APPLICATION FOR PERMIT

UNDERGROUND COAL MINING.

Garfield County, Utah

Davies Coal Mine

Date 8-20-91

Transportation - Marketing - Management

H. SAM NESLEN
Consultant

801-298-3459

1492 East 1200 South
Bountiful, Utah 84010

MARK K. BOYLE
ATTORNEY AT LAW
AMERICAN TOWER, SUITE 1506 S.
44 WEST BROADWAY
SALT LAKE CITY, UTAH 84101
(801) 364-0511

Submitted by:

GARFIELD COAL COMPANY

Submitted to:

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS, AND MINING
Salt Lake City, Utah

RECEIVED
AUG 20 1991
DIVISION OF
OIL GAS & MINING

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments that, based on my inquire of those persons immediately responsible for obtaining certain information in this permit application, I believe the information is true, accurate and correct. I am aware that there are significant penalties for submitting false information, including the possibilty of fine and imprisonment.

Alfred L. Foster

Alfred L. Foster, President
GARFIELD COAL COMPANY

8-20-91

Date

Garfield Coal Company
Coal Mining • "Dedicated To A Clean Environment"
Star Route
Panguitch, Utah 84759
(801) 834-5227
Fax (801) 834-5304

Facility Name

GARFIELD COAL COMPANY, a Utah Corporation

Facility Contact

Al Foster, President
801-834-5227

Facility Location

T.36S, R.2W

1.- NONE OF THE PROPOSED MINING WILL BE ON INDIAN LANDS.

2.- THE 42 YEAR CHRONOLOGICAL HISTORY, SUPPORTED BY EVIDENCE SUPPORT DOCUMENTS SHOWS PRE-EXISTING RIGHTS FOR THE DAVIES COAL MINE.

3.- NOTICE OF INTENT TO MINE WAS FILED ON MARCH 27, 1982.

Garfield Coal Company
Coal Mining • "Dedicated To A Clean Environment"
Star Route
Panguitch, Utah 84759
(801) 834-5227
Fax (801) 834-5304

STATEMENTS BY APPLICANT

1.- Applicant does not now hold or has had a previous mining permit subsequent to 1970.

2.- Applicant has never had a Federal or State mining permit suspended or revoked.

3.- Applicant has never forfeited a mining bond or similar security deposited in lieu of bond.

4.- Applicant has had no administrative or judicial proceedings, what-so-ever.

5.- Applicant has no other licenses or permits connected with this application.

6.- Applicant states this mine and State Coal Lease is not in an area designated unsuitable for underground mining or the surface effects there-from.

7.- Applicant states mining will be by continuous miner with continuous haulage system. Estimated first year production 25,000 ton low and 50,000 ton high.

8.- Mine will operate with one section having one production shift per day and one maintenance shift.

9.- Large production is not projected - mining for local consumption only. Two small co-generation plants are projected, one in Escalante Utah and one in Panguitch Utah utilizing the major part of coal production. Federal Energy regulatory permits for these co-generation plants were issued in November 17, 1987. Docket # QF87-576-000 and #QF87-577-000 to Escalante - Panguitch Micro Energy Co-Generation Inc. (Not affiliated with Garfield Coal Company) NO PROTESTS OR PETITIONS TO INTERVENE HAVE BEEN FILED.

GARFIELD COAL COMPANY
Alfred L. Foster, President

TYPE OF PROJECT: Proposed Coal Mine COUNTY: Garfield

PROJECT NAME: Davies Mine OGM File # ACT/017/020

COMPANY: Garfield Coal Co.
3455 S. State, SLC, Ut. 84111

LOCATION: Vicinity of Bryce Canyon T 36 S R 2 W

RESOURCE BASE: Not Available
In Place Reserves:
Recoverable Reserves:
Coal Field: Kaiparowits

RESOURCE CHARACTERISTICS:
BTU:
Sulfur:
Not Available

YEAR	PRODUCTION (MMT)	EMPLOYMENT CONSTRUCTION	EMPLOYMENT OPERATIONS
1980			
1981			
1982			
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990			

TECHNOLOGY:

Underground

LEASE ACREAGE:

Not Available
Private
State
Federal
Total Acres

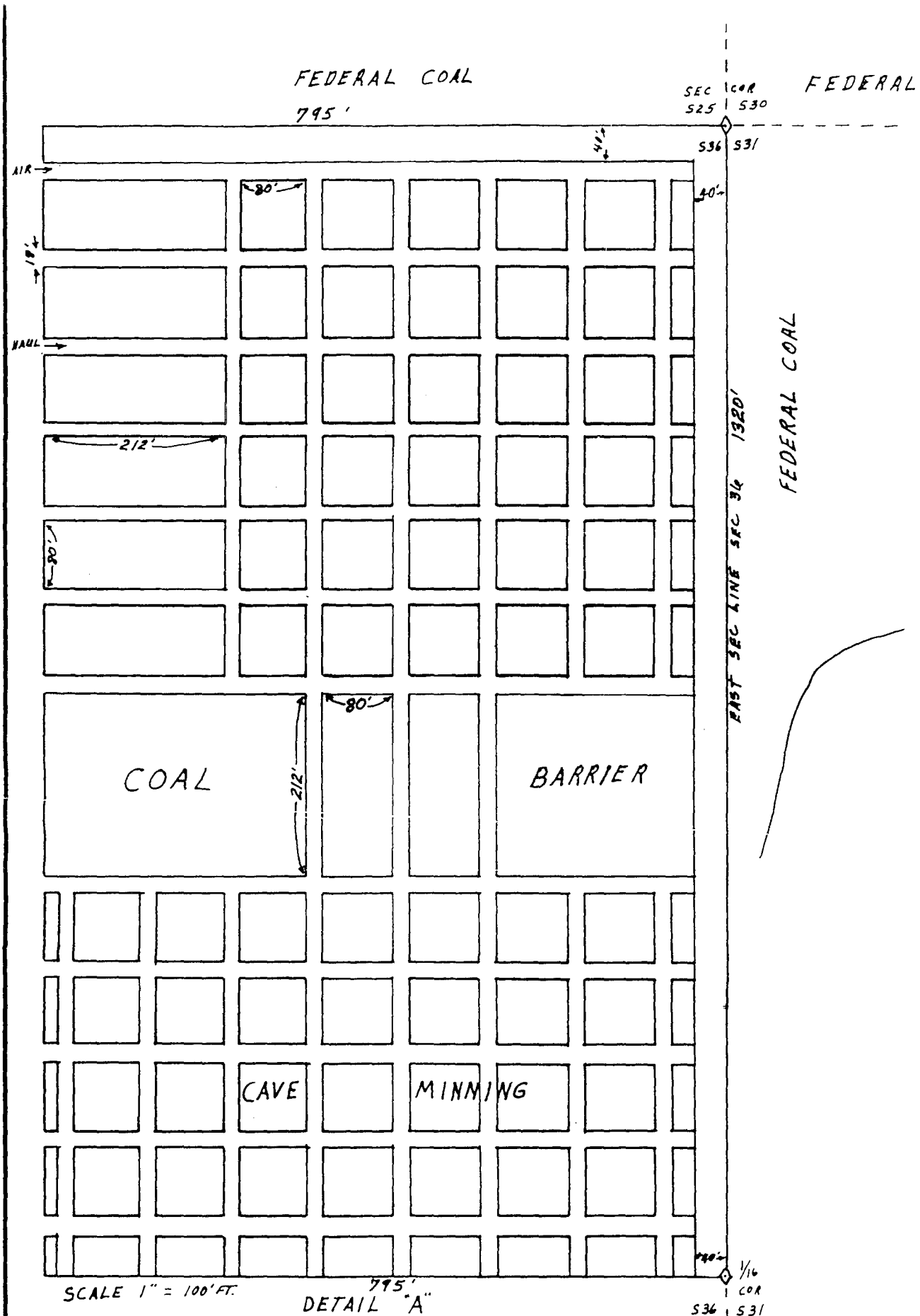
DEVELOPMENT STAGES:

1 LACC	2 IDOGM	3 EHPDC	4 PRO	5 MPS	6 MPA	7 CC	8 CP

CURRENT STATUS: Inactive

COMMENTS:

Mine plan previously submitted to OGM. Currently on inactive list. Would have to return to stage two for development.



DETAIL "A"

ENTRIES = 9' X 18'
COAL PILLARS = 80' X 80'
CAVE MINNING ON LOWER PORTION OF LEASE ONLY.

PROPOSED MINNING PLAN

STATE OF UTAH

NORMAN H. BANGERTER
GOVERNOR

OFFICE OF THE GOVERNOR
SALT LAKE CITY
84114

December 23, 1989

Mr. Alfred Foster
Garfield Coal Company
Bryce Canyon, Utah 84717

Dear Mr. Foster:

I would like to take this opportunity to acknowledge your efforts to develop coal reserves in Garfield-County, Utah. Development is important to our rural areas and to the wise use of our state's most valuable resources.

Garfield County also contains some of the most spectacular scenery in the world; scenery which supports a growing tourist industry. With wise planning, this area can support concurrent growth in both industries. I encourage you to work closely with the Division of Oil, Gas, and Mining, and other federal, state, and local agencies as you plan and permit this operation. Those agencies will give your proposal a timely and equitable review.

Again, thank you for your interest in the development of Utah's resources and the growth of our rural industries.

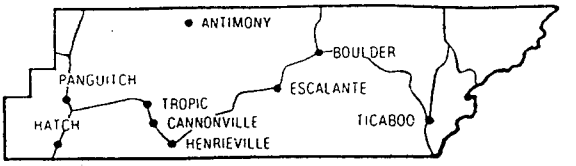
Sincerely,

Norman H. Bangerter
Governor

NHB;clg

COUNTY COMMISSION
Tom Hatch
Sherrell Ott
Louise Liston
Hazel Rich, Clerk

GARFIELD COUNTY



Tom Simkins, Assessor
Patrick B. Nolan, Attorney
Mamie D. Hatch, Recorder
Judy Henrie, Treasurer
Robert Judd, Sheriff
John W. Yardley, Justice of the Peace

P.O. BOX 77
PANGUITCH, UTAH 84759

February 7, 1990

Mr. Leonard Decker
Decker Coal Company

Reference: GARFIELD COAL CO.

Dear Mr. Decker:

This letter is to confirm that Garfield County will construct the road which we have discussed into the coal mine, consisting of a six (6) inch gravel base sealed with permazyme.

Should you need any further information please feel free to call.

Very truly yours,

Sherrell Ott

Sherrell Ott
Garfield County Commissioner

SO/pj
pc: file

CHRONOLOGICAL HISTORY

OF THE "DAVIES COAL MINE".

GARFIELD COUNTY UTAH

1920's - Mr. Jack Pollock mined coal in the "Jimmie Canyon" area, across the canyon, westerly, from the DAVIES COAL MINE. Coal mined was for local consumption by team and wagon.

1950's - Mr. Byron Davies, a local well known Geologist, Mr. Bert Abel, financier, and Mr. J.D. Stack,Vice President Denver & Rio Grand Railroad formed the BRYCE CANYON COAL & COKE COMPANY, Cannonville, Utah. They envisioned bringing in the railroad from Marysvale Utah to haul the coal from the DAVIES COAL MINE, but the death of Mr. Stack stopped the railroad idea. Byron Davies and Mr. Abel persisted in the mine preparation and road building work, evidenced by their many checks written in the 1950's on the UTAH FIRST NATIONAL BANK of Salt Lake City.

Their check #1032 dated July 15, 1952 was one of the first checks to the STATE OF UTAH for royalty payments at 12.5% on 12 tons of mined coal, in the amount of $6.00. In those days $6.00 was a great deal of money, as well as the $10,000 spent on the coal mine, installing the chute, generator, explosives, and other items found within their check-book.

1951 - Mr. Wallace Ott of Tropic Utah purchased into the BRYCE CANYON COAL & COKE COMPANY on August 15, 1951 for $206.00 with a 60 day post dated check, until he sold a cow to raise the money. (Of course Mr. CRANDEL at the First State Bank of Salina would have honored the check, and everyone knew this)

1952 - By this time, Byron Davies and Frank Shakespear had driven two "entries" into the coal out crop, some 85 feet, Easterly, mining over 100 tons of good coal. Mr. Abel had to drop out of the company.

1960 - The road to the mine was a constant problem due to the run-off waters, and having no culverts and our now modern equipment, it became a costly problem for the Company.

1966 - In this remote area, so to speak, survey pegs were very hard to find. Wallace Ott found a survey peg, and they determined just where they were, and filed the present UTAH STATE COAL LEASE,

CHRONOLOGICAL HISTORY

OF THE "DAVIES COAL MINE".

Continued

1966 - Byron Davies and Al Foster, being associated in the mining of Bentonite, teamed up to get the DAVIES COAL MINE into a better production picture. Foster brings in heavy equipment such as a D-8 Cat and #6 Traxcavator, and once again up grades the road up to the mine. About 100 tons of coal was mined still mining the "hard way".

1974 - At the direction of the COUNTY COMMISSION, the County Road Crew pitched in and helped on the mine road because local people were wanting coal for the winter. Approximately 300 tons were mined for local consumtion.

1977 - With Byron Davies health a problem, Foster & Davies travel to Salt Lake City and form GARFIELD COAL COMPANY, a Utah Corporation to obtain fresh financial help. GARFIELD COAL COMPANY was all ready to begin larger operations, when the Environmentalists protested the proposed ALTON strip mining project, near BRYCE CANYON NATIONAL PARK. The protestors drew a circle around the PARK which also took in our DAVIES underground coal mine.

1980 - The strip mining project at ALTON lost its case, and the SECRETARY OF THE INTERIOR ruled that the DAVIES COAL MINE was indeed acceptable for underground coal mining near the PARK because we are so totally hidden from view on Utah State Land. GARFIELD COAL COMPANY lost an overseas coal contract due to the Environmental protest on a mining operation not remotely connected to the DAVIES MINE.

1982 - GARFIELD COAL COMPANY continues further development of the DAVIES COAL MINE with a $7,505.00 contract to Lyman Construction Company and files their NOTICE OF INTENT TO MINE ON March 27, 1982.

Todate Financial and other preparations proceeding on schedule. This 42 year history, supported by evidence of support documents shows PRE-EXISTING RIGHTS for the DAVIES COAL MINE.

Alfred L. Foster

GARFIELD COAL COMPANY
Alfred L. Foster, President

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE		AMOUNT
Dec. 19, 1952		
Utah State Coal Lease Rental 1952		

NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN

31-5
1240

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

SALT LAKE CITY, UTAH Dec. 19 1952 No. 1041

PAY TO THE ORDER OF Utah State Land Board $20 00

Twenty + 00/100 ---------- DOLLARS

BRYCE CANYON COAL & COKE CO.

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

FORM R

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE		AMOUNT
July 15 1953		
Royalty on Coal		

NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN

31-5
1240

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

SALT LAKE CITY, UTAH July 15 1953 No. 1032

PAY TO THE ORDER OF Utah State Land Board $6 00

Six + 00/100 ---------- DOLLARS

BRYCE CANYON COAL & COKE CO.

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

H-10098

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE		AMOUNT
June 30, 1952		
Mine Supplies		

NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

31-5
1240

SALT LAKE CITY, UTAH June 30 1952 NO. 1033

PAY TO THE ORDER OF Thompson Company $76.00

Seventy Five and 00/100 DOLLARS

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

BRYCE CANYON COAL & COKE CO.
A. Hill Allen
Byron Haines

FORM R

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE		AMOUNT
June 30 - 1952		
Mine Supplies		
for Cash		

NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

31-5
1240

SALT LAKE CITY, UTAH June 30 1952 NO. 1029

PAY TO THE ORDER OF Mine & Smelter Supply $118.00

One Hundred Eighteen and 00/100 DOLLARS

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

BRYCE CANYON COAL & COKE CO.
A. Hill Allen
Byron Haines

FORM R

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE	AMOUNT
5 19	1000 -
advanced for Road to Coal Mine	

NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

31-5
1240

SALT LAKE CITY, UTAH 5-19 19 51 No. 1000

PAY TO THE ORDER OF Bert Abel $1000 00

One Thousand and 00/100 DOLLARS

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

BRYCE CANYON COAL & COKE CO.
Bert Abel pres.
Byron Davis V Pres

FORM R

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE	AMOUNT
5 19	51 00 --
Surveying Water Line.	
Transferring Coal Lease	
80 Acres Coal - Filing and Land	

NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

31-5
1240

SALT LAKE CITY, UTAH 5-19 19 51 No. 1002

PAY TO THE ORDER OF Bert Abel $560 00

Five hundred Sixty and 00/100 DOLLARS

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

BRYCE CANYON COAL & COKE CO.
Bert Abel pres.
Byron Davis V. Pres.

FORM R

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE	AMOUNT
5/15	1000 -
Additional Coast to complete road to Mine	

NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

31-5
1240

SALT LAKE CITY, UTAH 5-15 19 51 No. 1004

PAY TO THE ORDER OF Byron Davis $1000 00

One Thousand and 00/100 DOLLARS

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

BRYCE CANYON COAL & COKE CO.
Bert Abel pres.
Byron Davis V. Pres

FORM R

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE	AMOUNT
11/14/51	113 02
Election Cafe & Cabl	
NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN	

BRYCE CANYON COAL & COKE CO.
CANNONVILLE UTAH

2

31-5
1240

SALT LAKE CITY, UTAH Nov. 16 1951 No. 1022

PAY TO THE ORDER OF Pearson & Crofts $113 02

One Hundred Thirteen & 02/100 DOLLARS

BRYCE CANYON COAL & COKE CO.
Bert Alef
Byron Vanes

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

FORM R

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE	AMOUNT
Coal Land Application	
NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN	

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

31-5
1240

SALT LAKE CITY UTAH June 1 1952 No. 1023

PAY TO THE ORDER OF United State Treasury $10 00

Ten & 00/100 DOLLARS

THIS CHECK IS IN PAYMENT OF AN OBLIGATION TO THE UNITED STATES AND MUST BE PAID AT PAR. N. P. AS NON-PAYMENT

07001

BRYCE CANYON COAL & COKE CO.
Bert Alef
Byron Vanes

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
15770 SALT LAKE CITY, UTAH

FORM R

BY ENDORSEMENT THIS CHECK IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE	AMOUNT
6/27	1000 -
Additional Money for Completion of Mine	
NO RECEIPT NECESSARY IF INCORRECT PLEASE RETURN	

BRYCE CANYON COAL & COKE CO.
CANNONVILLE, UTAH

31-5
1240

SALT LAKE CITY, UTAH 6-27-51 No. 1006

PAY TO THE ORDER OF Byron Davies $ 1000 00

One Thousand and 00/100 DOLLARS

TWO SIGNATURES REQUIRED

BRYCE CANYON COAL & COKE CO.
Bert Alef Pres.
Byron Vanes V.P.

UTAH FIRST NATIONAL BANK
OF SALT LAKE CITY
SALT LAKE CITY, UTAH

FORM R

Cannonville, Utah
August 15, 1951

To Whom It May Concern:

This agreement, dated the 15th of August, 1951, by and between Byron Davies, Cannonville, Utah, and Wallace Ott, Tropic, Utah.

Witnesseth:

Whereas, I Byron Davies do own 39% of the Bryce Canyon Coal and Coke Company, the principal asset of this company being Federal Coal Lease S. L. Serial Number 064862, located in Township 36 South, Range 2 West, Salt Lake Base Meridian.

B.D. <---- Also Utah State Coal Lease NE¼ NE¼ Sec. 36, Tp. 36 S., R. 2 W.

Whereas, I Byron Davies, for $10.00 (Ten Dollars) and other good and valuable considerations do hereby sell, assign and convey to Wallace Ott 10% (ten per cent) of stock and assets in the Bryces Canyon Coal and Coke Company. This said 10% equals 10/39 of Byron Davies' interest in the Bryce Canyon Coal and Coke Company.

Byron Davies

Garda Davies

State of Utah

County of Garfield

On this 15th day of August, 1951, before me personally appeared Byron Daviesto me known to be the person described in and who executed the foregoing instrument and acknowledged that he executed the same as his free act and deed.

Given uner my hand and official seal this 16th day of August 1951 A.D.

Wilford Clark
Notary Public

My commission expires
4-17-52

Residing at Cannonville Utah

97-92
1243

FIRST STATE BANK OF SALINA

SALINA, UTAH Oct. 8 19__ No. ______ 206.00

PAY TO THE ORDER OF Byron Davis $206.00/xx

Two Hundred and Six ——————— DOLLARS

W. C. Wallace, Jr.

BOYLE & BOYLE
ATTORNEYS AT LAW
SUITE 400
10 BROADWAY BUILDING
SALT LAKE CITY, UTAH 84101
(801) 363-3550

MARK K. BOYLE
MICK BOYLE

March 3, 1982

Lincoln Lyman
Escalante, Utah

Re: Garfield Coal Company

Dear Lincoln:

This will confirm our telephone conversation of this date supplementing a previous conversation last week regarding the earth moving work you have discussed with Al Foster on behalf of Garfield Coal Company.

Al has indicated to you, generally, what we have in mind with regard to the access road and the work in and about the face of the mine and the plateau area around the face.

You advised that your cat work will be on the basis of $90.00 per hour and that will include a rough road to the face, the work around the face and the plateau area, which you estimate to be between $8,000 and $10,000 total, even though these estimates are rough, either on the low or the high side.

I indicated that we have approximately $5,600 in the bank committed to this project, and we agreed that before you get to an expenditure of $5,000, you will contact us to determine what future expenditures are required. It is our understanding that you will be in a daily contact with Al so that we will all be apprised as to how the project is progressing.

You indicated that you will be able to start either March 5th or the weekend of March 5th, and that you should be in a position to give us a report within ten days from your start-up time.

By copies of this letter to Al Foster and the other members of the Board of Directors, we are hereby committing the Garfield Coal Company to the project outlined above.

Best regards,

Mark K. Boyle

MKB/mr
cc: Al Foster
Larry Mills
Sam Neslen

Lincoln Lyman Construction Co., Inc.
Phone 826-4229
Escalante, Utah 84726

Nº 2840

Tractor Service

Cat and Backhoe

Concrete Work

Trucking

BOYLE & BOYLE

SUITE 400 10 BROADWAY BUILDING

SALT LAKE CITY, UTAH 84101

Date	Work Done	Time	Amount
	REQUEST FOR PAYMENT FOR WORK DONE FOR GARFIELD COAL CO.:		
3-4-82	Working on road intocoal mine loaation. H-D-21 @ $95.00 per hr.	5 hrs	$ 475.00
3-5-82	Working on road and starting to cut off over burden, to make landing and access to vane of coal. H-D-21 @ $95.00 per hr.	7 hrs	665.00
3-8-82	Working on portal entry and landing. H-D-21 @ $95.00 per hr.	7 hrs	665.00
3-9-82	Working on portal entry and landing. H-D-21 @ $95.00 per hr.	2 hrs	190.00
3-10-82	Working on portal entry and landing. H-D-21 @ $95.00 per hr.	2 hrs	190.00
3-11-82	Working on portal entry and landing. H-D-21 @ $95.00pper hr.	7 hrs	665.00
3-12-82	Working on portal entry and landing. H-D-21 @ $95.00 per hr.	7 hrs	665.00
3-15-82	Working on portal entry and landing H-D-21 @ $95.00 per hr.	7 hrs	665.00
3-16-82	Working on portal entry and landing. H-D-21 @ $95.00 per hr.	7 hrs	665.00
3-17-82	Working on portal entry and landing. H-D-21 @ $95.00 per hr.	7 hrs	665.00
3-18-82	Working on portal entry and landing. H-D-21 @ $95.00 per hr.	7 hrs	665.00
3-19-82	Working on portal entry and landing. H-D-21 @ $95.00 perhr.	7 hrs	665.00
3-22-82	Working on portal entry and landing. H-D-21 @ $95.00 perhhr.	7 hrs	665.00
	TOTAL		

BOYLE & BOYLE
ATTORNEYS AT LAW
SUITE 400
10 BROADWAY BUILDING
SALT LAKE CITY, UTAH 84101
(801) 363-3550

MARK K. BOYLE
MICK BOYLE

April 9, 1982

Lincoln Lyman
% Lincoln Lyman Construction Company
Escalante, Utah 84726

Dear Lincoln:

Enclosed is Garfield Coal Company's check No. 26 in the amount of $7,505.00 representing payment in full for the road and portal work you did for that company beginning March 4th and ending March 22nd, 1982. This is in payment of the invoice submitted to Boyle & Boyle, a copy of which is enclosed herewith.

It is my understanding that this is full payment for the entire job which we authorized and which you have completed.

Very truly yours,

Mark K. Boyle

MKB/mr
Enclosure
cc: Larry Mills
Sam Neslen
Al Foster

BY ENDORSEMENT THIS CHECK WHEN PAID IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE		AMOUNT
Federal Coal Lease Application —		
TOTAL OF INVOICES		
LESS % DISCOUNT		
LESS		
TOTAL DEDUCTIONS		
AMOUNT OF CHECK		

June 29, 1982

IF INCORRECT PLEASE RETURN. NO RECEIPT NECESSARY.

Rocky Mountain Bank Note F

GARFIELD COAL COMPANY
345 SOUTH STATE STREET
SALT LAKE CITY, UTAH 84111

021

97-152/1243

6-29-82 19

Pay to the order of Dept of the Int. - BLM $ 250.00

Two hundred fifty + no/100 Dollars

Bank of Iron County
PAROWAN, UTAH 84761

GARFIELD COAL COMPANY

Mark Boyack

Laurence Mills

⑆1243⑆0152⑆ 005 683 9⑈ ⑈0000250⑆

BY ENDORSEMENT THIS CHECK WHEN PAID IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE		AMOUNT
Filing fee		
TOTAL OF INVOICES		
LESS % DISCOUNT		
LESS		
TOTAL DEDUCTIONS		
AMOUNT OF CHECK		

IF INCORRECT PLEASE RETURN. NO RECEIPT NECESSARY.

Rocky Mountain Bank Note F

GARFIELD COAL COMPANY
345 SOUTH STATE STREET
SALT LAKE CITY, UTAH 84111

022

97-152/1243

6-29-82 19

Pay to the order of Dept of the Int - BLM $ 10.00

Ten + no/100 Dollars

Bank of Iron County
PAROWAN, UTAH 84761

GARFIELD COAL COMPANY

Mark Boyack

Laurence Mills

⑆1243⑆0152⑆ 005 683 9⑈

BY ENDORSEMENT THIS CHECK WHEN PAID IS ACCEPTED IN FULL PAYMENT OF THE FOLLOWING ACCOUNT

DATE		AMOUNT
TOTAL OF INVOICES		
LESS % DISCOUNT		
LESS		
TOTAL DEDUCTIONS		
AMOUNT OF CHECK		

IF INCORRECT PLEASE RETURN. NO RECEIPT NECESSARY.

Rocky Mountain Bank Note F

GARFIELD COAL COMPANY
345 SOUTH STATE STREET
SALT LAKE CITY, UTAH 84111

026

97-152/1243

April 9 19 82

Pay to the order of ~~Lincoln Lyman Construction Company~~ $ 7,505.00*

**Seven thousand five hundred five and no/100------ Dollars

Bank of Iron County
PAROWAN, UTAH 84761

GARFIELD COAL COMPANY

Mark Boyack

Laurence Mills

⑆1243⑆0152⑆ 005 683 9⑈ ⑈0007505⑆

[C NOTICES
E PEOPLE MUST KNOW'
Guardianship Notices
f District Court or the
for further information.

U.S. DEPARTMENT OF INTERIOR OFFICE OF SURFACE MINING

Notice of Receipt of a Complete Petition for Designation of Lands as Unsuitable for Surface Coal Mining Operations

AGENCY: Office of Surface Mining Reclamation and Enforcement

ACTION: Notice of Receipt of a Complete Petition for Designation of Lands as Unsuitable for Surface Coal Mining Operations

SUMMARY: Pursuant to Section 769.16 of Title 30, Code of Federal Regulations, notice is given that the Office of Surface Mining has received a petition to designate certain Federal lands in southern Utah as unsuitable for mining. The petition is described below:

LOCATION OF LANDS PETITIONED FOR DESIGNATION

Petitioners: Environmental Defense Fund, Friends of the Earth, Sierra Club Legal Defense Fund, Sylvan Johnson, Leon Lippincott, Caroline Lippincott, Jet Mackelprang, Cynthia Myers, Susan Hittson and Larry Little

State: Utah

Counties: Kane and Garfield

Township, Range, Section: The federal lands within Salt Lake Meridian, Utah

T.40S, R.6W, S.L.M.
T.40S, R.5W, S.L.M.
T.40S, R.4-½W, S.L.M.
T.40S, R.4W, S.L.M.
T.39S, R.6W, S.L.M.
T.39S, R.5W, S.L.M.
T.39S, R.4-½W, S.L.M.
T.39S, R.4W, S.L.M.
T.38S, R.4W, S.L.M.
T.38S, R.3W, S.L.M.
T.37S, R.4W, S.L.M.
T.37S, R.3W, S.L.M.

A public hearing is planned for late September 1980, notice of which will be given prior to the hearing. A decision on the petition will be made by November 28, 1980.

This notice is issued at this time for the convenience of the public. The public file on the petition is available for public review during normal working hours at the Division of State and Federal Programs, Office of Surface Mining, Region V, second floor, Brooks Towers, 1020 15th Street, Denver, Colorado and at the Kanab Resource Area Headquarters, Bureau of Land Management, 320 North 1st East, Kanab, Utah.

Copies of the petition are available to the public from the Office of Surface Mining, Region V. Relevant information and comments on the issues raised in the petition are solicited.

FOR FURTHER INFORMATION CONTACT:

Barbara J. West, Office of Surface Mining, REGION V, Brooks Towers, 1020 15th Street, Denver, Colorado 80202.

SUPPLEMENTAL INFORMATONI:

Under Section 522 of the Surface Mining Reclamation and Control Act of 1977 and its implementing regulations, persons with interests which are or may be adversely affected by surface coal mining operations may petition the Office of Surface Mining to have an area desiganted as unsuitable for all or certain types of surface coal mining operations. In the petition submitted to OSM, the petitioners allege that (1) the lands in question could not be reclaimed in accordance with the requirements of the Act; (2) surface coal mining operations could result in significant damage to

[illegible] and
Garfield

Township, Range, Section: The federal lands within Salt Lake Meridian, Utah

T.40S, R.6W, S.L.M.
T.40S, R.5W, S.L.M.
T.40S, R.4-½W, S.L.M.
T.40S, R.4W, S.L.M.
T.39S, R.6W, S.L.M.
T.39S, R.5W, S.L.M.
T.39S, R.4-½W, S.L.M.
T.39S, R.4W, S.L.M.
T.38S, R.4W, S.L.M.
T.38S, R.3W, S.L.M.
T.37S, R.4W, S.L.M.
T.37S, R.3W, S.L.M.
T.37S, R.2W, S.L.M.
T.36S, R.3W, S.L.M.
T.36S, R.2W, S.L.M.

Office of Surface Mining Reference Number: 79-5-001

The petition, filed under Section 522 of the Surface Mining Control and Reclamation Act of 1977, seeks to have specified Federal lands in the area of Bryce Canyon National Park and the Dixie National Forest declared as unsuitable for mining. The petition was submitted to the Office of Surface Mining on November 28, 1979 and was found to be complete on December 27, 1979.

A review of the area's suitability for mining has been undertaken by this office. In addition, the Bureau of Land Management — Utah State Office and the Utah Regional Forester — United States Forest Service as the surface managing agencies for the petitioned area will make recommendations on the petition.

adversely affected by surface coal mining operations may petition the Office of Surface Mining to have an area desiganted as unsuitable for all or certain types of surface coal mining operations. In the petition submitted to OSM, the petitioners allege that (1) the lands in question could not be reclaimed in accordance with the requirements of the Act; (2) surface coal mining operations could result in significant damage to important historic, cultural, scientific, and aesthetic values and natural systems of fragile lands; and (3) such operations could result in a substantial loss or reductin of long-range productivity of water supply or of food or fiber products, including damage to aquifers and aquifer recharge areas of renewable resource lands. The proximity of mineable coal lands to Bryce Canyon National Park and the Dixie National Forest and the possible adverse affects of mining on the Park and Forest are of particular concern to the petitioners.

After completion of the analyses and hearing mentioned above, the Department can designate the area or a portion thereof as unsuitable for all or certain types of surface coal mining operations (which includes the surface effects of underground mining). The agency may also find the area as suitable for surface coal mining operations.

Information on which to base analyses of the issues raised by the petitioners is being sought from all interested parties.

Donald A. Crane
Regional Director

Published in the Garfield County News Jan. 31, Feb. 7, 1980.

United States Department of the Interior
OFFICE OF SURFACE MINING
Reclamation and Enforcement
BROOKS TOWERS
1020 15TH STREET
DENVER, COLORADO 80202

OFFICE OF THE REGIONAL DIRECTOR

January 16, 1980

Alfred and Leda Mae Foster
c/o James O. Thomas
Tropic, UT 84766

Dear Mr. and Mrs. Foster:

The Office of Surface Mining (OSM) has received a petition to designate specified Federal lands in the Alton-Bryce Canyon area as unsuitable for surface coal mining operations. Because our records indicate that you are an owner of interest in the area covered by this petition, we are sending you this information so that you will know about the petition process and how you can participate in it.

The petition is described below:

Petitioners:	Environmental Defense Fund, Friends of the Earth, Sierra Club Legal Defense Fund, Sylvan Johnson, Leon Lippincott, Caroline Lippincott, Jet Mackelprang, Cynthia Myers, Susan Hittson, and Larry Little.
State:	Utah
Counties:	Kane and Garfield
Location:	All Federal lands within the following townships:

T.40S, R.6W; T.40S, R.5W; T.40S, R.4-1/2W; T.40S, R.4W; T.39S, R.6W; T.39S, R.5W; T.39S, R.4-1/2W; T.39S, R.4W; T.38S, R.4W; T.38S, R.3W; T.37S, R.4W; T.37S, R.3W; T.37S, R.2W; T.36S, R.3W; and T.36S, R.2W; Salt Lake Meridian (S.L.M.), Utah.

Office of Surface Mining Reference Number:	79-5-001

The petition, filed under Section 522 of the Surface Mining Control and Reclamation Act, was submitted to this office on November 28, 1979. It was found to be complete on December 27, 1979.

GARFIELD COAL COMPANY
Attention: A.L. Foster
Star Route
Panguitch, Utah 84759
(801) 834-5227

United States Department of the Interior
Office of Surface Mining
Reclamation and Enforcement
Brooks Towers
1020 15th Street
Denver, Colorado 80202

Attention: Donald A. Crane, Regional Director:

RE: Notice of receipt of a complete petition for designation of lands as unsuitable for Surface Coal Mining Operations. Ref: #79-5-001

Dear Mr. Crane,

We have received your letter of January 16, 1980, and have noticed the publication of the above mentioned protest in the GARFIELD COUNTY NEWS, January 31, 1980. Garfield Coal Company (A Utah Corporation) is an interested party in this Environmental petition because of our mining property located in T.36S, R.2W, under Utah State Coal Lease #23331. Our mining operations have been, and would be in future operations, strictly underground mining in the Straight Cliffs geological formation, and more specifically the "Henderson Coal Zone" near the town of Henrieville, Utah. More specifically we are located in the "Kaiparowits Plateau Coal Field". We are in fact, directly East approximately twenty miles from BRYCE CANYON NATIONAL PARK.

It is our belief the Petitioners are more concerned with the surface mining of coal found within the "Kanab Coal Field" which is bounded on the East by the Paunsaugunt Fault and on the West by the Sevier Fault. Locally, we call this 'Dakota Coal' because it is found within the Dakota Formation and in many cases can be surfaced mined. In the Petitioners' efforts to protect our environment and the area around BRYCE CANYON NATIONAL PARK, they undoubtedly drew a circle around the Park, and protested a blanket area of land. In doing so they most assuredly took in our property, in which, we are endeavoring a minimum ten million dollar investment program, and now is hanging in the balance, until this petition is adjudicated! We find, after this petition, we are unable to answer the "Proposal Solicitations" from the Department of Energy, as indeed, we are on their 'Source List' for development of our Nations' coal fields which is the intent of our National Policy towards energy independence.

We ask your office to be fully aware of the following salient features of any and all operations that would be factual in the mining operations of our property;

1. Our mining methods would only be underground in the 'Straight Cliffs Formation' with 800 to 1000 feet of over-burden over our mine.

2. Any resultant surface indention would be absolutely impossible to see or notice, especially from BRYCE CANYON NATIONAL PARK.

3. It is impossible for people to notice or see visually any of our mining operations on the mining site. We are located approximately three miles from the main highway #12, hidden completely in 'Jimmie Canyon'.

4. Trucks hauling our coal would be seen by the public, however, for the past twelve years similar large trucks have hauled oil from the 'Upper Valley' oil field over the same highway #12 we would be utilizing, with no adverse affects.

5. Our underground operations would not create a substantial loss or reduction of long range productivity of water supply or of food or fiber products.

6. Our mining operations would not damage important historic, cultural, scientific, and aesthetic values and natural systems of fragile lands.

7. Our start-up operations will only be on Utah State Coal Lease #23331. At some future date it is entirely possible for us to become involved on Federal Land.

8. Almost as long as BRYCE CANYON NATIONAL PARK has been in Garfield County (1923), Tourism and the hauling of timber (logs) on our highways in and around the PARK have been compatible with one another.

9. Attached are signatures of many of our leading citizens who have signed a petition endorsing the mining of coal in Garfield

We are happy to participate in this process and trust we have submitted relevant information which should be considered by your office.

very truly yours,

Alfred L. Foster

Alfred L. Foster, President
GARFIELD COAL COMPANY
Star Route
Panguitch, Utah, 84759
(801) 834-5227

March 19, 1980

United States Department of the Interior
OFFICE OF SURFACE MINING
Reclamation and Enforcement
BROOKS TOWERS
1020 15TH STREET
DENVER, COLORADO 80202

OFFICE OF THE REGIONAL DIRECTOR

28 MAR 1980

Mr. Alfred L. Foster
Garfield County Coal Company
Star Route
Panguitch, Utah 84759

Dear Mr. Foster:

Thank you for your detailed and informative letter. We appreciate your concerns and will most assuredly consider your comments in our analysis of the allegations in the petition.

The petition concerns itself only with Federal lands (that is, Federal coal and/or Federal surface) so that your operations on State lands will not be affected by the decision on the petition. Perhaps I should explain that the Secretary of Interior's decision on the petition will not necessarily be one of declaring the area unsuitable for all mining or of rejecting the petition in its entirety. He can, for example, find the area unsuitable for surface mining methods but acceptable for underground mining. He could also find the area unsuitable for mining visible from Park but allow mining on those Federal lands where the mining activities (ventilation, shafts, portals, etc.) could not be seen.

We are working with other Federal agencies to balance the competing resource values which have been raised in the petition. Your comments will assist us in that analysis. We hope that you will participate in the public hearing to be held in late September. If you have any further questions or would like to make us aware of any further information, please do not hesitate to contact me.

Sincerely,

Don Crane

DONALD A. CRANE

PUBLIC SCOPING MEETING

on the

EVALUATION OF A PETITION TO DESIGNATE CERTAIN FEDERAL LANDS UNSUITABLE FOR COAL MINING IN SOUTHERN UTAH

TRANSCRIPT OF PROCEEDINGS

Red Hills Motel Convention Center, Kanab, Utah

REPORTED BY: Carilee Beus

DATE: May 6, 1980

DAVIS & SANCHEZ

Your Professional Reporters

812 BOSTON BUILDING • SALT LAKE CITY, UTAH 84111

(801) 363-7939

Utah, which would be examined and which were favorable for development and unfavorable for development. We went through every lease of the State and I gave the environmentalist viewpoint on each of those leases and when the Shakespear mine came up, I indicated that the environmentalist could not oppose the Shakespear mine because it was a small mine. It was meant for local uses and it was a deep mine and I still feel very strongly about that, although it is inside the boundary lines of this petitioned area.

I think it's very important to point out at this time these boundary lines were made for townships, it is a general area and Friends of the Earth is not going to oppose the development of the Shakespear mine. If you have any trouble from environmentalists opposing that mine, I want to hear about it 'cause we're not going to allow any road blocks in the way of the development of small mines, small underground mines in the State of Utah. That's a promise. I'm going to keep that to you, because coal mining is something that I do get involved with in the State of Utah. I don't want the entire area, put everything in the wilderness system and not allow any mining at all. That's not true. The Shakespear mine is a noteable exception. It is a small mine. It employs a dozen miners. It does serve an

Garfield Coal Company
Coal Mining • "Dedicated To A Clean Environment"
Star Route
Panguitch, Utah 84759
(801) 834-5227
Fax (801) 834-5304

MARCH 27, 1982

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS, AND MINING
1588 WEST NORTH TEMPLE
SALT LAKE CITY, UTAH 84116

REF: UMC 795, SMALL OPERATOR ASSISTANCE PROGRAM:

GENTLEMEN,

GARFIELD COAL COMPANY HEREBY INFORMS YOUR DIVISION OF OUR INTENT TO FILE A MINING PERMIT APPLICATION ON OUR UTAH STATE COAL LEASE #23331, LOCATED IN GARFIELD COUNTY, TO-WIT: NORTHEAST QUARTER OF NORTHEAST QUARTER OF SECTION THIRTY-SIX, TOWNSHIP THIRTY SIX SOUTH, RANGE TWO WEST, SALT LAKE MERIDIAN, CONTAINING A TOTAL OF FORTY ACRES, MORE OR LESS.

THE NAMES AND ADDRESSES OF THE OFFICERS AND STOCKHOLDERS OF GARFIELD COAL COMPANY (A UTAH CORPORATION) ARE AS FOLLOWS;

ALFRED L. FOSTER, PRESIDENT, 24 1/2 PERCENT OWNERSHIP, STAR ROUTE, PANGUITCH, UTAH, 84759, TELEPHONE 834-5227. (DIRECTOR)

LAURENCE MILLS, VICE PRESIDENT, 17 PERCENT OWNERSHIP, 77 EDGECOMBE DR. SALT LAKE CITY. (DIRECTOR)

MARK K. BOYLE, VICE PRESIDENT (LEGAL), 17 PERCENT OWNERSHIP, 10 BROADWAY BLDG. SUITE 400, SALT LAKE CITY, UTAH 84101. (DIRECTOR)

SAM NESLEN, SEC/TREASURER, 17 PERCENT OWNERSHIP, 1492 EAST 1200 SOUTH, BOUNTIFUL, UTAH 84010. (DIRECTOR)

GARDA DAVIES, STOCKHOLDER, CANNONVILLE, UTAH, 20 PERCENT OWNERSHIP.

WALLACE OTT, STOCKHOLDER, TROPIC, UTAH, 4 1/2 PERCENT OWNERSHIP.

GARFIELD COAL COMPANY WILL BE THE POTIENTIAL PERMIT APPLICANT, ALTHOUGH AT SOME FUTURE DATE A QUALIFIED OPERATOR COULD, IN FACT, BE CONTRACTED BY OUR CORPORATION, UPON APPROVAL OF THE BOARD OF DIRECTORS.

OUR ESTIMATED PRODUCTION FOR YEAR ONE, IS 15,000 TPY; YEAR TWO IS 35,000 TPY, AND YEAR THREE IS 50,000 TPY; THEREFORE, OUR PRODUCTION OF COAL WOULD NEVER EXCEED 100,000 TPY DURING ANY YEAR OF MINING UNDER A SMALL OPERATOR ASSISTANCE PROGRAM, (SOAP).

WE REQUEST ASSISTANCE UNDER THE SOAP PROGRAM IN THE EVENT YOUR

DIVISION WOULD EXTENSIVELY REQUIRE:

(A) THE DETERMINATION OF THE PROBABLE HYDROLOGIC CONSEQUENCES OF MINING AND RECLAMATION, UNDER SECTION 40-10-10 (2) (C) OF THE ACT; AND

(B) THE STATEMENT OF PHYSICAL AND CHEMICAL ANALYSES OF TEST BORINGS OR CORE SAMPLES, UNDER SECTION 40-10-10 (2) (D) OF THE ACT;

IN-WHERE, THE ANSWERS TO (A) AND (B) ABOVE BECOME SO INVOLVED, A SIZEABLE FINANCIAL OUTLAY WOULD BECOME NECESSARY.

I BRING TO YOUR ATTENTION, YOUR DIVISION ACCOMPLISHED HYDROLOGY FIELD WORK ON OUR "DAVIES-POLLOCK MINE" SOME TWO OR THREE YEARS AGO, AND FOUND WE WOULD NOT DAMAGE THE HENRIEVILLE CULINARY WATER SYSTEM. I AM SURE YOU ARE AWARE OF THE SEVERAL COMPREHENSIVE, IN-DEPTH STUDIES REGARDING WATER RESOURCES, GEOLOGY, TOPOGRAPHY, PALEONTOLOGY, VEGETATION, THREATENED OR ENDANGERED PLANTS, WILDLIFE, LAND USE, SOCIOECONOMICS, TRANSPORTATION FACILITIES, CULTURAL RESOURCES, SPECIAL DESIGNATION AREAS, VISUAL RESOURCES, RECREATION, POPULATION TRENDS, AND ENVIRONMENTAL CONSEQUENCES, TO NAME A FEW, IN REGARDS TO COAL MINING IN OUR AREA OF CONCERN. I VENTURE TO SAY; OUR GOVERNMENT HAS SPENT MORE MONEY, MAN-HOURS, PUBLICATIONS, CONTRACTED "EXPERTS", ON THE KAIPAROWITS COAL FIELD, THAN ANY OTHER FIELD, IN THE HISTORY OF THE WORLD, AND, WE HAVE NEVER MINED ONE POUND OF COAL FROM KAIPAROWITS!!!!!

ALL OF THIS COMPREHENSIVE DATA WILL BE DETAILED IN OUR MINING PERMIT APPLICATION, OF COURSE, BUT FOR THIS "SOAP" INTENT LETTER, IT NEED ONLY BE MENTIONED. WE REFER YOU TO THE "UINTA-SOUTHWESTERN UTAH - DRAFT ENVIRONMENTAL IMPACT STATEMENT, COAL" BY THE U.S. DEPT. OF THE INTERIOR - BLM.

WE WOULD BE MINING IN THE "HENDERSON COAL ZONE" FOUND WITHIN THE NORTH-WEST CORNER OF THE KAIPAROWITS COAL FIELD, BY UNDER-GROUND CONVENTIONAL METHODS, AND THE SURFACE EFFECTS WILL BE BY AERIAL PHOTOGRAPHY, ON CONTOURS, BEFORE AND AFTER THE FACT.

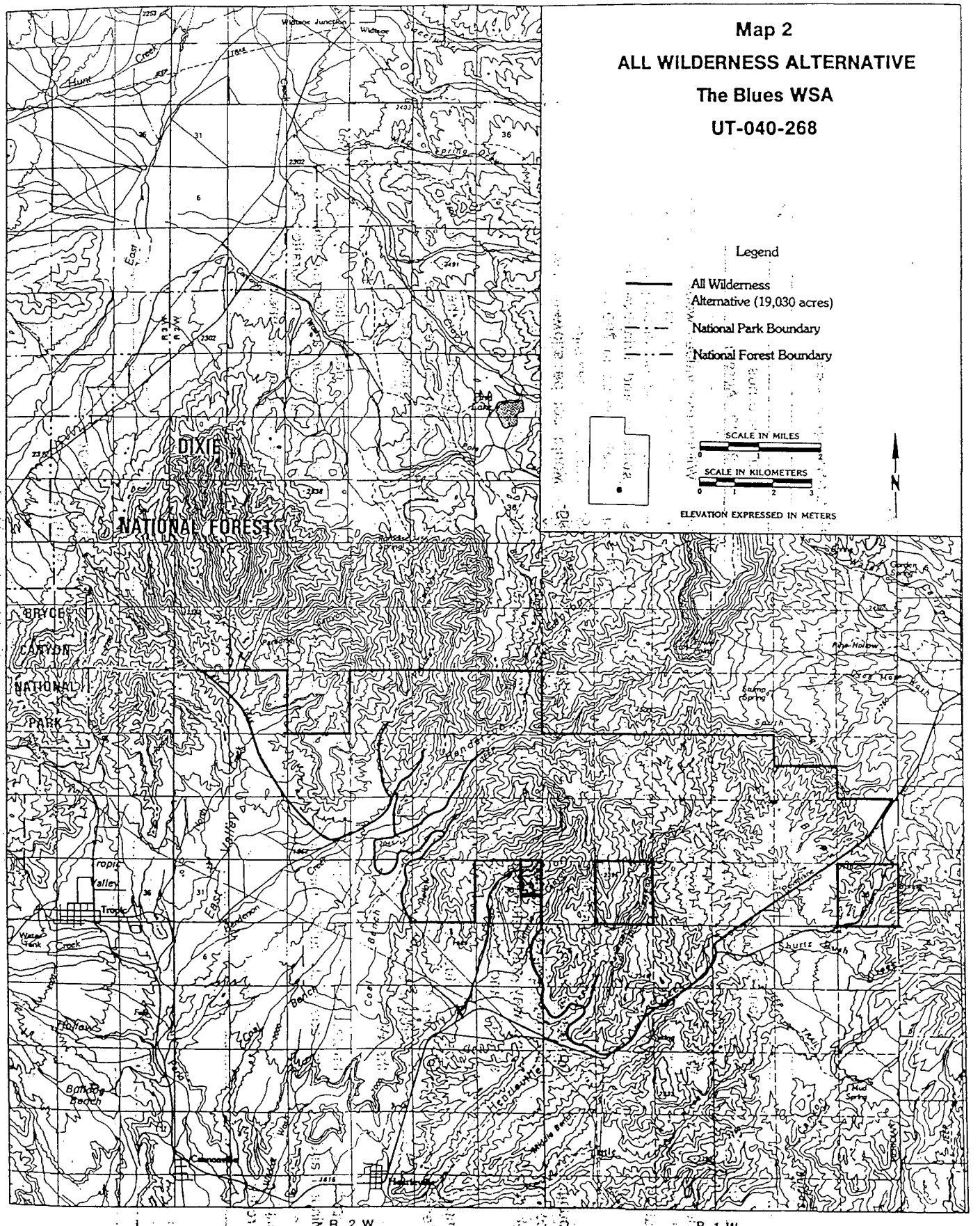
WE UNDERSTAND THE INTENT OF UMC 795.19 APPLICANT LIABILITY AS STATED.

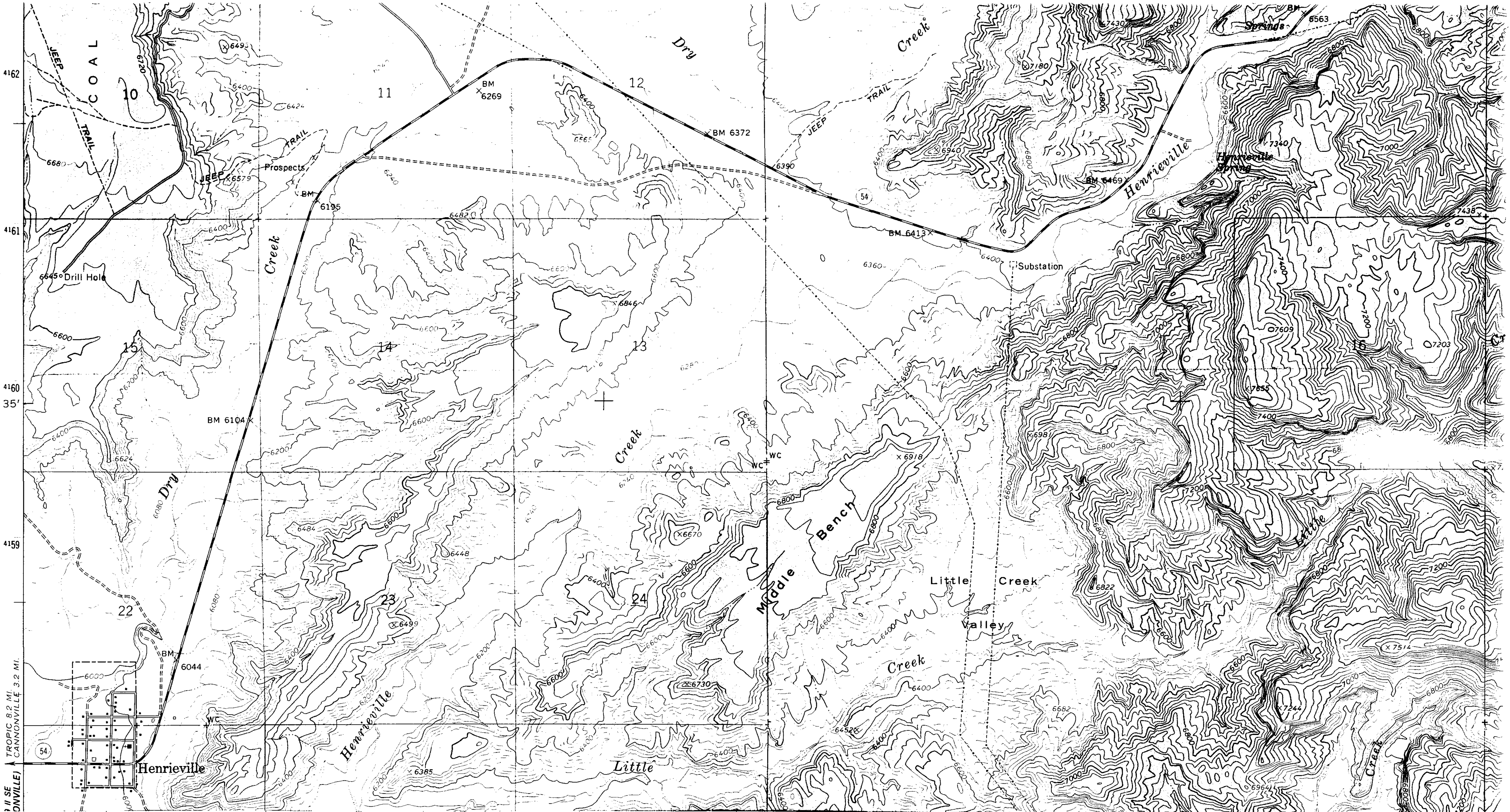
VERY TRULY YOURS,

Alfred L. Foster

ALFRED L. FOSTER, PRESIDENT
GARFIELD COAL COMPANY
STAR ROUTE
PANGUITCH, UTAH 84759
TELEPHONE 834-5227

COPIES TO ALL DIRECTORS & STOCKHOLDERS:
COPY TO THE GARFIELD COUNTY COMMISSION:


Map 2
ALL WILDERNESS ALTERNATIVE
The Blues WSA
UT-040-268
Legend
All Wilderness Alternative (19,030 acres)
National Park Boundary
National Forest Boundary
SCALE IN MILES
SCALE IN KILOMETERS
ELEVATION EXPRESSED IN METERS
N
DIXIE
NATIONAL FOREST
BRYCE CANYON NATIONAL PARK
T. 35 S.
T. 36 S.
37 S.
R. 2 W.
R. 1 W.



...hed by the Geological Survey
...GS

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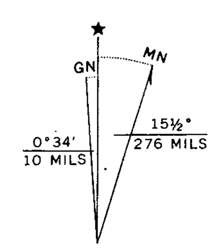
...Utah coordinate system, south zone
...sverse Mercator grid ticks,

...not been established



UTM GRID AND 1964 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

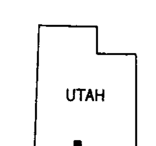
1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST



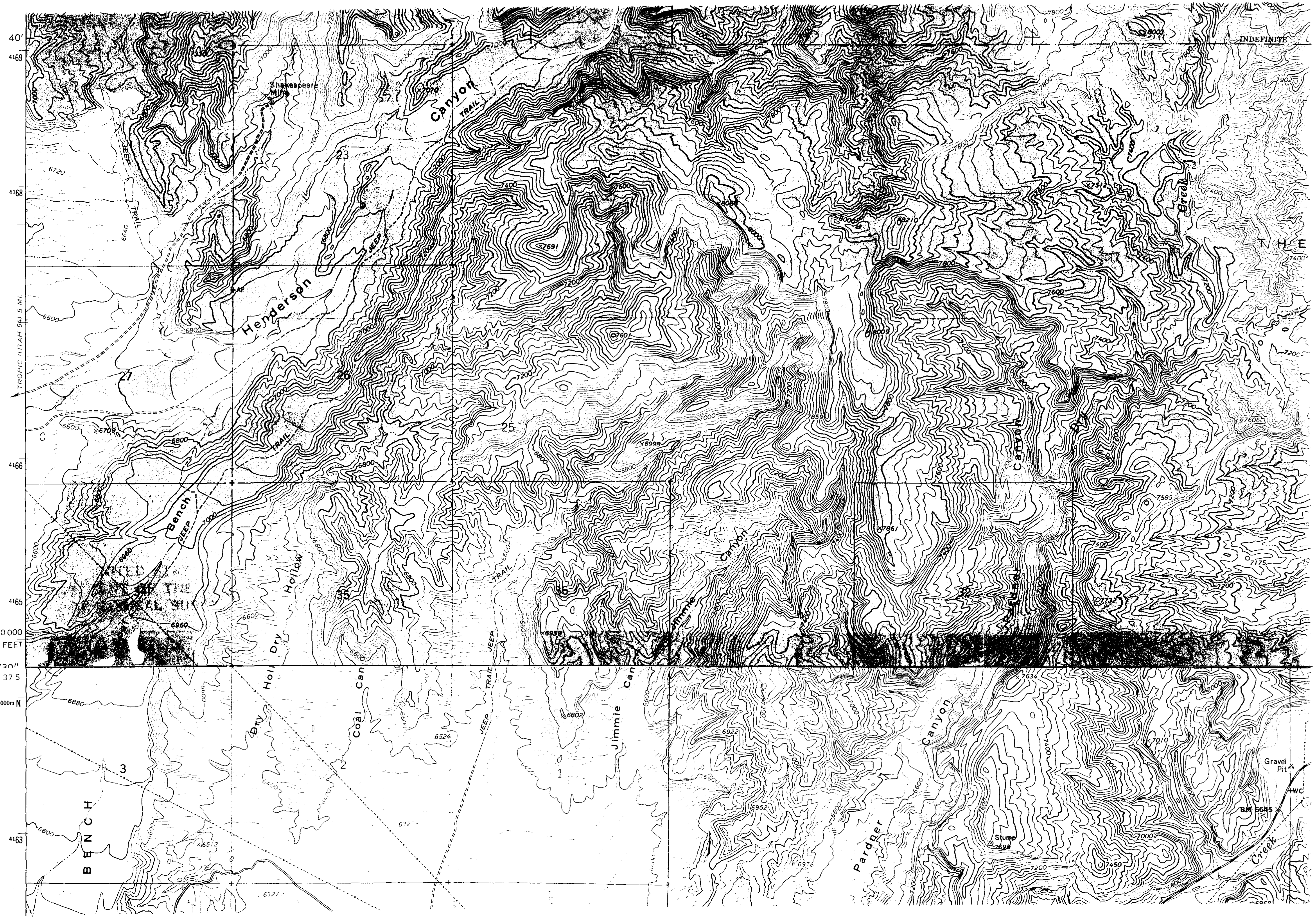
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Light-duty .... Unimproved dirt

PINE LAKE, UTAH
N3737.5—W11152.5/7.5

1964


40'
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4166
4165
350 000
FEET
37°37'30"
T 37 S
4164000m N
4163
INDEFINITE
Shakespeare Mine
Canyon
TRAIL
JEEP
Henderson
Bench
Dry Hollow
Coal Can
Jimmie Canyon
Jimmie Can
Pardner Canyon
Canyon
Creek
Gravel Pit
BM 6645
Stump
7698
BENCH
THE
TROPIC (UTAH 56) 5 MI
23
26
27
25
35
36
32
3
1

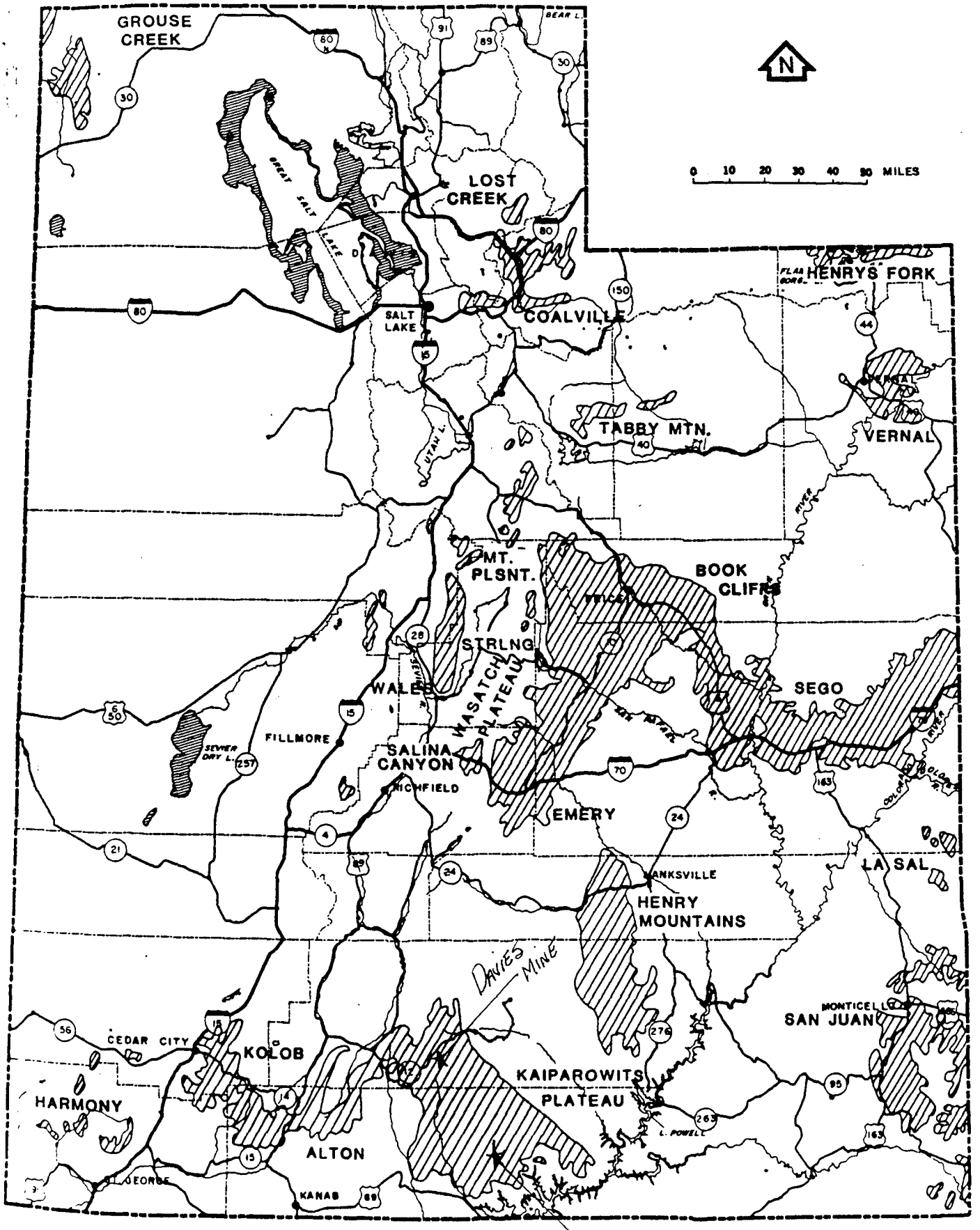


FIGURE 3-2
UTAH COAL FIELDS

Figure 4. Coal Section exposed near Davies Mine in the northwest part of the Kaiparowits Plateau field. Sec. 36, T. 36 S., R. 2 W.

Utah Geological & Mineralogical Survey - MAR 1964

At the Tropic coal mine, one coal bed averages about 15 feet in thickness. Coal is mined from drifts and cross-cuts about 7 to 10 feet high, and the roof and floor are coal. Analyses of coal from the mine have been given by Aresco and others (1957, 1959) and Robison (1963).

The Pollock mine, northeast of Henrieville, has been abandoned for many years. In 1952, Mr. Byron Davies opened a second small mine nearby, which was worked for one winter. The portal of the Davies mine is now nearly closed by slump material, but the drift is still accessible. A channel sample (#32) was taken from the back of the mine, about 80 feet from the portal, and an analysis is listed in the Appendix. The coal zone is well exposed in a stream cut about 300 yards north-northeast of the Davies mine (fig. 4 and 5). The following section was measured at that locality:

Section of coal in the SE 1/4 NW 1/4 Sec. 36, T. 36 S., R. 2 W.

	Feet	Inches
Sandstone: fine-grained; yellow to light-brown; cross-bedded and lenticular	20+	
Coal: (sample #31, see Appendix)	4	7
Coal: brownish-black; highly argillaceous	1	3
Coal: (sample #30, see Appendix)	6	2
Claystone: light-gray; slightly silty	3	7
Coal: may be slightly argillaceous; no sample was taken	1	6
Mudstone: medium brownish-gray, weathers light-gray to white; many plant fragments and some thin coal lenses		5
Coal: (sample #29, see Appendix). This is the same bed that was penetrated by the Davies and Pollock mines.	10	0

AL FOSTER ALSO MINED THE DAVIES MINE IN 1963.

UTAH DIVISION OF STATE LANDS
LEASE REPORT

LEASE NUMBER : ML 23331
LEASE STATUS : ACTIVE

NAME : GARFIELD COAL COMPANY
ADDRESS: AMERICAN TOWERS STE 1506S
44 WEST BROADWAY
SALT LAKE CITY UT 84101

LEASE TYPE : COAL
APPLICATION DATE: 2/01/66
DATE APPROVED : 2/07/66

DUE DATE : 1/01
EXPIRATION DATE : 12/31/95
REASSESSMENT DATE: 12/31/95

ACREAGE : 40.00
PAYMENT AMOUNT: 160.00
UNIT (Y OR N) : N

EXTENSION (Y OR N): N
BOND RECEIVED (Y OR N): N
TERM (YEARS) : MINROY

COUNTIES: GARFIELD

****

COMMENTS

2/28/78 Assn. to Garfield Coal Co. by Byron Davies
1/19/81 Min. Roy. Change
2/ 3/86 Lease Readjustment eff. 1/1/86--Annual rental increased from $1.50 to $4/acre-8% gross value production royalty Subject to further readjustment at 10 yr. intervals. Subject to cancellation after 10 yrs. if sustained commercial production is not attained.

****

LEGAL DESCRIPTION

TOWNSHIP	RANGE	SECTION	SURVEY	DESCRIPTION
36 S	2 W	36	SL	NE4NE4

****

PAYMENT HISTORY

NUMBER	DATE	PAYMENT AMOUNT	RENTAL AMOUNT	ROYALTY AMOUNT	APP DATE	RECEIPT #	REMARKS
1	12/28/76	40.00	20.00	20.00	1/01/77	V 1736	Lease began in 1966
2	12/06/77	40.00	20.00	20.00	1/01/78	V 16633	
3	1/02/79	40.00	20.00	20.00	1/01/79	W 18094	
4	12/12/79	40.00	20.00	20.00	1/01/80	X 15620	
5	12/29/80	40.00	20.00	20.00	1/01/81	Y 19137	
6	12/11/81	40.00	20.00	40.00	1/01/82	Z 19303	Short $20.00
7	12/29/82	80.00	20.00	40.00	1/01/83	B 19813	incl $20.00 short for 1982
8	12/20/83	60.00	60.00	.00	1/01/84	B 15686	
9	1/11/85	70.00	60.00	.00	1/01/85	C 05324	PAID $10.00 LATE FEE
10	12/24/85	160.00	160.00	.00	1/01/86	D 05478	PAID BY MARK K. BOYLE
11	1/05/87	170.00	160.00	.00	1/01/87	E 04624	PD $10 LATE FEE/PD BY H. SAM NESLEN
12	12/17/87	160.00	160.00	.00	1/01/88	F 03521	CK 1553 PD BY H.SAM NESLEN
13	12/19/88	160.00	160.00	.00	1/01/89	G 03720	
14	89						
15	90						
16	91						

****

LEASE INTERESTS

****

ASSIGNMENT

CERTIFICATE NO._____
G' 'ING LEASE NO._____
MI.ERAL LEASE NO. 23331

APPLICATION NO._____

The undersigned, as owner of record title interest as hereinafter specified in and to ML 23331 ; GL _____; Certificate No _____ as designated for good and valuable consideration and _____ DOLLARS does hereby assign to Garfield Coal Company
ADDRESS: 345 South State Street, Salt Lake City, Utah 84111
The rights, title, and interest in rights and privileges as lessee in such lands, to the extent indicated, subject to the reservation of overriding royalties as herein noted:

1. Land affected by this assignment in County of Garfield, State of Utah. Described herein as:
   NE 1/4 NE 1/4, Sec. 36, TWP 36S , Rge 2W, S.L.M.

40 ACRES

2. Interest of assignor in such lands Lessee
3. Extent of such interest conveyed to Assignee Entire
4. Overriding royalty reserved herein to Assignor None
5. Overriding royalty previously reserved (Note percentage only) None

It hereby certified that the statements made herein are true, complete, and correct to the best of the undersigned's knowledge and belief and are made in good faith.

Executed and witnessed this 31st day of December, 1977.

WITNESS:

Layton Smith

Byron Davies
BYRON DAVIES

STATE OF UTAH)
: ss.
COUNTY Garfield)

On the 31st day of December, A.D. 19 77, personally appeared before me Byron Davies, signer (s) of the above instrument, who duly acknowledged to me that He executed the same.

My Commission Expires: March 3, 1980

Melba O. Smith
Notary Public - Residing at:
Henrieville, Utah

3/3/80

ACCEPTANCE OF ASSIGNMENT
AFFIDAVIT OF CITIZENSHIP OF ASSIGNEE

I, e) _____ on oath, do solemnly swear that I am (we are) at the pr nt time (a) *_____ Citizen (a) of the United States of America and of legal age, an (we) hereby assume and agree to perform all of the covenants and obligations of said lease on the part of the lessee (s) to be kept and performed and accept the foregoing instrument.

BY _____

CERTIFICATE NO.

GRAZING LEASE NO.

23331
MINERAL LEASE NO.

Comes Now GARFIELD COAL COMPANY, a corporation of The State of Utah

AND HEREBY ACCEPTS THE ASSIGNMENT FROM Byron Davies of Cannonville, Utah

Certificate No. _____ **GL NO.** _____; **ML NO.** 23331

which assignment is dated April 14, 1966, **subject to all of the covenants and obligations of said Lessee.**

IN WITNESS WHEREOF Mark K. Boyle & Lawrence Mills ve has executed this acceptance this 5th day of January, 1978.

GARFIELD COAL COMPANY

BY Mark K Boyle

BY Lawrence Mills

STATE OF UTAH)
: ss.
COUNTY OF Salt Lake)

On this 5th day of January, 1978, **personally appeared before me** Mark K. Boyle and Lawrence Mills, **who being by me duly sworn did say, each for himself, that he, the said** Mark K. Boyle **(officer)** _____ **is the** Vice President ~~of~~ of Garfield Coal Company, ~~Board of Directors~~, and said Lawrence Mills is the Treas. of Garfield Coal Co that they _____ **and/executed the same and the seal affixed is the seal of said corporation.**

Carolyn K Marlow
Notary Public
Salt Lake County, Utah

My Commission Expires: July 29 1981

FILED

LEASE REPORT

LEASE NUMBER : ML 44182
LEASE STATUS : ACTIVE
NAME : H S NESLEN
ADDRESS: 1492 EAST 1200 SOUTH
BOUNTIFUL UT 84010
LEASE TYPE : COAL
APPLICATION DATE: 10/28/88
DATE APPROVED : 11/07/88
DUE DATE : 11/01
EXPIRATION DATE : 10/31/98
REASSESSMENT DATE:12/01/98

ACREAGE : 40.00
PAYMENT AMOUNT: 40.00
UNIT (Y OR N) : N
EXTENSION (Y OR N): N
BOND RECEIVED (Y OR N): N
TERM (YEARS) : 10
COUNTIES: GARFIELD

COMMENTS

LEGAL DESCRIPTION

TOWNSHIP	RANGE	SECTION	SURVEY	DESCRIPTION
36 S	2 W	36	SL	SE4NE4

PAYMENT HISTORY

NUMBER	DATE	PAYMENT AMOUNT	RENTAL AMOUNT	ROYALTY AMOUNT	APP DATE	RECEIPT #	REMARKS
1	11/01/88	60.00	40.00	.00	11/01/88	G 02515	Incl. $20.00 app. fee
2	10/23/89	40.00	40.00	.00	11/01/89	H 02135	

LEASE INTERESTS

Reference:
Garfield Coal Co.

ASSIGNMENT

MINERAL LEASE NO. 44182
GRAZING LEASE NO. —
CERTIFICATE NO. —

FILED
1990 JAN 25 AM 10 2
STATE OF UTAH
DIVISION OF STATE LANDS

The undersigned, as owner of record title interest as hereinafter specified in and to ML 44182; GL —; Certificate No. —; as designated, for good and valuable consideration and One DOLLARS does hereby assign to Garfield Coal Company
ADDRESS: 44 W Broadway Suite 1506S Salt Lake City ut. 84101,
the rights, title, and interest in rights and privileges as lessee in such lands, to the extent indicated subject to the reservation of overriding royalties as herein noted:

1. Land affected by this assignment in County of Garfield, State of Utah, as described herein:

Township 36 South, Range 2 West SLB+M

Sec 36: SE¼NE¼

40.00 ACRES

2. Interest of assignor in such lands 100%
3. Extent of such interest conveyed to Assignee (Note percentage of 2) 100%
4. Overriding royalty reserved herein to Assignor (Note percentage only) None
5. Overriding royalty previously reserved (Note percentage only) None

It is hereby certified that the statements made herein are true, complete, and correct to the best of the undersigned's knowledge and believe and are made in good faith.

Executed this 25 day of January, 1990

H. S. Nesler
(Lessee - Assignor)

LESSOR--ASSIGNOR'S ACKNOWLEDGEMENT

STATE OF)
):ss
COUNTY OF Salt Lake)

On the 25th dav of January, 1990, personally appeared before me H. S. Nesler, signer(s) of the above instrument, who duly acknowledged to me that he executed the same.

Given under my hand and seal this 25th day of January, 1990.

Leslie M. Warner
NOTARY PUBLIC, residing at: SLC

My Commission Expires: 2-3-92

NOTARY PUBLIC
LESLIE M. WARNER
355 W. North Temple, #400
SLC, UT 84180-1204
My Commission Expires
Feb. 3, 1992
STATE OF UTAH

THIS DOCUMENT MAY BE DUPLICATED

INSTRUCTIONS: Assignment must be submitted in duplicate. The original certificate, grazing lease or mineral lease must be produced with the assignment. Partial assignment permitted on mineral leases only. Total assignment--$10, Interest assignment-$10, and Partial Assignment--$15.

INDIVIDUAL'S ACCEPTANCE OF ASSIGNMENT
AFFIDAVIT OF CITIZENSHIP OF ASSIGNEE

I, (we) _____ on oath, do solemnly swear that I am (we are) at the present time (a) * _____ Citizen(s) of the United States of America and of legal age, and I (we) hereby assume and agree to perform all of the covenants and obligations of said lease on the part of lessee(s) to be kept and performed, and accept the foregoing instrument.

BY: _____

Subscribed and sworn to before me this _____ day of _____, 19 ____.

My Commission Expires: _____

_____
NOTARY PUBLIC, Residing at:

ACCEPTANCE OF ASSIGNMENT -- CORPORATE

Comes Now Garfield Coal Company a corporation of Utah AND HEREBY ACCEPTS THE ASSIGNMENT FROM H.S. NESLEN of Bountiful Ut 84010 Certificate No. —, GL No. —, ML No. 44182, which assignment is dated 1-25-90, subject to all of the covenants and obligations of said Lessee.

IN WITNESS WHEREOF Mark K. Boyle has executed this acceptance this 25th day of January, 19 90.

(Assignee) GARFIELD COAL CO

BY: Mark K Boyle
(Officer, Agent, Attorney-in-Fact)

ASSIGNEES ACKNOWLEDGEMENT

STATE OF)
):ss
COUNTY OF Salt Lake)

On the 25th day of January, 19 90, personally appeared before me Mark K. Boyle, who being by me duly sworn did say, each for himself, that (he, she, or they) is an officer, agent or Attorney-in-Fact for the assignee and is authorized to accept this assignment and has executed the same and the seal affixed is the seal of said corporation.

NOTARY PUBLIC
LESLIE M. WARNER
355 W. North Temple #400
SLC, UT 84180-1204
My Commission Expires
Feb. 3, 1992
STATE OF UTAH

Leslie M. Warner
NOTARY PUBLIC, residing at: SLC

My Commission Expires: 2-3-92

NOTE: a* Insert here whether native born or naturalized. If naturalized, it will be necessary to file with this office Proof of Citizenship or Declaration of Intention to become a citizen in the form of a letter or certificate of verification from Court of Issuance, and registration fee of $1.00.

LIST OF REFERENCES

Environmental Impact Statement: Kaiparowits, Chapter I

Environmental Impact Statement: Kaiparowits, Chapter II

Kaiparowits Coal Development and Transportation Study, Final Report

Kaiparowits Coal Development and Transportation Study Update

Proposed John Henry Mine

Southwestern Utah Coal Fields: Alton, Kaiparowits Plateau and Kolob-Harmony

Uinta-Southwestern Utah Coal Region: Round Two Final Environmental Impact Statement

Socioeconomics

Population, Income, and Employment

The area of analysis for the southern Utah region includes Garfield and Kane Counties. The 1980 census population of that area was 7,697. The estimated 1982 population is 8,800. (Unless otherwise noted, this discussion will rely on the data from the 1980 census). These counties are typical of rural counties in Utah with the population concentrated in a few small communities along major roads. The largest of the communities in the area is Kanab with 2,148 residents and Panguitch with about 1,343 people. Kane County has an average household size of 3.12 persons, and Garfield has 3.00 both smaller than the State average of 3.20. Kane County had a 1980 mean household income of $14,200, significantly below the State mean income of $20,320, and Garfield is also low with mean household income of $14,956. Garfield and Kane Counties had total wage and salary employment of 1,786 and 1,017 in 1980 with unemployment rates of 7.4 percent and 5.2 percent, respectively. Unemployment rates in 1982 rose to 8.6 percent in Kane County and 15.3 percent in Garfield. The government sector is the primary employment sector for Garfield County. With the fall in demand for uranium, mining and milling employment has declined since 1980. Kane County's primary employment sectors are trade, government, and services.

Infrastructure

Housing

The majority of housing units in both counties are conventional single family houses. Kane County has about 7 percent of their housing units in mobile homes and Garfield has about 4 percent mobile homes. Detail relative to the existing housing supply is presented in Table 3-22.

Education

The Garfield County School District had a 1981 enrollment of 920 students and 50 teachers, while the Kane County District had 1,002 students and 47 teachers. This represents pupil/teacher ratios of 18 to 1 and 21 to 1 for Garfield and Kane, respectively. These figures are significantly below the State service guide of 25 to 1.

Water and Sewer

Adequacy of culinary water systems is determined by the Utah Department of Health based on three components: water rights, supply/flow, and storage. Table 3-23 summarizes these components for the two-county area.

Septic tanks are the primary waste water facilities in all the counties and are presently considered adequate. NEW LAGOON SYSTEM IN TROPIC UTAH

Kanab City completed an extensive new sewage project in 1981. The lagoon system has more than adequate flow capacity. Orderville, Glendale, Mt. Carmel are on a cooperative regional sewer system called the Long Valley Sewer System. The present system has a design capacity for 800 population, which is adequate for the present population. Alton residents use septic tanks for sewage disposal. Table 3-24 gives additional information.

TABLE 3-22
SOUTHERN UTAH EXISTING DWELLING UNITS MIX BY COMMUNITY

County	Conventional	Mobile	Multi-family
Garfield			
Panguitch	570	20	4
Hatch	73	5	0
Total	643 (95.7%)	25 (3.7%)	4 (0.006%)
Kane			
Kanab	601 (37.7%)	45 (6.53%)	43 (6.2%)
Alton	31	4	0
Glendale	65	11	0
Mt. Carmel	35	4	0
Orderville	129	6	0
Total	861 (88.4%)	70 (7.19%)	43 (4.4%)
Grand Total	1,504 (91.4%)	95 (5.8%)	47 (2.9%)

TABLE 3-23
SOUTHERN UTAH
SUMMARY OF WATER SYSTEMS

county	Source	Connections	Storage Capacity Gallons per day	Water Rights	Flow Gallons per minute
Garfield					
Hatch	wells	64	50,000	399	224
Panguitch	springs, wells	391	1,000,000	4,272	1,500
Kane					
Alton		25	18,000	204	215
Glendale		174	300,000	120	67
Kanab	springs, wells	1,290	3,500,000	11,026	2,917
Mt. Carmel		33	30,000	580	323
Orderville		175	550,000	336	189

TABLE 3-24
SOUTHERN UTAH SEWAGE AND SOLID WASTE DISPOSAL FACILITIES

	Garfield County		Kane County				
Characteristics	Hatch	Panguitch	Alton	Glendale	Kanab	Mt. Carmel	Orderville
Sewage							
Capacity (100 gal/day)	--	--	--	800[a]	5,000	800[a]	800
Flow gallons per minute	--	--	--	80,000[a]	1,200,000	80,000[a]	80,000
System Type	Septic Tank	Septic Tank	Septic Tank	Lagoon	Lagoon	Lagoon	Lagoon
Plans for Expansion	no	yes	no	no	no	no	no
Solid Waste Disposal							
Type of Facility	Landfill	Landfill	Open Dump	Open Dump	Open Dump	Open Dump	Open Dump
Percent of Cap. Used	Adequate	Adequate	N/A	Limited	Limited	--	Limited
Type of Collection	Green Box	Green Box City	Volun-tary	Boy Scouts	Private	Individual	Individual
City/County	County	County	Private	City	City	City	Glendale

[a]Long Valley.

Public Safety

In general the affected counties rely on the county sheriff for the major portion of their law enforcement capacity. The larger communities in each county generally have a separate police force and facilities. Summary law enforcement data for each of these counties are presented in Table 3-25.

The communities of Garfield County have well organized volunteer fire departments. Panguitch is currently recruiting a full-time fire chief to further enhance reliability. Response time is indicated at 3 minutes average with maximum time of 30 minutes.

Currently, there are no county-administered fire protection services in Kane County. All communities of the county have some form of fire protection plan ranging from well organized volunteers to a loosely organized effort of every available citizen. The entire county has only four fire fighting vehicles, one of which is a push cart pumper. Local officials, particularly on the west side of the county, indicated some reliance on Federal and State fire fighters.

Garfield County is served by the 14-bed Garfield Memorial Hospital in Panguitch. The hospital had a 43.1 percent utilization rate and a 4.61 day average length of stay. Medical manpower is provided by two physicians, 16 nurses, and one dentist. The emergency medical services within the area are provided by 41 EMTs and five ambulances.

Kane County has one hospital at Kanab with 33 beds with a 22.2 percent utilization rate. In 1981, there were 1,620 patient days and a 2.9 day average length of stay. The County is served by two physicians, two dentists, and 13 nurses. The County is also served by nine EMTs and two ambulances.

Much of the solid waste disposal in the study area is accomplished with open dumps that are not State approved; however, there are several areas that have approved landfills which are generally considered to be adequate for the present and immediate future. Table 3-24 contains detailed information on present facilities.

Garfield County operates a State-approved landfill which serves Hatch and Panguitch, as well as other county communities. Collection is relatively sophisticated, employing a "green box" method refuse collection. The County has an established fee for cities and for each resident for use of the "green boxes" and the landfill. The landfill has had difficulty in maintaining open hours so that individuals can bring large items to the landfill. For this reason, some additional open dump sites still remain in use.

Social/Attitudes

The area of Kane and Garfield Counties is comprised of sparsely populated Mormon communities whose growth has been slow and, with the exception of Kanab in Kane County, has experienced a population decline. There is generally a very favorable attitude toward development of the area's coal resources.

TABLE 2-3
COAL TRANSPORTATION EMPLOYMENT ASSUMPTIONS FOR POPULATION PROJECTIONS

Employment	Slurry Pipeline	Truck Haul	Rail Haul
Operation	5.5 employees/ million tons coal shipped/year	1.3 employees/ 25-ton truck on	No significant change in employment
Construction Employment by Route	Alton to Hurricane Cliffs/ St. George area[1] 245 based in St. George and 455 in Kanab for 3 years	road	S. Kaiparowits to Cedar City 1,100 for 4 years 25% based in Hurricane, 25% in Fredonia (Kanab) 25% Glen Canyon City, and 25% transient along route
	N. Kaiparowits to Koosharem area[2] 390 based in Greenwich/ Koosharem and 390 in Escalante for 3 years		S. Kaiparowits to Milford 1,045 for 4 years 25% based in Beaver, 2525% in Alton, 25% in Glen Canyon City, and 25% transient along route
			S. Kaiparowits to Page 825 for 2 years 75% based in Glen Canyon City 25% transient along route
			N. Kaiparowits to Marysville 990 for 2 years 37% based in Antimony, 37% in Escalante, and 26% transient along route

Source: ERT Project Team

[1] Medium and high production levels
[2] Medium production level

Truck Haul Routes and Approximate Haul Distances on Existing Highway System

Alton to
- Cedar City (via Highway 14) - 66 miles
- Milford (via Highway 20) - 128 miles
- Salina (via Highway 89) - 148 miles
- Navajo Power Plant (east of Page, Arizona) - 88 miles
- Warner Valley Power Plant (south of Hurricane, Utah) - 98 miles

North Kaiparowits to
- Milford (via Highways 12, 89, and 20) - 144 miles
- Salina (via Highways 12 and 89) - 164 miles

South Kaiparowits to
- Cedar City (via Highway 14) - 138 miles
- Flagstaff (via Highway 89) - 158 miles
- Navajo Power Plant - 24 miles
- Warner Valley Power Plant - 130 miles

In order to insure comprehensive analysis, the Steering Committee decided to add the Navajo Power Plant (located 5 miles east of Page, Arizona) and the proposed Warner Valley Power Plant (located 11 miles south of Hurricane, Utah) to the scenarios as possible destinations for the truck haulage of coal during the low production level.

It should be noted that all transportation corridors are being considered for both railroads and coal slurry pipelines except corridor segments C2, C6, C8, and C12 which are being considered for slurry pipelines only (see Map 2-1). This is due to either topographic constraints or the absence of an existing railhead. Since the coal truck haul routes utilize the existing highway system, they are being considered separately from the transportation corridors.

Longwall blocks range from 300 to 600 feet wide and are sometimes a mile long. The longwall machine laterally shears or plows coals from the entire face, transports the fallen coal by an advancing conveyor to a secondary haulage conveyor, reverses direction at the end of a cut, and supports the roof in the area of the face by a self-advancing system of hydraulic jacks. To support the roof at the face, longwall mining originally used manually operated props, then gradually evolved to the presently used powered, self-advancing supports. The longwall mining machine is usually unmanned. The roof is allowed to cave-in behind the advancing work areas; the roof is occasionally blasted to ensure a controlled cave-in rate and to reduce overburden pressure on the coal bed being mined. This controlled cave-in can cause subsidence at the surface.

Longwall mining is used most efficiently in uniform coal seams of-medium height (42 to 60 inches) Coal recovery can be close to 100 percent for a given seam, but overall recovery for the study area would be lower. Waste materials are already in underground storage when mining is complete instead of on the surface.

Reclamation

The term reclamation is used here to mean any process for rehabilitating land disturbed by coal mining. Reclamation consists basically of making a mine site safe, acceptable in appearance, and available for other uses before mine abandonment. The goal of reclamation would be to return the land to its former level of diversity and productivity. The dominant surface uses of Federal land in the Alton and Kaiparowits lease areas are for livestock forage production, wildlife habitat, watersheds, and wide-ranging recreational activities.

Reclamation consists of four phases: planning, topsoil/overburden segregation, backfilling, and revegetation. The planning phase begins prior to mining and continues throughout the mining cycle. This phase mainly involves: (1) site mapping, (2) identification of the probable effects of mining before mining begins, (3) development of the reclamation plan, including mitigating measures to be followed during all mining activies, (4) preparation of periodic environmental reports, (5) bond and permit fee-related activities, (6) supervision of the reclamation work, (7) engineering and surveying for environmental protection, (8) water quality monitoring, (9) dust control, and (10) consultation with outside experts.

Topsoil/overburden segregation and backfilling usually include: (1) removal of vegetative cover when its removal is necessary for topsoil salvage, (2) removing and stockpiling toposil and overburden separately, (3) backfilling and grading cuts with original overburden, and (4) replacing topsoil.

The revegetation phase usually consists of the following: (1) soil preparation (discing and/or harrowing, fertiiizing, etc.), (2) seeding and/or planting, (3) mulching, (4) irrigation, and (5) maintenance. The methods used in each of the four categories could differ substantially in the three coal lease areas due to different topsoil characteristics and environmental conditions.

Truck Haulage

Transportation of coal by truck is used mainly for initial shipment from the mine to a railhead and for short haul transport to a final destination such as a power plant. Trucks are utilized to a very limited extent for long-haul coal transportation because of high units costs compared to railroads and slurry pipelines. In western states where existing rail services are sparse and capital costs of alternative transportation systems high, coal is frequently trucked longer distances of 100 miles or more. Construction of rail spurs and slurry pipelines can be financially justified only from high volume, long-term production fields. The major advantages of truck haulage of coal is the relatively low capital investment for trucks and their greater flexibility with respect to destination routing through use of the existing highway network.

Most of the coal-hauling trucks on the highways are in the range of 20 to 30-ton capacity, generally require a 35 to 40-ton gross vehicle weight (GVW) truck frame, and are similar to many tractor/trailer trucks currently in use on public highways. A truck this size will have a fuel consumption of approximately 5 miles per gallon, depending upon the vertical grade profile of the highway. The trucks are 2-wheel drive and can traverse grades as high as 10 to 11 percent. Loaded coal truck operations are limited by vehicle speed and maneuverability. On long steep vertical grades, the operating speeds of the loaded coal trucks can be reduced significantly below speeds for automobiles. Similarly, operation of coal trucks on narrow roadway segments or areas of excessive horizontal curvature such as a series of switchbacks can be difficult due to

TABLE 3-3
SOUTHERN UTAH COAL QUALITY DATA

	Average Percent			
	South Kaiparowits	North Kaiparowits	Alton (West)	Alton (East)
Moisture	9.63	10.51	17.0	19.3
Volatile Matter	42.44	45.39	40.1	43.6
Fixed Carbon	48.70	46.81	50.3	46.7
Ash	8.59	7.80	9.4	9.8
Sulfur	.75	1.26	1.3	1.07
Btu/lb	12,401	11,563	12,069	10,166

Source: Doelling and Graham, 1972.

The geology of the region has been summarized by Gregory and Moore (1931), Gregory (1951), Doelling and Graham (1972), and Sargent and Hansen (1976) and is shown on the geologic map of southwestern Utah (Hintze 1963). The geology of the study area (Map 3-1) has been simplified into five map units. These are: (1) Pre-Cretaceous sedimentary rocks of Jurassic, Triassic, and Permian age; (2) Upper Cretaceous coal-bearing rocks; (3) Tertiary and Upper Cretaceous sedimentary rocks; (4) Quaternary and Tertiary volcanic rocks; and (5) Quaternary and Tertiary sedimentary rocks, mostly alluvium. The exposed bedrock in the coal lease areas is of Cretaceous and Jurassic age with a small area of basalt in the Alton area. Corridor segments C9, C12, C13, and large portion of C4 contain mostly alluvium and volcanic rocks. The last 18 miles of corridor segment C1 is also alluvium. Corridor segments C2, C3, and C7 in Arizona are mostly sedimentary rocks of Pre-Cretaceous and Cretaceous age.

The Kaiparowits and Paunsaugunt Plateaus are underlain by geologic formations having gentle dips, generally trending northward, interrupted by monoclines, anticlines, and synclines. In addition, the formations are cut by numerous faults. Two major faults are the Paunsaugunt and Sevier, which trend northward and form the east and west boundaries of the uplifted Paunsaugunt Plateau. The North and South Kaiparowits lease areas are in the Kaiparowits structural basin, which extends from the Utah-Arizona border northward to the mountains west of Escalante, Utah. The structural relief in this basin is about 4,000 feet. The Alton lease area occurs between the Paunsaugunt and Sevier faults in a broad northward-trending syncline.

The Kaiparowits region is part of the intermountain seismic belt, which is a zone of pronounced earthquake activity that extends from Arizona to Montana. Seismic data (Cook and Smith 1967) indicate that Richter magnitudes in the area have not exceeded 4.9 and most are less than 4.0. Relevant data (U.S.D.I. Bureau of Land Management 1976) indicate that earthquakes of low intensity will occur; however, the effects of such earthquakes will be slight.

The Kaiparowits coal field, which includes the North and South Kaiparowits coal lease areas, has been described by Doelling and Graham (1972). Mineable coal beds which contain the best quality coal in the region (Table 3-3) occur in the Straight Cliffs Formation. Total reserves for the coal field, as defined by Doelling and Graham (1972), are estimated to be 15.2 billion short tons (Table 3-4). The amount of reserves for the coal lease areas would be less; however, data were not available to readily determine the amount. The coal occurs as lenticular seams and is confined to several zones, the most important being the Christensen (Henderson), Alvey, and Rees coal zones. These coal beds were deposited during Cretaceous time in a northwest-trending zone 18 to 25 miles wide which paralleled the old shore lines.

The Alton coal field has also been described by Doelling and Graham (1972). Two coal zones, Smirl and Bald Knoll, occur in the Dakota Sandstone. The quality of the coal is given in Table 3-3. Reserves for the field have been determined to be 2.1 billion tons (Table 3-4), of which about 0.2 billion tons occur less than 200 feet from the surface and are stripable.

TABLE 3-4
COAL RESERVES IN THE KAIPAROWITS STUDY AREA
(In Short Tons)

Reserve Classification[1]	Classification Criteria[1]	Alton Coal Field[1]	Kaiparowits Plateau Coal Field[1,2,3]
Measured reserves (Class I)	Based on adequate exploration and development data, properly correlated.	———	———
Indicated reserves (Class II)	Based on geologic measurement supplemented by limited drill hole data and limited to 1½ miles from a control point.	643,800,000[4]	3,984,800,000[4]
Inferred reserves (Class III)	Based on geologic inferrence and projection of the habit of the coal beyond 1 miles from control points.	865,600,000	3,893,200,000
Potential reserves (Class IV)	Based on geographic and geologic position, with little supporting data, and includes coal concealed by 3,000 feet or less of cover.	639,500,000	7,320,000,000
Total		2,148,900,000	15,198,000,000

Source: ERT Project Team
[1] After Doelling and Graham (1972).
[2] Much larger area than North and South Kaiparowits lease areas as defined in this environmental analysis.
[3] U.S. Department of Interior, Geological Survey (1979, Fig. II-6) for Kaiparowits Plateau Coal Field gives a preliminary estimate of 20 billion short tons of coal from coal beds 4 feet or more thick and overburden no thicker than 3,000 feet.
[4] Includes a small amount of Class I reserves.

Other mineral resources have been identified by Doelling (1975), Sargent and Hansen (1976), and U.S. Department of the Interior, Geological Survey (1979). Several test wells for oil and gas have been drilled, and a small oil field was developed in 1964 on the Upper Valley anticline about 10 miles southwest of Escalante. Locally, combustible gases occur in and near some coal beds; however, the concentrations are unknown.

Limestone suitable for rock-dusting in coal mines is available at several places in the Kaiparowits region. According to the U.S. Bureau of Land Management (U.S.D.I., BLM 1976), such limestone occurs in the Wasatch Formation on the west side of Johns Valley in T34S, R3W, in the Canaan Peak area, and in the Carmel Formation east of Orderville, Utah (Map 3-1). Because other outcrops of limestone occur in the Kaiparowits region, more localities having potential as quarries are probably present. Clay, gypsum, sand and gravel, and dimension stone are present throughout the Kaiparowits region.

Soils

The soils of the study area reflect the variability of the soil-forming factors (geology, topography, climate, and vegetation). Generally, the soils have developed from fine-grained igneous materials in the northern part of the study area and sandstones and shales in the southern part, resulting in textures ranging from clayey to sandy. Soils over most of the area receive low amounts of precipitation resulting in limited soil development and productivity potential. Mean annual soil temperature ranges from about 47°F in the mountainous areas to 59°F in the lower valleys. Typically, soils where annual precipitation is under 15 inches exhibit a high soluble salt content, high pH, low organic matter content, and an accumulation of carbonate in the subsoil which may form a hardpan. As elevation and precipitation increase, these characteristics reverse, resulting in better soil development and increased productivity potential.

Traffic Flow Analysis

The capacity of a highway is a measure of its ability to accommodate traffic and is a function of physical geometries such as number of lanes, lane width and grade, magnitude and composition of demand volumes, and operating speeds. The results of the roadway capacity analyses are summarized in Table G-3 in Appendix G. Even under maximum July recreational peak demand conditions, all of the roadway facilities with the exception of segment 89e, are operating at the Level of Service B standard (UDOT assigned) or better. Segment 89e has a low assigned service volume B standard because of the long steep vertical grades and the sharp horizontal curvature. On the east-west segment of U.S. 89, the highest volume/capacity ratio of 0.75 occurs east of Kanab on segment 89f. U-9, which serves as a connection between Interstate 15 and U.S. 89, has the highest computed ratio for local roadways. The results of the capacity analyses indicate that the existing traffic operations in the study are generally in a stable flow range.

Geometric Design Consideration

The rural highways serving the Kaiparowits region have certain key geometric design characteristics that have operational significance for traffic movement. Specific criteria include pavement construction and horizontal and vertical curvature. The majority of the two-lane highways in the Kaiparowits region were constructed to carry light to moderate traffic demand. The roadway segments that are an exception to this condition are 89f and 89g between Kanab and Glen Canyon City. This portion of U.S. 89 has been resurfaced with a 3- to 4-inch pavement overlay within the last four years. Based on field inspection, the overlay appears to be holding up well under the existing levels of coal hauling truck activity between Salina and Page, Arizona. U.S. 89 heading north from Kanab needs to be upgraded by a pavement overlay treatment since the existing pavement on the highway is starting to deteriorate.

Physical design considerations on the westerly segment of U-12 include the steep vertical grade from Tropic to the Bryce Canyon access road and the two natural rock formation tunnels in the Red Canyon area. UDOT has been working with the National Park Service on a feasibility study for providing a climbing lane on the vertical grade for trucks. The two tunnels have sufficient clearance for standard size trucks, but are not adequate for oversize loads. From Bryce Canyon east to Escalante the roadway is characterized by narrow lane widths, areas of pavement deterioration, long steep vertical grades, and horizontal curvature problems. A major operational consideration on U-12 during the summer months is the tourist use of the roadway to access Bryce Canyon National Park and natural areas around Escalante. Tourists frequently park along the side of the road to view the natural features of the area. The parked vehicles present problems to the existing logging and crude oil truck activity on the road.

Winter weather conditions are a major roadway operational consideration in the south-central Utah region. U-14 is frequently closed during winter months because of snow accumulation. During the spring thaw, U-14 has a 20,000-pound load limit because of extremely wet sub-base conditions. Many of the gravel and dirt roads traversing the Alton and Kaiparowits fields are closed from November to May because of snow and wet conditions.

Railroads

The Kaiparowits Plateau region has no rail service at the present time. The nearest railroad lines terminate to the north and west of the coal lease areas (see Map 3-12). To the north, the Denver & Rio Grande Western Railroad enters from Colorado, passes through Price, and continues to Salt Lake City. From this main line, a spur line extends southward through Richfield to Marysvale. The Marysvale spur is classified as a B Branch Line of a Class I railroad in the Utah State Rail Plan (UDOT 1978c). B Branch lines are identified as light density lines carrying less than 1 million gross tons per year. The section of spur line between Richfield and Marysvale has been identified as a potential problem area for economic viability (UDOT 1978c), while the section between Salina and Marysvale could not sustain coal unit train traffic without being rebuilt.

West of the Kaiparowits region, a Union Pacific Railroad main- line passes southwestward from Salt Lake City on its way to Las Vegas. A branch line extends from Lund to Cedar City. The Cedar City rail connection is classified as an A Branch Line of a Class I railroad. A Branch Lines are defined as carrying less than 5 million gross tons, but at least 1 million gross tons per year. South of the region, the Atchison, Topeka, & Santa Fe Railroad crosses east to west through central Arizona and Flagstaff. No railroad bridges cross the Colorado River in northern Arizona.

TABLE 4-4
POTENTIAL LAND USE/TRANSPORTATION CONFLICT POINTS

Truck Haul Route Segment	Agricultural Areas	Heavy Recreation Traffic (approx. mi.)	Potential Sensitive Land Uses[1]	
			Residential Communities	Others
20	-	-	-	-
89a	2	-	4	6
89b	1	-	1	8
89c	1	20	1	-
89d (incl. Long Valley Juntion)	-	5	1	-
89e (incl. Kanab)	-	35	5	14
89f	-	5	-	-
89g	-	50	-	-
89h (incl. Glen Canyon City and Page)	-	15	2	4
89i	-	50	-	-
14 (incl. Cedar City)	-	45	1	33
389 (incl. Hurricane)	3	65	3	12
12 (excl. Escalante)	1	65	3	5
136a	2	-	1	-
136b	1	-	-	-
98	-	-	-	-

Source: ERT Project Team
[1]All sensitive uses in a residential community may not be subjected to truck impacts depending on location and internal routing

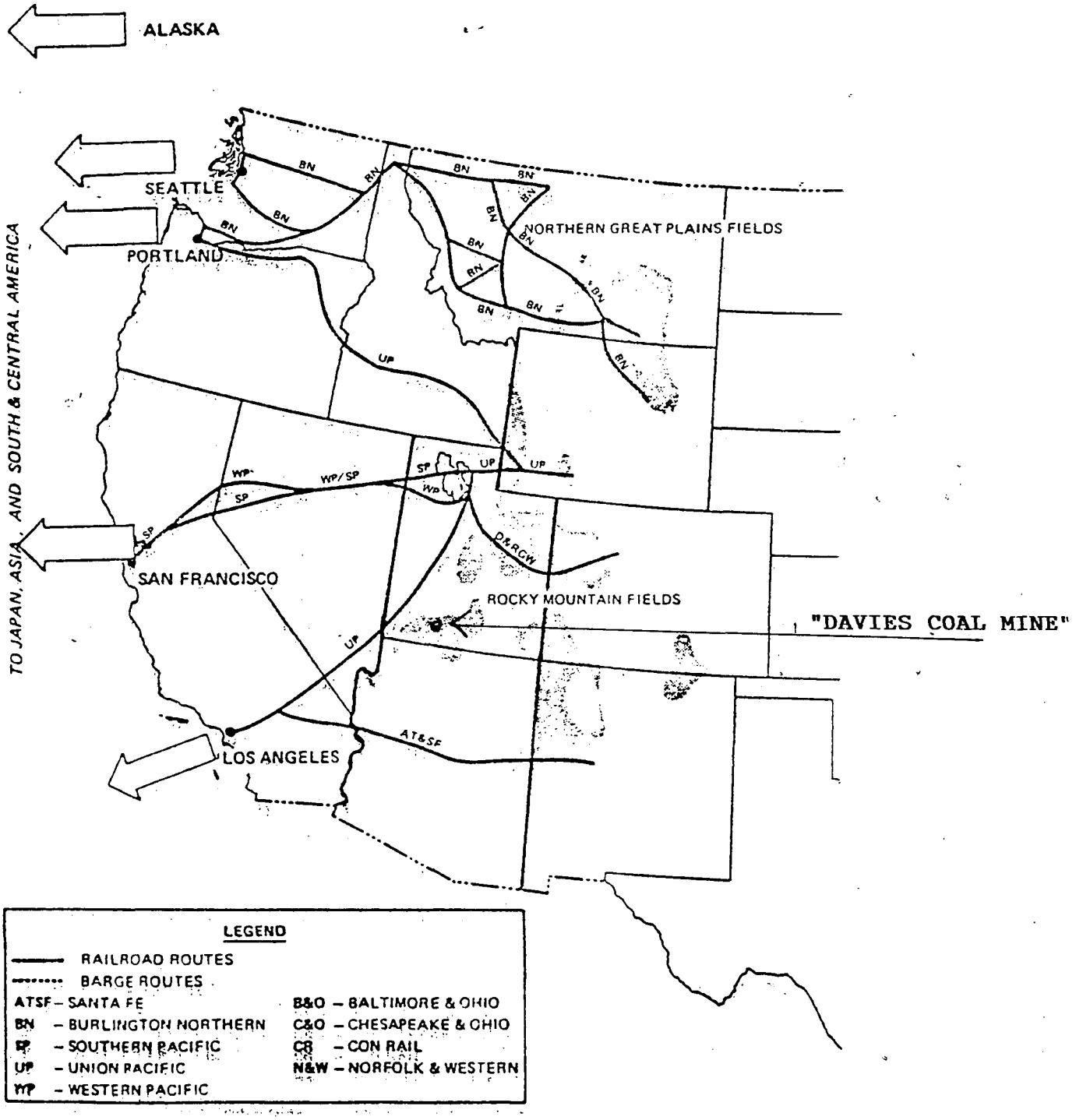
A summary of the maximum hourly truck volumes on each of the haul route segments can be found in Item 25 in the assumptions. In determining the impacts generated by the coal trucks, a worst case approach based on the maximum possible utilization of each route was used.

The impact of the coal trucks on U-12 traffic flow would be most pronounced in areas of steep vertical upgrades and sharp horizontal curvature because of the reduction in operating speeds. Parts of U-12 have lengthy sections of vertical curvature in excess of 6 percent, such as east of Bryce Canyon and south of The Blues, Figure 4-1, and areas of pronounced horizontal curvature. The lateral clearance between the pavement edge and adjacent major drop-offs in elevation are minimal. With the accompanying narrowing of pavement width, the potential impact of trucks on operating speeds and vehicle maneuverability is of concern. For the large areas of vertical upgrade on U-12, a speed reduction in the order of 10 to 25 MPH from average auto operating conditions could occur. The reduction in operating speed would increase the probability of vehicle accident occurrence due to illegal passing on the two-lane facility.

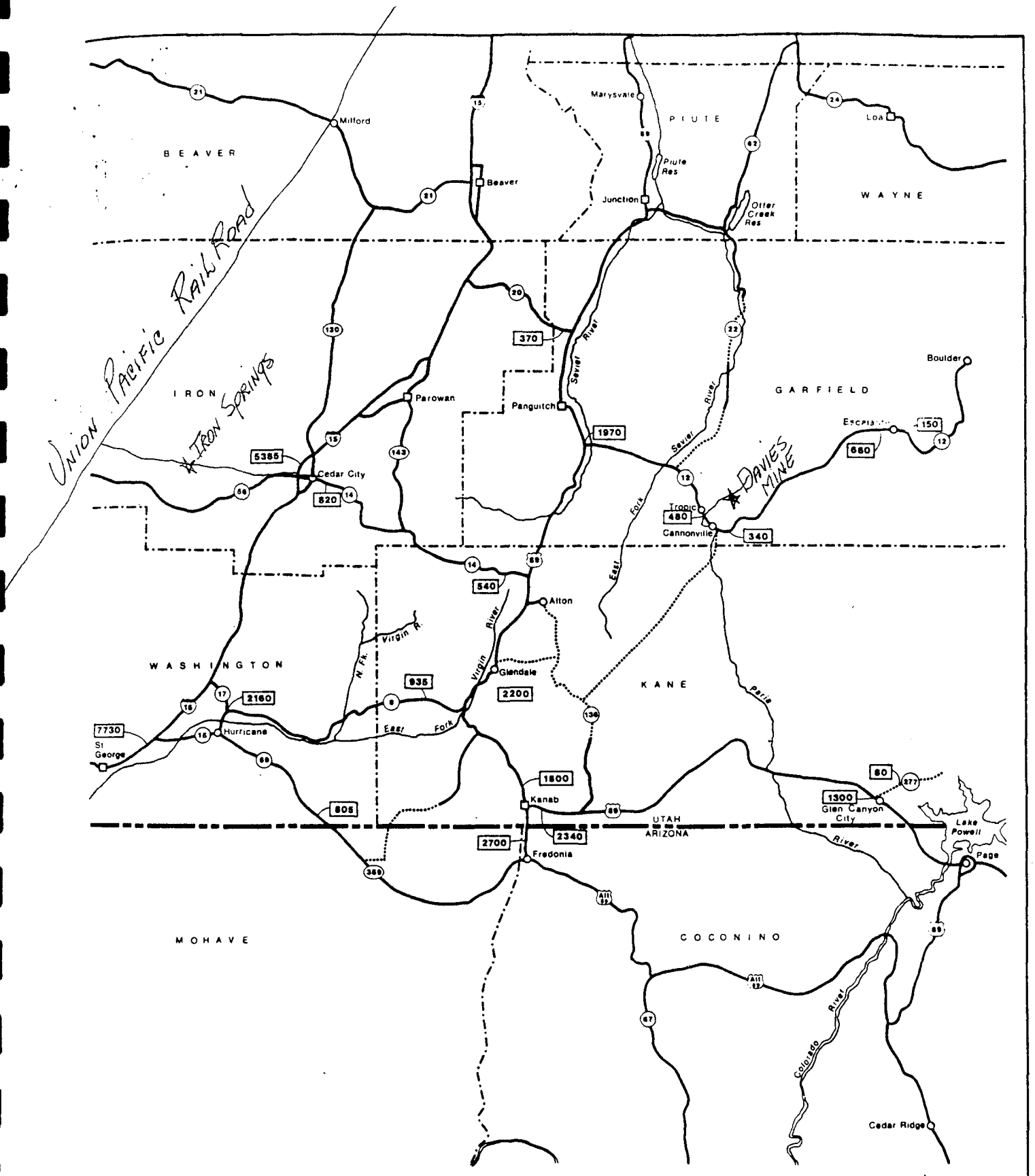
In the areas of Bryce Canyon and Red Canyon, tourists frequently pull off along the side of U-12 in areas with scenic views. This creates a potential for accident occurrence because of the limited available pavement and shoulder area for trucks to pass parked autos. During periods of inclement winter weather conditions (ice, snow), truck maneuverability and operational safety could be restricted in the areas of severe horizontal and vertical curvature.

Trucks using U-12 would pass through the communities of Escalante, Henrieville, Cannonville, and Tropic. Several of these communities have residential development in close proximity to the roadway edge, exposing them to both truck noise and vibration effects. The repeated axle loadings of coal trucks would accelerate the deterioration of the pavement surface. The section of U-12 from the eastern boundary of Bryce National Park to Escalante appears to be particularly susceptible to this occurrence given the existing condition of the pavement surface. As the pavement surface deteriorates, both noise and vibration effects become more pronounced.

FIGURE 5. RAIL NETWORK FROM THE ROCKY MOUNTAINS TO THE WEST COAST



SOURCE: World Coal Study, Future Coal Prospects: Country and Regional Assessments, Massachusetts Institute of Technology (Cambridge, Mass.: Ballinger Publishing Co., copyright 1980), p. 496. Printed with permission from



MAP 3-11. Regional Highway System

TABLE 7

ORIGINAL PRINCIPAL RESOURCE BY COUNTY
(Millions of Short Tons)

County[a] (by position)	Resource	Percent	
1. Kane	7,016.9	28.9	
2. Carbon	5,096.3	20.9	
3. Emery	4,388.8	18.0	91.5%
4. Garfield	3,698.5	15.2	
5. Sevier	2,070.8	8.5	
6. Iron	650.8	2.7	
7. Sanpete	489.5	2.0	
8. Grand	293.6	1.2	
9. Summit	186.0	0.8	
10. Wasatch	177.3	0.7	8.5%
11. Uintah	177.1	0.7	
12. Duchesne	53.9	0.2	
13. Washington	25.3	0.1	
14. Wayne	23.6	0.1	
15. Morgan	1.1	---	
TOTAL	24,349.5	100.0	

DAVIES MINE

SOURCE: H. H. Doelling, Central Utah Coal Fields, Utah Geological and Mineral Survey, Monograph Series No. 3, 1972, p. 553.

[a]Counties not listed have no resource.

TABLE 2-1
STUDY SCENARIOS

Lease Area	Coal Production (106 T/yr.)	Mining Method	Transportation Mode
Low Level			
Alton	2	~~surface~~	truck
North Kaiparowits	(1)	underground	truck
South Kaiparowits	2	underground	truck
TOTAL	5		
Medium Level			
Alton	9[a]	~~surface~~ & underground	slurry pipeline
North Kaiparowits	(15[b])	~~surface~~ & underground	slurry pipeline
South Kaiparowits	30	underground	rail
TOTAL	54		
High Level			
Alton	9[a]	~~surface~~ & underground	slurry pipeline
North Kaiparowits	(30[c])	~~surface~~ & underground	rail
South Kaiparowits	45	underground	rail
TOTAL	84		

Source: ERT Project Team Years

[a]Years 1-20 all surface mining
Year 21, 75% surface, 25% underground
Year 22, 50% surface, 50% underground
Year 23, 25% surface, 75% underground
Years 24-40, all underground mining

[b]2 million tons/year surface mining
[c]3 million tons/year surface mining

No Strip Mining Allowed in Utah

KAIPAROWITS PLATEAU COAL FIELD

by

H. H. Doelling[1] *and R. L. Graham*[2]

INTRODUCTION

Location and Extent

The Kaiparowits Plateau coal field is located in south central Utah in Garfield and Kane counties (Preface, figure 1a). The plateau is about 54 miles across its greatest width at the south end and is 66 miles from north to south, an area of approximately 1,600 square miles. It is limited by the edges of the Cretaceous outcrop, i.e., at the base of the Dakota Formation outcrops along the Straight Cliffs (Fiftymile Mountain) to the east, the base of the overlapping Tertiary strata of the Table Cliff and Aquarius plateaus to the north, the Paunsaugunt fault and the base of the Dakota Formation outcrops along the East Kaibab monocline to the west, and the base of the Dakota Formation outcrops along the deep canyons of the Colorado River system to the south. It is contiguous to the Alton coal field to the west and is separated from it by the prominent Paunsaugunt fault.

Topography and Drainage

The area is one of undulating plateau surfaces deeply incised by steep-walled canyons (figures 1 and 2). Along these canyon walls the coal seams are exposed. The drainages in the south part of the field trend southeast toward the Colorado River. This south part of the plateau is a natural geographic division useful in dividing coal areas and is designated the Smoky Mountain area. No important drainages cut across the East Kaibab monocline. In the area near the town of Tropic an amphitheatre opens to the south. Several drainages from the northeast, north and northwest collect in the amphitheatre to produce the south-flowing Paria River. The coal cropping out along the walls of this amphitheatre are in a natural subdivision designated the Tropic area. In the north part of the plateau east of the Table Cliff Plateau the drainages are basically eastward, supplying water to the Escalante River. Only two important drainages, Left and Right Hand Collet washes, cut through the Fiftymile Mountain cliff that extends from the town of Escalante to the Colorado River. These waters enter the Escalante River. All the eastward-draining canyons expose coal belonging to the third natural division, the Escalante area.

If one discounts the erosional remnant of the Table Cliff Plateau south of Upper Valley known as Canaan Peak (Kaiparowits Peak), elevations in the field range from 3,800 to 8,000 feet above sea level. The highest elevations are in the north part of the field and along Fiftymile Mountain. The lowest are along the Dakota outcrops in the south end of the field. The average elevation is about 6,000 feet above sea level. Coal seams occur throughout the entire range of elevations.

Population, Industries and Transportation

Man's use of the Kaiparowits Plateau is limited to grazing. An oil field exists along the Upper Valley anticline in the Garfield County portion, north central part of the plateau. Five small communities are located on the fringes of the coal field. Most of the plateau is accessible only with four-wheel drive vehicles. The poor roads extend for as much as 100 miles with no chance for fuel or water. There are large areas where no roads exist and where even a horse would have difficulties.

The two paved roads are U. S. Highway 89 and Utah Highway 54 (figure 1). Highway 89 skirts the southwest edge of the Kaiparowits Plateau joining Kanab, Utah, with Glen Canyon Dam and Page, Arizona. The town of Glen Canyon lies below the Kaiparowits Cliffs just north of the highway. Highway 54 drops into the Tropic amphitheatre through Tropic Canyon from the Paunsaugunt Plateau (Bryce Canyon) and connects the three hamlets of Tropic, Cannonville and Henrieville, then crosses the Kaiparowits Plateau east to Escalante. The amphitheatre towns had a population of 587 in 1970, Escalante had 638. The town populations are involved in agriculture (ranching, grazing, farming), providing support personnel for the National Park Service, the National Forest Service and Bureau of Land Management, working for a local sawmill (Escalante) drawing timber from the higher plateaus, and providing goods and services to oil well operators and tourists.

Other graded roads are the Widtsoe Junction-Escalante (Main Canyon) road, Cottonwood Creek road, Alvey Wash road, Smoky Mountain road, Hole-in-the-Rock road and the Upper Valley oil field road. They are shown on the Topography and Roads Map (figure 1). During the summer flash floods often wash out the roads.

The nearest railroad is about 75 miles northwest of the central Kaiparowits. A spur of the Denver and Rio Grande Western Railway is at Marysvale in Piute County and joins the main line at Thistle, Utah, 150 miles north. The main line of the Union Pacific Railroad is about 125 miles west of the Kaiparowits; the Cedar City spur comes almost as close as that of the Denver and Rio Grande. The lands between the railroads and the Kaiparowits are rough with high relief. The nearest regularly served airport is at Page, Arizona, just across the Utah border near Glen Canyon Dam. Several dirt landing strips are located on benches on the plateau.

Climate

Rainfall varies between 6 and 20 inches, depending on altitude, indicating a steppe climate. This means that evaporation exceeds precipitation and water becomes scarce especially in the lower altitudes (water is discussed separately in the Water Resources section). High areas generally have two peaks in precipitation, one in the winter months due to cyclonic storms and one commencing in late June or early July due to convection. The convectional storms are usually short-lived and spotty but often severe causing great damage in flash floods. The lower areas have similar but subdued peaks and storms are less frequent. The driest part of the year is usually spring. The average high temperature during July in Escalante is nearly 90 degrees. At the south edge of the Kaiparowits Plateau below the cliffs the average high temperature is about 100 degrees in that month. Evening temperatures during July range between 50 and 60 degrees. During January, at Escalante, the average low temperature is about 13 degrees and the average high about 41 degrees.

HISTORICAL OUTLINE

Though the coal of the Kaiparowits was known and mined in early years, it had not been systematically studied until Gregory and Moore studied the area and published their work in 1931. This work provided the basis for geologic work in the following years. Robison, Grose and Peterson, to name a few, have made detailed studies of the geology and coal.

Kaiparowits coal was mined soon after the first settlers became established in the 1870's and 80's in the Alvey Wash area

[1] Economic geologist, Utah Geological and Mineralogical Survey.

Spencer mine was opened in Warm Creek on the southeast edge of the plateau. The coal was used to run a river boat on the Colorado River and reported to have been used as fuel at gold mining operations on the Paria River (Averitt and Cashion, 1965).

Mining limited to local needs continued with some prosperity through the early 1900's. It persisted until the early 1960's. All mines are now closed, many are abandoned and caved or in a state of disorder. Conversion from coal to other fuels by the local people forced the abandonment of the mines.

A list of the important mines and their production where available follows (table 1).

Table 1. Coal mines and their production, Kaiparowits Plateau coal field.

Mine	Years of Activity	Average Production tons/yr.
Alvey	1952-1962	1,200
Cherry Creek	1962-1964	214
Christensen	1893-1930	100
Corn Creek	?	?
Davies	1952-1953	100 tons total
Pollock	1920-1925	?
Richards	1913-1928	100
Shakespear	1952-1964	480
Shurtz	1913-1928	100
Schow	1893-1930	?
Spencer	1910-1913	115 tons total
Winkler	1920's	?

In the past decade the need for power in the more populated areas of the west United States has heightened the interest in the Kaiparowits coal field. Many large and impressive programs have been undertaken to establish the exact quantities and distribution of the coal. Lands set aside for coal leases have been acquired by large companies and small operators. Many of the early mine properties are still held by their original owners.

The convenience of Lake Powell as a source of water makes possible steam-powered electric plants in the area. Three such proposals are now being studied (see section on Economic Consideration).

GEOLOGIC SETTING

Stratigraphy

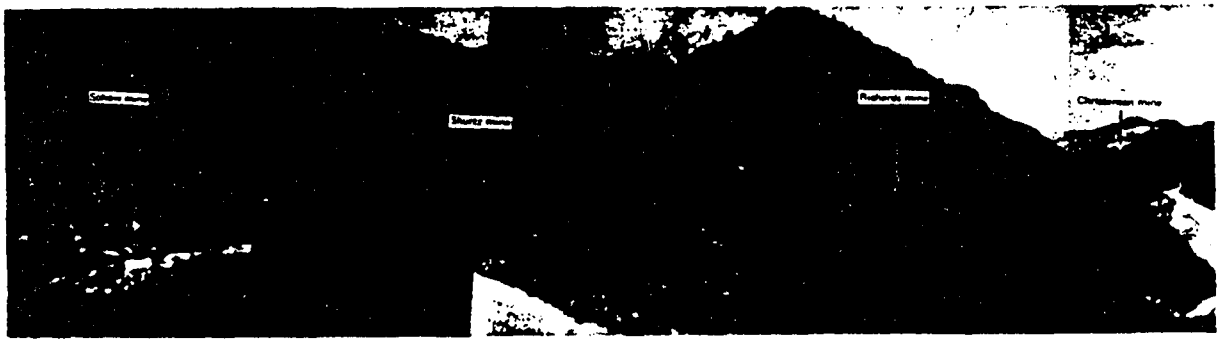
The coal of the Kaiparowits Plateau field is confined to Cretaceous rocks; the lithology, correlations, conditions, facies and other changes that are associated with them are of great importance (figure 3). The Generalized Section of Rock Formations of the Kaiparowits region follows and should be helpful in understanding the geologic setting (figure 4).

Navajo Sandstone

The stratigraphic units underlying the Cretaceous shown on the geologic maps are all of Jurassic age and begin with the lower Jurassic Navajo Sandstone (figure 3). The formation is easy to recognize and well displayed to the east, west and south of the plateau. To the east it forms the walls and rimrock along the Escalante River Canyon and to the south it is exposed along the rim of Glen Canyon although much is now submerged under Lake Powell. The walls of the Paria River to the west are also lined with the Navajo. The unit is everywhere a cliff former. Between canyons it forms uneven surfaces, mounds and rounded masses. It is mostly a fine-grained sandstone, with elaborate aeolian cross-bedding, otherwise massive with calcareous cementation. On occasion a limestone bed interrupts the sequence of sand. The Navajo is strongly jointed, usually vertically, often widely spaced. Sometimes one trend dominates, most often two. The joints localize the secondary canyons cut into the formation. The sand is frosted quartz loosely held together by the cementing material. The cement also contains varying amounts of iron oxides which give the unit its colors. The colors that dominate are cream-yellow, white, pink and tan. The Navajo ranges in thickness from 1,200 to 1,800 feet, thinning west to east. It intertongues with the overlying Carmel Formation and is, at least in part, unconformable with it.

Carmel Formation

The Carmel is everywhere found above the Navajo Sandstone. To the east it is exposed in the flats below Fiftymile Bench, to the south along the Glen Canyon section of the Colorado River (where it is not inundated), to the east it is seen along the Cockscomb with a broad irregular outcrop south of the Tropic amphitheatre. The unit consists of interbedded shale, sandstone, limestone and gypsum. Most of the unit is stained red to maroon. Near Escalante the unit contains gypsum beds, white to light green, which disappear south of the Kane-Garfield County line.



Panorama along Willow Creek.

System	Series	Stratigraphic Unit		Thickness (Feet)	Description
TERTIARY	Oligocene?	Latite flows		220- 600	Volcanics, mainly latite flows.
					Unconformity
	Eocene	Chuska Formation	Upper variegated member	0- 550	Pink, white, orange calcareous sandstone, siltstone, shale and limestone, with subordinate mudstone; upper part variegated siltstone, mudstone and sandstone; middle part mostly white limestone; and lower part mostly pink limestone.
			White limestone member	0- 550	
			Pink limestone member	0- 900	
					Unconformity
	Paleocene	Unnamed mudstone and conglomerate (Pine Hollow and Chuska Peak fms.)	Mudstone member	0- 400	Red and gray sandstone and bentonitic claystone overlying interbedded light brown, gray, pink and red sandstone, conglomeratic sandstone and conglomerate.
CRETACEOUS	Campanian		Conglomeratic member	0- 500	
					Unconformity
		Kaiparowits Formation		2,000-2,500	Gray to dark gray, fine- to moderately coarse-grained, friable 'salt and pepper' arkosic sandstone with subordinate light gray mudstone; weak calcareous cement, forms badlands and slopes.
		Wahweap Formation		760-1,350	Yellow-gray resistant sandstone, gritstone and conglomerate alternating with yellow-orange nonresistant sandstone and gray mudstone; lower half dominantly nonresistant, upper half massive and hard.
		Straight Cliffs Formation	Upper: Drip Tank Member	100- 350	Yellow-brown to gray-orange, fine- to medium-grained sandstone with some gritstone and conglomerate interbedded with subordinate gray shale; resistant cliff former.
			Upper: John Henry Member — *MAJOR COAL SEAMS*	500- 900	Interbedded yellow-gray, white and orange medium-grained sandstone, gray shale, carbonaceous mudstone and *coal*; forms ledgy outcrops; often exhibits reddish to black outcrops from clinker and burned sandstone due to natural burning of coal.
	Santonian				
	Coniacian				
					Unconformity
	Turonian		Lower: Smoky Hollow Member — *MINOR COAL*	24- 500?	Interbedded white or yellow-gray sandstone, light gray to dark gray mudstone and sometimes thin *coal* seams; lower part ledge to slope forming, upper part cliff forming.
			Lower: Tibbet Canyon Member	70- 185	Yellow-gray and gray-orange, medium-grained sandstone interbedded with subordinate gray mudstone; cliff former.
		Tropic Shale — *MINOR COAL*		550-1,000	Medium- to dark-gray argillaceous to sandy shale, contains thin yellow-gray sandstone beds at top and base, otherwise uniform; forms badlands and slopes.
	Cenomanian	Dakota Formation — *MINOR COAL*		0- 250	Yellow-gray sandstone alternating with gray shale, carbonaceous shale and *coal*; forms semiresistant ledge.
					Unconformity
JURASSIC	Upper	Morrison Formation		0- 565	Mostly yellow, gray and brown sandstone, gritstone and conglomerate, massive, interbedded with subordinate blue-green or purple mudstone; highly resistant cliff former, occasionally overlain by thin interval of purple and blue-green claystone.
		Summerville Formation	Cow Springs Sandstone	0- 200 / 0- 150	Summerville is light red, brown and gray sandstone forming banded cliffs. Cow Springs is pale greenish yellow to gray-orange fine-grained sandstone with minor mudstone and conglomerate.
		Entrada Sandstone		200- 900	Mostly orange fine-grained sandstone with reddish shale; upper part more resistant than lower part and is strongly cross-bedded; upper unit often gray-white color; colluvium or sand often found on lower unit.
		Carmel Formation		80- 520	Pink and red sandy shale, white and yellow sandstone, maroon and blue-green limestone, white and light green gypsum beds; weathers to badlands.
	Lower	Navajo Sandstone		1,200-1,800	Cream-yellow, white, pink and tan medium- and fine-grained sandstone, exhibiting large-scale aeolian cross-bedding; calcareous and cliff forming.

Figure 4. Generalized section of rock formations, Kaiparowits Plateau coal field.

Straight Cliffs Formation

The Straight Cliffs Formation, lying above the Tropic Shale, contains the most important coal resource in the Kaiparowits region. Gregory and Moore (1931, p. 91) named the unit after the escarpment of Fiftymile Mountain south of Escalante where the lower cliff-forming sandstones of the unit are beautifully exposed. Subsequent workers (Peterson and Waldrop, 1965, p. 62-63; Bowers, 1968a and b) dropped the sandstone term and applied the more general "formation" to the unit. This was done because the strata are composed not only of sandstone but also contain significant amounts of mudstone and some coal, conglomerate, siltstone and coquina. Peterson (1969a and b) conducted a detailed study of the formation and its stratigraphy and facies changes in the south half of the Kaiparowits Plateau (figure 6). He subdivided the Straight Cliffs Formation into four members, oldest to youngest, the Tibbet Canyon, Smoky Hollow, John Henry and Drip Tank members. The lower and upper members are almost universally cliff formers, dominantly sandstone and barren of coal. The Smoky Hollow is ledge and slope forming in some areas and very cliffy in others. It contains thin coal seams and a large amount of carbonaceous mudstone. The John Henry is the thickest member and contains coal seams up to 25 feet in thickness; they congregate in three or four irregularly spaced major zones.

Tibbet Canyon Member

The lower member, the Tibbet Canyon, forms the first prominent sandstone cliff above the Tropic Shale. From a distance, when the contact is not obscured by talus or landslide debris, the boundary is sharp, but close examination reveals a zone of alternating sandstone and shale beds. The map contact is placed at the base of the first prominent ledge-forming sandstone bed which is more than three feet thick (Lawrence, 1965, p. 87-88). This zone intertongues with the Tropic. The Tibbet Canyon is mainly a yellow-gray to gray-orange, fine- to medium-grained sandstone interbedded with sandy gray mudstone. The unit varies from 70 and 185 feet in thickness, is persistent and is usually recognizable throughout the Kaiparowits region. Along the base of Fiftymile Mountain the unit often is concealed by talus, especially the lower contact. The overlying Smoky Hollow is cliffy and looks very much like the Tibbet Canyon in this locality. The exact position of the upper contact is difficult to locate. Elsewhere the Smoky Hollow is a series of less resistant beds making a generally sharp contact. Occasionally fossils of inoceramids, cephalopods and shark teeth occur in the Tibbet Canyon. The type section of the Tibbet Canyon Member is located on the east side of the southeast-trending spur on the north side of Tibbet Canyon in the N NE NE of sec. 14, T. 42 S., R. 3 E. on the Nipple Butte NE quadrangle (Peterson, 1969a, p. J26).

Smoky Hollow Member

The succeeding Smoky Hollow Member is an alternating cliff- and slope-forming unit with sandstone, mudstone, carbonaceous mudstone and coal beds. In the south Kaiparowits the unit can be divided into three subordinate members: a coal zone at the bottom, a middle barren zone and an upper Calico bed. The coal zone ranges up to 47 feet in thickness but is absent over some of the anticlinal areas. No coal appears along the Straight Cliffs, but some thin coal beds are reported in the lower part of the Straight Cliffs by Robison (1966, p. 35), Bowers (1968b) and Zeller (1967a) in other parts of the plateau. These thin coal beds seem to fit in the same stratigraphic interval occupied by the Smoky Hollow. The seams are usually thin, rarely exceeding 4 feet thick.

The middle barren zone consists of alternating, mostly gray mudstone and pale yellow-brown sandstone beds. It varies from 13 to 110 feet in thickness in the south Kaiparowits and is difficult to recognize elsewhere. The outcrop pattern produces steep step-like ledges leading up to the mostly resistant upper Calico bed. The Calico bed ranges up to 51 feet in thickness in Peterson's area of study and is not everywhere present. The dominant lithology is white or very light gray, fine- to coarse-grained, poorly sorted sandstone. Occasionally there are conglomerate or gritstone lenses. The white coloration is a prominent marker in the south Kaiparowits and is not found elsewhere in the region.

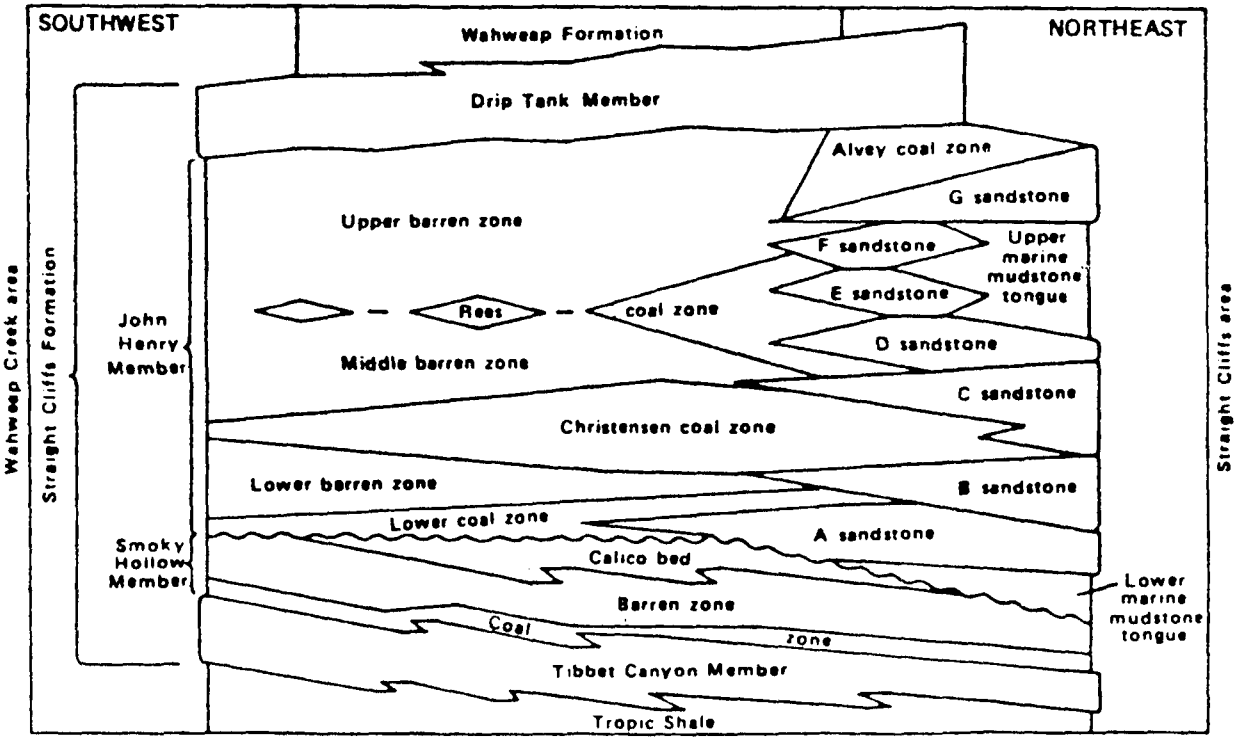


Figure 6. Relations of members and informal units in the Straight Cliffs Formation [illegible]

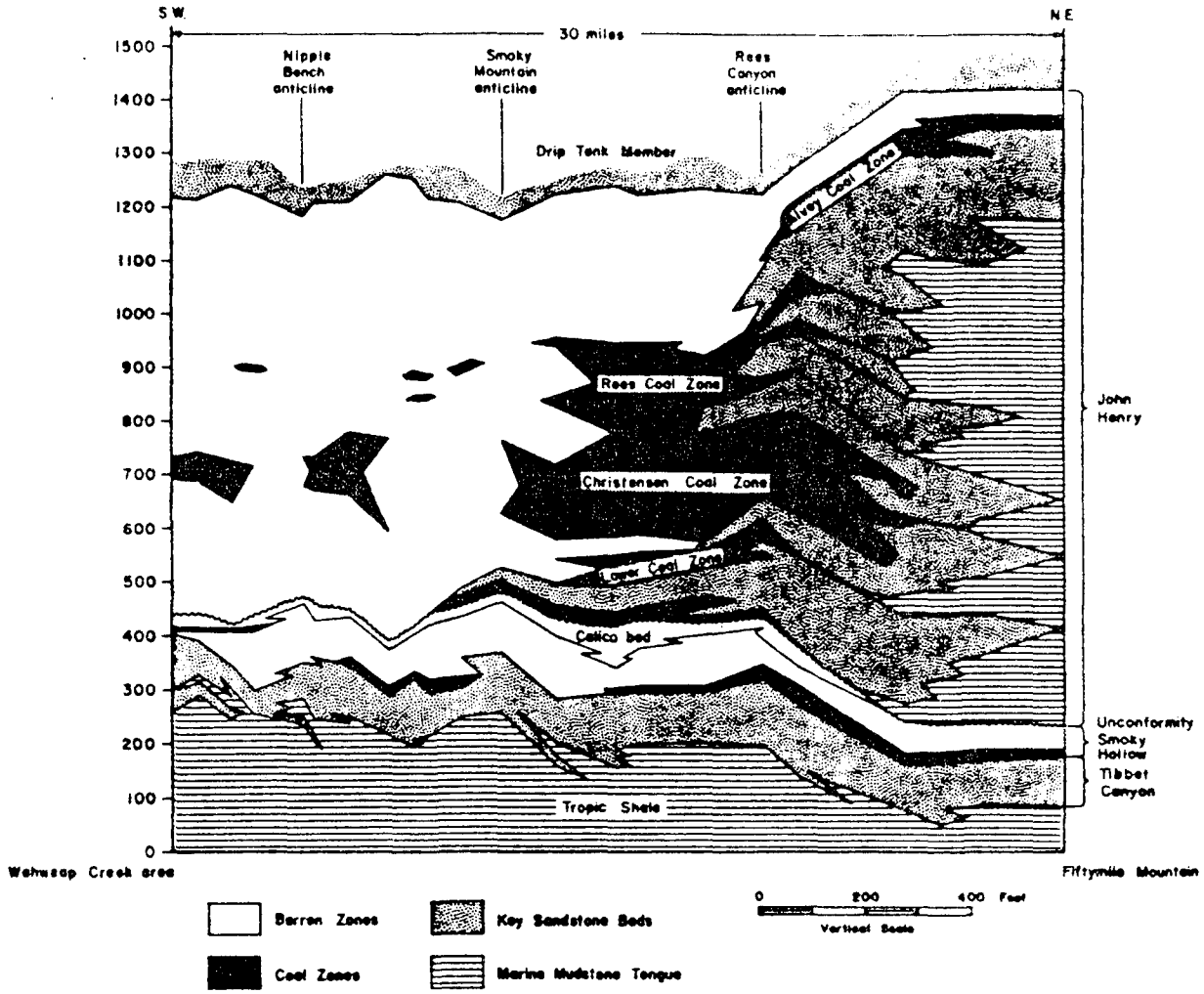


Figure 7. Diagrammatic section of Straight Cliffs Formation facies, south Kaiparowits Plateau (after Peterson, 1969 b, p. 149, 150).

anticline and in most of Croton syncline, the fine-grained well-sorted thick cliff-forming key sandstone beds are common. And in the northeasternmost part of the Straight Cliffs escarpment, the interbedded very fine-grained, well-sorted sandstones and gray mudstones of the marine mudstone tongues are common.

He diagrammatically illustrates the relations of the southeast Kaiparowits (figures 6 and 7). The composite sections (figure 8) show some of the relations in other areas as well. A study of these indicates the presence of at least four coal zones and facies changes that limit the coal in the Kaiparowits region.

The four coal zones, in ascending order, are the Lower coal zone and the Christensen, Rees and Alvey coal zones. The Alvey and Christensen have the most promising seams. The Christensen is probably correlative with the Henderson coal zone of the Tropic area where it is the only important one. In the Escalante area the Christensen and Alvey zones are most important and in the Smoky Mountain area the Rees and Christensen zones are the more valuable ones. East of Croton-Rogers Canyon the John Henry Member becomes increasingly sandy with the exclusion of mudstone and coal. West of Warm Creek the coal zones thin at the expense of the barren zones. More detail about the condition of coal in various areas is given in the discussion of the coal deposits.

Coal has burned naturally in outcrop throughout the coaliferous part of the John Henry. Several fires are in fact still burning. The burning is estimated to have continued to as much as 200 to 300 feet behind the outcrops leaving the John Henry slopes cluttered with red-burned sandstones and red, pink, green, purple, black and yellow brick clinkers that give an overall reddish hue to the outcrops. Most of the thinner coals, especially those of the Lower coal zone, are unburned. Larger areas have been burned in the south part of the Kaiparowits. Where the burning has been intensive, overlying rock layers have collapsed, creating faults, grabens and general turmoil in the beds.

The upper part of the John Henry interfingers with the Drip Tank Member. The contact is generally easy to find at the base of the first thick cliff-forming sandstone above which no significantly thick mudstone beds can be found. Fossils are not abundant but occasional coquina beds yield a varied fauna including pelecypods, gastropods and cephalopods. Shark teeth occur occasionally in the thicker sandstone units.

Drip Tank Member

The youngest member of the Straight Cliffs Formation is the Drip Tank Member. The resistant sandstone units form a caprock from which overlying formations are either completely removed or well eroded back. The bench is a prominent one best developed along a north-south line from Nipple Bench to Carcass Canyon. The lower part is more resistant than the upper and forms the caprock of the canyon cliffs.

As indicated, the Wahweap-Kaiparowits formations in the Kaiparowits region have little in common with the Mesaverde. The presence of coal in the Mesaverde is in marked contrast to the youngest Cretaceous strata of the Kaiparowits Plateau.

Areas Southeast of the Kaiparowits Plateau

The Cretaceous Dakota Sandstone in the San Juan and Black Mesa regions is equivalent to the Dakota of the plateau. In the San Juan Basin, though, the Dakota is not the first Cretaceous unit encountered; the Burro Canyon Formation underlies it. According to Peterson (1969b) the Black Mesa region in Arizona, the Tropic Shale and the Mancos Shale are equivalent. The lower Straight Cliffs is stratigraphically equivalent to the Toreva Formation and the Wepo Formation correlates with the upper Straight Cliffs of the Kaiparowits area. Within the Mancos are coaley members corresponding to the Straight Cliffs Formation of the Kaiparowits Plateau. Toward the top of the section there is no correlation to speak of. The Wahweap and Kaiparowits formations are unique to southwest Utah. The correlation diagram of Cretaceous units in south Utah (figure 12) shows the east-west relationship of the coal-bearing rocks in and around the Kaiparowits Plateau as discussed.

COAL DEPOSITS

Status of Information

The early work of Gregory and Moore (1931) and the work of private individuals who opened the mines were the only serious studies of the Kaiparowits coal field prior to 1960. At that time it became evident that the nation, in the face of increasing populations and higher energy demands, would soon require the exploitation of the large untapped coal resources of south Utah. Lands were acquired by various companies and private exploration soon followed, principally in the form of drilling. Atlantic-Richfield, Peabody Coal Co., Resources Co., Sun Oil Co. and J. H. Knight have had extensive drilling programs on their properties and probably nearly 300 tests were made. Governmental agencies such as the U. S. Geological Survey, the U. S. Bureau of Mines and the Utah Geological and Mineralogical Survey sent geologists to the Kaiparowits to gather surface data and to map the important parts of the region. Many studies are in progress. Knowledge of the area is still preliminary although in some areas the data are becoming detailed.

Analytical data are inadequate except in dealing in generalities. Little or no data exist concerning roof or floor conditions for the seams. Correlations are still insecure, even in areas where drilling has been extensive, due mainly to the lenticular nature of the seams. Many areas on the plateau are still unmapped.

Mines, Prospects and Production

Mines and prospects in the Kaiparowits Plateau coal field are listed below (table 3) with their locations and other pertinent data. The total coal removed from all mines is unknown but probably totals less than 25,000 tons (Grose, 1965, p. 132). These mines are now abandoned or inactive. Figure 13 shows locations of the coal seams and mines in the Kaiparowits Plateau coal field.

Land Ownership (figure 14)

Land and minerals of the Kaiparowits Plateau coal field are owned by the U. S. Government and the state of Utah in a proportion of approximately 10 to 1 (figure 15). Land holdings by corporations and individuals are in the form of federal leases and permits and state leases (table 4). Federal leases are distinguished from permits in that the former are obtained by competitive bidding by qualified persons and allow the lessor to mine or hold without mining designated lands for a 20-year renewable period.

Table 3. Coal mines and prospects of the Kaiparowits Plateau coal field.

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	

Table 4. Coal land holdings in the Kaiparowits Plateau coal field.

Name	Acres		Total acres
	State of Utah leases	Federal leases or permits	
Armstrong, D.E.	840.00	–	840.00
Atlantic–Richfield	14,163.72	25,738.72	39,902.44
Bryce Canyon Coal & Coke	–	40.00	40.00
Consolidation Coal	–	25,533.41	25,533.41
Dunklef, M.	–	1,093.34	1,093.34
Davies, B.	40.00	–	40.00
Delcoal, Inc.	3,200.00	15,929.53	19,129.53
Dev. & Resources Co.	1,280.00	–	1,280.00
Fallick, M. L.	960.00	–	960.00
Frandsen, G. H.	–	160.00	160.00
Healy, R. L.	803.95	–	803.95
Hiko Bell Mgn. & Oil	1,280.00	1,040.00	2,320.00
Hollberg, R. J.	3,797.88	–	3,797.88
Knight, J. H.	160.00	12,904.75	13,064.75
Peabody Coal Co.	1,280.72	28,084.72	29,365.44
Phillips, J. W.	160.00	–	160.00
Rasmussen, W. L.	1,919.96	8,774.72	10,694.68
Resources Co.	6,210.44	39,355.19	45,565.63
Seatry Royalty Co.	1,280.72	–	1,280.72
Shakespear, A.	–	80.00	80.00
Sun Oil Co.	4,511.60	21,711.00	26,222.60
West, S. H.	–	960.88	960.88
Woods Petroleum Co.	–	14,249.05	14,249.05
Grand Totals	41,888.99	195,655.31	237,544.30

A permit holder may prospect or mine from his lands for two years. The permit may be extended for two years by continuing to pay an annual rental and agreeing to perform certain exploration work during the renewal period. This work customarily consists of drilling one hole in each square mile of the land. This permit may be converted to a lease without competitive bidding at any time during its life after the land has been proved to contain minable coal.

The locations of the above land holdings are shown on the Leases and Permits Map (figure 16). The major land-holding units were selected beginning in 1961 on the basis of information then available from the few published reports. Most of the leased lands owned by the federal government were obtained first by permit and then converted to leases. More recently certain smaller tracts were obtained by competitive bidding after it had been established that the lands did contain coal in minable quantities. Several hundred holes were drilled to prove the land by the major land holders, but only a small part of the data have been made available for publication.

The purposes for land acquisition are varied. The utilities group (Resources Co.) wants reserves for use in a projected steam-generating plant. Firms active in coal production elsewhere look to the future for possible markets for coal that they hope to mine from their holdings; others acquired leases and permits for investment while firms active in petroleum regard coal reserves as a source of hydrocarbons convertible to gas and liquid forms when technology and economics provide a suitable method.

Quality of Coal

More than 100 analyses of Kaiparowits Plateau coal are available (table 5). The rank ranges from subbituminous C to high-volatile bituminous A. In general the ash content is moderate to high and the sulfur content as mined is low to moderate. The coal has no coking properties and in some areas would require mechanical cleaning to insure a satisfactory fuel for power production or as a source of solid hydrocarbons for conversion to other forms of fuel. Rank and other constituents of the analyses vary from area to area.

Table 5. Quality data for the Kaiparowits Plateau coal field.

	Percent		No. of analyses
	Range	Average	
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
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

About one-half of the analyses are from surface outcrops or from the old mines. Most are channel samples, a few grab samples. In the Smoky Mountain area the Btu/lb value is a trifle higher since most of the analyses were made of the Christensen coal zone, the deepest of the more valuable zones. Coal in the Christensen zone of the Escalante area is comparable; Alvey coals run an average of 500 to 1,000 Btu/lb less. The lowest heat value is from the Tropic area in the Christensen (Henderson) zone where coal contains more moisture and ash.

Moisture is greatest in the Tropic area and about 2 and 3 percent greater than Escalante and Smoky Mountain respectively. In the Escalante area the coal becomes more moist west of the Upper Valley anticline. It is not known whether adequate precautions were taken in some of the sampling procedures to protect them from moisture before testing.

The highest figures for volatile matter and the lowest ash content were in the Escalante area. The highest fixed carbon and lowest volatile matter were found in the Smoky Mountain area. The Tropic area was lowest in fixed carbon and highest in ash content.

Sulfur content was highest in the Escalante area but this characteristic is not typical of the area. Several high sulfur analyses were obtained from one mine (Schow mine) that affected the average figure. It is believed that the figure is more like that for the Tropic or Smoky Mountain area. The sulfur averages shown in table 5 (page 93) were all calculated on a dry basis. A very low sulfur analysis from the Escalante area is the only one available for breakdown into forms of sulfur. It was taken at the Alvey mine in 1945 (table 6) and classed as subbituminous B (Walker and Hartner, 1966).

Table 6. Analysis of 2-inch tipple sample, as-received, from the Alvey mine (in percent).

	Percent
Moisture	17.7
Ash	7.8
Sulfur	0.42
Sulfate	0.03
Pyritic	0.10
Organic	0.29

Gomez, Landers and Boyd (1967, p. 12) calculated carbonization product yields from coal at the Alvey mine, Escalante area (weight-percent of maf coal: char 68.2, water of decomposition 8.0, tar plus light oil 14.1, gas 9.0, gas volume (scf/lb) 1.313 and gas (Btu/scf) 581. Carbonization temperature is 500° C.

Reserves

Coal resources of the Kaiparowits Plateau coal field are contained in two, possibly three formations: the Straight Cliffs, Dakota and possibly the Tropic Shale. The combined reserves calculated in this study and including all classes of reserve total 15.2 billion short tons. The minable portion of this figure will be limited to between 33 and 50 percent of that amount. This tonnage figure includes only seams four feet or more thick. In 1931 Gregory and Moore provisionally estimated Kaiparowits Plateau reserves as 3 billion short tons. This figure was carried by the U. S. Geological Survey by Paul Averitt (1961, 1964) until the mid-1960's and increased to 40 billion tons based on recent work and study of the general geology of the area. In 1970 the U. S. Geological Survey reported 7.2 billion tons as indicated reserve based on measurements less than 1½ miles apart (Westerberg, 1970). This analysis by the U. S. Geological Survey implies that much more will be added to indicated reserves as more drill-hole information is obtained and becomes available. It is assumed that data from nearly 200 drill holes on federal lands were available for the compilation of this estimate. It is not clear, however, whether seams less than four feet were considered in the estimation.

Resources Co. (Arizona Public Service, Southern California Edison and San Diego Gas and Electric) estimated a total reserve of 1.855 billion tons of coal in its 71-square-mile holding. This is based on coal beds of four feet or more in thickness. A total of 372 square miles of Kaiparowits coal lands are under lease or permit. It then appears reasonable to assume that the total area contains proportionately as much as the Resources holdings because a substantial amount of the total area seems to contain equal or better surface indications of coal. Thus reserves on all holdings in the Kaiparowits Plateau coal field would total 9.719 billion short tons. Some of the nonleased areas that have been studied are sure to contribute additional reserves. Calculations indicate that the figure might be enlarged to 11.1 billion tons. If one-third is recoverable that would allow 3.7 billion tons for exploitation. Some appreciation of the magnitude of this amount of energy reserve may be gained from the realization that it would supply about eighteen 2,000,000-kw electric generating plants for a 35-year period.

The reserves calculated for this report are classed as follows (table 7):

Table 7. Definition of reserves for Kaiparowits Plateau coal field (in short tons).

Class I	Measured reserves	Based on adequate exploration and development data, properly correlated.
Class II	Indicated reserves 3,984,800,000[1]	Based on geologic measurement supplemented by limited drill-hole information and limited to 1½ miles from a control point.
Class III	Inferred reserves 3,893,200,000	Based on geologic inference and projection of the habit of the coal beyond 1½ miles from control points.
Class IV	Short tons 7,320,000,000	Based on geographic and geologic position with little supporting data and includes coal up to 3,000 feet of cover.
Total	15,198,000,000	

[1] Includes a small amount of Class I reserve.

A breakdown of the reserve into quadrangles is given in table 8. The information indicates that the Christensen coal zone is the most valuable and that reserves for all zones lower than the Christensen, including those of the Tropic and Dakota, are minor. No coal seams less than 4 feet thick were included and no coal deeper than 3,000 feet was considered.

The above shown reserve estimates compare favorably with those based on Resources Co. drill-hole data. A Class IV determination was made to extend the Resources Co. calculation to unleased areas where the geology inferred that an additional potential reserve could be expected (table 9).

In summary, the reserve that can be considered for exploitation in the foreseeable future is between 14 and 15 billion short tons, and depending on many unknown factors including recoverability, at least 4 billion tons should be minable.

Coal Seams (figures 13 and 17)

Escalante Area

The Escalante area of the Kaiparowits Plateau coal field contains a little more than 3.5 billion tons of reserve in five coal zones (excludes Class IV). These five coal zones are, in ascending order: Dakota, Christensen, Rees, Alvey and Upper Alvey. Another lower zone contains coals of poor quality in thin seams.

The Dakota coal zone fringes the Kaiparowits Plateau along its northeast edge in the Escalante area. The coal in the unit rarely occurs in seams more than 4 feet thick, but in the Dave Canyon quadrangle, a few miles south of the town of Escalante, several

Table 8. Coal reserves by quadrangle of Kaiparowits Plateau coal field (in millions of short tons).

Quadrangles / Class	Alvey Coal Zone II	Alvey Coal Zone III	Ross Coal Zone II	Ross Coal Zone III	Christensen Zone II	Christensen Zone III	Minor Coal Zones[5] II	Minor Coal Zones[5] III	Total X 10^6
Basin Canyon	–	–	–	–	–	–	–	–	–
Canaan Creek	89.3	30.2	23.4	–	175.3	79.6	–	–	397.8
Calico Peak-Horse Flat	–	–	–	–	–	–	–	–	–
Carcass Canyon	168.8	37.5	6.3	–	258.8	157.6	–	–	629.0
Collet Top	143.3	25.2	–	–	54.8	246.6	–	–	469.8
Dave Canyon	42.0	4.0	–	–	79.3	15.4	29.7	–	170.4
Death Ridge	63.2	295.6	9.5	–	97.0	594.8	–	–	1,060.2
East of Navajo	1.1	–	3.7	–	6.6	12.2	4.0	–	27.6
Griffin Point	105.0	72.9	109.7	–	71.9	89.6	–	–	449.1
Gunsight Butte NE	–	–	–	–	17.9[1]	–	–	–	17.9
Gunsight Butte NW	–	–	–	–	230.2[1]	199.7[1]	–	–	429.9
Gunsight Butte SE	–	–	–	–	–	–	–	–	–
Henrieville	–	–	–	–	13.0[2]	17.0[2]	13.4	–	43.4
Needle Eye Point	–	–	86.6	156.5	208.8	231.5	–	–	683.4
Nipple Butte NE	–	–	–	–	212.5[3]	59.7[3]	–	–	272.2
Nipple Butte NW	–	–	–	–	–	–	–	–	–
Nipple Butte SE	–	–	–	–	10.3[4]	5.0[4]	23.0	–	38.3
Nipple Butte SW	–	–	–	–	–	–	–	–	–
Paria NW	–	–	–	–	–	–	0.4	–	0.4
Petes Cove	116.1	251.7	6.3	–	–	434.5	–	–	808.6
Pine Lake	–	–	–	–	297.0[2]	314.0[2]	–	–	611.0
Soap Flat	–	–	–	–	19.2	8.9	–	–	28.1
Ship Mountain Point	–	–	–	–	963.0[3]	302.8[3]	–	–	1,265.8
Slickrock Bench-Butler Valley	–	–	–	–	0.5[2]	–	–	–	0.5
Tropic Canyon	–	–	–	–	160.0[2]	161.0[2]	–	–	321.0
Upper Valley	34.1	46.9	12.6	42.8	10.6	–	–	–	147.0
Other areas	–	–	–	–	–	–	6.6	–	6.6
Total	762.9	764.0	258.1	199.3	2,886.7	2,929.9	77.1	–	7,878.0
Zone totals	1,526.9		457.4		5,816.6		77.1		
Potential reserve	Unmapped areas with little supporting data.								7,320.4
Grand total									15,198.0

[1] All Straight Cliffs (John Henry) zones combined.
[2] Henderson coal zone (correlative).
[3] Includes some coal from the Ross zone.
[4] May include some coal from Lower coal zone.
[5] Includes Lower, Smoky Hollow, Dakota and Tropic coal zones.
(Totals are rounded)

sections indicate coal between 4 and 5 feet thick. The seams occur at the foot of Fiftymile Mountain, have shale or shaley sandstone roofs and would have to be deep-mined. The seams are located in the middle of the formation which is about 140 feet thick.

The Lower coal zone occurs in the lower 500 feet of the Straight Cliffs Formation and exhibits spotty thin seams which seem to be more abundant in the west part of the area.

The Christensen zone is the most valuable of all the coal zones in the Escalante area. It is well developed in most parts of the area, except perhaps in the Upper Valley and Griffin Point quadrangles and in the extreme north part of the Canaan Creek quadrangle. In that part of the Escalante area the seams are more lenticular and in places the zone does not have seams of minable thickness. The zone improves to the west and south where often there are several thick seams. This is especially evident in Death Ridge and Carcass Canyon quadrangles where seams more than 25 feet thick have been discovered. These thick coal beds often have considerable separation. In the extreme west part of the Carcass Canyon quadrangle the Christensen zone pinches out as lagoonal facies are supplanted by beach and nearshore sands. The west limit of coal occurs 2 or 3 miles west of the plateau front near the mouths of Right and Left Hand Collet canyons.

Table 9. Comparison of reserve estimates from various sources for the Kaiparowits Plateau coal field.

	This estimate (billion short tons)	Based on Resources Co. drill-hole data	U. S. Geological Survey
Class I, II	3.985	1.855	7.200
Class III	3.893	9.245	
Class IV	7.320	3.135	32.800
Total	15.198	14.235	40.000

The roof rock varies from place to place and no areal generalizations can be made. For example the Shurtz and Schow mines are located less than 1,000 feet from each other on the same coal bed. The Schow mine has a sandstone roof and the Shurtz mine has a shale roof.

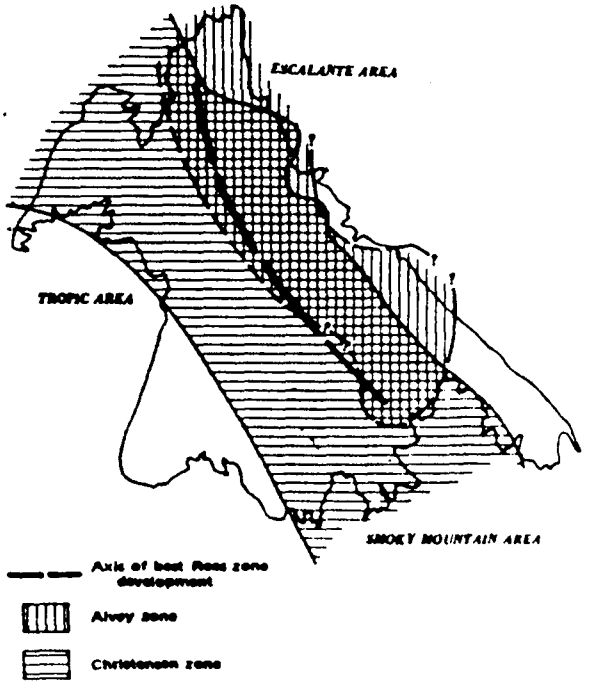


Figure 17. Areas of coal deposition, Kaiparowits Plateau coal field.

The Christensen zone is coincident with the broad band of commercial coal discussed previously which trends north-northwest from the northern limits of the plateau to the southeast area of the field. Outside this band, to the northeast, there is little or no coal in the Christensen zone. Southwest of the band the coal beds thin to less than 4 feet but persist for a few more miles into the Nipple Butte area. In the best areas the coal seams are 15 feet thick. The zone divides into many coal beds near the center of the plateau much like the other zones. Because erosion has stripped overlying formations from the top of the Straight Cliffs Formation, the zone is never more than 800 feet below the surface in the east part of the area. To the west the Wahweap rests above the formation and forms a deep cover over the zone.

The minor Lower zone of coal lying near Needle Eye Point has the same characteristics as the other zones. The thickest seam is about 5 feet; extent of the zone is limited and erratic. An additional coal zone occurs in the Smoky Hollow Member of the Straight Cliffs Formation. The coal seams are usually less than 4 feet thick.

Natural burning in the Smoky Mountain area along the outcrops has been so hot that slag was formed from the shales and sandstones. The south part of the plateau was hardest hit by burning which devastated as much as 100 square miles around Smoky Mountain. A few continue to burn unchecked. The location of these fires is as follows (1970):

Location	Comments
SW.SE.22-39S-5E	Odor of smoke from fractures
SW.NW.35-40S-5E	Dense smoke from fissures
SE.NE.7-40S-5E	Dense smoke from fissures
East side of Smoky Mountain	Bureau of Mines working to quench fire

These fires are wasting an important natural resource. It is sometimes difficult to tell which coal seam has burned because of the effect of the fire on other seams. The extent of the burn underground is probably several hundred feet and has collapsed overlying strata, making correlation of seams difficult.

The structural elements of the Smoky Mountain area will not cause difficulty in mining the coal. Dips are gentle and faults are few and of minor displacement.

Tropic Area

Significant coal beds in the Tropic area occur in the Dakota and Straight Cliffs formations of Cretaceous age. The thickest seams are confined to the Straight Cliffs and are of the most economic importance. The Dakota Formation may prove to be an important coal-bearing unit but sufficient data are not available to give many details at this time. Early papers reporting poor quality and thin lenticular nature of the Dakota coal have been responsible for the limited exploration of the unit. Certain properties in the Tropic amphitheatre directly over the Dakota have been leased for coal. The average elevation above sea level of the Dakota outcrops in the Tropic area is about 6,000 feet.

Robison (1966), reporting on the Tropic area wrote:

> The Dakota at any given locality commonly contains from one to several coal beds, but few are more than one foot thick. The beds are lenticular and most extend laterally less than a few hundred feet, and some extend only a few tens of feet. Coal beds may occur anywhere from bottom to top of the formation, and do not appear to be concentrated in persistent zones as in some other areas in southern Utah. Analyses indicate a high ash lignite to subbituminous B coal.

An outcrop 5½ miles southwest of Cannonville, as measured by Robison, contains 12.2 feet of coal; the thickest single seam is nearly 6 feet. Thomson (1970) found coal up to 13.5 feet thick in the Henrieville quadrangle. If seams of this thickness can be found over a large area, portions of the Dakota may prove to be strippable.

The Straight Cliffs Formation crops out in the amphitheatre at an altitude of about 6,800 feet and is the dominant cliff and ledge unit responsible for the geomorphic feature. In contrast with the Dakota Formation, the Straight Cliffs in the Tropic amphitheatre has two persistent coal zones. The better and thicker coal of the unit occurs in the upper or Henderson coal zone. The Lower coal zone contains thin and lenticular coal. Thicknesses for the Lower coal zone vary from 5 to 20 feet and the stratigraphic placement ranges about 60 to 130 feet above the base of the formation. Coal beds of economic thickness were not observed in surface exposures of this zone, but drilling to the northeast in the Johns Valley anticline showed multiple coal seams up to 14 feet thick in the approximate position of the Lower coal zone. A typical section at the outcrop of the Lower coal zone reveals roof and floor of shales, mainly siltstone, with three splits of coal each less than 1 foot thick. Where coal is absent the zone contains dark carbonaceous shale.

The Henderson coal zone, named after Henderson Canyon northeast of Tropic, is perhaps correlative with the Christensen zone in the east part of the Kaiparowits Plateau. Around Tropic the base of the zone ranges from 400 to 700 feet above the base of the Straight Cliffs, placing the coal at approximately 7,300 feet above sea level. Between the Henderson zone and the Lower coal zone is a conglomeratic sandstone 60 to 360 feet thick, varying the thickness of the formation below the Henderson coals. At any one locality, the coal occurs in multiple seams with a cumulative thickness up to 25 feet in outcrop. Drill holes on Johns Valley anticline reveal cumulative coal of 20 to 75 feet. The individual seams thicken to the northeast to 12 feet.

Generally the ceiling of the zone is a competent sandstone; the barren upper member of the Straight Cliffs, though locally siltstone or mudstone, may make up the immediate roof. In the areas of thickest seams, bone coal is less evident. Shaley splits prevail in the southwest outcrops and diminish as the coal thickens northeasterly. Individual seams cannot be correlated from place to place with certainty but their continuous projection under the cover to the northeast is assured. Reserves for the Tropic area are somewhat less than 1 billion tons.

In the Antimony-Johns Valley area a drilling program was undertaken by the U. S. Geological Survey to study groundwater conditions along the East Fork of the Sevier River. Coal discovered there seems to be in the Tropic Shale although it could be coal of the Straight Cliffs Formation or Dakota Formation.

Four test holes were drilled and coal was discovered in two of them at a depth between 354 and 416 feet below the surface. Eardley and Cohenour (1963) studied the test hole data and measured a total thickness of 35 feet of coal. Property was leased by a private concern to further investigate the coal. The leases were dropped early in 1970.

Study of the structure of the amphitheatre suggests some difficult mining areas. The Johns Valley anticline, where it dips 45 degrees to the east, is certainly a major obstacle to underground mining. From the crest of the anticline the structure falls and loses approximately 5,000 feet of relief across a distance of about 10 miles. As previously explained, the coal seams thicken to the northeast. Wells drilled in the Johns Valley anticline for petroleum encountered good quantities of coal in thick seams in the Henderson zone. Further exploration might increase estimates of reserve in that area by a significant amount.

The remainder of the area, though warped by minor flexures with dips from 4 to 10 degrees, should not present structural difficulties in mining. Because the coal beds are exposed along the escarpments and cliffs of the Tropic amphitheatre and the overburden increases rapidly behind the outcrop, it is assumed that the exploitation of most of the Henderson coal will necessitate deep-mining.

Table 10. (continued)

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of Samples	Ref. Source
				AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
2	Outcrop Alvey zone	7–36S–3E	A C	11.6 –	41.5 46.9	36.1 40.8	9.5 10.7	1.3 1.5	–	–	–	–	–	10,799 12,216	–	–	–		37
									DEATH RIDGE QUADRANGLE										
1	Outcrop Alvey zone	NE.NE.NE.NE.NW.18–37S–2E 4161110mN 436215mE	A C	7.2 –	38.3 41.3	50.0 53.9	4.5 4.8	–	–	–	–	–	–	10,410 11,218	–	–	–		15
2	Outcrop Christensen zone	SE.SE.SE.7–37S–2E 4161375mN 436820mE	A C	5.4 –	41.0 43.3	48.3 51.1	5.3 5.6	–	–	–	–	–	–	11,244 11,886	–	–	–		15
3	Outcrop Christensen zone	E.6–37S–2E 4163760mN 436695mE	A C	6.0 –	41.0 43.6	46.6 49.6	6.4 6.8	–	–	–	–	–	–	10,958 11,657	–	–	–		15
4	Outcrop Rees zone	NE.NE.NE.NE.NW.18–37S–2E 4161220mN 436500mE	A C	7.1 –	45.8 49.3	41.2 44.3	4.9 5.3	–	–	–	–	–	–	9,229 9,934	–	–	–		15
									EAST OF THE NAVAJO QUADRANGLE										
1	Outcrop Rees zone	NE.SW.33–40S–5E 4126380mN 466950mE	A C	9.08 –	34.68 38.15	50.06 55.07	7.12 7.84	0.85 0.93	–	–	–	–	–	10,220 11,242	–	–	–		17
2	Outcrop Lower zone	NE.7–40S–6E 4133810mN 473960mE	A C	12.50 –	37.98 43.41	39.08 44.67	10.44 11.93	0.83 0.95	–	–	–	–	–	9,420 10,767	–	–	–		17
									GRIFFIN POINT QUADRANGLE										
1	Cherry Creek mine Zone E (U. Alvey)	SE.SE.SE.8–35S–1E 4180700mN 429185mE	A C	17.7 –	35.3 42.9	37.0 45.8	10.0 12.1	.7 .8	–	–	–	–	–	8,920 10,830	–	10.8	–		19
2	Cherry Creek mine		A C	17.7 –	37.8 46.0	37.4 45.3	7.1 8.7	.5 .6	–	–	–	–	–	8,340 10,140	–	8.2	–		19
3	Cherry Creek mine		A C	24.8 –	33.0 43.8	32.9 43.8	9.3 12.4	.4 .6	–	–	–	–	–	7,420 9,880	–	11.3	–		19
4	Cherry Creek mine		A C	21.8 –	35.9 45.9	37.0 47.3	5.3 6.8	.4 .6	–	–	–	–	–	9,160 11,720	–	14.3	–		19
5	Cherry Creek mine		A C	7.6 –	46.0 49.8	40.0 43.3	6.4 6.9	–	–	–	–	–	–	9,963 10,782	–	–	–		15
6	Cherry Creek mine		A B C	15.30 7.70 10.30	37.13 39.58 41.23	37.87 41.54 40.69	10.50 11.18 7.78	.47 .76 .55	–	–	–	–	–	8,366 9,995 10,093	–	–	–		22
7	New Cherry Creek mine Zone E (U. Alvey)	SE.SE.8–35S–1E 4180670mN 429185mE	A C	15.1 –	41.1 48.4	39.1 46.0	4.7 5.6	.9 1.1	–	–	–	–	–	10,125 11,920	–	–	–		24
8	Outcrop Zone E (U. Alvey)	SE.8–35S–1E	A C	16.5 –	41.5 49.8	34.0 40.8	6.7 8.0	1.3 1.56	–	–	–	–	–	9,985 11,887	–	–	–		24
9	Corn Creek mine Zone D (L. Alvey)	SE.5–35S–1E 4182210mN 428600mE	A C	6.2 –	45.0 48.0	42.0 44.8	6.8 7.2	–	–	–	–	–	–	9,066 9,665	–	–	–		15
									HENRIEVILLE QUADRANGLE										
1	Outcrop Henderson zone	NE.SE.6–37S–1W 4162790mN 417540mE	A C	22.7 –	34.6 44.7	32.5 42.1	9.6 12.4	0.6 0.8	–	–	–	–	–	7,768 10,049	–	–	–		39
2	Outcrop Henderson zone (Middle bed)	SE.SE.NE.29–37S–1W 4157850mN 419300mE	A C	17.7 –	35.9 43.6	37.8 46.0	8.6 10.4	0.69 0.84	–	–	–	–	–	9,510 11,555	–	–	–		AHC
3	Outcrop Dakota zone	NW.NW.SW.2–38S–2W 4153600mN 414150mE	A C	19.8 –	36.1 45.0	37.1 46.3	7.0 8.7	0.37 0.46	–	–	–	–	–	9,410 11,734	–	–	–		AHC
									NEEDLE EYE POINT QUADRANGLE										
1	Outcrop Christensen zone	27–40S–4E	A	6.7	38.5	50.2	4.6	.6	–	–	–	–	–	10,460	–	–	–		22
2	Outcrop Rees zone?	NW.9–40S–4E	A C	23.7 –	37.6 49.2	29.5 38.6	9.2 12.2	1.2 1.6	–	–	–	–	–	8,453 11,056	–	–	–		24
3	Outcrop Rees zone?	SW.9–40S–4E	A C	12.3 –	40.8 46.4	38.6 45.3	7.3 8.3	1.1 1.5	–	–	–	–	–	10,142 11,562	–	–	–		24
4	Outcrop Christensen zone?	SE.16–40S–4E	A C	12.4 –	40.1 45.2	42.0 47.9	5.5 6.3	1.3 1.5	–	–	–	–	–	10,372 11,848	–	–	–		24
5	Outcrop Smoky Hollow zone	SE.SE.NW.36–40S–4E 4126920mN 462100mE	A C	4.22 –	42.20 44.06	44.77 46.74	8.81 9.20	1.40 1.46	–	–	–	–	–	11,800 12,319	–	–	–		17
6	Outcrop Christensen zone	SW.SW.SW.22–40S–4E 4129400mN 458500mE	A	7.35	20.31	66.24	6.10	.52	–	–	–	–	–	11,750	–	–	–		17
7	Outcrop Christensen zone	NE.NE.NE.33–40S–4E 4127660mN 458240mE	A	7.03	37.46	50.08	5.43	.41	–	–	–	–	–	11,785	–	–	–		17

Table 10. (continued)

No.	Mine or Prospect-Coal bed	Township & Range UTM grid		PROXIMATE ANALYSES					ULTIMATE ANALYSES						OTHER TESTS			Kind of Samples	Ref. Source
				AN	M	VM	FC	Ash	S	H	C	N	O	Btu/lb	AST	ADL	HGI		
8	Outcrop Christensen zone	C.N.SW.25–40S–4E 4128220mN 462000mE	A	8.49	38.20	44.18	9.13	.62	–	–	–	–	10,850	–	–	–			17
9	Outcrop Christensen zone	NE.SW.6–41S–5E 4124740mN 463660mE	A	5.79	21.37	66.22	6.62	.93	–	–	–	–	11,400	–	–	–			17
10	Outcrop Christensen zone	SW.NE.SW.8–40S–5E 4133040mN 465320mE	A	14.59	30.58	46.05	8.78	.83	–	–	–	–	9,850	–	–	–			17
11	Outcrop Christensen zone	NE.NW.SW.20–40S–5E 4130820mN 465000mE	A	9.97	51.66	28.54	17.83	1.29	–	–	–	–	9,785	–	–	–			17
								NIPPLE BUTTE NE QUADRANGLE											
1	Spencer mine Ross zone?	SW.SW.SW.3–42S–3E 4114940mN 448789mE	A	5.4	38.1	51.0	5.5	.6	–	–	–	–	10,610	–	–	–			46
			B	4.9	38.3	51.3	5.5	.6	–	–	–	–	10,660	–	–	–			
			C	–	40.2	54.0	5.8	.6	–	–	–	–	11,210	–	–	–			
			D	–	42.7	57.3	–	.7	–	–	–	–	11,890	–	–	–			
2	Spencer mine		A	5.9	40.9	47.5	5.7	.5	5.4	68.0	2.0	18.4	11,880	–	–	–			46
			B	5.5	41.1	47.7	5.7	.5	5.4	68.3	2.0	18.1	11,930	–	–	–			
			C	–	43.5	50.5	6.0	.6	5.8	72.3	2.2	13.9	12,630	–	–	–			
			D	–	46.3	53.7	–	.6	5.3	76.9	2.3	14.9	13,400	–	–	–			
3	Spencer mine		A	3.7	45.1	47.4	3.8	1.1	–	–	–	–	12,297	–	–	–			38
			C	–	46.8	49.3	3.9	1.1	–	–	–	–	12,756	–	–	–			
4	Warm Creek Prospect Christensen zone	SW.SW.SW.3–42S–3E 4114850mN 448690mE	A	4.7	40.7	48.6	6.0	.7	–	–	–	–	12,190	–	–	–			22
5	Outcrop Christensen bed A	SW.SW.19–41S–4E 4119930mN 453700mE	A	12.0	39.3	38.1	10.1	1.2	–	–	–	–	9,820	–	–	–			38
			C	–	45.3	43.2	11.5	1.3	–	–	–	–	11,163	–	–	–			
6	Outcrop Christensen bed B	SW.SW.19–41S–4E 4119930mN 453700mE	A	11.2	42.6	36.1	10.1	1.2	–	–	–	–	9,858	–	–	–			38
			C	–	48.0	40.6	11.4	1.4	–	–	–	–	11,112	–	–	–			
7	Outcrop Christensen bed C	SW.SW.19–41S–4E 4119930mN 453700mE	A	21.6	35.9	35.8	6.7	1.1	–	–	–	–	8,992	–	–	–			38
			C	–	45.8	45.7	8.5	1.4	–	–	–	–	11,468	–	–	–			
8	Outcrop Christensen bed D	SW.SW.19–41S–4E 4119930mN 453700mE	A	24.2	35.9	33.9	6.0	.9	–	–	–	–	8,778	–	–	–			38
			C	–	47.3	44.8	7.9	1.1	–	–	–	–	11,582	–	–	–			
								NIPPLE BUTTE SE QUADRANGLE											
1	Dakota mine Dakota zone	NE.NW.7–42S–4E 4104830mN 453960mE	A	5.3	45.1	44.1	5.5	1.6	–	–	–	–	10,670	–	–	–			44
			B	5.1	45.2	44.2	5.5	1.6	–	–	–	–	10,690	–	–	–			
			C	–	47.7	46.5	5.8	1.7	–	–	–	–	11,270	–	–	–			
			D	–	50.6	49.4	–	1.8	–	–	–	–	11,970	–	–	–			
								PINE LAKE QUADRANGLE											
1	DH-1 core 289-292 Henderson zone	SW.NE.22–35S–2W 4177720mN 412570mE	A	9.30	32.39	28.31	29.94	–	–	–	–	–	–	–	–	–			39
			C	–	35.73	31.23	33.03	–	–	–	–	–	–	–	–	–			
			D	–	51.25	48.75	–	–	–	–	–	–	–	–	–	–			
2	DH-1 core 293-298		A	17.57	34.36	26.37	21.70	–	–	–	–	–	–	–	–	–			39
			C	–	41.68	36.00	26.33	–	–	–	–	–	–	–	–	–			
			D	–	55.13	44.87	–	–	–	–	–	–	–	–	–	–			
3	DH-1 core 298-304		A	17.98	38.26	33.15	10.61	–	–	–	–	–	9,740	–	–	–			39
			C	–	46.65	40.42	12.64	–	–	–	–	–	11,875	–	–	–			
			D	–	52.86	47.14	–	–	–	–	–	–	11,010	–	–	–			
4	DH-1 core 304-307		A	19.77	37.23	35.12	7.88	–	–	–	–	–	10,130	–	–	–			39
			C	–	46.4	43.77	9.82	–	–	–	–	–	12,666	–	–	–			
			D	–	50.86	49.14	–	–	–	–	–	–	11,080	–	–	–			
5	DH-1 core 310-317		A	17.80	37.81	30.58	13.81	–	–	–	–	–	–	–	–	–			39
			C	–	46.0	37.2	16.8	–	–	–	–	–	–	–	–	–			
			D	–	54.40	45.60	–	–	–	–	–	–	–	–	–	–			
6	DH-1 core 318-324		A	18.89	36.71	35.96	8.44	–	–	–	–	–	10,300	–	–	–			39
			C	–	45.26	44.33	10.41	–	–	–	–	–	12,699	–	–	–			
			D	–	49.86	50.12	–	–	–	–	–	–	11,350	–	–	–			
7	Davies mine Henderson zone	NE.NE.36–36S–2W 4165740mN 416230mE	A	11.3	41.3	39.2	8.5	.9	–	–	–	–	10,126	–	–	–			39
			C	–	46.1	44.1	9.5	1.0	–	–	–	–	11,363	–	–	–			
8	Outcrop Henderson zone	NW.SE.26–36S–2W 4166550mN 414260mE	A	28.6	–	–	–	–	–	–	–	–	7,372	–	–	–			39
			C	–	45.0	44.5	10.5	.9	–	–	–	–	10,326	–	–	–			
9	Outcrop Henderson zone	NW.23–36S–2W 4166630mN 413530mE	A	13.1	37.8	40.9	6.7	1.5	–	–	–	–	11,367	–	–	–			24
			C	–	43.5	41.87	7.71	1.73	–	–	–	–	13,081	–	–	–			
10	Pollock mine Henderson zone	SE.SE.25–36S–2W 4165940mN 416305mE	A	19.2	37.6	36.0	7.2	.8	–	–	–	–	9,260	–	–	–			39
			C	–	46.6	44.5	8.9	1.0	–	–	–	–	11,475	–	–	–			
11	Pollock mine		A	22.0	37.2	30.6	10.2	1.3	–	–	–	–	8,544	–	–	–			39
			C	–	47.7	39.3	13.0	1.6	–	–	–	–	10,994	–	–	–			
12	Pollock mine		A	16.3	40.4	34.7	8.6	.9	–	–	–	–	9,685	–	–	–			39
			C	–	48.3	41.4	10.3	1.0	–	–	–	–	11,342	–	–	–			

Geology and topography

Kaiparowits Plateau impact area

General

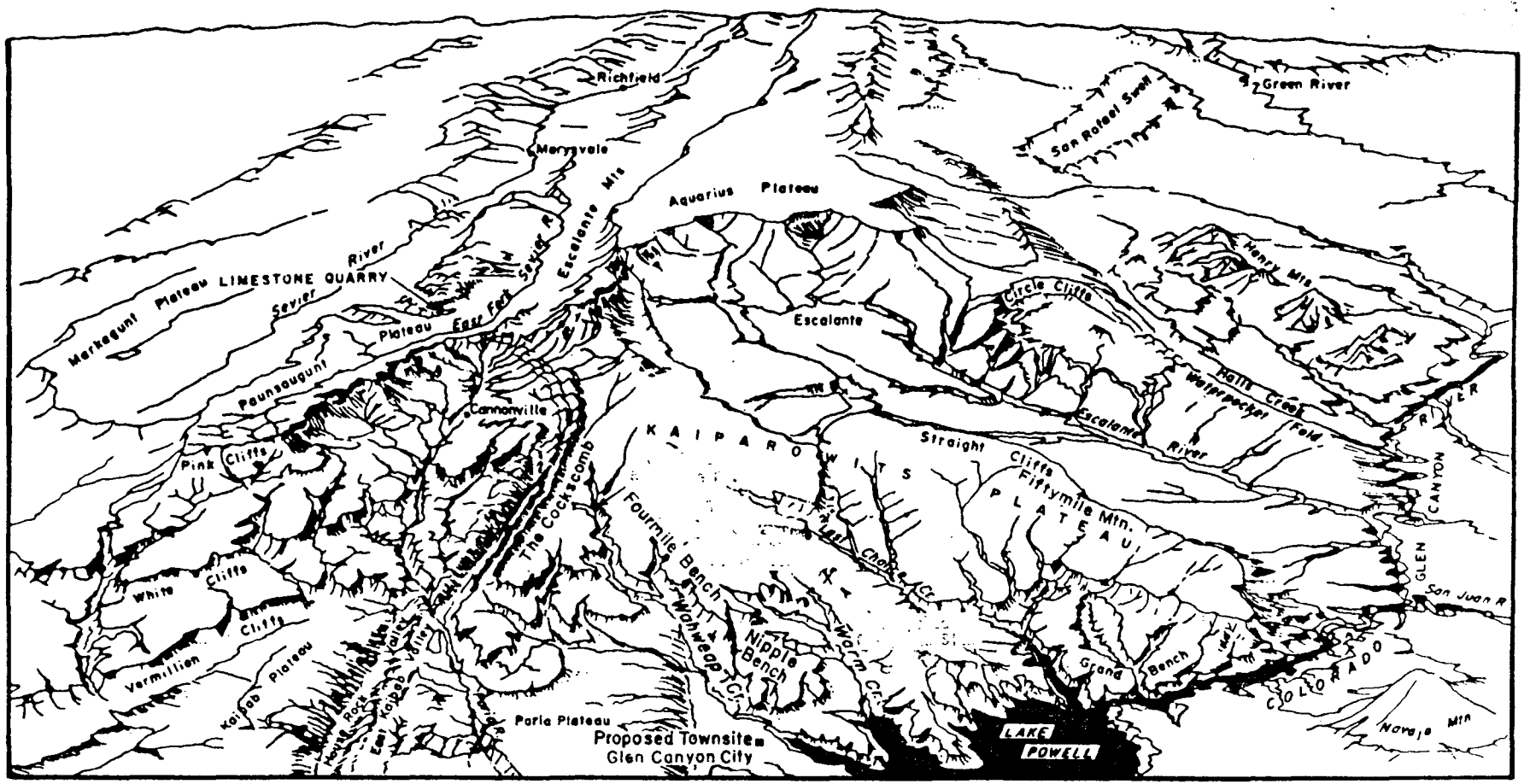
The Kaiparowits Plateau embraces an area of approximately 1,600 square miles of sedimentary rock (Doelling and Graham, 1972). The plateau is bounded on the north by the Aquarius Plateau, on the east by the Straight Cliffs (Fiftymile Mountain), on the south by a high erosional escarpment cut by several tributary canyons to Lake Powell, and on the west by the East Kaibab Monocline (the Cockscom (Illustration II-10).

The plateau lies wholly within the Canyonlands section of the Colorado Plateau physiographic province. Topographically, the plateau is an undulating surface, deeply cut by steep-walled canyons. The region is characterized by terraced plateaus, vertical cliffs, cliff-bound benches, and deep canyons (Gregory and Moore, 1931). A typical view of the terrain is shown in Illustration II-11.

Elevations range between 3,000 and 8,600 feet, mean sea level, the northern part of the plateau being higher than the southern. Average elevation is about 6,100 feet.

Drainage in the northern part is into the Escalante and Paria Rivers, and in the southern part directly into Lake Powell. Along the northern shore of Lake Powell, the main drainages are Rock Creek, Little Valley, Croton Canyon, Last Chance Creek, Warm Creek and Wahweap Creek. All of these drainages are intermittent. Only the Colorado River (Lake Powell) and the nearby Paria and Escalante rivers are perennial.

Drainages have cut into the plateau, forming deep, winding canyons that separate the individual benches. The canyons are deepest near the cliffs which bound the plateau and decrease in depth upstream. The canyons are from 3 to 10 miles in length and range in width from about 1/2 mile near the mouths to several hundred feet near the heads. Gradients of the canyon bottoms are between 60 to



(Modified from Gregory and Moore, 1931)

ILLUSTRATION II-10

Kaiparowits Plateau Region

Looking North From Utah-Arizona State Line

90 feet per mile in the lower and middle parts of the canyons, and somewhat steeper near the headwaters.

Relatively flat alluvial deposits cover the floor of most canyons, except near the canyon heads where the bottom gradient is too steep to permit stream deposition. Boulders and talus slopes from erosion or collapse of the canyon walls frequently litter the canyon floors. Stream terracing of the alluvium is evident in some parts of the canyons, particularly where the canyons are wide and the stream channels meander.

The intermittent streams of the plateau flow during the rainy season of late summer-early fall, during the winter months, and during the spring thaw. In late spring and early summer, the streams are completely dry except for occasional springs and seeps, which reveal water-bearing aquifers and subterranean stream flows.

The rainy season, usually accompanied by violent thunderstorms, brings substantial surface-stream swelling. Watermarks on the canyon sides indicate that, at times, entire canyon bottoms have been flooded by swiftly-flowing, violent flash floods. More erosion occurs during the rainy season than during the rest of the year.

Excluding recent Tertiary and Quaternary surface cover, the entire plateau is of Cretaceous sedimentary rocks (Illustration II-12 and Figure II-22). The important coal resources are in the Straight Cliffs formation (Figure II-23). The Upper Cretaceous Kaiparowits formation covers much of the surface of the Fourmile Bench area, with the underlying Wahweap formation exposed over the remaining area.

The Kaiparowits Plateau is a basin with a system of folds trending northwest, plunging toward the Central basin. Dips up to 45 degrees have been measured in the northern portions of the plateau where the Upper Valley anticline dips west into the Table Cliff syncline. In the south-central portion, three

FIGURE II-22

Generalized Section of Cretaceous Sediments in Kaiparowits Plateau

POST-CRETACEOUS TERTIARY AND QUATERNARY

System	Series	Stratagraphic Unit	Thickness (ft)	Description
CRETACEOUS	Campanian	Conglomeratic member	0- 500	Red and gray mudstone and bentonitic claystone overlying interbedded light brown, gray, pink and red sandstone, conglomeratic sandstone and conglomerate.
		— Unconformity —		
		Kaiparowits Formation	2,000-2,500	Gray to dark gray, fine- to moderately coarse-grained, friable 'salt and pepper' arkosic sandstone with subordinate light gray mudstone; weak calcareous cement, forms badlands and slopes.
		Wahweap Formation	760-1,350	Yellow-gray resistant sandstone, gritstone and conglomerate alternating with yellow-orange nonresistant sandstone and gray mudstone; lower half dominantly nonresistant, upper half massive and hard.
		Straight Cliffs Formation, Upper: Drip Tank Member	100- 350	Yellow-brown to gray-orange, fine- to medium-grained sandstone with some gritstone and conglomerate interbedded with subordinate gray shale; resistant cliff former.
	Santonian	Straight Cliffs Formation, Upper: John Henry Member *MAJOR COAL SEAMS*	500- 900	Interbedded yellow-gray, white and orange medium-grained sandstone, gray shale, carbonaceous mudstone and *coal*; forms ledgy outcrops; often exhibits reddish to black outcrops from clinker and burned sandstone due to natural burning of coal.
	Coniacian			
		— Unconformity —		
	Turonian	Straight Cliffs Formation, Lower: Smoky Hollow Member *MINOR COAL*	24- 500?	Interbedded white or yellow-gray sandstone, light gray to dark gray mudstone and sometimes thin *coal* seams; lower part ledge to slope forming, upper part cliff forming.
		Straight Cliffs Formation, Lower: Tibbet Canyon Member	70- 185	Yellow-gray and gray-orange, medium-grained sandstone interbedded with subordinate gray mudstone; cliff former.
		Tropic Shale *MINOR COAL*	550-1,000	Medium- to dark-gray argillaceous to sandy shale, contains thin yellow-gray sandstone beds at top and base, otherwise uniform; forms badlands and slopes.
	Cenomanian	Dakota Formation *MINOR COAL*	0- 250	Yellow-gray sandstone alternating with gray shale, carbonaceous shale and *coal*; forms semiresistant ledge.

PRE-CRETACEOUS JURASSIC

(Modified from Doelling and Graham, 1972, p. 74)

ILLUSTRATION II-12

Generalized Geologic Map
of Kaiparowits Plateau

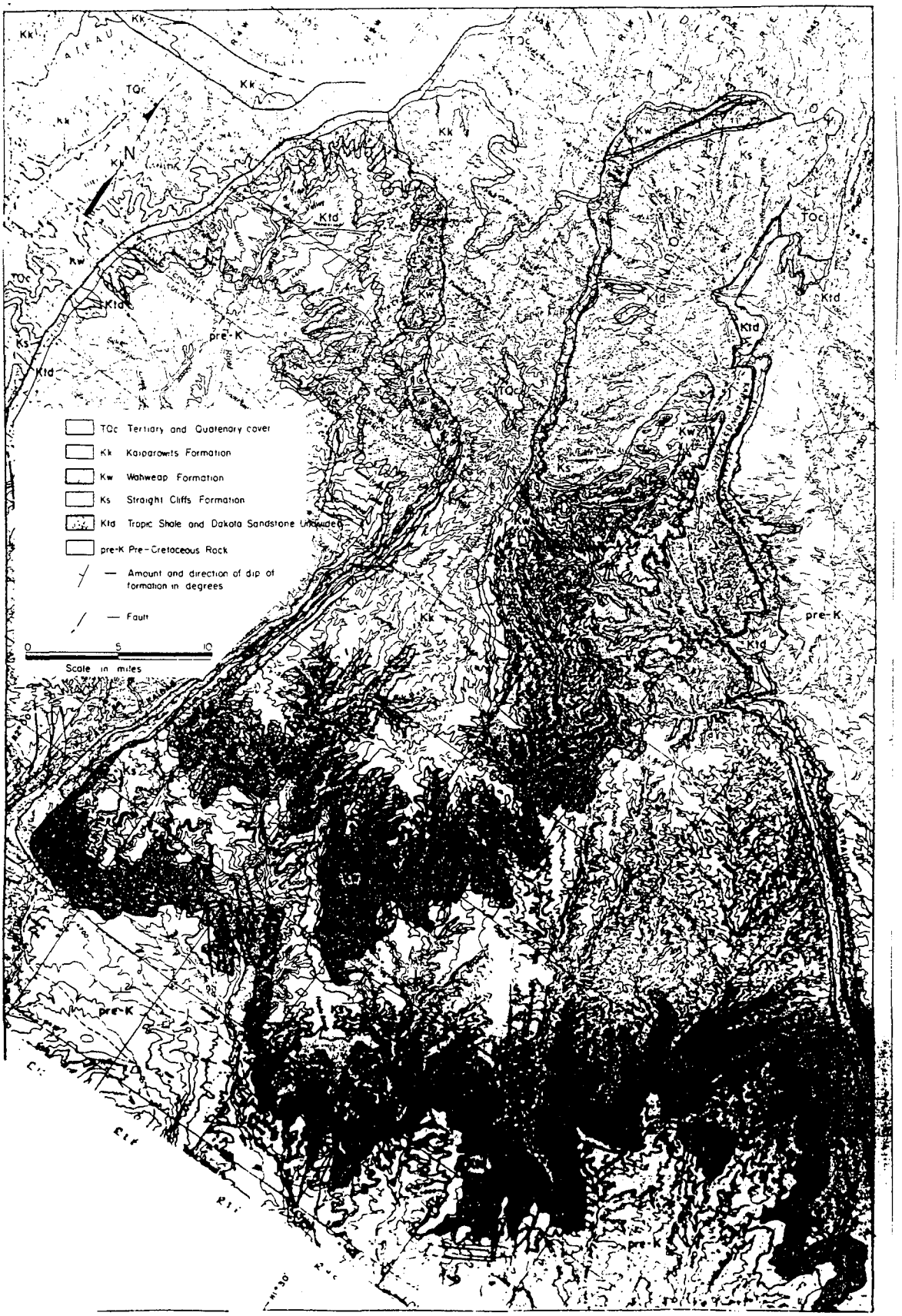
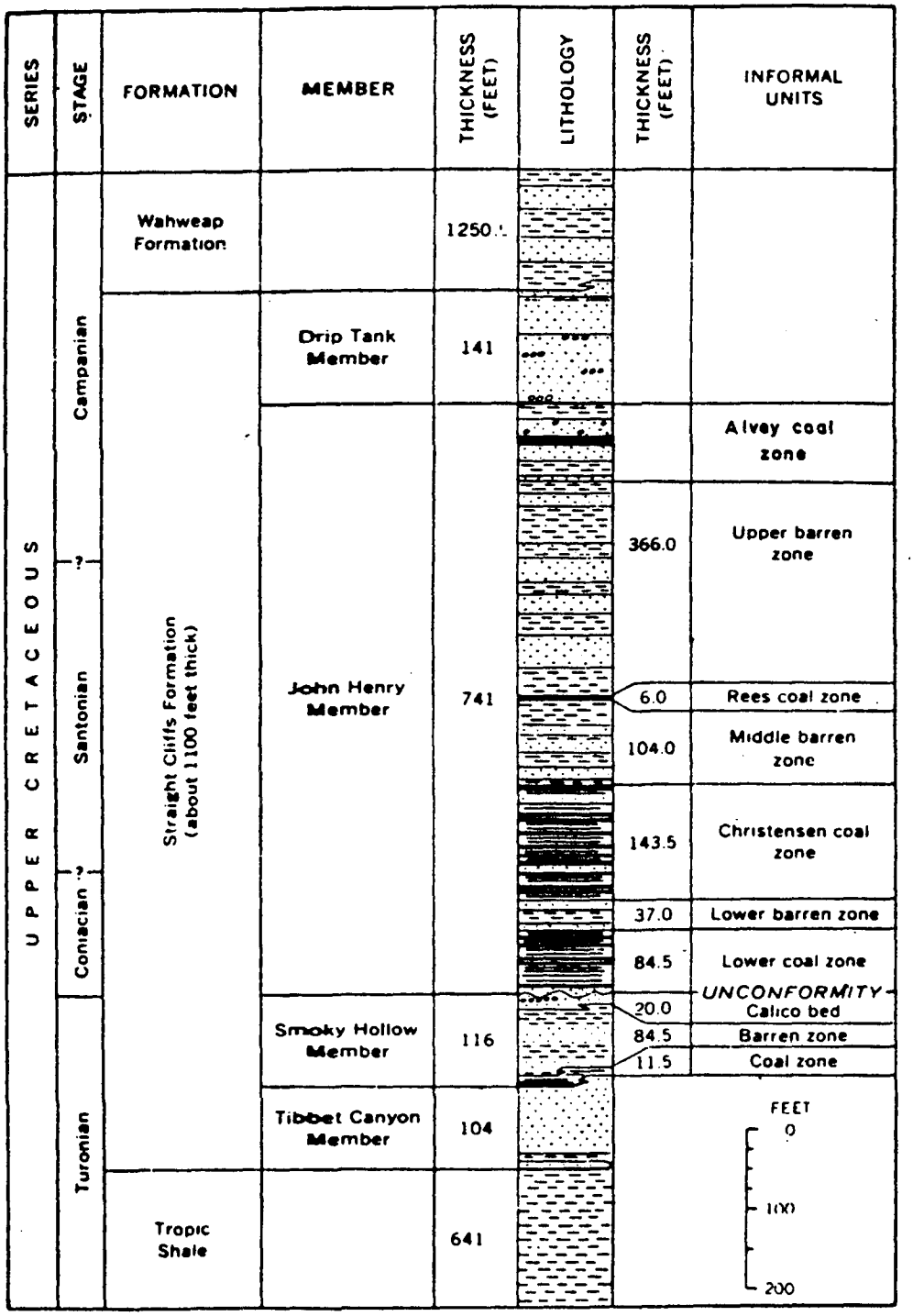


FIGURE II-23

Composite Columnar Section - Straight Cliffs Formation



(Modified from Peterson, 1969)

northwesterly-trending folds - the Last Chance syncline, the Smoky Mountain anticline, and the Warm Creek syncline - constitute the principal structures in the proposed project area. Dips in the flanks of these structures seldom exceed 10 degrees, averaging less than 5 degrees (Southwest Energy Study, 1972).

Few faults are present in the plateau proper. The nearest major fault to the proposed project area is the Paunsaugunt Fault, 30 to 35 miles to the west. Closer to the project area a system of lesser faults associated with the Cockscomb area has been mapped (Hackman and Wyant, 1973). In the immediate proposed project area, faulting is minor and is generally of two types: surface faults or collapse structures at or near canyon rims resulting from the natural burning of coal beds, and normal tectonic faults caused by deformations of the earth crust.

Economic geology

Coal

The Straight Cliffs Formation, which overlies the Tropic Shale and underlies the Wahweap Formation, contains all important coal resources in the plateau. Minor coals are contained in both the Tropic Shale and the Dakota Formations. The Straight Cliffs Formation contains four members, designated in ascending order as the Tibbet Canyon, Smoky Hollow, John Henry and Drip Tank Members (Peterson, 1969) (Figure II-23).

The Drip Tank Member, varying in thickness from about 141 to 225 feet, caps the Straight Cliffs Formation, forming the broad, relatively flat-surfaced benches typical of the lower Kaiparowits Plateau. The Drip Tank contains no coal. The Smoky Hollow Member is reported to contain coal beds up to 4 feet thick in several places, although none appears economically minable. The John Henry Member contains all of the economically important coal beds in the plateau. The Tibbet Canyon Member contains no coal.

Four coal zones have been recognized in the John Henry Member. They are, in descending order, the Alvey, Rees, Christensen and Lower Coal zones as shown in Figure II-23. The Alvey and Christensen zones in the northern part of the plateau contain the most important coal deposits in the Escalante area. The Rees and Christensen zones are considered to be the most potentially valuable

A typical cross section through the heart of the area initially proposed for mining is shown in Chapter I.

The U.S. Geological Survey (USGS) has been conducting an intensified geologic mapping and coal resource evaluation program in the Kaiparowits Plateau since the early 1960's. As of January 1, 1967, the USGS estimated a total resource of 7.3 billion tons of coal under 3,000 feet, or less, of cover (Averitt, 1969).

As more information became available the Utah Geological and Mineralogical Survey calculated total reserves under the following classification (Doelling and Graham, 1972):

Class	Type of Reserve	Explanation
I	Measured reserves	Based on adequate exploration and development data, properly correlated.
II	Indicated reserves 3,984,800,000 tons (Includes a small amount of Class I reserve)	Based on geologic measurement supplemented by limited drill-hole information and limited to 1 1/2 miles from a control point.
III	Inferred reserves 3,893,200,000 tons	Based on geologic inference and projection of the habit of the coal beyond 1 1/2 miles from control points.
IV	Additional inferred 7,320,000,000 tons	Based on geographic and geologic position with little supporting data and includes coal up to 3,000 feet of cover.
Total	15,198,000,000 tons	

With continued field mapping and expanded exploratory drilling on the plateau it is expected that the reserve totals will be refined upwards appreciably.

Resources Company, a subsidiary affiliate of the participants, has estimated that their lease holding, constituting approximately 21 percent of all

leased Kaiparowits coal lands, contains about 1.5 billion tons, in beds 4 feet thick or greater, based on limited exploratory drilling of the Straight Cliffs Formation coals.

A recent USGS evaluation of coal reserves at the proposed Fourmile Bench plant site, based on nearby drill hole data, indicates that as much as 92 million tons of coal underlie the site, in beds 4 feet thick or greater (Peterson, 1974). The coal is 1,900 feet below the surface.

The quality of coal from the entire Kaiparowits Plateau is extremely variable. Quality ranges from subituminous C to high-volatile bituminous A. Sulfur content is low to high, ranging between 0.26 and 3.40 percent, with ash varying from 3.38 to 33.03 percent. Heating value is moderate to high, ranging from 8,499 to 14,236 British thermal units (Btu) per pound (Doelling and Graham, 1972).

The coal has no coking properties and in most cases would require mechanical cleaning to produce a satisfactory fuel for power production, gasification, or liquification. Alvey zone coal is generally of lower quality than coal of the Christensen zone.

A detailed analysis of coal sampled from exploration core drilling by the participants is shown in Figure II-24. Data concerning concentrations of trace elements are shown in Figures II-25 and II-26.

Coal has never been mined extensively in any part of the Kaiparowits Plateau. Numerous small mines have operated around the periphery of the plateau, mostly in the general areas of Escalante and Tropic. The Alvey mine near Escalante was the largest, with a production of about 1,250 tons per year between 1952 and 1961. All other mines produced 100 tons a year or less. At present, there are no producing mines in the area.

FIGURE II-24

Burned Coal Analysis by Resources Company

Proximate Analysis - %	Average*	Range
Moisture	12.55	11.60 - 13.25
Ash	9.25	8.75 - 10.00
Volatile Matter	36.60	33.00 - 39.30
Fixed Carbon	41.60	38.90 - 45.40
Total	100.00	
Sulfur	0.52	0.21 - 1.43
Heating Value, BTU/lb. (as received)	10,800	10,600 -11,000
Ultimate Analysis - %		
Moisture	12.55	11.60 - 13.25
Carbon	61.32	58.60 - 63.60
Hydrogen	4.33	3.90 - 4.75
Nitrogen	0.95	0.45 - 1.30
Chlorine	0.02	0.00 - 0.06
Sulfur	0.52	0.21 - 1.43
Ash	9.25	8.75 - 10.00
Oxygen (by differential)	11.06	9.72 - 12.55
Ash Fusion Temperature - °F		
Reducing - Initial def.	2235	2070 - 2700+
- Soft (H=W)	2300	2130 - 2700+
- Soft. (H=½W)	2385	2145 - 2700+
- Fluid	2510	2155 - 2700+
Oxidizing - Initial def.	2265	2135 - 2700+
- Soft (H=W)	2360	2150 - 2700+
- Soft (H=½W)	2445	2210 - 2700+
- Fluid	2580	2220 - 2700+
Ash Analysis		
Silica, SiO_2	55.44	41.33 - 74.60
Ferric oxide, Fe_2O_3	4.97	2.20 - 9.50
Alumina, Al_2O_3	17.81	11.91 - 29.30
Titania, TiO_2	0.94	0.58 - 1.30
Lime, CaO	9.13	1.50 - 22.00
Magnesia, MgO	2.04	0.31 - 4.97
Sulfur trioxide, SO_3	6.86	0.34 - 14.90
Phosphate pentoxide, P_2O_5	0.27	0.04 - 1.94
Potassium oxide, K_2O	0.61	0.51 - 1.75

(Continued)

FIGURE II-24 (Continued)

Ash Analysis	Average	Range
Sodium oxide, Na_2O	1.50	0.68 - 3.30
Undetermined	0.43	0.01 - 1.06
Alkalies in dry coal as Na_2O	0.17	0.03 - 0.37
Water soluble alkalies Na_2O	0.058	0.038- 0.101
Water soluble alkalies K_2O	0.003	0.001- 0.013
Silica Value	77.31	50.24 - 94.09
Grindability index (Hardgrove)	46.5	38.9 - 52.6
Free Swelling index	1	0 - 2
Viscosity - Crit. temp.		
Poises	640	28 - 1140
°F	2580	2360 - 2645
T 250 °F	2655	2135 - 3000+
Disposal - in place density	60 lb/ft^3	

*The table is based upon analysis of 103 core samples taken from 50 bore holes during the coal drilling exploration program through 1972. The analyses were performed by Commercial Testing and Engineering Company in Denver, Colorado and were checked by the Colorado School of Mines Research Institute in Golden, Colorado. The results are based upon a washed coal product and are representative of the actual coal to be burned at the generating station.

Trace elements

Trace elements are those that appear in nature in relatively minute amounts, many of which take an active part in important biological processes. Others such as beryllium, mercury, lead, arsenic, cadmium, fluorine, and selenium, are potentially hazardous to living organisms, including man, when present in sufficient quantities. Adverse environmental effects of abnormally high concentrations of trace elements include the action as catalysts in formation of secondary air pollutants, and their corrosiveness, causing economic loss. Because coal is the product of ancient biological activity, it contains small quantities of many of these elements, the variety and concentration of which depend upon the nature of the coal bed formation. Results of analyses of coal samples from the Kaiparowits area are shown in Figure II-10. Results represent five independent core sample trace element analyses, using different techniques. The range of values, mean and standard deviation of the Kaiparowits samples, and typical concentration in coal samples from deposits around the world are shown in Figure II-10. Concentrations found in Kaiparowits coal are generally well within expected range, and most are in the lower portion of the range. Combustion can release these materials to the ecosystem. Trace elements in the atmosphere have been measured at Page by the Arizona Department of Health since 1969. Results are summarized in Figure II-11.

FIGURE II-10

Concentrations of Trace Elements Found in Coal and Ash of Kaiparowits Coal and Concentrations From Deposits Around the World

Trace Element		Concentration (ppm)				
		Kaiparowits			World Wide[c]	
		Coal		Ash	Coal	Ash
		APS[a]	SWES[b]	SWES[b]		
Antimony	Sb		.13 ± .07		10 - 30	
Arsenic	As	.83 ± .81	.90 ± .20		0.8 - 500	
Barium	Ba			2290 ± 2055		18 - 2200
Beryllium	Be	.48 ± .19		3.40 ± 3.30		1 - 4000
Boron	B			1400 ± 834		52 - 10,000
Cadmium	Cd	.87 ± .73		0.7 ± 0.7		No data
Cerium	Ce		BLD			No data
Chromium	Cr	3.6 ±2.3		62 ± 11		0.1 - 7,400
Cobalt	Co			12 ± 10		5 - 2,000
Copper	Cu			80 ± 11		10 - 1,200
Fluorine	F	54 ± 42	120 ± 23		40 - 480	
Gallium	Ga			26 ± 5		10 - 3,200
Germanium	Ge		BLD			9 - 47,000
Lanthanium	La		BLD			30 - 700
Lead	Pb			38 ± 11		200 - 31,000
Lithium	Li			72 ± 26		No data
Manganese	Mn	6 ± 2		210 ± 164		100 - 22,000
Mercury	Hg	.06 ± .07	.04 ± .01		.001 - 300	
Molybdenum	Mo			6 ± 3		5 - 6,000
Nickel	Ni	5 ± 1		34 ± 21		
Selenium	Se	4 ± 4	1.98 ± .58			No data
Strontium	Sr			560 ± 261		0 - 1,000+
Scandium	Sc			14 ± 2		60 - 400
Tellurium	Te				No data	
Thallium	Tl		.02	.34 ± .12		No data
Titanium	Ti			3,000 ± 1		100 - 35,000
Uranium	U	8 ± 1	.66 ± .36		0 - 24,000	
Vanadium	V			92 ± 35		10 - 25,000
Yitrium	Y			44 ± 24		10 - 2,000
Ytterbium	Yb			4 ± 1		No data
Zinc	Zn			64 ± 70		115 - 21,000
Zirconium	Zr			150 ± 1		0 - 7,000

[a]APS - Data supplied to Arizona Public Service.

[b]SWES - Southwest Energy Study, Report of Coal Resources

Other minerals

Several other mineral commodities occur in the area. Since 1964, oil has been produced in commercial quantity from Pre-Cretaceous rock in the Upper Valley Field towards the extreme northern part of the plateau. (Townships 35, 36 and 37 South, Ranges 1 and 2 East, Salt Lake Meridian). As of June 1974, 12,470,000 barrels had been produced from this field. Exploration in other areas of the plateau has not been productive thus far, nor have commercial quantities of natural gas been found.

Large quantities of clinker, rock baked and fused by burning of adjacent coal beds, are present in many of the canyons where coal bearing strata are exposed. Clinker is commonly used as a road surface material and as railroad ballast.

Sources of aggregate, which could be processed for asphalt and concrete mixes, or used as road subbase, fill, borrow or ballast, occur in canyon bottoms and along terraces throughout the region. Important deposits are contained in the Wahweap Creek drainage near Glen Canyon City, where sand and gravel are mined, on Horse Mountain and along the Paria River drainage.

Common clays and bentonitic mudstones occur in the area and might be suitable for lining ponds at the proposed generating station and coal washery. Clay, in beds up to 100 feet in depth, is found throughout the Tropic Shale Formation which outcrops along the base of the plateau. Bentonitic mudstone occurs as lenses within the Kaiparowits Formation capping the central and western parts of the plateau.

Limestone is common in southern Utah. Many deposits, known to be high-carbonate varieties, are suitable for chemical applications, such as stack scrubbing of SO_2 in coal-fired electric generating plants, or as mine rock dust for protection against fire and explosion propagation.

HENRIEVILLE QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

The Henrieville quadrangle is located on the east edge of the Tropic Amphitheatre (figures 18 and 41). The town of Henrieville is located on the west central edge of the quadrangle. The quadrangle contains the foothills and flats below the Kaiparowits Plateau and the cliffs and benches to the east which rise steadily onto the plateau. Utah Highway 12 joins Henrieville with Escalante and gives access to the north part of the quadrangle. The Cannonville-Cottonwood Creek road gives access to the south half.

Elevations range from 5,600 feet in Little Dry Valley (southwest) to more than 7,800 feet along the east edge of the quadrangle. The coal seams are exposed at elevations 6,400 to 6,900 feet above sea level.

STRATIGRAPHY

The oldest unit is the Jurassic Carmel Formation cropping out in scattered poorly exposed patches in Big Dry Valley.

The Entrada Sandstone is exposed along the margins of bluffs separating Henrieville and Dry creeks. The Entrada is present in three members in the amphitheatre. The entire unit is more than 700 feet thick; only the upper member of 180 feet is exposed near Henrieville where it is a white to light yellow-brown fine-grained friable sandstone. These members are described in detail in a publication by Thompson and Stokes (1970).

The Cretaceous Dakota Formation crops out just above the Entrada and is 150 to 250 feet thick. It consists of alternating mudstone and sandstone with local thickenings of coal, claystone and conglomerate. The latter beds are highly lenticular in the ledge- and slope-forming units.

Above the Dakota lies the Tropic Shale. The formation is composed principally of medium to dark gray claystone with thin beds of bentonite. It is basically a slope former and is 689 feet thick in sec. 2, T. 37 S., R. 2 W.

The important coal-bearing unit is the Straight Cliffs Formation that crops out in a band in the east half of the quadrangle. A measurement in sec. 8, T. 37 S., R. 1 W. shows the formation to be 1,495 feet thick and composed of alternating sandstone and mudstone with small amounts of coal and conglomerate. Cliff-forming sandstone dominates the upper 500 feet; the Henderson coal zone is located 400 to 700 feet above the base.

The Wahweap has also been measured on the quadrangle in secs. 4 and 9, T. 37 S., R. 1 W. The unit consists of alternating mudstone and sandstone but contains no coal. The 1,364-foot unit is more slope forming in the lower half and more cliff forming in the upper.

The Kaiparowits Formation is the youngest consolidated unit on the quadrangle. Only the lower 200 to 300 feet of the 2,500-foot formation are exposed. The Kaiparowits is an arkosic badlands-forming sandstone.

Prominent pediment surfaces on the Tropic Shale outcrops are composed of poorly stratified clay and gravel deposits 100 feet thick. Alluvium fills the valleys of Henrieville and Dry creeks. In places the creeks have cut deeply into this alluvium.

STRUCTURE

All strata on the quadrangle (except west of the Tropic anticline) dip easterly, gently in the west half of the quadrangle and gradually steepening to as much as 45 degrees to the east. The north-south anticlinal axis (Tropic anticline) occurs just inside the west margin of the quadrangle.

PROPERTY CONTROL

Private property (10.4 percent) is scattered in the lowlands around Henrieville and Dry Valley. The state lands (16.0 percent) are scattered in their usual configuration over the quadrangle except surrounding Kodachrome Flat (Chimney Rocks State Park). The remainder of the land is controlled by the Bureau of Land Management.

Only about 3.8 percent of the land is leased for coal, all on state lands. About 30 percent can be counted as coal land if the Dakota Formation is excluded. Development and Resources Co. holds 1.9 percent (state lease) and R. J. Hollberg holds 1.9 percent (state lease).

COAL

Surface Information

North of Pardner Canyon the seams in the Henderson zone of the Straight Cliffs Formation are 4 or more feet thick. Thin coal beds were discovered near Horse Valley ranging up to 2.5 feet. The Dakota coal is locally thick especially in the area of Dry Valley Creek, where the thickest bed is 13.5 feet (figure 42).

Subsurface Information

No drill holes are available to supply information about the coal. The cover over the coal increases about 1,000 feet each half-mile behind the outcrop of Straight Cliffs coal.

Quality of Coal

Two analyses for the Henderson coal and one from the Dakota are presented in table 10. Moisture is high in all samples (17.7 to 22.7 percent) and sulfur is less than 1 percent in all cases. Calorific value averages about 11,000 Btu/lb on a dry basis.

Mines and Development

No mines have been opened on the quadrangle and there is no development for coal except for a small prospect in the Dakota Formation, 25-37S-2W, Little Creek.

Reserves

Robison (1966, p. 40) estimates the reserves of the northern part of the quadrangle as follows (table 25). The figures have been modified to fit the area of the quadrangle:

Table 25. Coal reserves in the Henrieville quadrangle (in short tons).

Henderson coal zone (feet)	Class II	Class III	Totals
0-1,000	8,000,000	6,000,000	14,000,000
1,000-2,000	5,000,000	5,000,000	10,000,000
2,000-3,000	–	6,000,000	6,000,000
Totals	13,000,000	17,000,000	30,000,000

(Minable coal will be between 33 and 50 percent of the amounts)

The extent of the thick Dakota coal is unknown but presumed small, perhaps 640 acres. Additional exploration might expand that assumption. Using an average thickness of 12 feet adds another 13.4 million tons to the reserve, all within 1,000 feet of the surface (Class II).

PRINCIPAL WORK

Robison (1966), University of Utah, provided most of the information for the north half of the quadrangle; the remainder is from Thomson (1970).

One such deposit of limestone having the desired qualities for industrial use occurs in the Wasatch Formation on the west side of Johns Valley, north of the Kaiparowits Plateau and Bryce Canyon National Park (Township 34 South, Range 3 West, Salt Lake Meridian). Other deposits are found north-northwest in the high plateau of the Wasatch Formation, in the Canaan Peak area east of Henrieville, Utah, and west in the Carmel Formation near Orderville, Utah.

Titaniferous sandstone deposits are reported in the Escalante area in the northern portion of the plateau, and in the Rees, Croten, and Sunday Canyon area in the southern sector. These deposits, occurring within the Straight Cliffs Formation, are presently noncommercial.

Early prospecting efforts in the area resulted in the discovery of a few impure deposits of copper, gold, and manganese in sedimentary rocks, but none of the minerals have proven to be of commercial grade. Extensive prospecting for uranium has been conducted, without apparent success, in various sedimentary formations in the area, including those formations which have been significant producers elsewhere on the Colorado Plateau.

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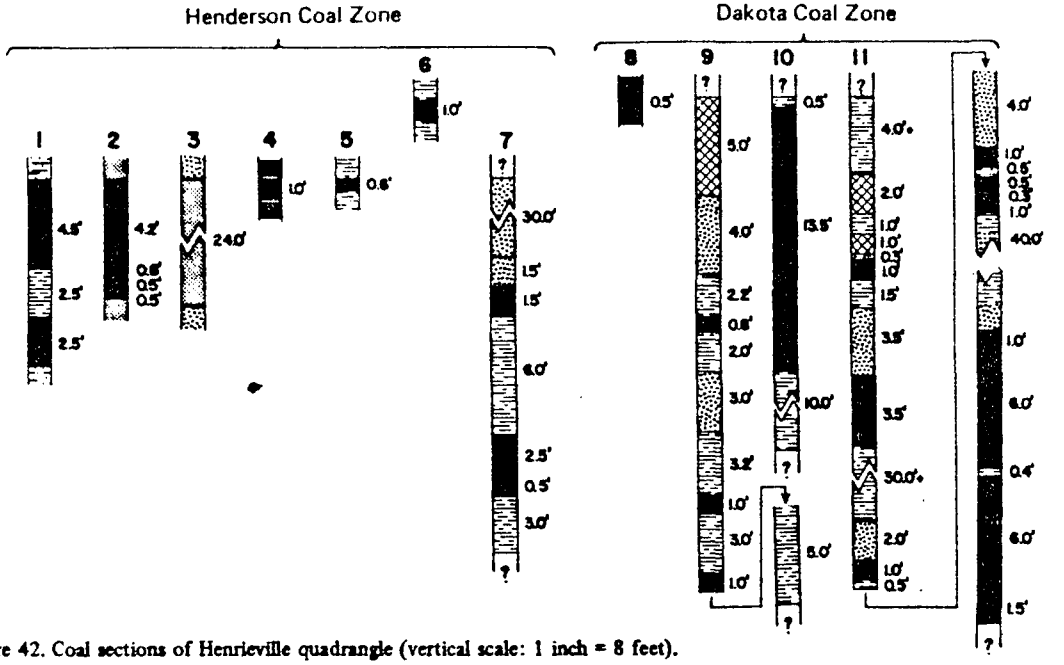

Figure 42. Coal sections of Henrieville quadrangle (vertical scale: 1 inch = 8 feet).

View across the Kaiparowits Plateau into the Henrieville quadrangle.

PINE LAKE QUADRANGLE

LOCATION, GEOGRAPHY AND ACCESSIBILITY

Pine Lake quadrangle is in the west Kaiparowits Plateau in the Tropic area in Garfield County (figures 18 and 55). The northeast corner of the quadrangle includes the Table Cliff Plateau. The boundary between the plateaus and the Tropic basin or amphitheatre is an arcuate line of cliffs extending from southeast to northwest. The only true Kaiparowits surface is in the northwest corner of the map.

Of the roads on the quadrangle, those on the plateau surface in the northwest join Utah Highway 22 a few miles north and west and another road from Utah Highway 54 gives access to the Shakespear coal mine from the southwest.

Elevations range from 6,500 feet in Henderson Canyon to about 8,000 feet in the Pine Lake area to almost 10,300 feet on Table Cliff Plateau. The nearly 4,000-foot relief results in rugged inaccessible land. The coal seams crop out between 6,800 and 7,200 feet above sea level.

STRATIGRAPHY

No detailed geology mapping of the northeast part of the quadrangle is available and such data would not be pertinent to study of the coal. The coal which probably underlies these lands is too deeply buried for exploitation. Cretaceous and Tertiary beds are exposed; the older beds crop out to the southwest and the younger beds northeast.

The oldest formation exposed is the Tropic Shale whose thickness ranges from 690 to 900 feet; only the upper part is exposed in the quadrangle. The Tropic is composed of medium to dark gray nonresistant shale. Its surface is often littered with landslide debris or a pediment has formed upon it.

Overlying the Tropic is the Cretaceous coal-bearing Straight Cliffs Formation, here subdivided into a lower and upper member. The lower part corresponds to the Tibbet Canyon and Smoky Hollow members in the Smoky Mountain area and consists of sandstone and mudstone; the resistant sandstones dominate the softer mudstones 3:1. The initial unit is a 20- to 125-foot cliff former followed by a lower coal zone (60 to 130 feet above the base) which contains thin coal seams.

The upper member again consists of alternating sandstone, mudstone and claystone. It can be divided roughly into three units. The lower division is the Henderson coal zone, 10 to 50 feet thick. Above is a thick succession of beds, including coal stringers, that produces ledges and slopes. This is followed by the caprock of mostly resistant sandstones and granule to pebble conglomerate. This upper part corresponds to the Drip Tank Member elsewhere in the plateau and is 200 to 550 feet thick. The entire Straight Cliffs Formation in the Pine Lake quadrangle varies from 1,800 to 1,500 feet. The thinner outcrops lie to the south.

The Wahweap Formation overlies the Straight Cliffs in a northwest-trending band of outcrops. The contact between the two formations is gradational and some interfingering of beds is evident. According to Robison (1966, p. 25):

> ...the Wahweap is about 1,360 feet thick. The lower and middle parts consist of alternating units of resistant sandstone and nonresistant mudstone that forms an irregular succession of cliffs, ledges and steep slopes. It is capped with a cliff-forming unit that consists of more than 370 feet of conglomeratic sandstone, which is similar to the unit found at the top of the Straight Cliffs Sandstone.

The Kaiparowits is the youngest Cretaceous formation and crops out along the east part of the mapped portion of the quadrangle. The typical exposures are best shown at a locality known as the Blues. Here gray, mostly sandstone beds with a sprinkling of mudstone create a magnificent vista of badlands. Inspection of the sandstone reveals it to be friable, arkosic, with a salt-and-pepper appearance. In these exposures the unit is 2,000 to 2,500 feet thick; to the north near Pine Lake it is 200 feet thick. The entire Kaiparowits has been removed farther west. In this quadrangle the top has been bevelled by erosion. The unconformity between the unit and the overlying Tertiary beds has an angular discordance of about 15 degrees.

Above the plane of unconformity are Claron Formation beds producing the pink and white cliffs of the Table Cliff Plateau. The scenic formation consists mostly of limestone, but beds of quartzite or chert pebble conglomerate and calcareous mudstone also occur in it. Most of the conglomeratic strata lie at the base of the lower 1,000-foot pink member. Above is a 600-foot white member forming the rimrock of Table Cliff Plateau.

Sand, silt and gravel alluvium of Henderson and Pole canyons and the pediment deposits occur on various erosion surfaces. The pediment deposits consist of poorly sorted unconsolidated particulate matter ranging in size from clay to boulders. The thickness of these pediments is uniform, about 100 feet, but locally thinned by more recent erosion.

STRUCTURE

The strata in the east part of the Pine Lake quadrangle dip easterly toward the Table Cliff syncline at an angle of about 5 degrees. The northwest-trending asymmetrical Johns Valley anticline lies northwest. East flank dips of 45 degrees compare with 7 degrees on the west. The Pasture Canyon syncline southwest of the Johns Valley axis is nearly symmetrical and dips are gentle. No faults were mapped. Those observed were small in extent with displacements of less than 10 feet.

COAL

Surface Information

Two coal zones are exposed on the quadrangle, both in the Straight Cliffs Formation. The lower coal zone of Robison (1966, p. 35) probably correlates with the Smoky Hollow zone in the Smoky Mountain area. It occurs 60 to 130 feet above the Tropic Shale contact. The coal is in thin lenticular seams which nowhere on the quadrangle exceed 1.4 feet in thickness.

Just above the contact between the lower and upper members of the formation is the Henderson coal zone. The coal is interbedded with shale, carbonaceous mudstone and thin sandstone beds. Five measured coal sections indicate the condition of this zone. The average cumulative thickness of the coal is 13.9 feet with a maximum of 23.3 feet and a minimum of 5 feet. The average bed is 10.3 feet thick. The poorest part of the zone with respect to seam thickness is at the south central map edge, measured section 6, where one 5-foot bed is found. The measured coal sections are found on figure 56.

Subsurface Information

One drill hole in sec. 22, T. 35 S., R. 2 W. showed more than 30 feet of cumulative coal in the Henderson coal zone. The section is designated measured coal section 1 (figure 56). Oil well logs indicate multiple coal beds up to 14 feet thick in the immediate area of the coal drill hole in the lower coal zone. The same logs indicate cumulative thicknesses of coal from 20 to 75 feet in the Henderson zone. California No. 1 Johns Valley, NW ¼ SE ¼ sec. 22, T. 35 S., R. 2 W., logged the lesser amount of coal and the Tidewater No. 41-27 Johns Valley, NE ¼ NE ¼ sec. 27, T. 35 S., R. 2 W., the greater amount. The coal drill hole was placed between the two oil company wells.

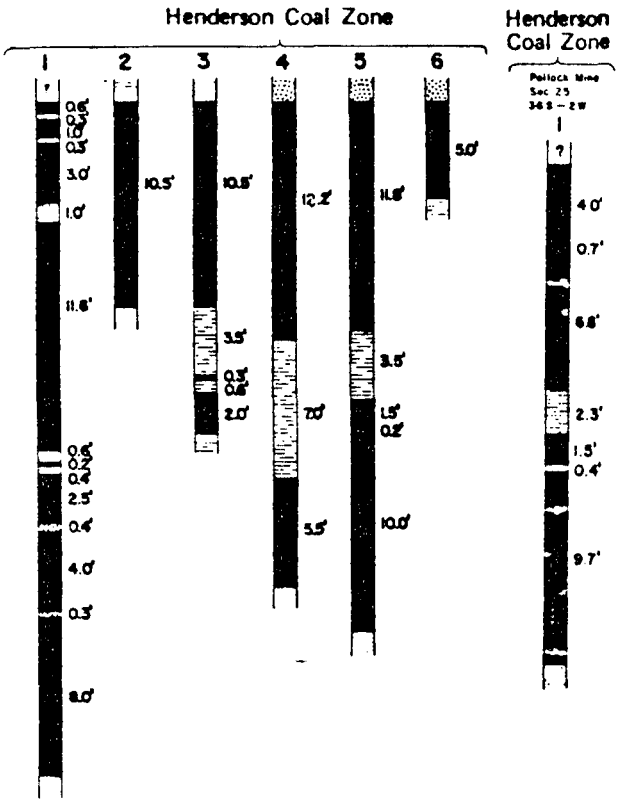

Figure 56. Coal sections of Pine Lake quadrangle (vertical scale: 1 inch = 8 feet).

Quality of Coal

Approximately 15 analyses of coal from Pine Lake quadrangle are available (table 10). Six are from drill-hole measured section 1 in sec. 22, T. 35 S., R. 2 W. The remainder are from outcrops or mines. The drill hole had no sulfur determinations, ash ranged from 7.88 to 29.94 percent, moisture from 9.36 to 19.77 percent and heat value from 9,740 to 10,130 Btu/lb on an as-received basis. Sulfur analyses from the remaining samples varied from 0.7 to 1.6 percent, averaging 1.0 percent. The heat value ranges from 7,372 to 11,367 Btu/lb, averaging 9,286 on an as-received basis. Moisture is high, 11.3 to 28.6 percent, averaging 18.7 percent. The ash content averages 10.1 percent and ranges from 6.7 to 13.0 percent on an as-received basis. Table 35 gives average proximate analyses for the Henderson zone.

Table 35. Average proximate analyses of coal, Henderson zone, Pine Lake quadrangle.

	No. of Samples	Percent	
		Average	Range
Moisture, as-received	15	18.3	9.4-28.6
Volatile matter, dry	15	44.4	35.7-48.3
Fixed carbon, dry	15	41.7	31.2-47.0
Ash, dry	15	13.6	7.7-33.0
Sulfur, dry	9	1.09	0.7- 1.73
Btu/lb, dry	12	11,683	10,326-13,061

Mines and Development

The three mines in the Pine Lake quadrangle, the Shakespear, Pollock and Davies, are abandoned (table 36). The largest mine, the Shakespear (also known as the Ray or Tropic mine) was last operated in 1962. The principal coal bed averages 15 feet and dips 7 degrees northeast. The coal was mined from drifts and cross-cuts 7 to 10 feet high underlying an area of about 15 acres. Unmined coal is found in the roof and floor and in the mine is relatively dry and nongassy. A coal mine fire in recent years necessitated the abandoning of one portal and constructing a new one. This new one is now caved. Two hundred and twenty to 680 tons were mined each year from 1952 to 1962, the average 480 tons. Total production as reported by Robison (1966, p. 41) probably totalled a few tens of thousands of tons.

Table 36. Coal mines in the Pine Lake quadrangle.

Mine	Location	Remarks
Davies mine	NE.NE.36-36S-2W 4,165,740m.N. 416,230m.E.	Active 1952-1953
Pollock mine	SE.SE.25-36S-2W 4,165,940m.N. 416,305m.E.	Active 1920's
Shakespear (Tropic)	NW.NW.23-36S-2W 4,168,630m.N. 413,530m.E.	Active 1952-1963? 480 TYP Average (inactive)

The Davies mine was opened in 1952 and operated only one year. The workings consist of an 80-foot drift.

The Pollock mine was probably mined in the 1920's. The amount produced is unknown. The coal beds at the mine dip 2 degrees northeast.

Reserves

Reserves estimated by Robison (1966, p. 40) are summarized for the Pine Lake quadrangle. No additional information has been acquired to warrant modification (table 37).

Table 37. Coal reserves for the Henderson coal zone, Pine Lake quadrangle (in short tons).

Henderson coal zone (feet)	Class II	Class III	Totals
0-1,000	222,000,000	62,000,000	284,000,000
1,000-2,000	67,000,000	159,000,000	226,000,000
2,000-3,000	8,000,000	93,000,000	101,000,000
Totals	297,000,000	314,000,000	611,000,000

(Minable coal will be between 33 and 50 percent of the amounts)

PRINCIPAL WORK

Robison's work (1966) on the geology and coal resources of the Tropic area serves as the principal work from which much of the data for the Pine Lake quadrangle is drawn. Work by U. S. Geological Survey and Bureau of Mines geologists also considered are Gregory and Moore (1931), Grose (1965) and Grose and others (1967).