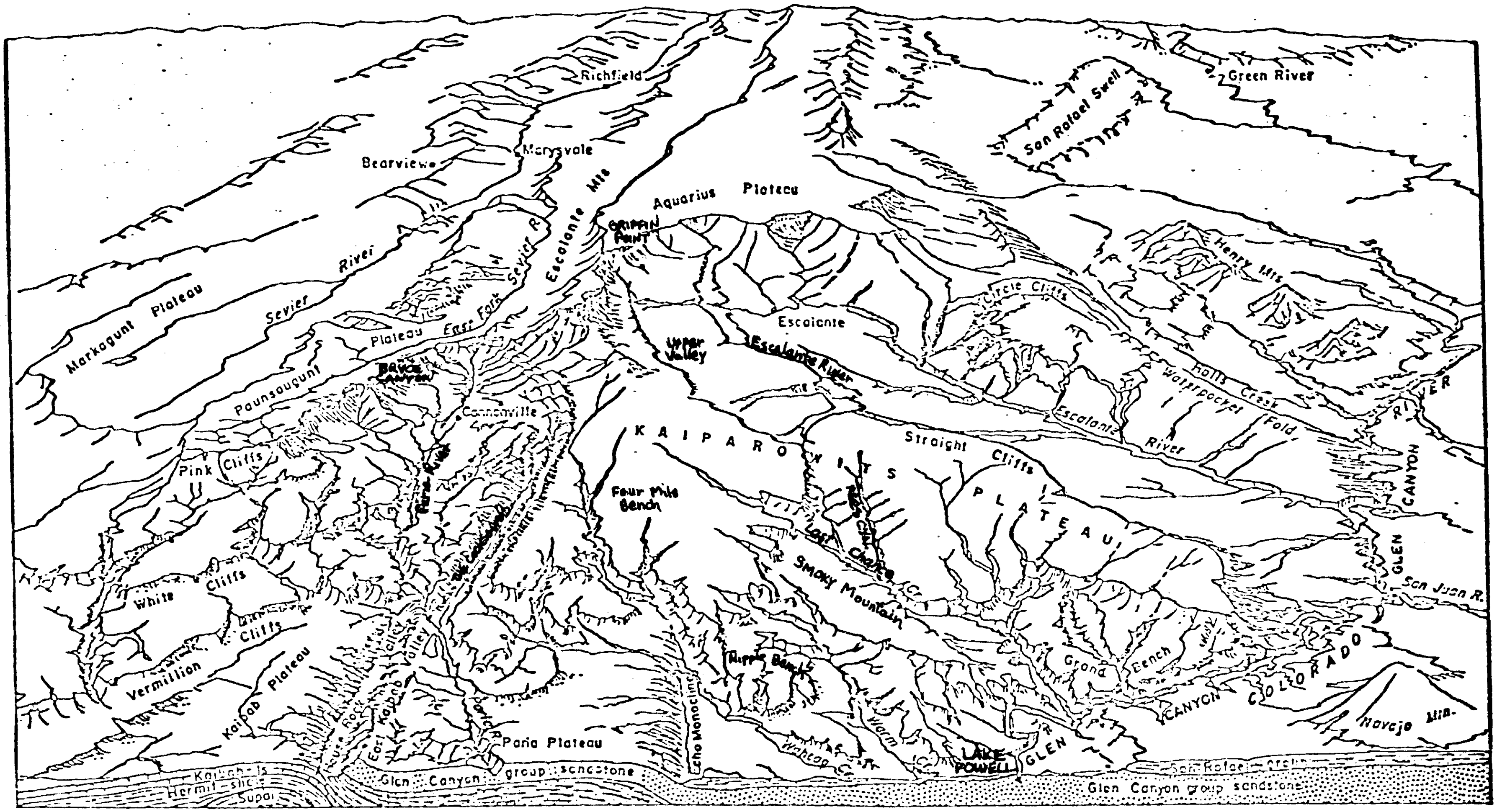
3. Quantity of Coal in the Kaiparowits Region

Prior to the publication in 1931 of Gregory and Moore's work The Kaiparowits Region, nothing was known about the extent of the coal deposits on the Kaiparowits Plateau except in the area immediately surrounding the town of Escalante and the Henrieville-Tropic area. However, since the early 1960s, increased interest in coal as an energy source has caused both private energy interests and public information agencies to look in much greater detail at the coal deposits of the Kaiparowits Plateau. The beginning of serious geological assessment of coal resources in the Kaiparowits region coincided in time with the completion of Glen Canyon Dam in 1963.

Estimates of the amount of coal in the Kaiparowits Plateau have been published by both the U. S. Geological Survey and by the Utah Geological and Mineralogical Survey. These estimates are listed in Table 1. Many factors can influence the accuracy of these estimates. First, because of the absence of working mines and lack of detailed exploratory drilling in the area, most of the information about the thickness of the coal seams has been obtained from outcrops. Many of these outcrops have been burned. The U. S. Geological Survey estimates that over 10 billion tons of Kaiparowits coal have burned in natural fires during the last million years.[9] In many

Figure 7. Physiography of the Kaiparowits region.

Adapted from Doelling, H.H., and R. L. Graham, 1972, "Kaiparowits Plateau Coal Field," *in* H.H. Doelling and R. L. Graham, *Southwestern Utah Coal Fields: Alton, Kaiparowits Plateau and Kolob-Harmony*, Utah Geological and Mineralogical Survey Monograph Series No. 1, p. 70, Figure 2.



Generalized view of the Kaiparowits Plateau region looking north from the Utah–Arizona boundary line (from Gregory and Moore, 1931).

Figure 7.

Table 1. Estimates of Quantity of Coal in the Kaiparowits Plateau

Year	Source	Amount
1961	U. S. Geological Survey[a] Initial gross estimate of reserves in beds over 14 inches thick and under less than 3000 feet of overburden. Based on a few measurements of coal thicknesses made by Gregory and Moore (1931) and on general considerations of the thickness and nature of the coal-bearing rocks.	3 billion tons
1969	U. S. Geological Survey[b] Resources determined from mapping and exploration for coal with up to 3000 feet of overburden. Estimate by F. C. Peterson based on detailed mapping then in progress, with estimate that potential total would be much larger.	7.3 billion tons
1972	Utah Geological and Mineralogical Survey[c] Coal reserves based upon geologic and geographic position and coal outcrop and drill-hole information where available. Includes coal in beds more than 4 feet thick and under less than 3000 feet of overburden.	15.2 billion tons
1974	U. S. Geological Survey[d] Unpublished information based on mapping and coal drill-hole information. This is a gross estimate of total resources made for in-house use and includes coal in seams as thin as 14 inches and coal under as much as 6000 feet of overburden. This figure is being revised upward as of November 1974.	40 billion tons

[a]Averitt, Paul, 1961, Coal Reserves of the United States, A Progress Report, January 1, 1960, U. S. Geological Survey Bulletin 1136, U. S. Government Printing Office, pp. 79-80.

[b]Averitt, Paul, 1969, Coal Resources of the United States, January 1, 1967, U. S. Geological Survey Bulletin 1275, U.S. Government Printing Office, p. 42.

Table 1. footnotes continued

[c] Doelling, H. H. and R. L. Graham, 1972, "Kaiparowits Plateau Coal Field," in H.H. Doelling and R. L. Graham, Southwestern Utah Coal Fields: Alton, Kaiparowits Plateau and Kolob-Harmony, Utah Geological and Mineralogical Survey Monograph Series No. 1, pp. 102-103.

[d] Howard D. Zeller, personal communication, 1974.

areas, outcrops are limited, which makes estimation of the presence of coal subject to substantial uncertainties. Also, many coal seams are very lenticular, so that the lateral continuity and extent of coal seams seen in outcrop is always in question. Further, each estimate is subject to certain qualifications as to how much coal constitute reserves and how much may be counted as resources.[10]

The Utah Geological and Mineralogical Survey estimates that Kaiparowits Plateau coal reserves amount to 15.2 billion tons.[11] This figure includes only the coal in layers more than 4 feet thick and under less than 3,000 feet of overburden. The U. S. Geological Survey has been actively mapping the coal lands of the Kaiparowits Plateau since 1963,[12] and in 1969 the Survey increased its estimate of Kaiparowits coalfield resources from the original figure of 3 billion tons first estimated in 1961[13] to 7.3 billion tons.[14] These numbers refer to total resources as determined by ongoing mapping and exploration and as judged under the criteria of public coal lands.[15] Subsequently, based upon information obtained by additional mapping, the Survey has increased its estimate of total coal resources in the Straight Cliffs Formation of the Kaiparowits Plateau coalfield to 40 billion tons.[16]

Extensive mapping of the Plateau is still being conducted by the U. S. Geological Survey to obtain a complete picture of the coal seam outcrops. Also, federal and state coal land lessees have been conducting detailed drilling programs to determine the extent of their coal holdings. This information, when complete and publicly available, will almost certainly allow a more accurate assessment of the total coal resources of the Kaiparowits Plateau.[17]

The large quantity of coal on the Kaiparowits Plateau makes it one of the most important potential mining centers in the West. The coal resources in the Plateau constitute about 50% of the total coal resources in the State of Utah, and represent one of the largest untapped coalfields in the United States.[18]

a. Geographic Divisions of the Kaiparowits Coalfield

The Kaiparowits coalfield has been divided into three geographic areas (Figure 8A) and into three geological divisions defined by areas of deposition of three major coal zones (Figure 8B). The southern part of the Plateau which drains southeastward toward the Colorado River is called the Smoky Mountain area. The northern section of the Plateau, draining eastward into the Escalante River, comprises the Escalante area. The third division lies to the west, and contains the broad amphitheater that forms the headwaters of the south-flowing Paria River. It is called the Tropic Area.

b. Coal Zones

At Kaiparowits, coal of possible economic importance is confined to the Dakota and Straight Cliffs Formations in seven distinct zones. These zones, in order from oldest to youngest, are: Dakota, Smoky Hollow, Lower, Christensen (or Henderson), Rees, Alvey, and Upper Alvey. As shown in Figure 9, all but the Dakota zone are contained within the Straight Cliffs Formation. The Dakota, Smoky Hollow, and Lower coal zones very rarely contain coal seams thicker than 4 feet, although the Dakota may yet prove to be important in the Tropic area, where the Dakota has been little

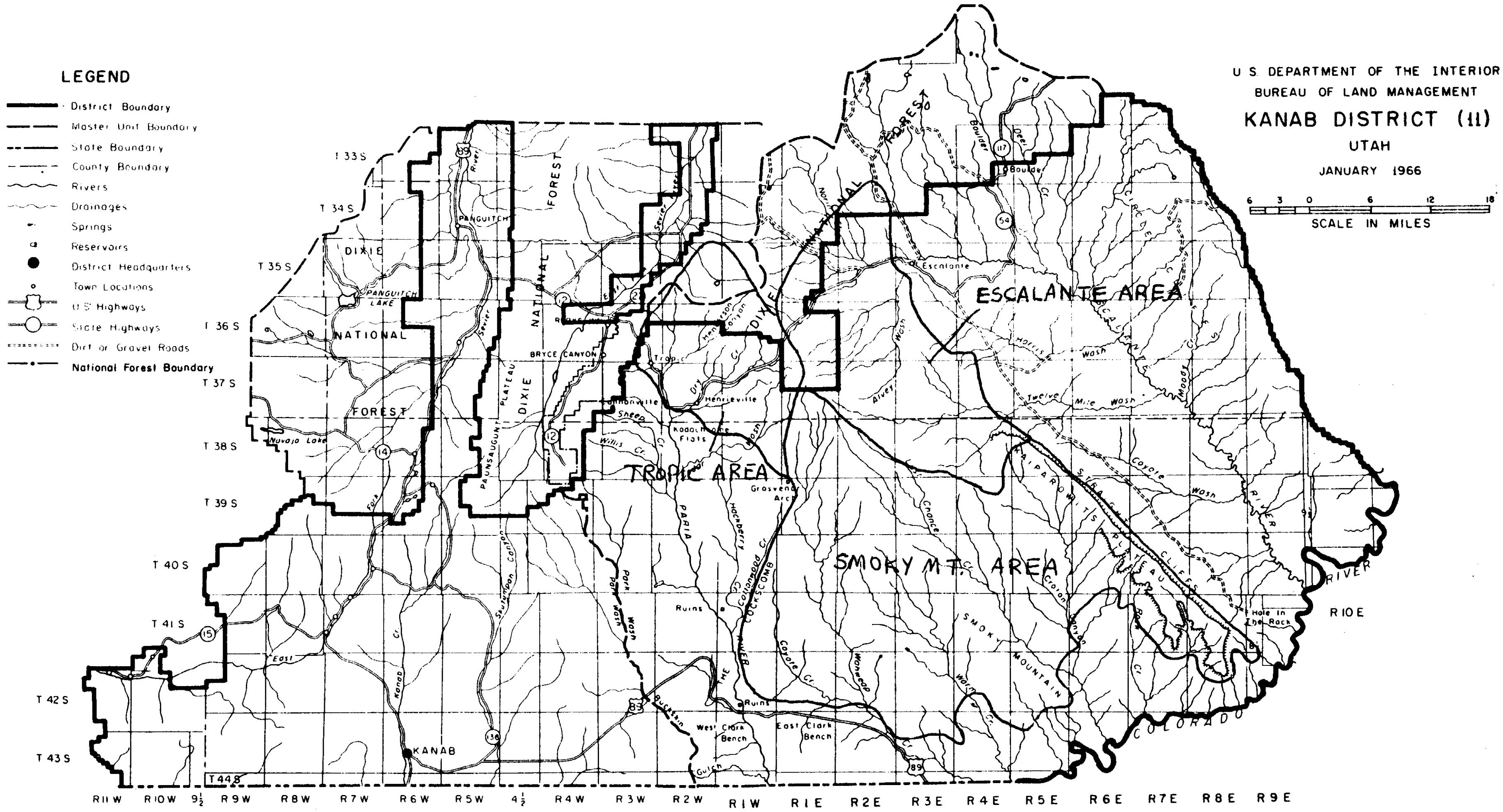


Figure 8A. Geographic divisions of Kaiparowits region: Tropic, Smoky Mountain and Kaiparowits areas.

Reproduced from map supplied by Morgan S. Jensen, District Manager, Bureau of Land Management, Kanab, Utah, to Orson L. Anderson, 26 November 1974.

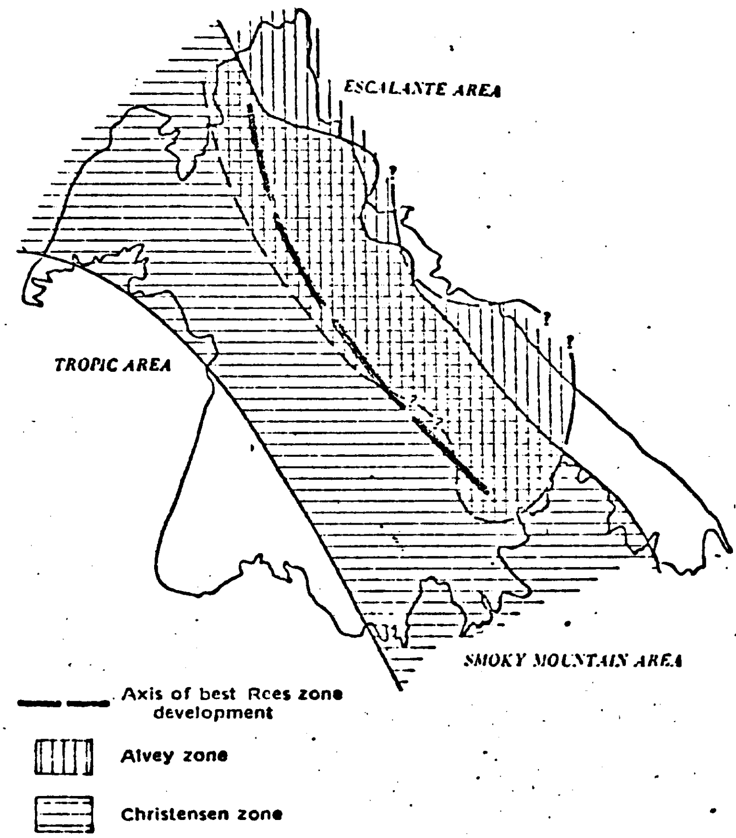


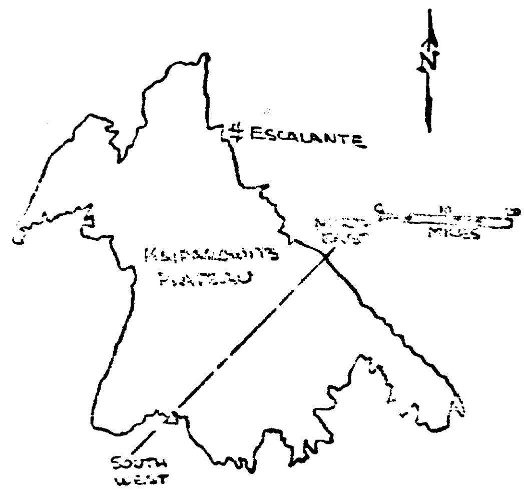
Figure 8B. Areas of coal deposition in the Kaiparowits coalfield.

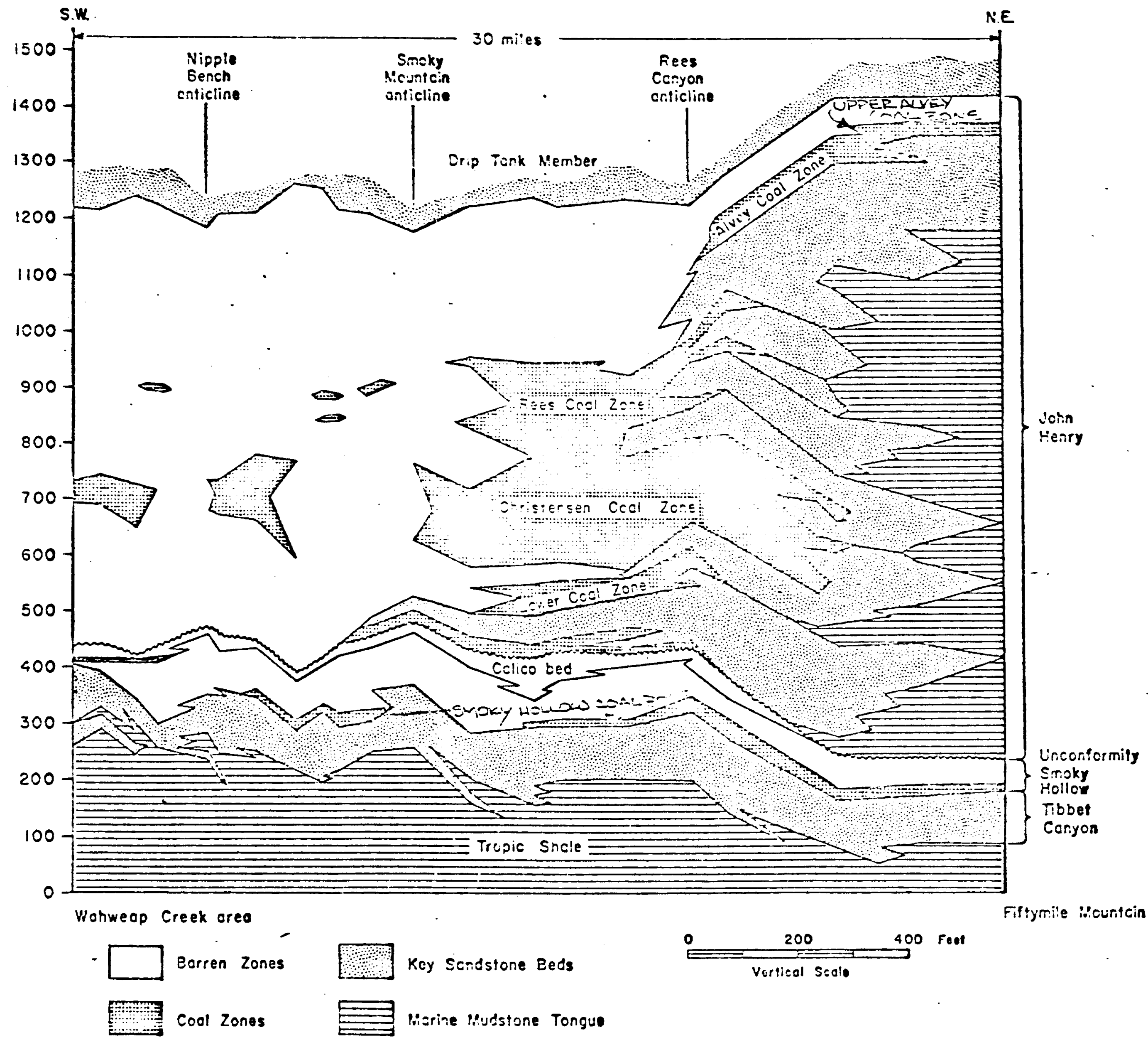
Reproduced from Doelling, H.H. and R. L. Graham, 1972, "Kaiparowits Plateau Coal Field," in H.H. Doelling and R. L. Graham, Southwestern Utah Coal Fields: Alton, Kaiparowits Plateau and Kolob-Harmony, Utah Geological and Mineralogical Survey Monograph Series No. 1, p. 103, Figure 17.

Figure 9. Diagrammatic representation of the coal zones within the Straight Cliffs Formation, southern Kaiparowits Plateau.

Reproduced from Doelling, H.H. and R. L. Graham, 1972, "Kaiparowits Plateau Coal Field," in H.H. Doelling and R. L. Graham, Southwestern Utah Coal Fields: Alton, Kaiparowits Plateau and Kolob-Harmony, Utah Geological and Mineralogical Survey Monograph Series No. 1, p. 79, Figure 7, modified from Peterson, Fred, 1969, Cretaceous Sedimentation and Tectonism in the Southeastern Kaiparowits Region, Utah, U.S. Geological Survey Open File Report, pp. 149-150.

Figure 9.


ESCALANTE
MILES
KAIPAROWITS PLATEAU
SOUTH WEST


S.W.
N.E.
30 miles
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Nipple Bench anticline
Smoky Mountain anticline
Rees Canyon anticline
Drip Tank Member
UPPER ALVEY COAL ZONE
Alvey Coal Zone
Rees Coal Zone
Christensen Coal Zone
Lower Coal Zone
Calico bed
SMOKY HOLLOW COAL ZONE
Tropic Shale
John Henry
Unconformity
Smoky Hollow
Tibbet Canyon
Wahweap Creek area
Fiftymile Mountain
0
200
400
Feet
Vertical Scale
Barren Zones
Key Sandstone Beds
Coal Zones
Marine Mudstone Tongue

studied.[19] The Upper Alvey coal zone reaches its maximum thickness of about 11 feet in the Griffin Point area, but it is of very minor importance elsewhere.

The Rees coal zone is best developed along an axis trending south-southeast from the Griffin Point-Upper Valley area to the junction of Rees and Last Chance Canyons (Figures 7 and 8). The zone lies about 850 feet above the base of the Straight Cliffs Formation, and coal may be found anywhere within the 250 to 300 foot vertical extent of the zone. Maximum measured thicknesses of coal seams in the Rees zone are about 14 feet, but they average only 5 feet along the axis and thin rapidly in both directions off the axis. In many places, the zone splits into many widely spaced seams which are always lenticular and difficult to trace.[20A]

The Alvey coal zone is about 950 feet above the base of the Straight Cliffs Formation, and is normally about 100 feet thick. Seams up to 20 feet thick have been found, but the average thickness is closer to 6 feet. The area of Alvey deposition is shown in Figure 8. The coal seams in the zone are lenticular, and many thin and pinch out. The Alvey zone is of greatest importance in the Escalante area, and is always mineable in its principal area of deposition.[20B]

The Christensen coal zone is by far the most valuable in the Kaiparowits Plateau coalfield. It occurs in a broad northwest-southeast trending band about 15 to 20 miles wide, and contains a few seams up to 25 feet thick (Figure 8). The zone itself varies in thickness, but is usually found from 550 to 650 feet above the base of the Straight Cliffs Formation. In the Tropic area, the zone known as the Henderson coal zone is probably correlative with the Christensen. Individual seams in the Christensen zone appear to thicknen to the northeast.[21] Like the Alvey coal zone, individual coal seams of the Christensen zone thin and thicken, and in places pinch out, but again there is almost always at least one mineable seam present.

Natural coal fires burning in the Smoky Mountain and Burning Hills areas have destroyed many of the good coal seams originally present. Apparently, the U. S. Bureau of Mines has successfully extinguished a number of these fires, but still some continued to burn in the summer of 1974.

4. Rank and Quality of Kaiparowits Coal

The grade or quality of coal is usually quite independent of the rank of the coal.[22] The quality of a coal sample describes its content of deleterious constituents, such as ash and sulfur, whereas a coal's rank describes its heat content and moisture. Figure 10 shows how the rank of coal is related to carbon content (see also Figure 2 and Footnote 4). The oxygen and hydrogen content of coal also varies with rank.

The environmental impact of burning coal varies according to its rank and its concentrations of contaminants. Combustion of low sulfur coal with a small heat content may have as large an impact on the environment as burning a high rank coal with a relatively high sulfur content. Similar impacts may be produced by combustion of a low ash, low heat content coal, although ash and heat

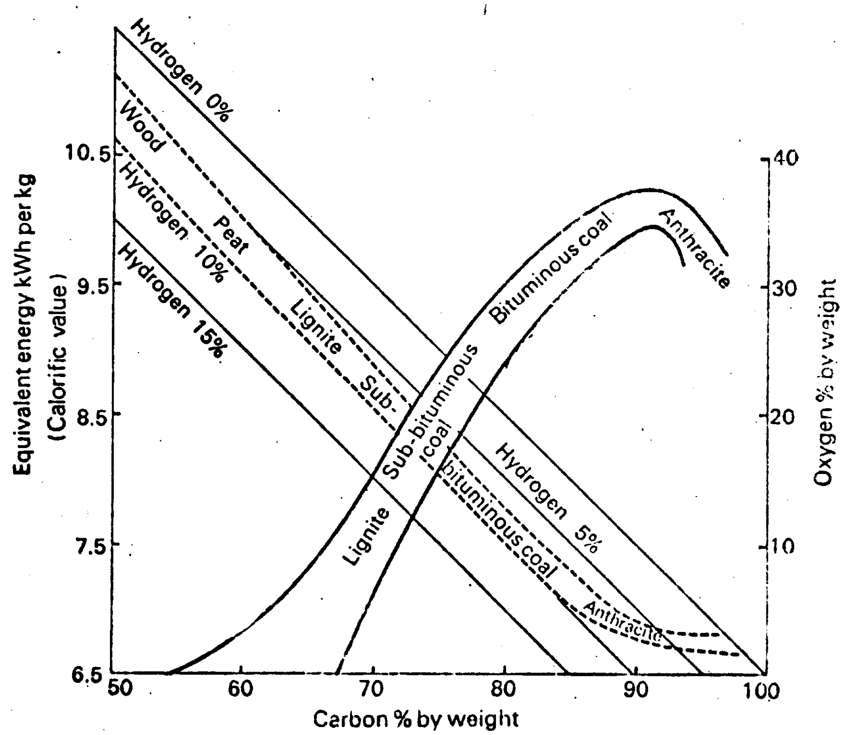


Figure 10. Relationship between rank, composition and heat content of coal. Heat content plotted as calorific value in equivalent energy of kilowatt-hours per kilogram. Solid curves should be read in units of the bottom and left-hand scales, dashed curves and straight lines are read from the bottom and right hand scales.

Reproduced from Open University Course Team, 1974, The Earth's Physical Resources, Block 2: Energy Resources, Open University Press, p. 24, Figure 13.

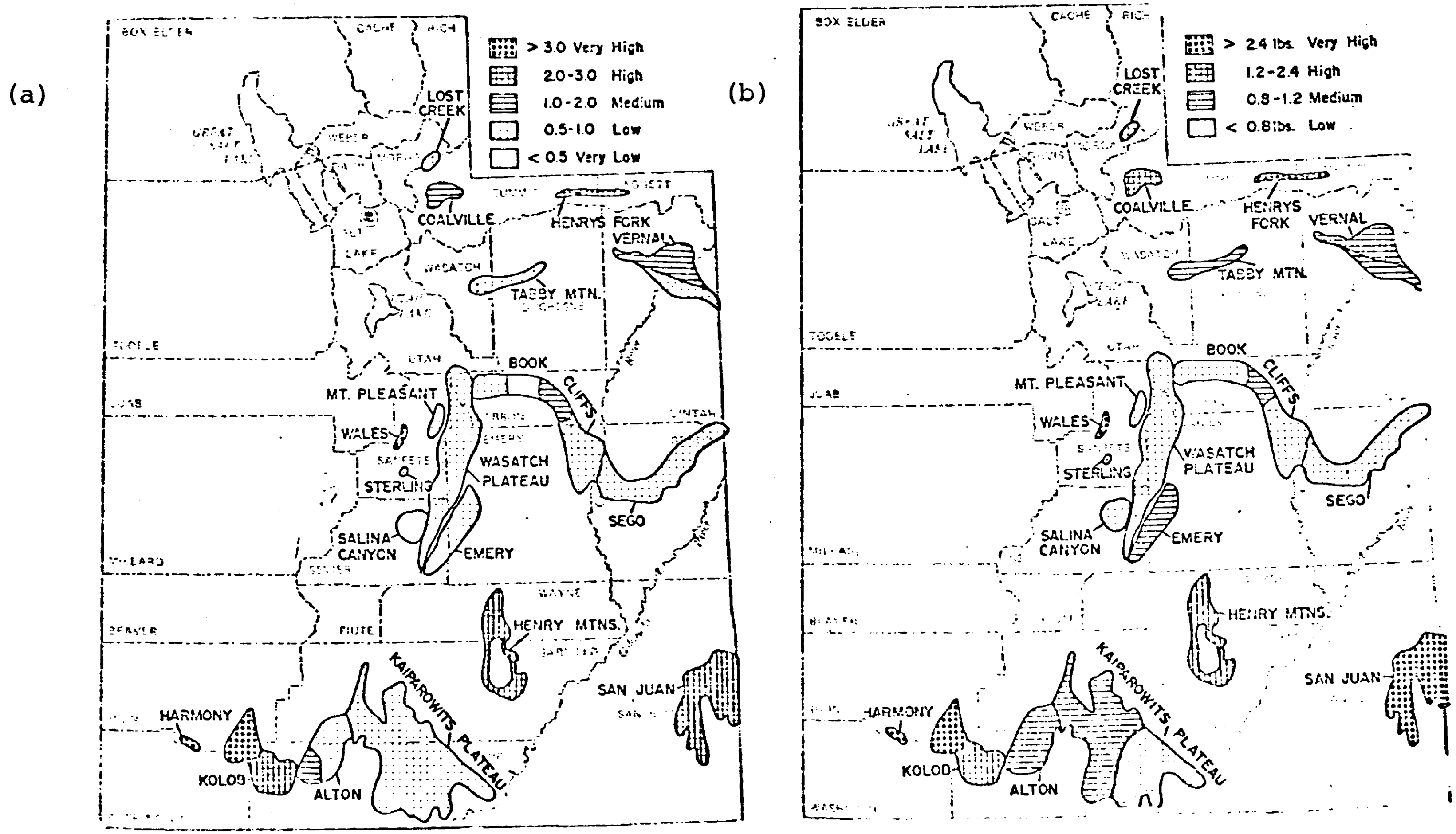


Figure 11. Sulfur content of Utah coals. (a) relation of sulfur content in as-received coal to area; (b) relation of pounds sulfur content per million Btu to area.

Reproduced from Doelling, H.H., 1972, "Coal in Utah - 1970," in H.H. Doelling, Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery, Utah Geological and Mineralogical Survey Monograph Series No. 3, p. 556, Figures 16 [a] and 17 [b].

Figure 12. Heat content vs. sulfur content for coals from Kaiparowits and surrounding coalfields.

Source: Plotted from data in Doelling, H.H., 1972, "Coal in Utah - 1970," in H.H. Doelling, Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery, Utah Geological and Mineralogical Survey Monograph Series No. 3, pp. 557-558.

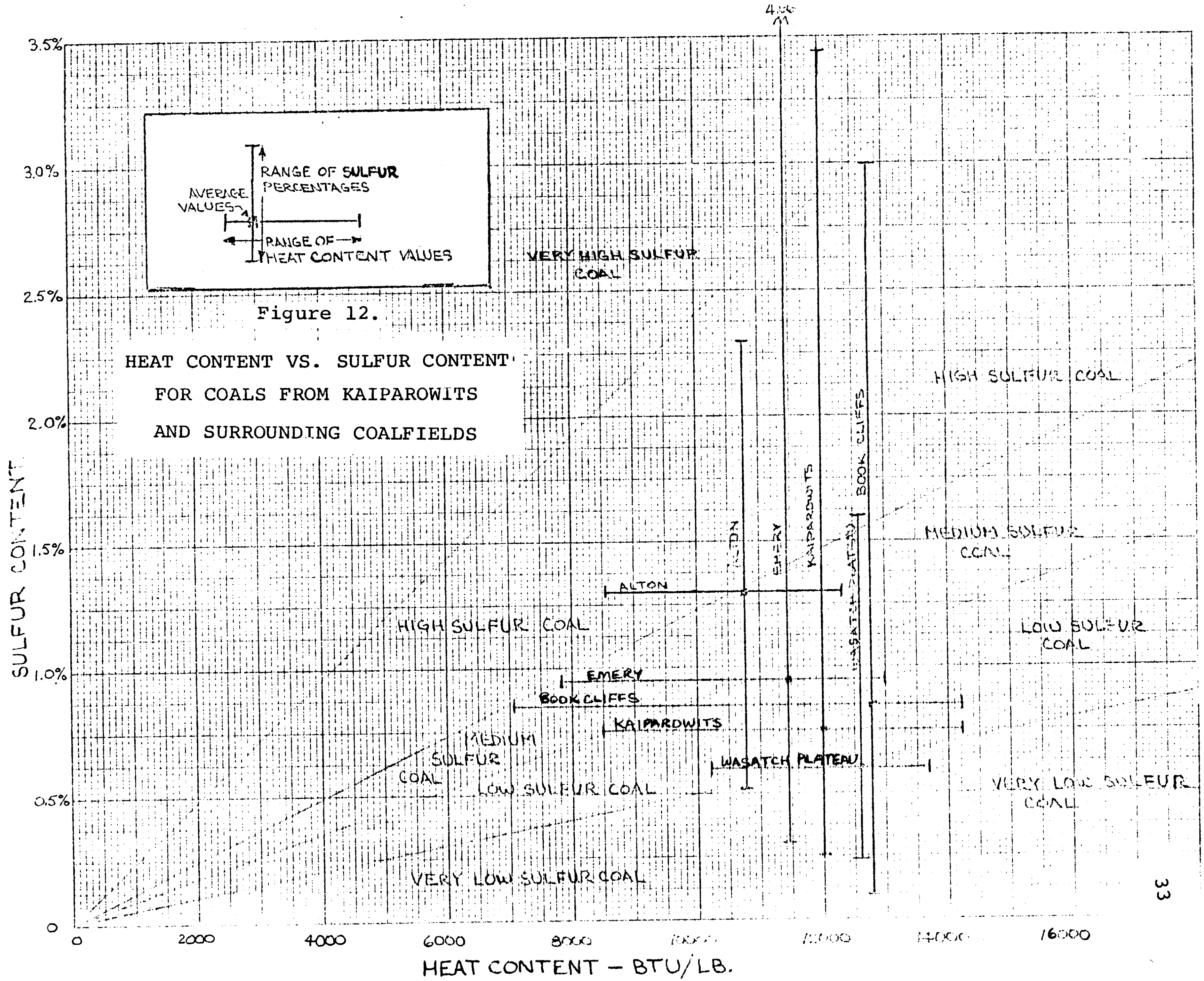


Figure 12.

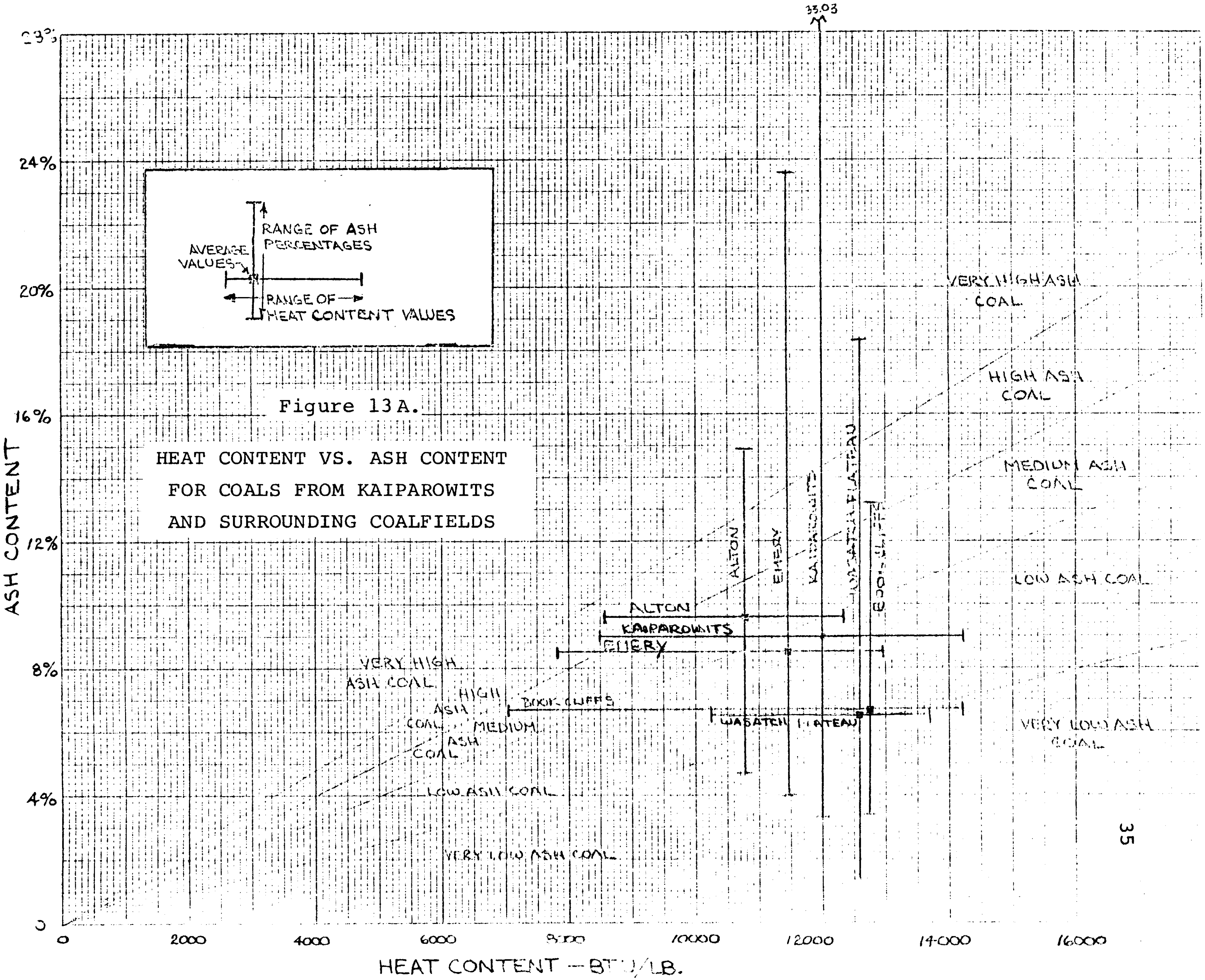
HEAT CONTENT VS. SULFUR CONTENT FOR COALS FROM KAIPAROWITS AND SURROUNDING COALFIELDS

Figure 13A. Heat content vs. ash content for coals from coals from Kaiparowits and surrounding coal-fields.

Source: Plotted from data in Doelling, H.H., 1972, "Coal in Utah - 1970," in H.H. Doelling, Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery, Utah Geological and Mineralogical Survey Monograph Series No. 3, pp. 557-558.

Figure 13A.

HEAT CONTENT VS. ASH CONTENT FOR COALS FROM KAIPAROWITS AND SURROUNDING COALFIELDS



content are more often associated than sulfur and heat content. Figures 11, 12, and 13A show graphically how coal from several Kaiparowits coal zones compares with other coals from surrounding areas in terms of environmentally significant properties.

Analyses of coal from the various areas of the Kaiparowits Plateau are shown in Table 2. About half of these analyses are for weathered samples from surface outcrops and old mines. Since these samples are weathered, they show slightly lower overall rank than do fresh samples, and thus they lower slightly the average coal rank of the entire area. The rank ranges from sub-bituminous C to high volatile bituminous A. The ash content is moderate to high, and the sulfur content is moderate to low. The lowest heating value is found for coal from the Tropic area, where the coal contains more moisture and ash. The heating value of the Smoky Mountain coal is slightly higher than the others, because it is predominately from the Christensen zone. Sulfur content for the Escalante coals is thought to be abnormally high due to the high sulfur content of a very few samples from the Schow Mine which may not be representative of average Escalante coals.[23,25] Kaiparowits coal has no coking properties, and in some areas it would require cleaning (washing and removal of rock debris from the coal) to assure adequate quality for powerplant uses.[24] In general, of the two major coal zones, the Christensen (lower) coal zone is the highest quality zone while the Alvey (upper) coal zone averages about 500 to 1000 fewer Btu per pound.

Table 2. Quality of the Coals in the Kaiparowits Coalfield.[a]

	Percent Range	Percent Average	No. of analyses
KAIPAROWITS PLATEAU COAL FIELD (all areas)			
Moisture	3.60-28.70	11.33	137 as-received
Volatile matter	21.92-57.38	43.63	164 dry
Fixed carbon	22.81-71.51	47.25	164 dry
Ash	3.38-33.03	8.96	165 dry
Sulfur	0.26- 3.40	0.87	129 dry
Btu/lb	8,499-14,236	11,999	161 dry
SMOKY MOUNTAIN AREA COAL			
Moisture	3.70-24.20	9.63	77 as-received
Volatile matter	21.92-57.38	42.44	91 dry
Fixed carbon	22.81-71.51	48.70	91 dry
Ash	3.60-19.80	8.59	91 dry
Sulfur	0.26- 1.50	0.75	91 dry
Btu/lb	10,736-13,746	12,401	91 dry

	Percent Range	Percent Average	No. of analyses
ESCALANTE AREA COAL			
Moisture	3.60-24.80	10.51	40 as-received
Volatile matter	37.47-57.49	45.39	53 dry
Fixed carbon	38.49-53.59	46.81	53 dry
Ash	3.38-24.89	7.80	54 dry
Sulfur	0.42- 3.40	1.26	24 dry
Btu/lb	8,499-14,236	11,563	53 dry
TROPIC AREA COAL			
Moisture	9.36-28.70	19.50	20 as-received
Volatile matter	35.73-48.03	44.42	20 dry
Fixed carbon	31.23-47.07	41.81	20 dry
Ash	7.71-33.03	13.77	20 dry
Sulfur	0.60-1.73	0.98	14 dry
Btu/lb	8,826-12,699	11,207	17 dry

[a]Reproduced from Doelling, H.H. and R. L. Graham, 1972, "Kaiparowits Plateau Coal Field," in H.H. Doelling and R. L. Graham, Southwestern Utah Coal Fields: Alton, Kaiparowits Plateau and Kolob-Harmony, Utah Geological and Mineralogical Survey Monograph Series No. 1, p. 93, Table 5.

As more exploratory drilling is undertaken on the Plateau by groups owning leases and permits, additional analyses will be made. The results of these studies will be for the most part privileged information, and it is unknown when and if they will become public. However, they are not expected to contradict the general description given above, but will only provide more details.

5. Mineability of Kaiparowits Coal

The mineability of a coal seam in the Kaiparowits coalfield depends upon a great number of factors and conditions determined by the coal seam itself and by the characteristics of the general area surrounding it. Among these factors are accessibility to a possible mine site, surface topography, thickness and type of overburden, thickness, continuity and number of seams, and the condition of the surrounding rock. In addition to physical factors, the mineability of the coal may be greatly affected by the economic, political, legal and environmental constraints placed upon its extraction.

As of July 1974, there were no operating coal mines within the Kaiparowits coalfield. Previous production has been limited to very small mines supplying coal for local use only.[25] Total production from the entire coalfield has probably been less than 25,000 tons.[26]

Limited accessibility and lack of an economic market have been the primary obstacles to the previous exploitation of the extensive coal deposits of the Kaiparowits

Plateau. The Plateau is far removed from any major coal-use center, and it completely lacks any major transportation system that would be necessary to export large quantities of coal (see Chapter G, Land Base for Access and Development). Unless access to water from Lake Powell is considered, the Plateau also has insufficient surface water to develop and sustain a large coal-mining industry and very little is known about the possibilities of large groundwater deposits in the region (see Chapter E, Water Resources). Also, the extreme ruggedness of the Plateau, and its high mesas and deeply incised narrow canyons, pose obstacles to location of convenient access to mines. The very narrow canyons also rule out the possibility of economical surface mining in some areas where the coal is shallow enough to suggest surface extraction, for modern efficient strip-mining equipment cannot operate in such narrow canyons.

Additional factors imply that it will be impractical to use surface-mining techniques in any but a few very minor areas of Kaiparowits. Almost all of the coal on the Plateau lies well below the maximum acceptable stripping depth of approximately 200 feet of overburden. Future improvements in mining machinery may make strip-mining at greater depths economically feasible, but such developments remain speculative. Also, the uppermost member of the Straight Cliffs Formation, the Drip Tank, and many beds within the John Henry Member, which contain the best coal

Figure 13B. Areas of possible strippable coal in Kaiparowits coalfield.

Reproduced from map provided by Morgan S. Jensen, District Manager, Bureau of Land Management, Kanab, Utah, to Orson L. Anderson, 26 November 1974.

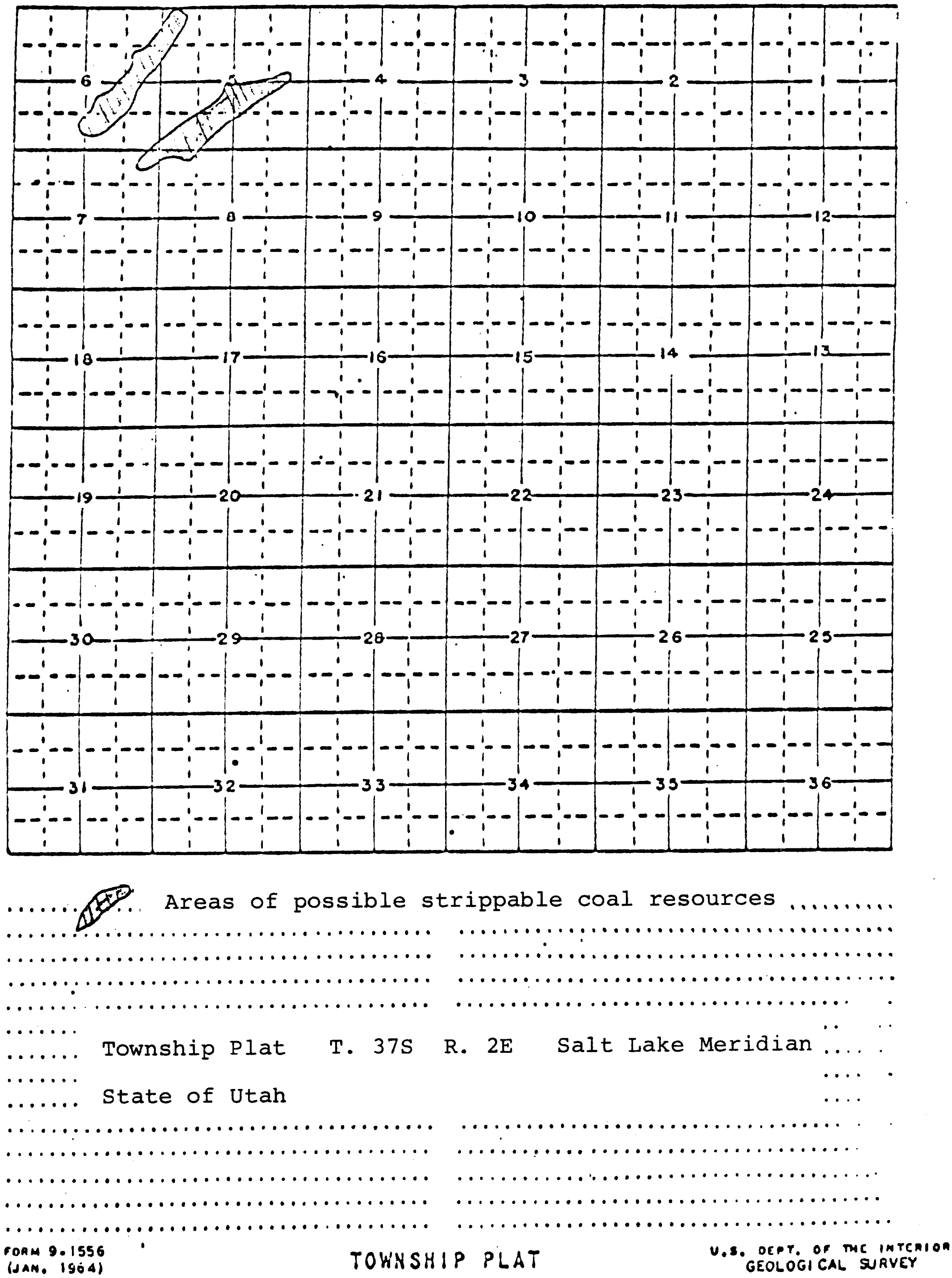


Figure 13B. Areas of possible strippable coal in Kaiparowits coalfield.

Figure 13C. Sketch map of strippable coal reserves west of the 100th meridian.

Reproduced from map supplied by Morgan S. Jensen, District Manager, Bureau of Land Management, Kanab, Utah, to Orson L. Anderson 26 November 1974.

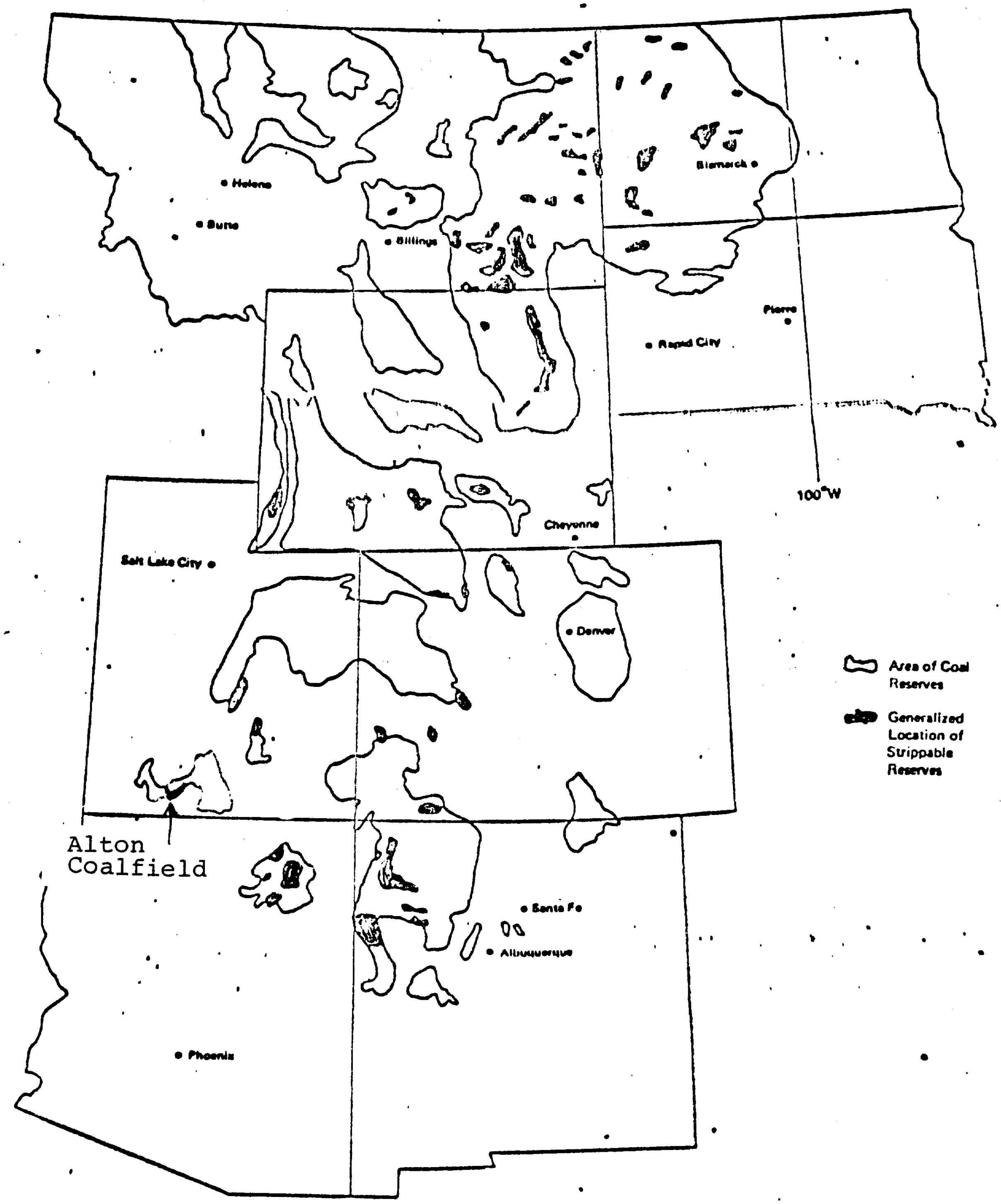


Figure 13C. Sketch map of strippable coal reserves west of the 100th meridian.

zones, are massive sandstone units forming resistant caprocks over the coal seams. They would require extensive blasting prior to removal of the coal below them. The Drip Tank Member also forms a very good local aquifer which would be very adversely affected by large-scale surface mining.

Stripmining is not being considered on the Kaiparowits Plateau.[27A] Previously published maps[27B] of the area showing supposedly strippable areas on the Kaiparowits Plateau are erroneous and appear to have been "based on 500 feet of overburden to the uppermost coal seam which in this region would be either impossible or impractical to surface-mine. All published geological data to date make it quite clear that Kaiparowits coal can only be extracted by underground mining."

Stripmining would be technically feasible in only one small area (Figure 13B); however, that area is too small to make stripmining economically feasible.[27A]

Known strippable coal does exist at the Alton coalfield, west of Kaiparowits. However, this area of strippable coal was omitted from published maps.[27B] Figure 13C is a revised copy of the National Academy of Sciences map showing deletion of the strippable areas in Kaiparowits and addition of the strippable portion of the Alton coalfield.

The coal seams in the Kaiparowits region present many obstacles to underground development as well. One such problem is the extremely lenticular and discontinuous nature of the individual coal seams. The total thickness of coal in any one zone increases and decreases rapidly within a short distance, and individual seams similarly thin and

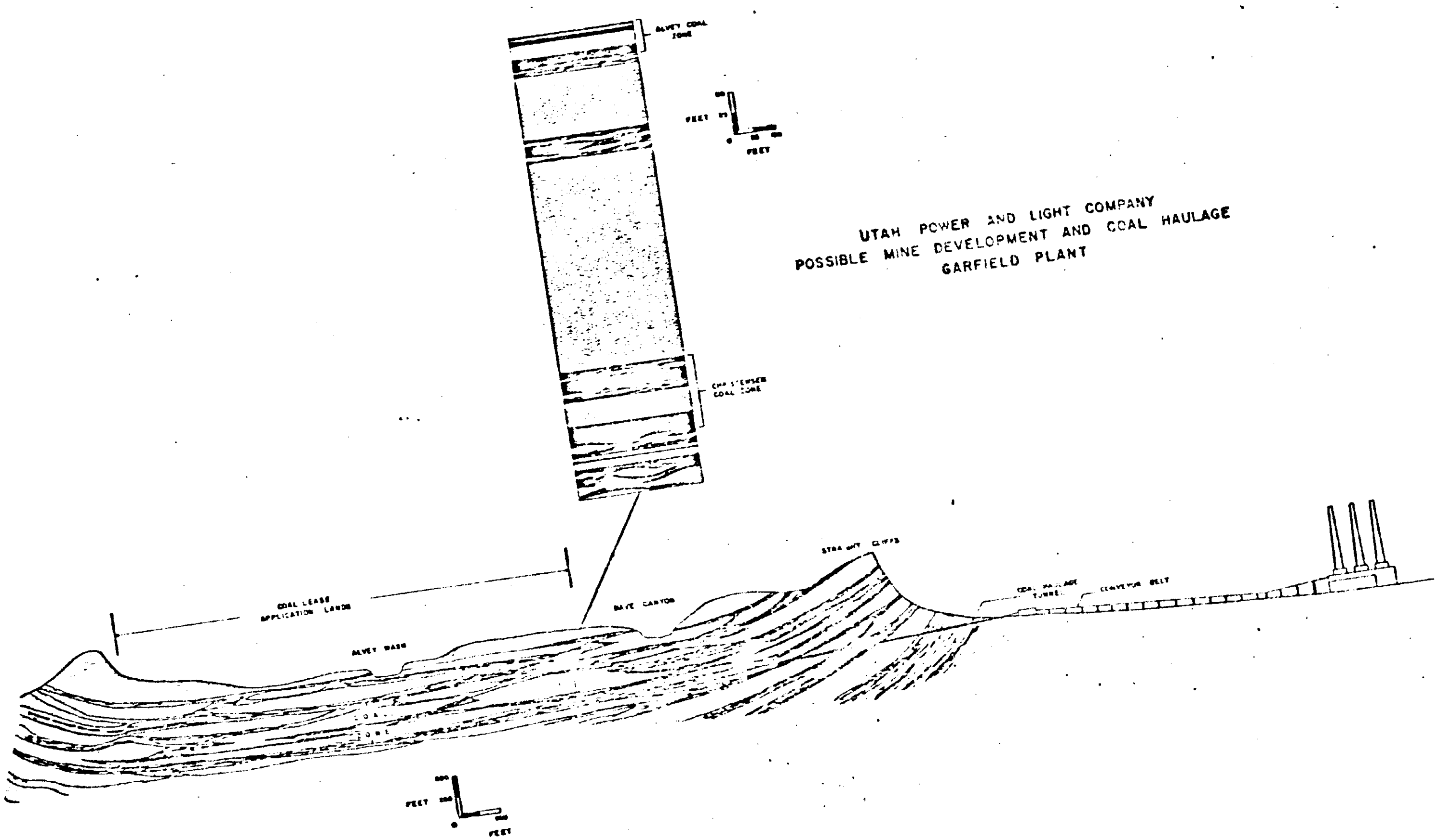


Figure 14. Diagrammatic representation of coal seams and zones within the Straight Cliffs Formation, Kaiparowits Plateau. Note the extreme irregularities in thickness and continuity for any one seam which are typical for Kaiparowits coal. Also note the generalized basin-like structure of the gently folded rock ... blished figure which appeared in a ... resentative of Utah ... urce Plan-

thicken, disappear, or are replaced by others.[28] Figure 14 diagrammatically illustrates the lenticular character of the seams. Such seam irregularities are not unique to the Kaiparowits field, but the pervasive discontinuities will pose great problems for design and engineering of large-scale underground coal-mining ventures within the Plateau.

Another problem in deep-mining much of the coal in the Kaiparowits will be the occurrence of thick and multiple seams (Figure 15). Either thick or multiple seams alone can both present severe problems for underground mines, and their extensive simultaneous occurrence in the Kaiparowits coalfield essentially prohibits efficient coal recovery from underground mines in these areas under present technology. Some of the best and thickest coal seams in the Plateau may at present be unworkable because only very thin weak rock layers separate them from other thick overlying seams. Multiple seams must usually be mined one at a time, and removal of any one seam will adversely affect the later removal of any seams lying directly above or below.[29]

The roof rock of any future large mine in the Kaiparowits Plateau will most likely be very non-uniform, varying from soft shale to massive sandstone. As an example, the Shurtz Mine has a shale roof, whereas the Schow Mine, 1000 feet away, in the same coal seam, has a sandstone roof. Thick, massive sandstones, such as the Drip Tank Member of the Straight Cliffs Formation, are groundwater aquifers at Kaiparowits. Mining of coal seams which lie immediately below these sandstones will be likely to harm the aquifers and also may cause uneven settling and subsidence of the ground surface, a common aftermath of extensive underground mining.

There are few geologic faults cutting the rocks of the Kaiparowits Plateau. The lack of faults, and the relatively mild folds in the rocks indicate that there are not likely to be problems arising from geologic structures which might limit mining activities.

All of the above factors will affect the ultimate recoverability, which is the fraction of the total amount of coal in the ground that can be actually removed by mining. The Utah Geological and Mineralogical Survey (Doelling and Graham) estimates that between 33% and 50% of the total coal resources of the Kaiparowits Plateau would be mineable.[30] It should be noted that the recovery from any one underground mine may vary greatly (from 30% to 90%), with the average value in the United States being about 50%.[31] Often, however, the actual amount of useable coal produced is a smaller percentage. Because newer, more efficient mining machines are also less discriminatory much of the coal must be cleaned before use, and an average of 20% of the mine output in such cases is discarded as refuse.[32] Thus only about 20% of the Kaiparowits Plateau total coal resources, or about 8 billion tons, can be considered now as fully recoverable, although it is quite possible that this figure could be increased by improvements in present mining practices or through the development of new, more efficient techniques.

Figure 15. Examples of coal sections showing thick and multiple seams in the Kaiparowits coalfield.

Reproduced from: Zeller, Howard D., 1973, "Geologic Map and Coal Resources of the Carcass Canyon Quadrangle, Garfield and Kane Counties, Utah," U. S. Geological Survey Coal Investigations Map C-56; Zeller, Howard D., 1973, "Geologic Map and Coal Resources of the Death Ridge Quadrangle, Garfield and Kane Counties, Utah," U. S. Geological Survey Coal Investigations Map C-58; and Bowers, William E., 1973, "Geologic Map and Coal Resources of the Pine Lake Quadrangle, Garfield County, Utah, U. S. Geological Survey Coal Investigations Map C-66.

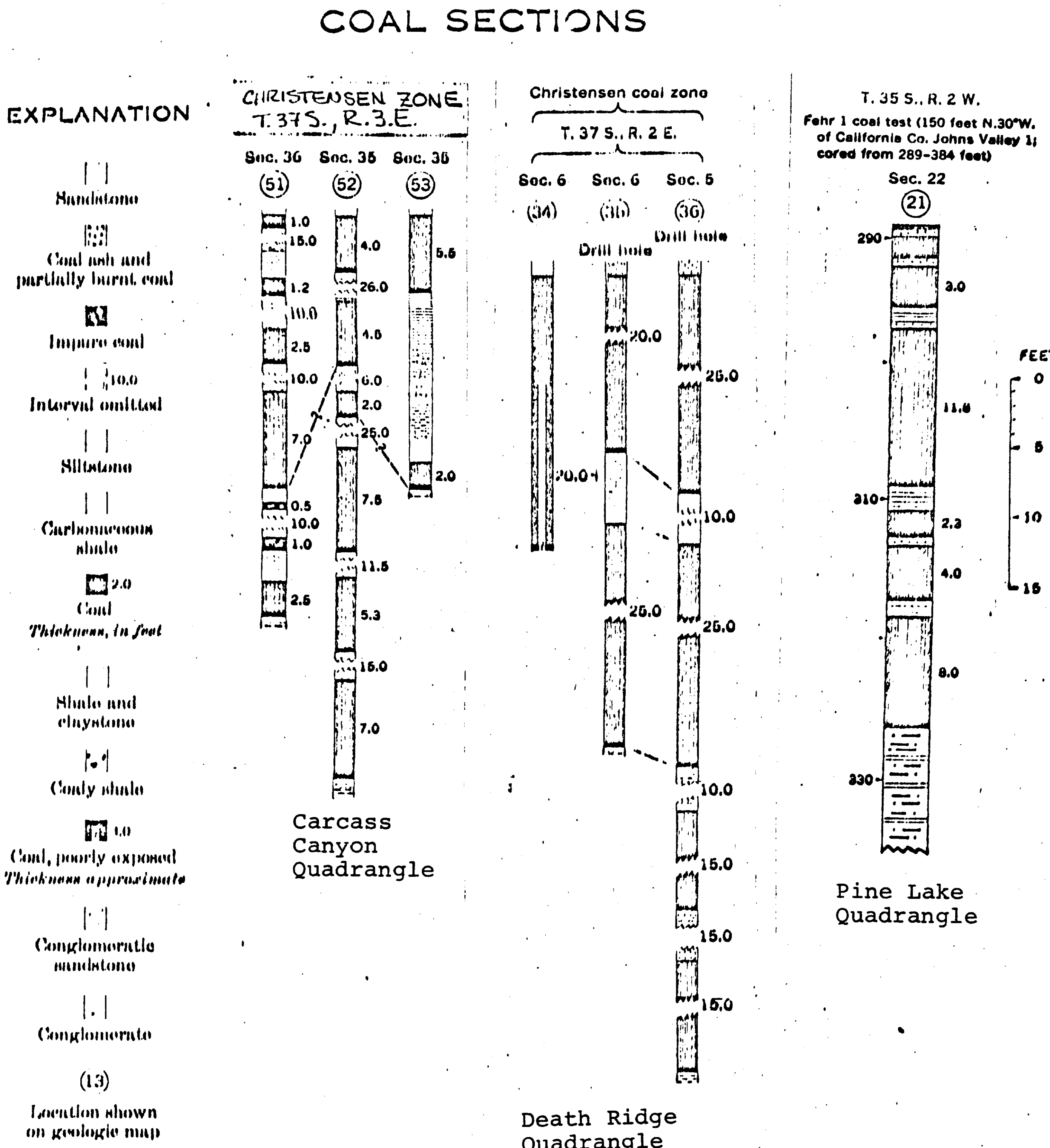

COAL SECTIONS
EXPLANATION
Sandstone
Coal ash and partially burnt coal
Impure coal
Interval omitted
Siltstone
Carbonaceous shale
Coal
Thickness, in feet
Shale and claystone
Coaly shale
Coal, poorly exposed
Thickness approximate
Conglomeratic sandstone
Conglomerate
(13)
Location shown on geologic map
CHRISTENSEN ZONE
T. 37 S., R. 3 E.
Sec. 36
Sec. 35
Sec. 35
Carcass Canyon Quadrangle
Christensen coal zone
T. 37 S., R. 2 E.
Sec. 6
Sec. 6
Sec. 5
Drill hole
Drill hole
Death Ridge Quadrangle
T. 35 S., R. 2 W.
Fehr 1 coal test (150 feet N.30°W. of California Co. Johns Valley 1; cored from 289-384 feet)
Sec. 22
FEET
Pine Lake Quadrangle

Figure 15.

B. LEGAL OWNERSHIP AND CONTROLS OF KAIPAROWITS C(

1. Introduction

a. Public Landlords and Private Tenants

The federal government administers approximat 91% of the coal lands on the Kaiparowits Plateau.[33] State of Utah controls all of the remainder except fo very small percentage under private control. In orde facilitate exploration and development of this public resource, federal and state law has opened most of th Plateau's coal lands to lease by private individuals and entities.

Some 187,610 acres of federally owned land on the teau are covered by private coal prospecting permits (64,178 acres) and coal leases (122,792 acres). Tab 4, and 5 and Figure 16 give details on ownership of interests. Approximately 28,000 acres of state-owne overlying the coal-bearing portions of the Plateau a rently being leased. Since there is considerably mo eral than state acreage involved, the following disc will concentrate on federal permits and leases.

b. Federal and State Policies

Historically, there have been several signif changes in federal policy as to coal lands. From 18 1920, coal on public lands could be purchased in lin amounts at set rates. Coal could also be obtained b steading from 1862 until 1906, when all coal lands w cluded from settlement under the public land laws.[3 gress made coal lands subject to leasing, rather tha sales, by passing the Mineral Lands Leasing Act.[35]

NOTE

Tables 3, 4, and 5, and Figure 16 were compiled by Judith Wegner from records in offices of the U. S. Geological Survey, the Bureau of Land Management, and the State Land Board in Salt Lake City, Utah. The records were examined in August 1974, and the information in these tables represents the lease and permit status as of July 1, 1974.

Numerous individual leases on state lands are located within the undesignated spaces on Figure 16; these holdings are not individually described here in order to maintain the figure's clarity.

Table 3: Federal Coal Leases in the Kaiparowits Region, Utah

Map Number	Lessee	Lease Number	Date	Terms of Lease[a]	Acreage
1	El Paso Natural Gas	U-0130985	11-1-68	SPR	2560.00
2	El Paso Natural Gas	U-0130986	10-1-67	SPR	2561.52
3	El Paso Natural Gas	U-0148535	10-1-67	SPR	1920.00
4	El Paso Natural Gas	U-0115791	7-1-67	SPR	2560.00
5	El Paso Natural Gas	U-0115793	7-1-67	SPR	1280.00
6	El Paso Natural Gas	U-0130988	7-1-67	SPR	1907.24
7[b]	El Paso Natural Gas	U-24427	3-1-67	SPR	1280.00
8[b]	El Paso Natural Gas	U-27835	11-1-65	SPR	640.00
9	El Paso Natural Gas	U-0130989	10-1-67	SPR	2560.00
10	El Paso Natural Gas	U-0115792	10-1-67	SPR	1280.00
11	El Paso Natural Gas	U-0115833	10-1-67	SPR	640.00
12	El Paso Natural Gas	U-0140837	10-1-67	SPR	2553.40
13	El Paso Natural Gas	U-0136512	10-1-67	SPR	1279.28
14	El Paso Natural Gas	U-0140826	10-1-67	SPR	2557.28
15	El Paso Natural Gas	U-083005	12-1-64	CB[c]	640.00
16	El Paso Natural Gas	U-083000	12-1-64	CB[d]	1440.00
17	Consolidation	U-0105418	9-1-67	SPR	2560.00
18	Consolidation	U-0149373	11-1-69	SPR	2560.00
19	Consolidation	U-0103107	9-1-67	SPR	2560.00
20	Consolidation	U-098783	5-1-67	SPR	2540.64
21	Consolidation	U-098785	5-1-67	SPR	2542.84
22	Consolidation	U-098787	5-1-67	SPR	2560.00
23	Consolidation	U-0103129	9-1-67	SPR	2560.00
24	Consolidation	U-098784	5-1-67	SPR	2537.69
25	Consolidation	U-0103109	9-1-67	SPR	2557.36
26	Consolidation	U-0103130	9-1-67	SPR	2554.88

Table 3 (continued)

Map Number	Lessee	Lease Number	Date	Terms of Lease[a]	Acreage
27	Hiko Bell	U-0118366	11-1-65	SPR	1920.00
28	Hiko Bell	U-0120794	3-1-66	SPR	1920.00
29	Hiko Bell	U-0146654	12-1-65	SPR	2560.00
30	G.H. Frandson	SL-050638	5-10-41	MP[e]	40.00
31	G.H. Frandson	SL-048223	4-5-30	MP[e]	120.00
32	Peabody	U-098786	3-1-67	SPR	2549.60
33	Peabody	U-0103108	3-1-67	SPR	2560.00
34	Peabody	U-096476	3-1-67	SPR	2551.52
35	Peabody	U-0115657	11-1-67	SPR	2560.00
36	Peabody	U-0103131	4-1-67	SPR	2560.00
37	Peabody	U-0103132	4-1-67	SPR	2171.68
38	Peabody	U-0103133	4-1-67	SPR	1273.16
39	Peabody	U-0115656	11-1-67	SPR	2560.00
40	Peabody	U-096477	3-1-67	SPR	1276.68
41	Peabody	U-0101140	4-1-67	SPR	1600.00
42	Peabody	U-0101141	4-1-67	SPR	1760.00
43	Peabody	U-0113254	8-1-67	SPR	160.00
44	Resources	U-0101142	4-1-67	SPR	1562.08
45	Resources	U-096496	11-1-65	SPR	2560.00
46	Resources	U-087836	11-1-65	SPR	1279.92
47	Resources	U-087835	11-1-65	SPR	639.92
48	Resources	U-096497	11-1-65	SPR	2560.00
49	Resources	U-096495	11-1-65	SPR	2559.84
50	Resources	U-096494	11-1-65	SPR	2560.00

Table 3 (continued)

Map Number	Lessee	Lease Number	Date	Terms of Lease[a]	Acreage
51	Resources	U-092139	11-1-65	SPR	1934.73
52	Resources	U-092140	11-1-65	SPR	2022.48
53	Resources	U-092141	11-1-65	SPR	1972.16
54	Resources	U-087834	11-1-65	SPR	2560.00
55	Resources	U-087806	11-1-65	SPR	1945.32
56	Resources	U-087805	11-1-65	SPR	2064.44
57	Resources	U-087807	11-1-65	SPR	1920.00
58	Resources	U-096486	11-1-65	SPR	640.00
59	Resources	U-087833	11-1-65	SPR	2517.68
60	Resources	U-087828	11-1-65	SPR	2560.00
61	Resources	U-092138	11-1-65	SPR	1891.44
62	Resources	U-096509	11-1-65	SPR	1478.70
63	Resources	U-096508	4-1-66	SPR	658.28
64	Resources	U-092142	11-1-65	SPR	1750.20
65	A. Shakespear	SL-071561	3-1-51	MP[f]	80.00

[a]SPR = Standard preference right. Standard lease terms are 15¢/ton for underground coal and 17.5¢/ton for strip mined coal for the first 10 years, increasing to 17.5¢/ton underground and 20¢/ton strip mined coal thereafter. The required rental to be paid in advance if no coal is being produced is $1 per acre per year.

[b]Effective November 1974.

[c]Competitive Bid bonus $8.75/acre.

[d]Competitive Bid bonus $9.25/acre.

[e]15¢/ton maximum production 275 tons.

[f]15¢/ton maximum production 550 tons.

Table 4: Federal Coal Permits in the Kaiparowits Region, Utah (Circled Numbers on Lease Map, Figure 16)

Map Number	Permitee	Permit Number	Date	Rental	Acreage
1	Woods Petroleum	U-6652	10-1-69	25¢/acre	4203.05
2	Woods Petroleum	U-6653	10-1-69	25¢/acre	4926.00
3	Woods Petroleum	U-6654	10-1-69	25¢/acre	4480.00
4	Jesse Knight	U-0149368	5-1-67	25¢/acre	4453.35
5	Jesse Knight	U-0149348	5-1-67	25¢/acre	2304.00
6	Jesse Knight	U-149349	5-1-67	25¢/acre	4726.84
7	Sun Oil	U-5666	7-1-69	25¢/acre	3680.00
8	Sun Oil	U-5667	7-1-69	25¢/acre	5120.00
9	Sun Oil	U-5668	7-1-69	25¢/acre	4454.00
10	Sun Oil	U-5669	7-1-69	25¢/acre	5120.00
11	(Delcoal)[a]	U-5233	10-1-68	25¢/acre	2500.32
12	(Delcoal)[a]	U-5234	10-1-68	25¢/acre	1440.00
13	(Delcoal)[a]	U-5235	10-1-68	25¢/acre	2560.00
14	(Delcoal)[a]	U-5236	10-1-68	25¢/acre	2560.00
15	(Delcoal)[a]	U-5237	10-1-68	25¢/acre	2522.68
16	(Delcoal)[a]	U-1375	10-1-68	25¢/acre	2306.45
17	(Rasmussen)[a]	U-1362	2-1-69	25¢/acre	2552.76
18	(Rasmussen)[a]	U-1363	2-1-69	25¢/acre	1882.87
19	Hiko Bell	U-9901	7-1-70	25¢/acre	968.72
20	Hiko Bell	U-11898	7-1-70	25¢/acre	776.95
21	Hiko Bell	U-0145657	10-1-65	25¢/acre	640.00

[a] Map numbers 11 through 18: Utah Power and Light bought option in 1971, was assigned right in 1973 with amendment in 1974. No effective federal right until after moratorium.

Table 5: State Coal Leases in the Kaiparowits Region, Utah

Map Number	Lessee	Lease Number	Date	Acreage[a]
S-1	El Paso Natural Gas	20545	1-1-64	640.00
S-2	El Paso Natural Gas	19785	1-1-63	640.00
S-3	El Paso Natural Gas	19916	1-1-64	640.00
S-4	El Paso Natural Gas	24154	3-27-67	640.00
S-5	El Paso Natural Gas	21357	1-1-65	640.16
S-6	El Paso Natural Gas	21356	1-1-65	640.00
S-7	El Paso Natural Gas	21355	1-1-65	640.00
S-8	El Paso Natural Gas	19661	1-1-63	640.00
S-9	El Paso Natural Gas	19784	1-1-63	640.00
S-10	El Paso Natural Gas	19357	5-11-62	640.00
S-11	El Paso Natural Gas	20440	1-1-64	725.84
S-12	Hiko-Bell	26719	12-15-69	1280.00
S-13	Hiko-Bell	26600	10-10-69	480.00
S-14	Hiko-Bell	26601	10-10-69	323.95
S-15	Peabody	23904	11-18-66	640.00
S-16	Peabody	19914	1-1-64	638.48
S-17	Peabody	20556	1-1-64	640.00
S-18	Peabody	19660	1-1-63	640.00
S-19	Peabody	20547	1-1-64	640.00
S-20	Resources	19652	1-1-63	640.00
S-21	Resources	19651	1-1-63	640.00
S-22	Resources	19650	1-1-63	640.00
S-23	Resources	19432	6-11-62	640.00
S-24	Resources	19427	6-11-62	640.00
S-25	Resources	19653	1-1-63	690.44
S-26	Resources	19654	1-1-63	640.00

Table 5 (continued)

Map Number	Lessee	Lease Number	Date	Acreage[a]
S-27	Resources	19656	1-1-63	640.00
S-28	Resources	19655	1-1-63	400.00
S-29	Resources	19678	1-1-63	640.00
S-30	Resources	19786	1-1-63	640.00
S-31	Sun Oil	25367	5-6-68	1280.00
S-32	Utah Power & Light	25368	5-6-68	2391.60
S-33	Utah Power & Light	25189	3-7-68	639.96
S-34	Utah Power & Light	25188	3-7-68	640.00
S-35	Utah Power & Light	23906	11-18-66	640.00
S-36	Utah Power & Light	23905	11-18-66	640.00
S-37	Utah Power & Light	25105	2-13-68	1280.00
S-38	Rasmussen	19359	5-11-62	640.00
S-39	Fallick	26842	3-2-70	640.00

[a]For lands under state lease, rental is 50¢/acre/year for the first two years, and at least $1/acre/year for nonproducing land thereafter, while royalty on producing land is paid at a rate of 4% of the gross coal produced from underground mines and 6% from strip mines, or at the rate prevailing at the time of payment for federal leases on land of similar character under coal lease, whichever is greater.

1920 Act, among other things, authorized the Secretary of the Interior to grant to private parties two types of rights in coal lands: prospecting permits and leases of indefinite duration (competitive bid leases, or preference right leases arising when commercial coal is discovered under a prospecting permit).

Coal on state lands is also subject to being leased, but not sold, by the Utah State Land Board.[36] As in the case of federal coal leases, state leases contain specific rental and royalty provisions. State leases differ in that they are for a set term of ten years, and will expire at that time unless coal is being produced. It is also noteworthy that state lands are isolated, covering only specific noncontiguous tracts in each section.[36A] Consequently, a given lessee may hold leases on a fairly large tract of land, part of it state and part federal.

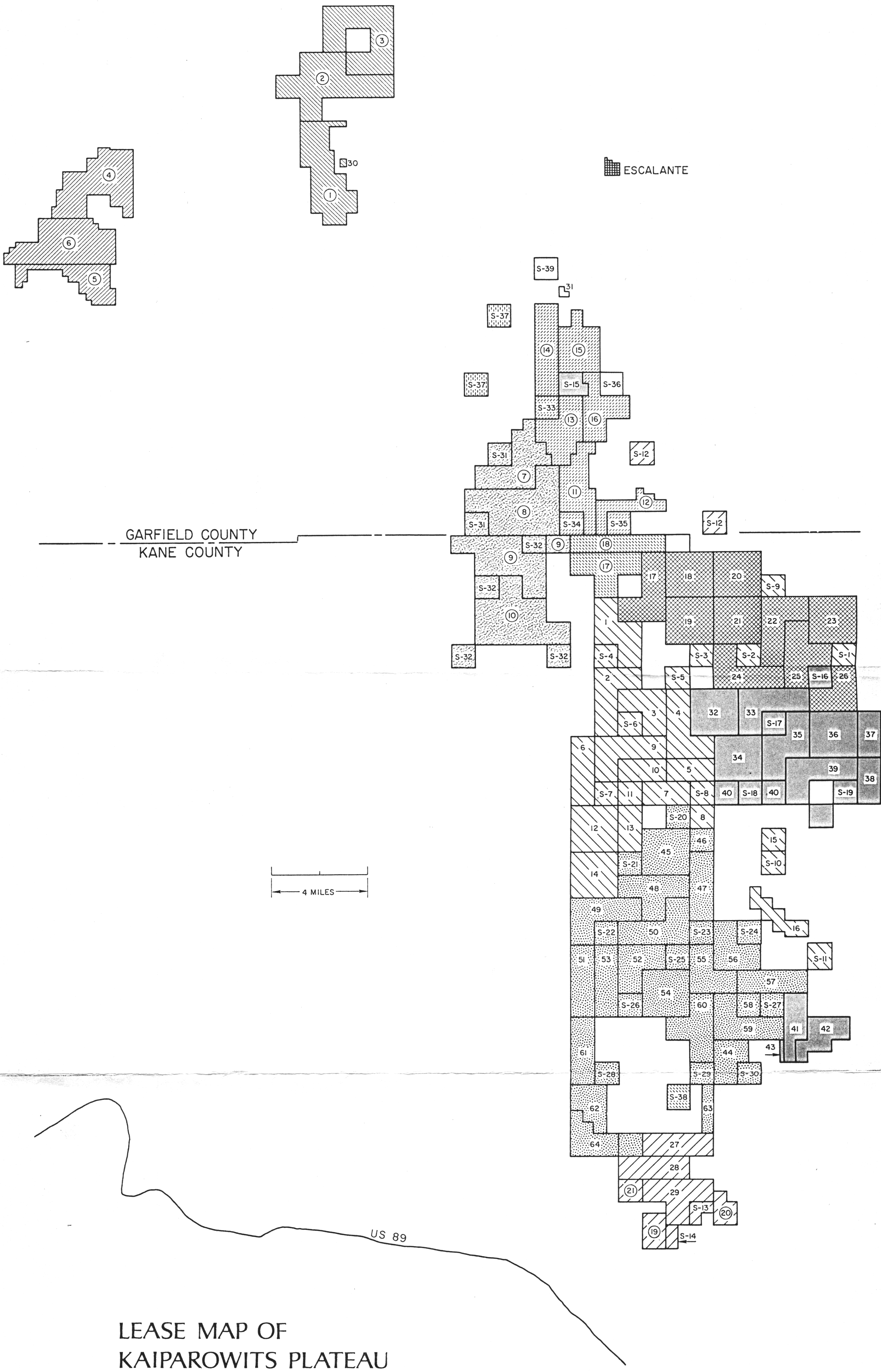
c. History of Coal Development on the Plateau

Coal production on the Plateau historically has been limited to a few small mines near Escalante, serving local domestic needs. The first such mine began production in 1893. (A list of early mines may be found in Table C at footnote 25.) The large-scale leasing of the federal coal lands on the Plateau occurred during the 1964-1970 period, as shown in Table 3. Production at many of these lease sites is expected shortly, as discussed below under "Future Outlook."

d. Prospecting Permits

Although no new prospecting permits are presently being granted (see "Moratorium on Coal Leasing," below), this type of interest in coal has been an important factor

Figure 16. Lease Map of the Kaiparowits Plateau. Uncircled numbers refer to federal coal leases listed in Table 3; circled numbers refer to federal coal permits in Table 4; and S-numbers refer to state coal leases in Table 5.



LEASE MAP OF KAIPAROWITS PLATEAU

in the development of this resource on the Plateau. Under the 1920 Mineral Lands Leasing Act, prospecting permits may be issued to the first qualified applicant[36B] in cases where "prospecting or exploratory work is necessary to determine the existence or workability of coal deposits in any unclaimed, undeveloped area."[37] The duration of the permit is two years, but it may be extended for two more years when additional time is considered necessary to complete prospecting work. To receive an extension, the permittee must be able to show that his failure to perform diligent prospecting activities was due to conditions beyond his control, that he has drilled at least one adequate test hole on the permit area or has performed other comparable prospecting prescribed in the permit, and that he has been unable to determine the existence or workability of the deposits on the permit.[38]

A single permit may not exceed 5,120 acres.[39] Permit and lease holdings by one person, association, or corporation cannot exceed 46,080 acres in any one state.[40] Lands covered by a permit or lease must be reasonably compact in form and must lie within an area of six square miles or six surveyed or protracted sections, except in cases where noncontiguous tracts can be efficiently worked in a single mine or unit.[41]

The major function of the prospecting permit system is to encourage the discovery and development of coal. As a sort of reward, a permittee who discovers valuable mineral deposits in the land before his permit expires is entitled to a "preference right lease" of all or part of the reasonably compact lands in the permit. With a preference right lease, he does not have to face the chance of losing out to someone else in a competitive bid situation. And he does not have to pay a bonus bid in addition to the lease rental and royalty required. The decision whether to grant a prospecting permit is therefore very important.[42]

e. Leases

If the existence and workability of coal is known, the Secretary of the Interior cannot issue a permit, but may offer land for lease based on competitive bidding.[43] Notice of the offering for lease must be published in advance in the Federal Register. The U.S. Geological Survey (USGS) sets rates for royalty payment in advance, without competitive bidding. The royalty rate depends on the character of the coal.[44] After the royalty rate is fixed there is a bid upon the bonus to be paid per acre for the right to lease the land. Minimum bid is usually $1.00 per acre. Sealed bids are submitted, but oral bidding follows, if desired, among those who submitted sealed bids, once they are opened.

Apart from this bonus, competitive and preference right leases have the same terms. They are issued for an indefinite time period, but their terms are subject to review and revision at 20-year intervals.[45] Rental for the lease is set by statute to be at least $0.25 per acre for the first year, $0.50 per acre for the second through fifth years, and $1.00 per acre for following years.[46]

Rental payments may be credited against the royalty payments paid on coal actually produced. The standard royalty on Kaiparowits Plateau leases is $0.15 per ton "underground," and $0.175 per ton "strip" for the first ten years, increasing afterwards to $0.175 per ton underground and $0.20 per ton strip. The amount of the required bond is recommended by the USGS. The maximum acreage for each lease is a matter of agency discretion.

Leases also include a requirement that there must be diligent development of coal on leased lands and therefore at least minimal production.[47] Under leases on the Kaiparowits Plateau, this requirement can be satisfied without production by merely paying the required rental ($1.00 per acre) a year in advance.[48] Although there was once a policy requiring a showing that more coal was needed nationally before more coal could be leased, this is not currently the case.[49] Coal leases may be granted and will continue to run even if no immediate production is planned.[49A] A coal lease cannot be cancelled. The only way the government can end it is by taking court action.[50]

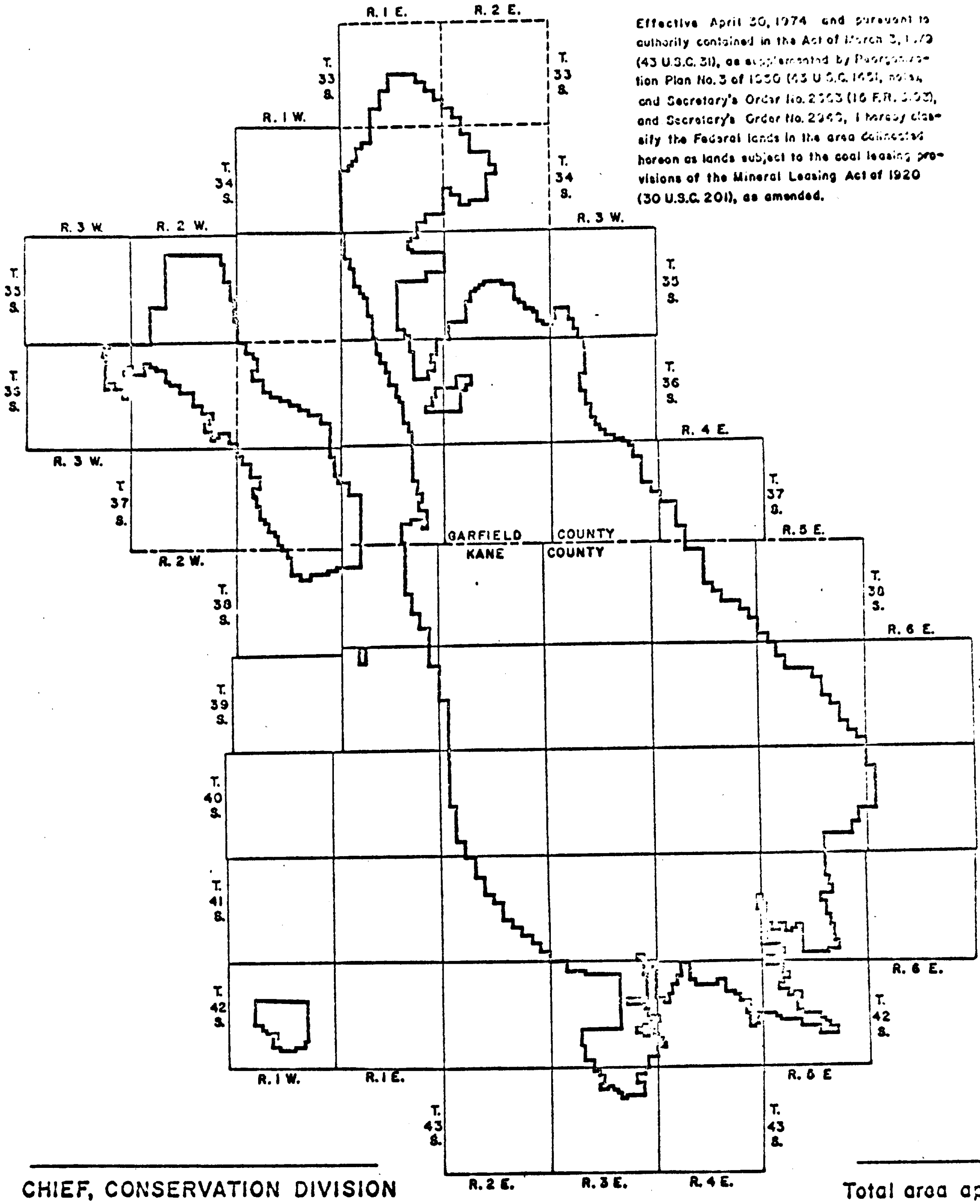
2. Controls

a. Federal Agencies

The Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS) jointly administer most federal coal leasing.[50A] The BLM is the principal leasing agency, exercising the Secretary of the Interior's discretion to lease or not to lease, but it depends quite heavily on the USGS to supply necessary information about the land. After a request for a lease or prospecting permit is received by the BLM, copies are sent to the USGS with a request to answer two questions: (1) whether a prospecting permit is appropriate, if requested, or whether competitive bid leasing is required; and (2) the contract terms to be required by the government (including such items as royalty

Figure 17. Kaiparowits Known Coal Leasing Area.

Reproduced from Utah Coal Land Leasing Minutes No. 2, Minutes of the Mineral Land Evaluation Committee, April 30, 1974; Subject: Kaiparowits Known Coal Leasing Area. (unpublished)



Effective April 30, 1974 and pursuant to authority contained in the Act of [illegible] (43 U.S.C. 31), as supplemented by [illegible] tion Plan No. 3 of [illegible] (43 U.S.C. [illegible], note), and Secretary's Order No. [illegible] (16 F.R. [illegible]), and Secretary's Order No. [illegible], I hereby classify the Federal lands in the area delineated hereon as lands subject to the coal leasing provisions of the Mineral Leasing Act of 1920 (30 U.S.C. 201), as amended.

CHIEF, CONSERVATION DIVISION
U.S. Geological Survey

Total area approximately
530,805 acres

KAIPAROWITS PLATEAU KNOWN COAL LEASING AREA

Tps. 33–43 S., Rs. 6E–3W., Salt Lake M., Utah rate, rental and size of bond). In answering the first question, the USGS Area Mining Supervisor requests a geological report from the USGS Mineral Evaluation Division regarding the existence and characteristics (such as depth, thickness, and quantity) of coal to be found on the land. From this information, the Mining Supervisor must determine not only whether the coal exists, but whether it is "workable"--economical to excavate. If it is unclear whether coal exists or whether it is workable, a prospecting permit may be granted. There appears to be broad discretion exercised in making such determinations, although recently the USGS has begun to formalize their criteria for determining existence and workability. Figure 17 is a map outlining the Known Coal Lease Area on the Plateau. Lands within this area must be leased by competitive bid, and no prospecting permits can be issued here.[51]

Since 1973, the BLM and USGS have also required an environmental analysis and technical examination before issuance or modification of a coal prospecting permit or coal lease.[52]

Once the USGS Mining Supervisor determines what recommendations are to be made, he forwards them first to Denver and then to Washington, D.C., where they are reviewed and signed by the Director of the Conservation Division.

The BLM makes the ultimate decision on whether or not to grant a prospecting permit or lease. Once a prospecting permit is issued, the lessee pays rental to BLM. Similarly, rental accruing under a coal lease is paid to BLM for the first five years or until production of coal begins, at which time royalties are paid to the USGS. In both situations, the USGS is the agency directly involved with the lessee in approving plans for operational activities, making compliance inspections, and maintaining records of production.

In order to mine coal on National Forest land, consent must be obtained from the U.S. Forest Service in the Department of Agriculture. Department of Agriculture policy is generally against such leasing, however, and special stipulations are usually added to the leases which are granted.

Coal lands located in National Parks and in National Monuments may not be leased.

b. Moratorium on Coal Leasing

Between 1971 and 1973, an informal moratorium on coal leasing existed within the Department of the Interior. In February 1973, Secretary of the Interior Rogers Morton issued two orders that resulted in an end to issuance of further prospecting permits until further notice (February 13, 1973) and allowed for the issuance of coal leases only when the applicant could demonstrate that specified "short-term criteria" applied (February 17, 1973).[52A] The short-term criteria are as follows: a lease may be issued, first, (a) when coal is needed now to maintain an existing mining operation, or (b) when coal is needed as a reserve for production in the near future; and second, (a) when the land to be mined will in all cases be reclaimed in accordance with lease stipulations that will provide for environmental protection and land reclamation, and (b) when an environmental impact statement covering the proposed lease has been prepared when required under the National Environmental Policy Act.

The BLM has construed Secretary Morton's order to limit the granting of such preference right leases unless the short-term criteria can be met. No preference right leases will be issued until the applicant can indicate that the area is ready to develop and produce within three years.[53] Those permittees who apply for a preference right lease under the new criteria need pay no rental while their applications are pending. However, the issue is posed whether permittees who cannot meet the short-term criteria within the stated permit term are given any grace period by administrative ruling or otherwise for perfecting their permits into preference right leases. No decision on this question has yet been reached, but a ruling is expected in the near future.[54]

When the moratorium, with its re-evaluation of federal leasing policy, was begun, the Department of the Interior had not considered its leasing of coal as a "major Federal action significantly affecting the quality of the human environment," and therefore requiring the preparation of an environmental impact study as required by the National Environmental Policy Act enacted in 1969. This re-evaluation has led to the preparation of EMARS (Energy Minerals Allocation Recommendation System), a new program for more systematic and effective development of the country's coal resources, which has not yet been fully explained to the public. The pre-EMARS period of evaluation was originally expected to continue until at least 1975, but it is unclear when leasing will again begin. The Department subsequently has prepared a draft program environmental impact statement explaining EMARS and covering all coal leasing on federal lands. Further delay may result from law suits challenging the sufficiency of this environmental analysis.[55]

c. Types of Environmental Controls

Federal coal leases contain a stipulation under which the holder of the lease agrees to refrain from causing unnecessary soil erosion or damaging forage or timber, from polluting air and water, from damaging crops or improvements on the land, and from destroying, damaging, or removing fossils, historic or prehistoric ruins, or artifacts. He must also agree to restore the land as much as possible to its former condition.

Other federal regulations require the submission to the USGS of detailed exploration and mining plans explaining likely environmental damage. The Survey must approve them before mining operations can begin.[56]

Although none of the coal on the Kaiparowits is economically strippable under present technology, new federal strip-mining regulations or possible future legislation could control such operations if they are ever undertaken.

The National Environmental Policy Act (NEPA)[58] is another important control on development. This law requires federal agencies to prepare a detailed "environmental impact statement" (EIS) for every "major federal action significantly affecting the quality of the human environment." Nearly all actions involved in large scale energy development come within these provisions. Therefore, an impact statement must be prepared by the agency,[58A] examining all the costs and benefits of the action to be taken[58B] (including its expected effect on the environment and on society), and analyzing possible alternative approaches, before a lease or permit for a right-of-way may be granted, or other federal action undertaken.

Such impact statements must be circulated in draft form to the public for comment, then are revised and reissued in final form in order to gather suggestions about the proposal and to provide interested persons with information. The EIS can act as an influential decision-making tool to the degree that it promotes careful and detailed planning by both the federal government and private developers before major action is taken.

C. FUTURE OUTLOOK FOR COAL DEVELOPMENT IN THE KAIPAROWITS REGION

1. Current Development Proposals

As of July 1974, at least five consortia had made serious proposals to develop portions of the coal of the Kaiparowits Plateau. However, only one of the consortia was at that time ready to commence development. Figure 18 shows approximately the distribution of proposed developments on the Plateau.

The Kane County Project (formerly known as the Kaiparowits Project), was nearest the construction stage as of July 1974. A consortium of Southern California Edison Company (through its wholly-owned subsidiary, Mono Power Company), Arizona Public Service Company (through its wholly-owned subsidiary , Resources Company), San Diego Gas and Electric Company (through its wholly-owned subsidiary, New Albion Resources Company) and the Salt River Project together wish to construct a 3000-megawatt (MW) coal-fired powerplant in the southern half of the Kaiparowits Plateau. Final decision as to the exact plant site for this proposed Kane County Project has not yet been made, but the two most likely sites are Four Mile Bench and Nipple Bench (Figure 7).[59] Resources Company has a total of nearly 48,000 acres of coal lands under lease in the southern part of the Plateau, and a two-shaft experimental mine was operated in 1971 on part of the lease to determine actual coal mineability. New Albion Resources Company has an approved application from the Utah State Engineer for 102,000 acre-feet (af) of water from Lake Powell. They are thus the only consortium proposing development of coal resources on the Plateau which has access to both coal and water resources.[60]

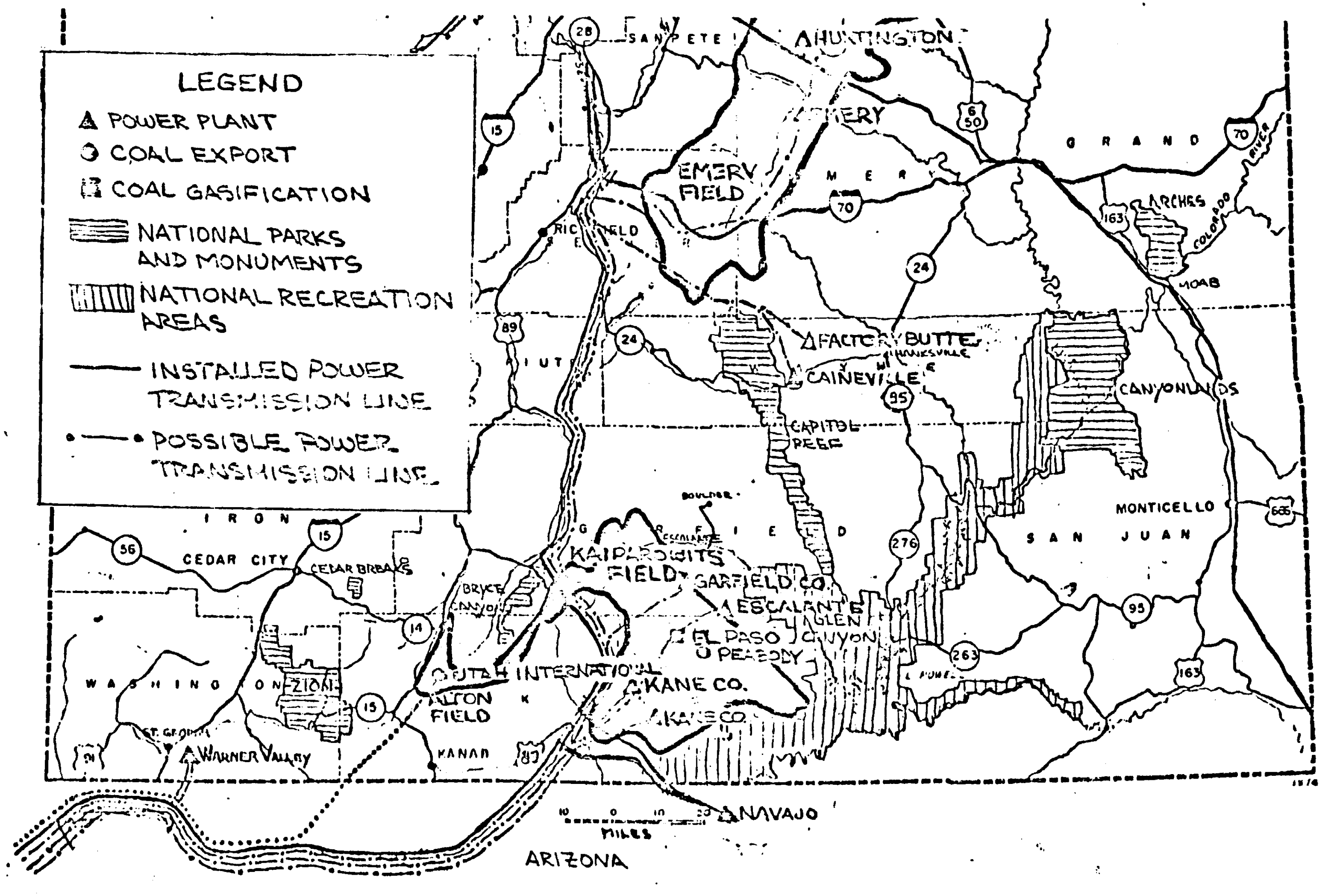


Figure 18. Proposed energy developments in the Kaiparowits region. (Base map: U.S. Bureau of Land Management, 1974)

The Bureau of Land Management (BLM) is currently (November 1974) drafting an Environmental Impact Statement (EIS) that is expected to be finished very early in 1975, with a final decision on whether or not to allow construction of the plant being expected from the Secretary of the Interior shortly thereafter. The consortium originally desired to have the initial unit of the powerplant operating by 1 June 1980, and the final unit on-line by 1 June 1982.[61] However, these dates have most likely been extended by the delays already experienced with the EIS, and additional delays are probable.

Peabody Coal Company has leased nearly 30,000 acres of federal and state coal lands near the center of the Kaiparowits coalfield, and has completed their initial phase of coal exploration. As of July 1974, they had not undertaken any further exploration work on their leases, and instead appear to be holding off development in expectation of increased future demand. The most probable use for the coal mined by Peabody will be for export out of the Kaiparowits region, although development to supply coal to one of the planned power projects near the Plateau is a possibility.

El Paso Natural Gas Company has purchased lease rights to about 35,000 acres of coal lands from Atlantic-Richfield Company. They are currently undertaking an intensive test drilling program to determine the quantity and mineability of their coal reserves. Although no definite plan or timetable has yet been announced, El Paso Natural Gas Company presumably has intentions of developing a coal-gasification plant complex on the Kaiparowits Plateau. They have not, as of July 1974, applied for water rights from the Utah State Engineer.

Utah Power and Light (UPL) has initiated plans to build a 2000 MW coal-fired powerplant about 7 miles south of the town of Escalante below the Escalante Rim of the Straight Cliffs.[62] The Garfield County Plant (formerly called the Escalante Plant) would consist of four 500-MW generators, two to be completed in the 1982-1985 period, and two more to be constructed at a later date. A storage reservoir would be built on one of the side canyons of the Escalante River, and the necessary water would be taken from either the Escalante River and/or underground water sources. Applications have been made to the Utah State Engineer for water from both sources, but all the applications are as yet unapproved.

Utah Power and Light, as of July 1974, had under lease over 6,000 acres of coal lands of the State of Utah, and committed assignments of over 18,000 acres of federal coal prospecting permits from W. L. Rasmussen and Delcoal, Inc. UPL has completed the first stage of their exploration program that is necessary to convert the prospecting permits into preference right leases, but the Secretary of the Interior has deferred conversion into leases until the applicant has met the short-term criteria (see above). Thus development plans have at present stagnated, but changes in the federal coal leasing policy may soon alter the situaton sufficiently to allow UPL to reactivate their proposal.

A consortium of California and Utah power concerns, under the title of Intermountain Power Project (IPP) has begun studies aimed at construction of a 3000-MW powerplant in south-central Utah.[63A] Initially, they considered three possible sites, two near Caineville, Utah, and one about 20 miles southeast of Escalante. In October 1974, the Salt Wash area of Wayne County (approximately 10 miles north of Caineville) was selected for primary study. IPP has announced that the proposed plant could begin generating power by 1981.[63B] Applications have been made to the Utah State Engineer for water from both the Escalante River and underground sources for the Escalante site. IPP holds no coal leases on the Kaiparowits Plateau, but expects to have no trouble obtaining coal from either the Kaiparowits coalfield or the Emery coalfield.

2. The National Demand

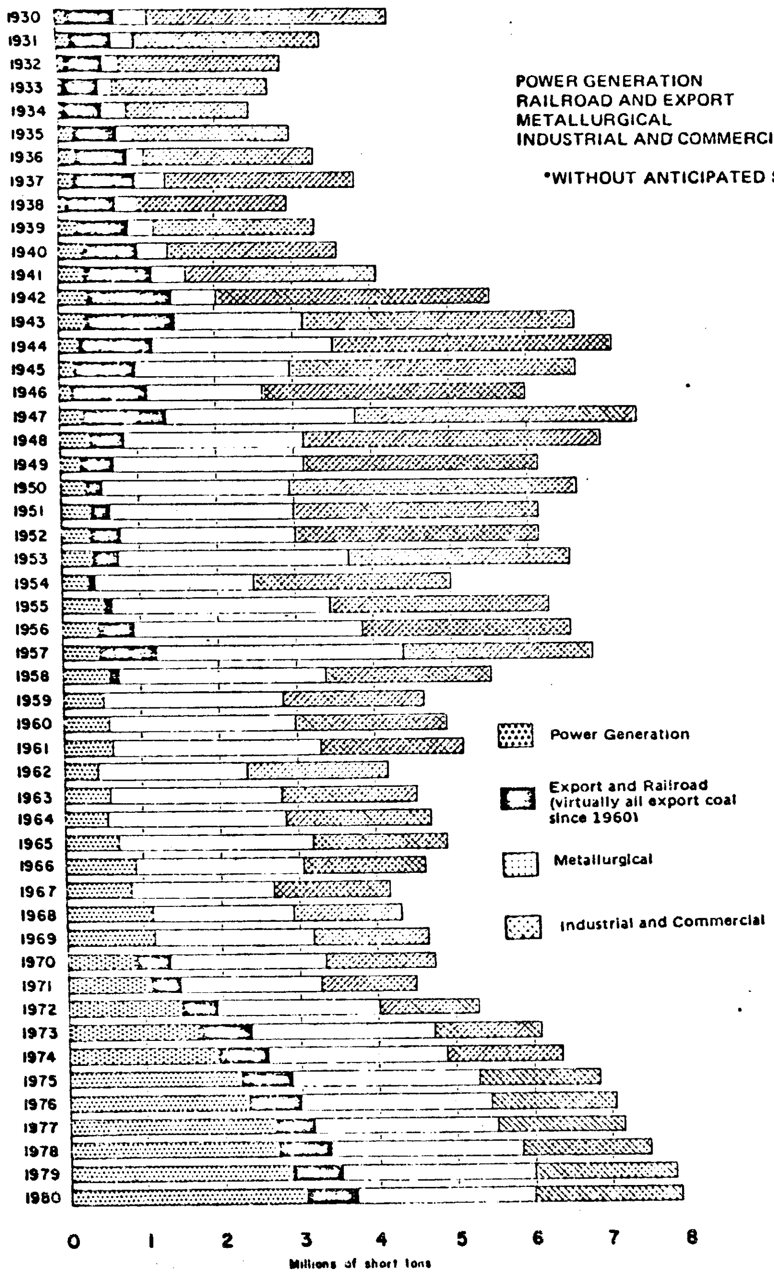
The prospects for the development of the Kaiparowits coalfield to a scale of large production are linked to the regional and national energy supply-demand picture. A number of studies of the national energy problem have shown that, due to petroleum shortages and prices, a great increase in coal production is essential to sustain the nation's economy for the ~~1974-1975~~ 1975-1985 period.[64]

The subsitution of coal for oil and gas in uses where such an exchange is possible has been given high priority by energy study groups.[65] However, the national effort which would be required to produce this massive substitution of coal for oil and gas is so large that many doubt whether it can actually be accomplished.[66]

The magnitude of the needed national effort, in which new coal mines are to be opened each month with production

Figure 19. Utah coal consumption by use, historical and projected, 1870 to 1980.

Reproduced from Heiner, Claude P., 1972, "Economic Evaluation of Utah Coal - 1972," in H.H. Doelling, Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs and Emery, Utah Geological and Mineralogical Survey Monograph Series No. 3, p. 569, Figure 1.

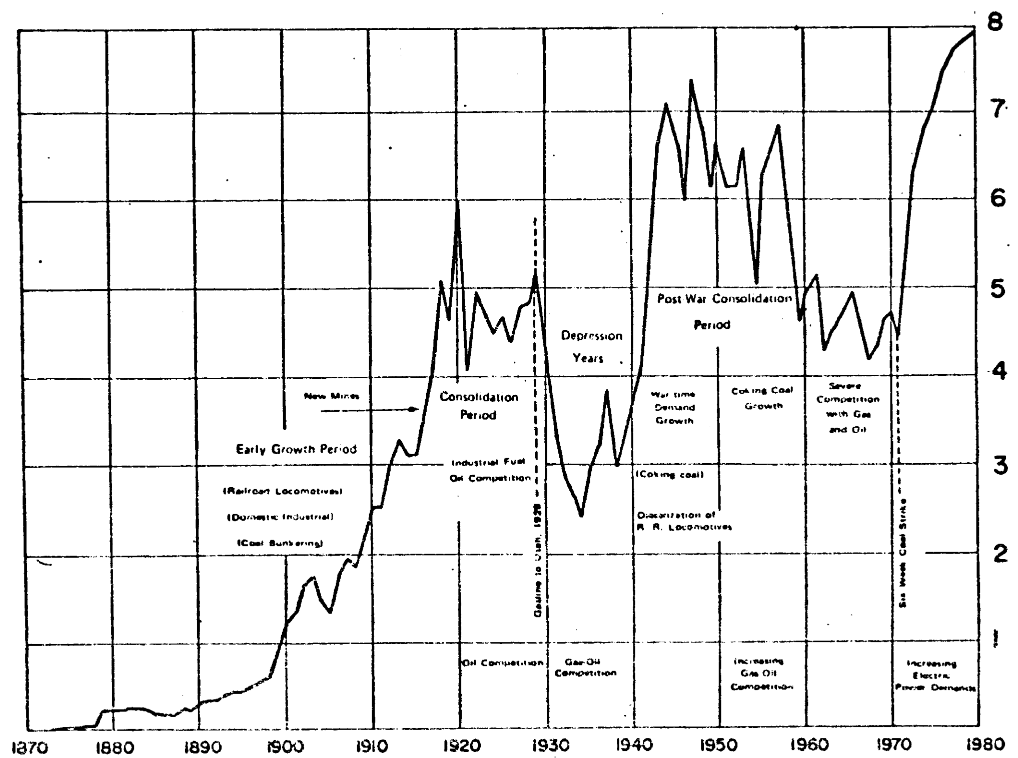


PERCENT OF TOTAL

	1930	1940	1950	1960	1970	1980	1980*
POWER GENERATION	3.3	9.7	4.6	12.2	18.4	78.7	38.3
RAILROAD AND EXPORT	14.1	19.0	3.3	0.3	9.1	2.8	8.2
METALLURGICAL	9.9	11.4	36.2	48.3	43.0	10.2	29.4
INDUSTRIAL AND COMMERCIAL	72.7	59.9	55.9	39.2	29.5	8.3	24.1

*WITHOUT ANTICIPATED SOUTHWESTERN UTAH PRODUCTION

Figure 19.



capacities of two to five million tons per year (MTPY), may be compared with the average annual production of coal in the State of Utah, which has rarely exceeded 7 MTPY (Figure 19).

The demand for scarce capital and limited labor to implement all of the expanded coal production on the national scale may very well impede the development of mining and power production in the Kaiparowits region. These potential scarcities will be called "checkpoints" in this chapter, and they will be treated below in terms of regional requirements.

Underground mining is the important mode of coal production in Utah at present, but it accounts for only a small part of the national production.[67]

Western coal mining has become synonymous with strip mining in national surveys and planning. Because proposed mining at Kaiparowits will be underground, as in most other areas in Utah, the industrial development of this region will have some special features not typical of large-scale coal production in other areas of the Western states.

3. Regional Demand

The Kaiparowits Plateau is estimated to contain about 8 billion tons of recoverable coal that is mineable by existing technology (see previous section), and the prospects are that the size of this estimate will increase in time. Using the conversion factor that generation of 1 MW of electricity requires about 10 tons of coal/day, we find that 8 billion tons of coal would support a production of 10,000 MW for about 220 years. This level of generation would imply an annual coal production of 36 MTPY, a figure which is large compared to Utah's present production, but which would still represent only a few percent of the projected total for Eastern underground production.

However, the importance of this large coal reserve to the power problems of the Southwestern load centers such as Phoenix, San Diego, and Los Angeles cannot be underestimated. If Southern California is effectively to substitute coal for gas and oil on a massive scale, it must look towards the coal fields which lie nearest the West Coast (Figure 20). The Kaiparowits coal field is the closest major field to Southern California, and it has the attraction of abundant coal with relatively low sulfur content. The Southwest could conceivably obtain its coal-fired energy from several large coal fields (such as those in northwest New Mexico, central Utah or Wyoming), but it appears more likely that much of the energy derived from Kaiparowits coal will flow to the power load centers in the Southwest.

4. Major Factors Affecting Development

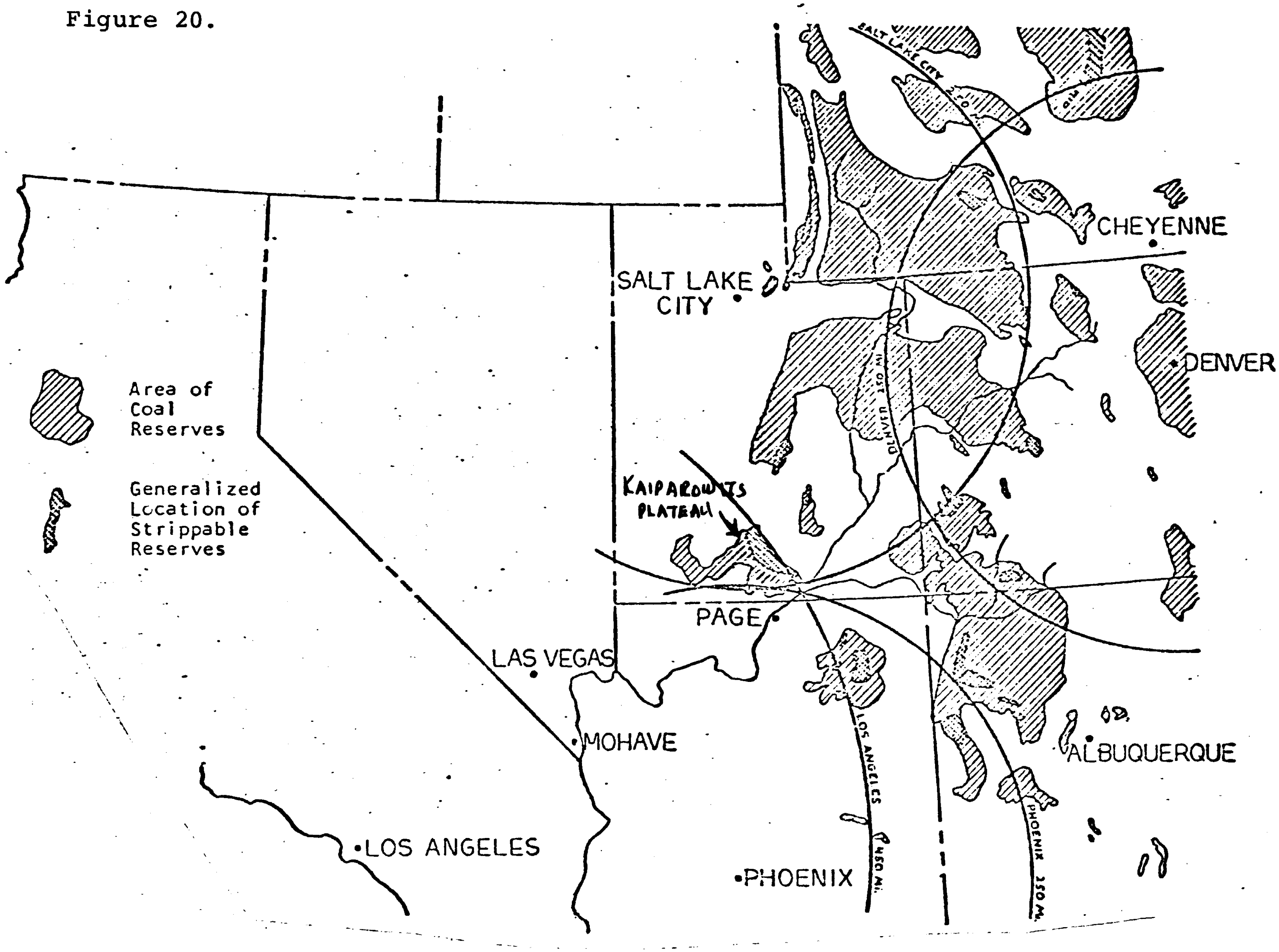
Even if there is general agreement on the part of industry, states, and the federal government that it is desirable to exploit the Kaiparowits coal fields by rapid industrial developments creating large mines and sizeable electric powerplants, the actual capability of building

Figure 20. Distances from major power-load centers to the Kaiparowits Plateau and other western coalfields.

Adapted from U. S. Department of the Interior, 1972, Southwest Energy Study, Appendix L, Alternative Uses of Colorado River Basin Coals, p. 56, Map 1.

(Note: Area of Kaiparowits Plateau shown as strippable in Southwest Energy Study map has been deleted as stripmining is not being considered in the Kaiparowits coalfield.[27A])

Figure 20.


Area of Coal Reserves
Generalized Location of Strippable Reserves
SALT LAKE CITY
CHEYENNE
DENVER
KAIPAROWITS PLATEAU
PAGE
LAS VEGAS
MOHAVE
LOS ANGELES
PHOENIX
ALBUQUERQUE
DENVER 350 Mi
LOS ANGELES 450 Mi.
PHOENIX 350 Mi.

and operating a large power capacity depends upon the solution of national problems. Certain major factors affecting development may arise in the form of limitations in capital, labor shortages, lack of raw materials, or constraints due to public regulations.

a. Water

It is now well recognized that massive power production in the Upper Colorado River Basin will probably require a large allocation of water from the Colorado River.[68]

The water available from the Colorado River system is oversubscribed because of a number of factors including: (1) at the present time the average flow is less than the supply that was anticipated when the Colorado River Compact was signed; (2) not all Indian and federal reserved rights are quantified; (3) losses in the reservoirs due to evaporation and bank storage are large.

Essentially all allocated water has been committed to present or future projects. One of the last large allocations of Utah water involving some 102,000 acre-feet per year, has been approved, but not yet perfected for the use of the proposed powerplant known as the Kane County Project, formerly known as the Kaiparowits Project. Reportedly, this exhausts Utah's official allocation, and thus, for the life of this proposed powerplant, no uncommitted water will be left for other power developments. Essentially, further power production in the Upper Colorado Basin, in Utah and elsewhere, can proceed only by augmenting the flow of the river, or by acquiring water rights as already assigned to agriculture, or by finding ground water resources.

The major hope for further development of the Plateau is to find large reserves of ground water beneath the Plateau.

b. Local Resource Availability

At the local level, the unavailability of certain bulk natural resources could hinder the large-scale development of the Kaiparowits coalfield. One possible constraint would be the lack of abundant, high-quality limestone and gypsum deposits close to the mines. Either or both of these minerals will be used in great quantities within the coal mining operations to prevent fires and explosions. Another possible constraint would be the local availability of a large gravel source from which the material could be cheaply transported to the construction sites. Gravel will be needed in quantity to both surface roads and to build powerplants. Lack of a cheap, abundant, and nearby supply of either of these materials could both raise construction costs and delay large-scale development.

c. Capital Expenditure and Financing

Requirements in the United States for capital to construct power-production facilities during 1974-1985 have been estimated to be $490 to $610 billion.[69] Of this total coal facilities have been estimated to require $34 to $46 billion in capital. Some recent estimates of financial requirements for energy developments in the United States are even higher. It appears that the annual cost of capital expenditures for energy facilities will exceed $50 billion. This amount is a sizeable fraction of the U.S. annual market. Thus, financing of new energy installations is closely interrelated with the overall working of the financial system of the United States.

The near-term costs will be more difficult to finance because of the long lead times necessary for obtaining the return on the capital investment. The lead times required to accomplish significant powerplant installations are:

Table 6

Typical 1973 Overall Project Lead Times

Type of Facility	Years
Coal-fired power plant	5-8
Surface coal mine	2-4
Underground coal mine	3-5
Uranium exploration and mine	7-10
Nuclear power plant	9-10
Hydroelectric dam	5-8
Produce oil and gas from new fields	3-10
Produce oil and gas from old fields	1-3

Source: NAE[70]

The availability of capital needed for the development of underground mines and mine-mouth coal-fired powerplants on the Kaiparowits Plateau depends upon the capital-commitment decisions made throughout the country. It is not clear that there will be enough available capital to finance all the plans for power facility installations across the nation.

d. Labor

A critical factor in the labor needs for the Kaiparowits Plateau projects is the underground nature of the proposed mines. The labor suppply for these mines must come from the same labor pool as that which serves the Eastern underground mining and the underground operations in Carbon and Emergy Counties in Utah. About 80,000 new

Eastern coal miners will be needed for new mines.[71] About half of that number will be employed in underground mines. The competition for this scarce labor force is bound to be intense. The problem for the Kaiparowits coal production is that the area is presently completely undeveloped. Most of the labor must be imported from outside the counties involved. Since coal miners will be able to choose among a number of alternate work sites, they will be likely to choose the best one from their point of view. Wages, schools, transportation, and housing in the Kaiparowits region will need to be competitive if skilled underground mine workers are to be recruited. A reasonably attractive townsite will have to be built for the workers in order to keep the labor turnover from being too high. Consequently, the decisions yet to be made which will determine the design and construction of a new town near the Kaiparowits Plateau will have an important effect on the long-term stability of the labor market.

Engineering manpower and construction craftsmen appropriate to the energy industry are projected to be in very short supply in the nation. The ability of projects in the Kaiparowits region to attract capable professionals and craftsmen will depend in the long run on the success of the projects in competing for this talent on a regional and national basis. Many problems are inherent in retraining engineers and craftsmen for coal-related occupations.[72]

e. <u>Transportation of Energy</u>

A national increase in the production of energy by massive use of coal will necessarily require an increase in national facilities for the transportation of energy. The problem of transportation of energy, or of energy resources, is especially acute in the Kaiparowits region, because of the undeveloped nature of the area and because of the long distances between the resource deposit and power load centers in the Southwest.

Roads, railroads, slurry pipelines, and power transmission line corridors must all be considered. The materials to construct transportation networks, especially steel, will be in short supply in the Kaiparowits region just as they are in the rest of the nation.[73]

The pace of development of a large power and mining industry in the Kaiparowits area depends upon the ability of industrial managers to successfully compete for the construction of a transportation system there, rather than some other place in the nation.

f. Environmental Impact

The environmental impact created by expansion of a massive coal industry is of serious concern to the public and to policy makers.

The main environmental issue associated with most Western coal production is the stripping of land and its rehabilitation after production is completed. This is not the main issue at the Kaiparowits Plateau because the mining will be underground. The most serious problem arising from the industrialization of the Kaiparowits region is the degradation of existing regional air quality which at present is among the cleanest and quietest in the United States.[74]

The air quality problem is intensified because there are five National Parks and a National Recreation Area within an 80-mile radius of the proposed site of the first Kaiparowits powerplant: Grand Canyon National Park, Zion National Park, Bryce Canyon National Park, Capitol Reef National Park, Canyonlands National Park, and Glen Canyon National Recreation Area. In addition, there are numerous National Monuments and National Forests in the vicinity.

The industrialization of the Kaiparowits Plateau will take place in the midst of this unusual concentration of national recreational and wilderness facilities. Effluents from the stacks of the powerplants are expected to degrade the regional air quality. The extent to which massive industrialization will affect the traditional recreational attractiveness of the region, and its parks, monuments, and forests, is unknown at present. It is possible that public opposition to degradation of the air quality may retard the plans for maximum development of coal-fired powerplants in the Kaiparowits region.

g. Legal Requirements

Other factors that could delay or discourage large-scale mining and power production include governmental regulations, particularly environmental regulations. Time-consuming review and approval by federal and state agencies is necessary to establish road and transmission rights-of-way, plant sites, rights to regulated water and acceptable air pollution abatement procedures. Environmental impact statements must be prepared, disseminated, reviewed, and finalized before major federal action significantly affecting the environment--such as the signing of leases and construction contracts--can be undertaken. The licensing of new powerplants presently is not centralized at one governmental level, which means that the utilities must spend several years seeking approvals from numerous public bureaus and agencies before beginning construction.

The Department of the Interior has also published proposed regulations[74A] that would require diligent development of coal leases, a condition that has only nominally existed in the recent past. The new regulations would require that a lessee be included in a "logical mining unit" (LMU)[74B] which must be "diligently developed"[74C] through either preparatory studies or construction work in order for the lease to be maintained. Every two years, the lessee would be required to report to the USGS Mining Supervisor what work had been done and what expenditures undertaken on the LMU. At the same time, he would also be expected to furnish information on his plans for development of the LMU for the following two years. If the lease were not being diligently developed, it could be lost. Moreover, if the lease or the Mining Supervisor so requires, continuous operation (i.e., extraction, processing, and marketing of coal in commercial quantities from the LMU without interruptions totalling more than six months in any calendar year) may be made a condition for maintaining the lease.[74D] If these regulations are adopted, and if they are applied to existing leases (which is a yet unresolved issue), they will revolutionize current practices of the coal industry on the Plateau.[74E] Many of the coal leases on the Plateau were acquired as prospecting permits up to ten years ago and are still nowhere near production. If these regulations are applied to existing leases, the Plateau will face heightened activity as the lessees seek to maintain their valuable interests in the area's coal.

Changes in the law or in federal agency regulations may also delay immediate development. One such change likely to have an important effect on the near future is the Department of the Interior's proposed EMARS (Energy Minerals Allocation Recommendation System) program.[75] This program would still involve competitive bid leasing of coal, but would institute a new two-step process before leasing could occur. First, an allocation process to determine the appropriate amount of coal to enter the market would be employed. A tract selection process would follow to choose the locations from which coal is to be drawn based on such considerations as the difficulty of rehabilitative work involved in reclamation.[76] Such determinations of allocation and selection are to be made only after consultation with the coal industry. Although it is unclear just how the EMARS program will operate, it seems evident that such a major change in agency procedures and requirements will affect both the amount and location of coal leased.

The Department of the Interior is also taking slow, careful steps on the state level, at least in Utah, toward increasing rental rates on leased coal lands by charging a rental equal to the specified percentgae of the gross value of the coal produced. Likewise, in 20-year reviews of coal leases, more stringent production requirements are being established, including the payment of advance royalty at rates keyed to the production of a specified amount of coal each year times a set royalty per ton. Both the amount to be produced and the royalty per ton increase over the term of the lease. This action is designed to make holding coal leases without production less profitable.

More fundamental changes in the law are also pending.[77] One important development is the legislation on strip-mining which was vetoed by President Ford on December 30, 1974. This legislation has been reintroduced in the 94th Congress;

new federal regulations of strip-mining have also been proposed.[78] Although such new developments would probably have little direct bearing on Kaiparowits, because nearly all the coal there is only recoverable by underground methods under present technology, its fairly stringent controls on surface mining may make development of underground supplies at the Kaiparowits more attractive to coal interests than would have been the case otherwise.

Policy changes are also forthcoming. As part of Project Independence, President Ford is pushing for conversion of baseline oil-fired powerplants to coal within the next 5 years.[79] Such a goal will put great pressure on federal agencies to promote rapid development of coal in areas such as Kaiparowits.

Finally, reorganization of federal agencies dealing with energy matters has recently occurred, and a new Energy Research and Development Agency (ERDA) has been created. ERDA is designed to coordinate all energy and resources activities under one agency. ERDA will include the Bureau of Mines, the Office of Coal Research, other parts of the Department of the Interior, the old Atomic Energy Commission (AEC) and parts of the National Science Foundation involved with energy. Certainly, the reconstruction of a viable organization cannot proceed without some delay due to overlapping functions and administrative uncertainty. The transition of federal agencies to ERDA could conceivably intensify the institutional crisis which exists because of the multiplicity of regulations and problems concerned with coal development.

GLOSSARY

(adapted from Glossary of Geology[80])

Aquifer -- A body of rock that contains sufficient water-filled pores to conduct groundwater and to yeild economically significant quantities of groundwater to wells and springs.

BTU -- British Thermal Unit -- 1 BTU equals the heat required to raise one pound of water one degree at or near its point of maximum density ($39.1^{o}F$).

Coke -- A combustible material consisting of the fused ash and fixed carbon of bituminous coal, produced by driving off by heat the coal's volatile matter. It is grey, hard, and porous, and as a fuel it is practically smokeless.

Coking Properties -- Those properties that produce in some coals the ability to coke.

Fixed Carbon -- The remaining solid, combustible matter in coal after removal of moisture, ash, and volatile matter, expressed as a percentage.

Lacustrine -- Pertaining to, produced by, or formed in a lake or lakes, as "lacustrine beds" deposited on the bottom of a lake.

Lenticular -- Resembling a lens in shape, especially a double convex lens.

Lithified -- To be changed from a loose sediment to a rock; to be changed to stone.

Monocline -- A unit of rock that dips or flexes from the horizontal in one direction only. It is generally a large feature of gentle dip.

Overburden -- Barren rock material, either consolidated or unconsolidated, overlying a mineral deposit and which must be removed prior to mining.

Peat -- An unconsolidated deposit of semicarbonized plant remains of a water-saturated environment, such as a bog, and of persistently high moisture content. Structures of the vegetal matter can be seen. When dried, peat burns freely.

Volatile Matter -- Those substances, other than moisture, given off as gas and vapor during combustion of coal. Standardized laboratory methods are used in analysis.

FOOTNOTES

Legal footnotes: The form of citing most of the legal references in the following footnotes may be found in A Uniform System of Citation published by the Harvard Law Review Association, Cambridge, Massachusetts (1967). Explanations of the abbreviations follow:

43 U.S.C. §184 = Title 43, United States Code, Section 184

43 C.F.R. §3511 = Title 43, Code of Federal Regulations, Section 3511

39 Fed. Reg. 43229 = Volume 39, page 43229, Federal Register

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1. "It has been estimated that a foot of bituminous coal contains plant material accumulated over a period of several centuries." Averitt, Paul, 1969, Coal Resources of the United States, January 1, 1967, U. S. Geological Survey Bulletin 1275, U.S. Government Printing Office, p. 16.

2. See Glossary.

3. Most often this heating value is measured in Btu per pound of coal. One Btu is the heat required to raise one pound of water one degree Fahrenheit.

4. Table A is reproduced from Simon, Jack A., and M. E. Hopkins, 1973, "Geology of Coal," in Cassidy, S.M.,ed., Elements of Practical Coal Mining, Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., New York, pp. 22-23, Table 1.

5. Local heating from intrusions of molten rock, and increased temperature and pressure due to geologic processes of deformation and mountain building, may aid the process of coalification.

6. However, with demands for cleaner emissions from coal-fired power plants, electric utility companies are beginning to seek coals with lower ash and sulfur contents to meet their needs. These coals are not only less abundant and more expensive, but also are often those needed by the metallurgical industry.

7. At its maximum extent during this time, the inland sea probably reached all the way to the area which is now Zion National Park. However, any sediments that might have been deposited then have since been eroded away.

Table A. Classification of Coals by Rank[4]

Classification of Coals by Rank *[a]

Class	Group	Fixed Carbon Limits, % (Dry Mineral-Matter-Free Basis)		Volatile Matter Limits, % (Dry, Mineral-Matter-Free Basis)		Calorific Value Limits, Btu per Lb (Moist,[b] Mineral-Matter-Free Basis)		Agglomerating Character
		Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than	
I. Anthracitic	1. Meta-anthracite	98	..	..	2	..	..	Nonagglomerating
	2. Anthracite	92	98	2	8	..	..	
	3. Semianthracite[c]	86	92	8	14	..	..	
II. Bituminous	1. Low-volatile bituminous coal	78	86	14	22	..	..	Commonly agglomerating[e]
	2. Medium-volatile bituminous coal	69	78	22	31	..	..	
	3. High-volatile *A* bituminous coal	..	69	31	..	14,000[d]	..	
	4. High-volatile *B* bituminous coal	..	..	..	..	13,000[d]	14,000	
	5. High-volatile *C* bituminous coal	..	..	..	..	11,500	13,000	
						10,500	11,500	Agglomerating
III. Subbituminous	1. Subbituminous *A* coal	..	..	..	..	10,500	11,500	Nonagglomerating
	2. Subbituminous *B* coal	..	..	..	..	9,500	10,500	
	3. Subbituminous *C* coal	..	..	..	..	8,300	9,500	
IV. Lignitic	1. Lignite *A*	..	..	..	..	6,300	8,300	
	2. Lignite *B*	..	..	..	..	..	6,300	

* From: American Society for Testing and Materials, D 388.

[a] This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48% dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free Btu per lb.

[b] Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[c] If agglomerating, classify in low-volatile group of the bituminous class.

[d] Coals having 69% or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[e] It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high-volatile *C* bituminous group.

8. This uplift was part of the creation of the Rocky Mountains, and is known to geologists as the Laramide Orogeny, a time of mountain building which has been named after Laramie, Wyoming.

9. Howard D. Zeller, personal communication, 1974.

10. Reserves are usually understood to mean those deposits that currently can be economically extracted by present mining methods. Resources are those deposits not yet practical to remove, but which might become economically mineable through future changes in cost or through more advanced mining techniques. New classification standards have just been adopted by both the U. S. Geological Survey and the U. S. Bureau of Mines to standardize resource terminology useage. This usage has been summarized in Table B below, which is reproduced from Speltz, Charles N., 1974, "Coal Resources of the Piceance Creek Basin, Colorado," in D. Keith Murray, ed., Energy Resources of the Piceance Creek Basin, Colorado, 25th Field Conference, Rocky Mountain Association of Geologists, Denver, Colorado, p.238.

11. Doelling, H.H., and R. L. Graham, 1972, "Kaiparowits Plateau Coal Field," in H. H. Doelling and R. L. Graham, Southwestern Utah Coal Fields: Alton, Kaiparowits Plateau and Kolob-Harmony, Utah Geological and Mineralogical Survey Monograph Series No.1, p. 102.

12. Daniel A. Jobin, personal communication, 1974.

13. Averitt, Paul, 1961, Coal Reserves of the United States, A Progress Report, January 1, 1960, U.S. Geological Survey Bulletin 1136, U.S. Government Printing Office, pp. 79-80.

14. Averitt, 1969, op.cit. p. 42 [footnote 1]

Table B. New Classification of Total Mineral Resources[10]

This classification has been adopted by the U. S. Geological Survey and the U. S. Bureau of Mines.

Key Criteria:

1. Extent of geologic knowledge about the resource.
2. Economic feasibility of recovery of the resources.

Glossary of Resource Terms

Resource — A concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Identified Resources — Specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category.

Reserve — That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term "ore" is used for reserves of some minerals.

The following definitions for measured, indicated, and inferred are applicable to both the "Reserve" and "Identified-Subeconomic" resources components:

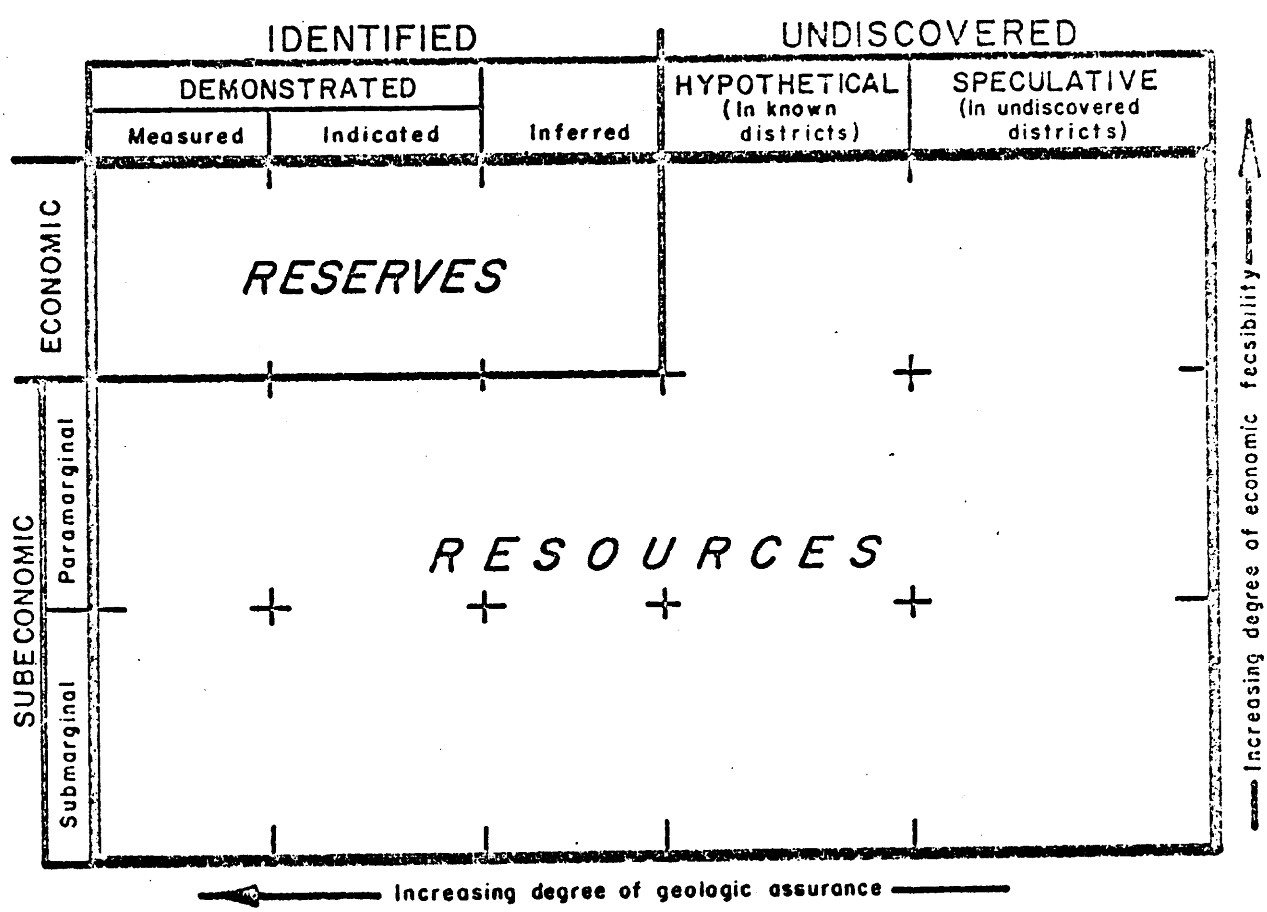
Measured — Material for which estimates of quality and quantity have been computed, within a margin of error of less than 20%, from sample analyses and measurement from closely spaced and geologically well-known sample sites.

Indicated — Material for which estimates of quality and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections.

Demonstrated — A collective term for the sum of materials in both measured and indicated resources.

Inferred — Material in unexplored extensions of "Demonstrated" resources for which estimate of the quality and size are based on geologic evidence and projection.

(Source: Department of the Interior News Release dated April 15, 1974, "New mineral resource terminology adopted.")



15. The following summary is reproduced from Bass, N. Wood, Henry L. Smith, and George H. Horn, 1970, Standards for the Classification of Public Coal Lands, U. S. Geological Survey Circular 633, U. S. Government Printing Office, pp. 9-10.

SUMMARY OF THE STANDARDS FOR THE CLASSIFICATION OF PUBLIC COAL LANDS

1. Land shall be classified as coal land if it contains coal having:
   - (a) A heat value of not less than 4,000 Btu (as-received basis) for an unwashed or washed, unweathered mine sample.
   - (b) A thickness of 14 inches for coals having a heat value of 12,000 Btu or more (as-received basis), increasing 1 inch for each decrease of 750 Btu between 12,000 and 9,000 Btu, and 1 inch for each decrease of 250 Btu between 9,000 and 4,000 Btu. Any coal bed whose thickness is more than 6 feet is treated as a 6-foot bed. In calculating the thickness of a coal bed that contains partings of shale, bone, or impure coal, the thickness of the thinner bench of coal directly above or below the parting is reduced by the thickness of the parting; thus, the total thickness of the coal bed (including partings) is reduced by twice the total thickness of the partings.
   - (c) A depth of not more than 6,000 feet for a bed of coal 6 or more feet thick having an as-received heat value of 15,000 Btu. The depth decreases 333 feet for each decrease of 1,000 Btu between 15,000 and 9,000 Btu and decreases 400 feet for each decrease of 1,000 Btu between 9,000 and 4,000 Btu. For a bed of minimum thickness, the depth may not be more than 1,000 feet. For beds of any thickness between the minimum and 6 feet, the depth is graduated between 1,000 feet and the maximum depth for a 6-foot bed. Moreover, the depth limit shall be computed for each individual bed except that, where two or more beds occur in such relations that they may be mined from the same opening, the depth limit may be determined on the group as a unit and is fixed at the center of weight of the group; no coal below the depth limit thus determined is to be considered.
2. Classification shall be made by quarter-quarter section, surveyed tract, or surveyed lot.

16. This estimate has never been published by the U. S. Geological Survey, but it has been used internally as the most recent value for total coal resources in the Kaiparowits Plateau coalfield. It is possible that the Survey will update this figure with a resource estimate based upon the new Known Coal Leasing Area (KCLA) criteria which include only that coal in beds greater than 4 feet thick and under less than 3000 feet of overburden (Howard D. Zeller, personal communication, 1974).

17. In cases where drill hole data have been released by private companies, their information has shown the U.S. Geological Survey's resource estimates to be consistently on the conservative side. This tendency to underestimate resources may stem from the fact that field estimates of the amount of coal must be based on the limited, widely spaced outcrops which are available on the Plateau. The Survey also uses conservative formulas for computing coal resources.

18. Averitt, 1969, op.cit. pp. 12-13 [footnote 1]

19. Doelling and Graham, 1972, op. cit. p. 105 [footnote 11]

20A. Ibid. p. 104

20B. Hellmut Doelling, Economic Geologist, Utah Geological and Mineralogical Survey, letter to O. L. Anderson dated 11/27/74.

21. It is possible that large quantities of coal exist at relatively great depths below the Table Cliffs and Escalante Mountains and, because of their great depth of burial, they could be of higher rank than the exposed coal of the Kaiparowits Plateau.

22. Averitt, 1969, op.cit. p. 18

23. Doelling and Graham, 1972, op.cit. p. 102.

24. Most new coal-fired powerplants now use pulverized coal, which has been crushed so that the coal has the consistency of talcum powder (about 200 mesh) and thus can be fed into the burner much like oil.

25. Coal mines and prospects of the Kaiparowits coalfield are listed in Table C, reproduced from Doelling and Graham, 1972, op.cit. p. 92, Table 3.

26. Doelling and Graham, 1972, op. cit. pp. 102-106.

27A. Morgan S. Jensen, District Manager, Bureau of Land Management, Kanab, Utah, letter of O. L. Anderson dated 11/26/74.

27B. Environmental Studies Board, Study Committee on the Potential for Rehabilitating Lands Surface Mined for Coal in the Western United States, 1974, Rehabilitation Potential of Western Coal Lands, National Academy of Sciences, Ballinger Publishing Company, Cambridge, Mass., p.28, Figure 3.3.

Table C. Coal mines and prospects of the Kaiparowits coalfield.[25]

Mine or Prospect (by quadrangle)	Location	Remarks
Canaan Creek		
Alvey mine	SE.NW.12-36S-2E 4,171,885mN 444,310mE	Active 1920-1962 1952-1961 1250 TPY (inactive)
Schow mine	SW.SW.36-35S-2E 4,174,305mN 443,755mE	Active 1893-1930
Prospects	1-36S-2E 4,173,625mN 444,465mE	
	1-36S-2E 4,173,685mN 444,465mE	
Christensen mine	C.NW.SW.SE.35-35S-2E 4,174,270mN 442,735mE	1893-1930 operated every year 1920-100 TPY (inactive)
Richards mine	NE.NE.NE.SE.SE.35-35S-2E 4,174,395mN 443,380mE	1913-1928 100 TPY average (inactive)
Shurtz mine	NW.SW.SW.36-35S-2E 4,174,295mN 443,545mE	1913-1928 100 TPY
Winkler mine	SW.SW.SE.NW. 12-36S-2E 4,171,630mN 444,215mE	Abandoned
Griffin Point		
Cherry Creek mine	SE.8-35S-1E 4,180,670mN 429,185mE	Active 1962-1964? 214 TPY (inactive)
Corn Creek mine	S½.5-35S-1E 4,182,210mN 428,600mE	
Prospects	S½.5-35S-1E 4,182,388mN 428,610mE	
	S½.4-35S-1E 4,182,930mN 430,230mE	
Gunsight Butte NW		
Prospect	8-42S-4E	
Henrieville		
Prospect (Dakota)	25-37S-2W Little Creek	
Needle Eye Point		
Prospect (John Henry)	NE.NE.NE.NE.33-40S-4E 4,127,670mN 458,240mE	
Nipple Butte NE		
Spencer No. 1 mine	SW.SW.3-42S-3E 4,114,850mN 448,690mE	1913- only 115 tons Abandoned
Spencer No. 2 mine	SW.SW.3-42S-3E 4,114,940mN 448,780mE	
Prospect (John Henry)	NW.SW.12-42S-3E 4,113,730mN 452,220mE	
Warm Creek Experimental mine (Missing Canyon)	N½.N½.36-41S-R3E 4,117,890mN 452,760mE	1971-
Nipple Butte SE		
"Dakota" mine	NE.SW.7-43S-4E 4,104,800mN 454,200mE	456 tons total production
Paria NW		
Bryce Canyon coal and coke mine	SW.NE.21-42S-1W 4,111,120mN 418,900mE	Intermittent 1939-1970?
Pine Lake		
Davies mine	NE.NE.36-36S-2W 4,165,740mN 416,230mE	Active 1952-1953
Pollock mine	SE.SE.25-36S-2W 4,165,940mN 416,305mE	Active 1920's
Shakespear (Tropic)	NW.NW.23-36S-2W 4,168,630mN 413,530mE	Active 1952-1963? 480 TPY Average (inactive)
Tropic Canyon		
Prospect	SE.NW.5-36S-2W 4,173,190mN 409,090mE	

28. Doelling and Graham, 1972, <u>op.cit</u>. pp. 102-106.

29. The U. S. Bureau of Mines soon hopes to assist in the development of a number of prototype methods for mining thick and multiple coal seams. One of the pilot plants to develop such techniques may be sited at Kaiparowits.

30. Doelling and Graham, 1972, <u>op.cit</u>., pp. 92, 96-97.

31. Averitt, 1969, <u>op.cit</u>. pp. 27-29.

32. <u>Ibid</u>. p. 29.

33. See Doelling and Graham, 1972, p. 92 and pp. 96-97.

34. An executive order by Pres. Theodore Roosevelt withdrew coal lands from homesteading in 1906. In 1910, Congress again opened public lands containing valuable coal to homesteading, but allowed only surface rights to be acquired, reserving rights to underlying coal to the federal government. See 43 U.S.C. 83(1970).

35. 43 U.S.C. §181 <u>et seq.</u> (1970).

36. See Utah Code Ann. §65-1-15 (1953).

36A. The state acquired these "school sections" in accordance with §6 of the state enabling act, 28 STAT. 107 (July 16, 1894). In southern Utah, the state usually has title to sections 2, 16, 32, and 36, while most of the intervening land, at least on the Plateau, is federal.

36B. To obtain a prospecting permit, an individual submits an application showing his qualifications, along with a nonrefundable $10.00 filing fee, to the Bureau of Land Management. He must also include full payment of the first year's rental at a rate of $0.25 per acre but no less than $20.00 per year.

37. 30 U.S.C. §201(b) (1970). For a discussion of the "workability" criterion, see note 51 and accompanying text.

38. See 43 C.F.R. §3511.3-2 (1973).

39. See 43 C.F.R. §3501.1-4 (1973).

40. See 30 U.S.C. §184(a)(1) (1970). See also 43 C.F.R. §3501.1-4 (1973).

41. See 43 C.F.R. §3501.1-3 (1973).

42. It appears that this decision involves a large degree of discretion. The absence of clear standards is widely recognized by decision-makers. According to the Conservation Division Manual 671.5.3C(2) (1968), coal is "workable" if "its value, as determined by its character and heat-giving quality, exceeds the cost of extraction, either as judged by actual experience on similar coals similarly situated elsewhere." A new formulation of standards on workability has been recently established by the Denver office of the USGS, using fairly objective standards such as size of outcrops and factors by which beds of coal seen there may be projected. The new standards apparently are being used to outline known workable coal areas for future leasing.

    In the past, the knowledge that coal is workable has meant that a competitive lease is required even though the coal's full economic significance or suitability for a particular economic use is not known. Even if there are known coal outcrops on the land in question or on adjoining land, there is not necessarily enough information to establish that the coal is workable and therefore necessarily requiring a competitive bid lease.

43. See 30 U.S.C. §201 (1970).

44. See 43 C.F.R. §3503.3-2 (1973).

45. See 30 U.S.C. §207 (1970).

46. Some change in these requirements has been made, however; a recent federal lease in Utah required $1.00 per acre per year for the first five years and $3.00 per acre per year thereafter.

47. See 30 U.S.C. §207 (1970).

48. Although some changes are being made toward really requiring minimum production by increasing such advance royalty payments, Kaiparowits Plateau leases will not be affected until about 1984 when the 20-year review period comes up for the first of them.

49. Previously, the Code of Federal Regulations indicated that "Every applicant for lease or permit must also furnish a showing as to the need for additional coal production which cannot otherwise be reasonably met, or, if such a showing of need cannot be made, a statement of the reasons why a lease or permit is desired" 43 C.F.R. §3131-2(d) (1969). This provision was deleted as unnecessary in 1970.

49A. But see "Future Outlook" section for discussion of the new production requirements recently proposed by the Department of the Interior.

50. See U.S.C. §185(h) (1970). This has never been done. See Council on Economic Priorities, Leased & Lost, p. 7 (1974).

50A. The division of authority between the BLM and USGS is outlined in Secretarial Order 2948 (October 6, 1972).

51. In contrast to this classification for leasing purposes, "known coal lands" is a designation used with respect to disposition of federal lands. The standards for this classification, which differ from those applied to land to be leased by competitive bid, are set out in Bass, Smith and Horn, 1970, op.cit. [note 15].

52. See U.S. Department of Interior, Bureau of Land Management, Draft EIS on Proposed Federal Coal Leasing Program, No. 74-53, p. I-149 (May 1974). [hereinafter cited as Draft Coal EIS.]

52A. Secretarial Order 2952.

53. See U.S. Department of Interior, Instruction Memorandum No. 73-231 on Application of the Secretary's Short-Term Leasing Criteria, p. 4 (June 6, 1973).

54. Telephone communication with Regional Solicitor's Office, Salt Lake City, Utah, November 8, 1974.

55. Recently, the Sierra Club has sought an injunction against any further development of coal in the Northern Great Plains region (particularly in South Dakota, but also throughout the Upper Missouri River basin) until an adequate EIS is prepared and NEPA requirements are met. Sierra Club v. Morton, 4 ELR (D.D.C., Feb. 14, 1974), now on appeal to the D.C. Circuit (Civ. No. 1182-73). Although this suit was begun and summary judgment

granted for defendants before the draft EIS was published in May 1974, it seems likely that a test of the adequacy of the coal EIS will take place in this or a similar forum.

56. See 43 C.F.R. §23 (1973).

57. New regulations on coal mining operations have been proposed recently by the USGS. See 40 Fed. Reg. 4428 (Jan. 30, 1975). The strip-mining bill passed by the 93rd Congress was vetoed by President Ford on Dec. 30, 1974, but further legislation may be introduced in the future.

58. 42 U.S.C. 4321 et seq (1970). for a detailed discussion of NEPA, see Anderson, NEPA in the Courts (1973) and Dolgin & Guilbert, Federal Environmental Law (1974).

58A. If a number of agencies are involved in the single action, they must work together in preparing the statement. A statement prepared by the developer may not be substituted for agency analysis. See Greene County Planning Bd. v. Federal Power Comm'n, 455 F.2d 412 (2d Cir.), cert. denied, 409 U.S. 849 (1972).

58B. Courts are grappling with how this requirement is to be applied in practice. Compare the district court's decision in Sierra Club v. Froehlke, 359 F. Supp. 1289 (E.D. Tex. 1973) with the court of appeal's reversal in Sierra Club v. Callaway, 499 F.2d 984 (5th Cir. 1974).

59. "Project Impact Examined: Kaiparowits Economic Changes for Kane County," Lake Powell Chronicle, November 6, 1974, p.1.

60. Although the State Engineer has approved the application for 102,000 af of water, the consortium has not yet offered proof of their application, so actually the approval could be retracted. However, retraction is considered unlikely. See Chapter E, Water Resources. [Chapter E is another section of the Data Book in preparation.]

61. Arizona Public Service Company, Salt River Project, San Diego Gas & Electric Company, and Southern California Edison Company, 1973, Kaiparowits Project: Environmental Report, Volume 1, p. I-4.

62. Unpublished information from Utah Power and Light Company.

63A. The seven public utilities that make up the Intermountain Power Project (IPP), and their percentages of participation in the Project, are given below:

Intermountain Consumers Power Association (Utah)...15%
(ICPA)
City of Anaheim (California).......................15%
City of Burbank (California)....................2-1/2%
City of Glendale (California)...................2-1/2%
City of Los Angeles (California)..................50%
City of Pasadena (California).......................5%
City of Riverside (California)....................10%

ICPA is acting as the lead utility within the State of Utah.

"The City of Los Angeles has been assigned the task of conducting the IPP feasibility study and could possibly undertake final project engineering."
Source: Information Packet, Intermountain Power Project, 1974, (unpublished). Material presented at a meeting concerning the Intermountain Power Project held at the Utah State Office of the Bureau of Land Management in Salt Lake City, Utah, April 30, 1974.

63B. Press release 25 October 1974 by Joseph Fackrell, President, Intermountain Power Project:

"The Salt Wash area of Wayne County in south-central Utah was selected as the primary study stie for a 3-million kilowatt electric power generating plant proposed by the Intermountain Power Project (IPP) of Sandy, Utah, Joseph C. Fackrell, IPP president, said today.

Selection of the Salt Wash site, approximately 10 miles north of the town of Caineville, was made following an extensive analysis performed at several preliminary study areas by Westinghouse Environmental System Department, other consultants, and IPP engineers.

Among the factors considered in selecting the Salt Wash area were availability of water and fuel, environmental impact, topography and geology, accessibility, and transmission lines.

A weather station with a 330-foot tower is being constructed during October in the vicinity of the Salt Wash site to measure and record wind direction and velocities, temperature, humidity, precipitation and other required information. Further environmental input will be gained through wildlife, vegetation and soil surveys to be conducted on a regular basis at the primary study area.

The coal-fired generating plant for the $1.5 billion project would occupy an area of about two square miles.

'The proposed plant could begin generating power by 1981, utilizing Utah coal resources, providing employment and creating a substantial tax base,' Fackrell said. 'IPP management is committed to "open planning" during the development of this vitally needed electric energy resource for the people of Utah and California,' he added.

Participating in the project feasibility study is the Intermountain Consumer Power Association of Sandy, Utah, comprised of 26 municipal electric systems in Utah and all six rural cooperatives. Other study participants are the California cities of Anaheim, Burbank, Glendale, Los Angeles, Pasadena and Riverside."

64. Task Force on Energy of the National Academy of Engineering, 1974, U. S. Energy Prospects: An Engineering Viewpoint, National Academy of Engineering, Washington, D.C., p. 6. [This reference is cited below as NAE, 1974.]

> Recoverable coal reserves in the United States are capable of supplying many energy needs for centuries. This study concludes that the 1973 coal production rate of 600 million tons per year (MTPY) could be doubled to at least 1,260 MTPY by 1985.

65. Ray, Dixy Lee, 1973, The Nation's Energy Future: A Report to Richard M. Nixon, President of the United States, U. S. Atomic Energy Commission Report WASH-1281, U.S. Government Printing Office, p. 48.

In the report to the President submitted by Dr. Dixy Lee Ray, Chairman of the Atomic Energy Commission, one of the five tasks required to regain and maintain energy self-sufficiency was defined as:

> Task 3. SUBSTITUTE COAL FOR OIL AND GAS ON A MASSIVE SCALE. This task can be divided into two parts. The first is to switch wherever possible to the direct use of coal where oil and gas are now used, as in boilers in industry and in central power stations...Coal is an

> enormous domestic resource, and immediate and intensive efforts must be mounted to mine more of it... The second part of the coal-substitution task is the conversion of coal to synthetic fuels.

Later in the same report, there appears the statement:

Ibid., p. 101.

> to obtain energy self-sufficiency, U. S. coal mining capability will have to at least triple in this century. In the near-term over 600 million tons/year of additional coal production capacity will be required by 1985.

66. NAE, 1974, pp. 34-35.

According to the NAE study, "it is within the capability of the coal industry to expand mine production by about 660 MTPY in the next 11 years."

> The magnitude of the projected increase in coal production can be grasped better if the numbers are translated into physical facilities to be added. Listed below are the kinds of actions that would be needed to achieve the estimated 1985 production levels.
>
> - Develop 140 new 2-MTPY eastern underground mines.
> - Develop 30 new 2-MTPY eastern surface mines.
> - Develop 100 new 5-MTPY western surface mines.
> - Recruit and train 80,000 new eastern coal miners.
> - Recruit and train 45,000 new western coal miners.
> - Manufacture 140 new 100-cubic-yard shovels and draglines
> - Manufacture 2,400 continuous mining machines.
>
> Stated another way, on the average one new deep mine and one new surface mine must be brought into production every month for 10 years.

67. NAE, 1974, pp. 33-34.

The NAE report does not list western underground production in its discussion of coal production and its problems.

Table D.

Estimated Coal Flows for 1973 and 1985

Sources	1973 Output (MTPY)	1985 Output (MTPY)
Eastern underground	300	480
Eastern surface	240	220
Western surface	60	520
Total	660	1,260

Source: Adapted from NAE, 1974, pp. 33-34.

68. U.S. Department of the Interior, Water for Energy Management Team, 1974, <u>Report on Water for Energy in the Upper Colorado River Basin</u>.

69. NAE, 1974, p. 96

70. NAE, 1974, p. 92.

71. NAE, 1974, p. 35

72. NAE, 1974, pp. 103-105

73. NAE, 1974, p. 92.

> Prior to the imposition of the oil embargo, material and equipment lead times were already long and were becoming longer in most cases as new plant orders increased during 1972-1973. Since last November [1973] the steel mills supplying sheet, tubular products, and rolled shapes have been supplying distributors on an allocation basis. The result is that lead times have extended considerably because of market instabilities and shortages of raw materials. Indeed, if steel production capacity is not expanded rapidly, beginning immediately, the goals outlined in this [NAE] report could probably not be attained.

NAE, 1974, pp. 37, 39.

> Shortages of locomotives, gondola cars, and hopper cars are apparent even now; and in many cases power plant or mine owners will probably want to purchase their own rolling stock. Safety and environmental problems will probably increase as traffic increases on mainline trackage. All new overland transportation systems will need new additional rights-of-way, new facilities, new crews, and new rolling stock.

The estimated increase in transportation systems which will be necessary in the period 1974-1985 to handle the new coal production needed by the United States has been presented in the NAE report:

NAE, 1974, p. 40.

- Construction of 60 new 2-MTPY eastern rail-barge systems of 100 to 500 miles each
- Construction of 70 new 3-MTPY western rail-barge systems of 1,000 to 1,200 miles each
- Construction of 4 new 25-MTPY slurry pipelines of 1,000 miles each
- Construction of 2 new 2.5 BCFD [billion-cubic-feet-per-day] gas pipelines of 1,000 miles each
- Manufacture of 8,000 railroad locomotive units
- Manufacture of 150,000 gondola and hopper cars each of 100-ton capacity

74. Walther, E.G., M.D. Williams, R. Cudney, and W. Malm, 1974, Air Quality in the Lake Powell Region, Lake Powell Research Project Bulletin No. 3, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, 43 p.

The legal controls on such degradation of air quality are now in a state of flux. See Sierra Club v. Ruckelshaus, 344 F. Supp. 254 (1972), aff'd mem. sub nom Fri v. Sierra Club, 412 U.S. 541 (1973); and the new EPA Guidelines, 39 Fed. Reg. 42510 (Dec. 5, 1974). For a more complete discussion of legal controls on air quality, see the forthcoming Kaiparowits Plateau Handbook publication on that subject.

74A. 39 Fed. Reg. 43229 (Dec. 11, 1974).

74B. Id. § 35500.0-5 (d).
"An LMU is a compact area of coal land that can be developed and mined in an efficient, economical and orderly manner with due regard to conservation of coal reserves and other resources and in accordance with an approved Mining Plan. An LMU may consist of one or more Federal leaseholds, and may include intervening or adjacent non-Federal lands, insofar as all lands are under the effective control of a single operator. It may also consist of lands committed to a contract for collective prospecting, development or operations approved by the Secretary pursuant to 30 U.S.C. 201-1. The Mining Supervisor is authorized to approve or establish an LMU."

74C. "Diligent development means preparing to extract coal from an LMU in a manner and at a rate consistent with a Mining Plan approved by the Mining Supervisor. Activities that may be approved as constituting diligent development of an LMU include: environmental studies, including gathering base-line environmental data and design and operation of monitoring systems; on-the-ground geological studies, including drilling, trenching, sampling, geophysical investigation and mapping, engineering feasibility studies, including mine and plant design, mining method survey studies; and research on mining methods contracting for purchase or lease of operating equipment and development and construction work necessary to bring the LMU into production. The work performed and the expenditure of monies may take place on or for the benefit of the leased land, or on other lands within the LMU, or at a location remote from the land so long as they are undertaken for the purpose of obtaining production from the LMU."
Id.§ 3500.05 (e)

74D. These regulations borrow significantly from the law of oil and gas. For a discussion of unitization and implied covenant to develop see H. Williams and C. Meyers, Oil and Gas, abridged edition, 1973.

74E. The new regulations would apply "to coal leases issued after the effective date of these regulations and to the extent possible to existing coal leases." There is therefore some doubt whether the new policy would apply to existing leases on the Plateau. Clearly, however, they would govern leases to be made in the future.

75. Although the details of this attempt to develop an orderly plan for the production of the nation's coal have not yet been made public, the broad outline of the plan appears in the Draft Environmental Impact Statement for the Proposed Federal Coal Leasing Program issued in May 1974. The final statement is expected to be issued in November 1974.

76. U. S. Department of Interior, 1974, op.cit. p. I-1-5 [footnote 20].

77. One example is S. 3528 introduced in May 1974 and reported favorably by the Senate Committee on Interior and Insular Affairs, which would change the present system of leasing coal for indefinite terms to allow leases only for 20-year terms, to terminate at that time if coal is not being produced. Under the proposal, all leases would be issued only under a competitive arrangement and preparation of comprehensive land use plans would be required before leases would be approved and development and reclamation would also be required.

78. Proposed new regulations to govern coal mining operations were published in December 1974, see 40 Fed. Reg. 4428 (January 30, 1975). A strip mining bill very similar to that vetoed by President Ford in December 1974 has passed the Senate (S-7) on March 12, 1975. The House version of the bill (HR-25) is expected to be acted upon soon. See BNA Environmental Reporter, 5, Current Developments, 1791 (March 14, 1975).

79. Coal News, No. 4234, October 11, 1974, p. 1:

"Mr. Ford said he will ask Congress after its election recess for new laws 'to require use of cleaner coal processes and nuclear fuel in new electric power plants and the quick conversion of existing oil plants. I propose that we together set a target date of 1980 for eliminating oil-fired plants from the nation's base loaded electrical capacity.'"

See also Energy Supply and Environmental Coordination Act of 1974, Public Law No. 93-319, §2 (June 22, 1974).

80. Gary, M., R. McAfee, Jr., and C. L. Wolf, eds., 1972, Glossary of Geology, American Geological Institute, Washington, D.C., 805p.

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