CHARACTERISTICS OF UTAH COALS IN THE UNIVERSITY OF UTAH'S COAL SAMPLE BANK

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ABSTRACT

In 1986, the Utah Geological Survey and the University of Utah's Department of Chemical and Fuels Engineering (formerly Department of Fuels Engineering) entered into a cooperative agreement to collect samples from the coal seams in Utah's active mines. As a result, there are 28 coal samples stored at the Department of Chemical and Fuels Engineering which represent 16 different coal seams. The following characteristics are summarized for each sample: vitrinite reflectance, maceral analyses (white and UV light), combined microlithotype analyses, density, porosity, coking potential (Composition Balance Index, Rank Index, and Stability Factor), and chemical analyses (elemental and proximate). This information should be of use to both coal operators and purchasers to determine the best uses for Utah coal.

INTRODUCTION

In 1986, the Utah Geological Survey (UGS) (formerly the Utah Geological and Mineral Survey) and the University of Utah's Chemical and Fuels Engineering Department (formerly the Department of Fuels Engineering) initiated a program to collect samples from and characterize all coal seams then (9 years ago now) being mined in Utah. The UGS was responsible for describing and collecting 300 pounds (136 kg) of channel samples from all operating coal mines in the state and for determining the porosity, bulk density, and petrographic characteristics of the samples. The Department of Chemical and Fuels Engineering was responsible for chemically analyzing the samples (elemental analysis, proximate analysis, and heat of combustion) and for storing the samples in appropriate containers for future examination. All the information collected is summarized in the accompanying tables and appendix.

The sampling started in May, 1986 and was completed in December, 1990. A total of 28 coal samples from four coal fields was collected from 16 different seams in 24 active mines (figure 1). Fifteen coal companies cooperated in the project. The UGS sample numbers, locations, mine names, mine operators, seam names, formations, coal fields, and quadrangle names are summarized in table 1.

All samples are of Cretaceous age; 26 samples are from the Blackhawk Formation, one is from the Ferron Sandstone Member of the Mancos Shale, and one sample is from the Frontier Formation.

DEPOSITIONAL ENVIRONMENTS OF COAL-BEARING FORMATIONS

Blackhawk Formation

Twenty-six coal samples were collected from the Blackhawk Formation; seventeen samples from eight different seams in the Wasatch Plateau coal field (figure 2a), and nine samples from eight different seams in the Book Cliffs coal field; (figure 2b). The Blackhawk Formation, deposited in a wave-dominated deltaic system, is characterized as regressive nearshore deposits that intertongue with both the coastal-plain and prodelta marine rocks of the Mancos sea (McGookey, 1972). Sediments were shed from the Sevier orogenic highlands to the west. The formation consists of yellow to gray, fine- to medium-grained sandstone, interbedded with subordinate gray, often carbonaceous, shale and coal (Doelling, 1972).

Coal swamps were localized along the coastline in near sea-level deltaic, interdeltaic, and coastal plain settings. The thickest and most extensive Blackhawk coal beds accumulated on the delta plains. The dominant factors controlling coal distribution and thickness were subsidence rates and the geometries of the delta platforms (Balsley, 1980).

Ferron Sandstone

One sample was collected from the Ferron Sandstone Member of the Mancos Shale in the Emery mine in the Emery coal field (figure 3a). The Ferron Sandstone was deposited in a fluvial-dominated deltaic system. This member accumulated during transgressions and

regressions along the western shoreline of the Mancos sea (Ryer, 1983). Sediments were transported from the Sevier orogenic highlands to the west. The Ferron Sandstone consists of alternating yellow-gray sandstone, sandy gray shale, and coal (Doelling, 1972). The major coal beds are associated with the delta-plain facies, where peat accumulations became isolated between river channels of the alluvial plain as the deltaic system prograded. The thicker coal beds are associated with landward pinch-outs of delta-front sandstones. The peat swamps extended landward 6 miles (9.7 km) from the pinch-outs (Ryer, 1983).

Frontier Formation

One sample (figure 3b) was collected from the Frontier Formation in the Boyer mine (Coalville field). The Frontier Formation was deposited in a variety of non-marine and marine environments representing four major episodes of transgressions and regressions of the Mancos sea during the Late Cretaceous. The Frontier Formation in the Coalville area consists of ten members; lithologies include conglomerate, sandstone, siltstone, shale, and coal (Hale, 1960).

The coal occurs in the Coalville and Dry Hollow Members. The Coalville Member was deposited when a transgression of the Mowry sea occurred at the close of Greenhorn time and the upper part of the Dry Hollow Member was deposited during westward transgression of the Niobrara sea (McGookey, 1972). Coal swamps and lagoons were located marginal to the transgressing shoreline (Ryer, 1976). The sample was collected in the Wasatch coal zone of the Coalville Member.

STUDY METHODS

Megascopic Coal Description

The coal faces from which the samples were taken were described and categorized as follows: vitrain-bright coal, clarain-banded coal (vitrain and semi-bright coal), and durain-dull coal. All mineral and fusain bands were recorded. The descriptions and stratigraphic columns are contained in appendix A.

Sample Collection

Each sample was collected by making a channel with coal picks in a recently worked seam face and placing 300 pounds (136 kg) of coal for each seam in seven plastic buckets with rubber seal lids. The air was purged from the buckets with nitrogen gas before sealing the coal sample inside. Once outside the mine, the buckets of coal were unsealed, filled with water, resealed, and transported to the laboratory.

Sample-Bank Processing

In the laboratory, the coal was crushed, as a slurry, to 1/4-inch size in a hammer mill and the entire sample collected in a large container. An additional five gallons of water per sample were added during crushing, to maintain wet-grinding conditions. The sample was mixed well

and divided into four representative samples of two buckets each. One of the two bucket sets was wet riffled and half of that set wet pulverized to -100 mesh. After processing, each sample consisted of seven buckets of 1/4-inch top-size coal and one bucket of -100 mesh coal. All samples are now stored in water at the University of Utah and may be further examined by contacting Dr. David Bodily, at the Department of Chemical and Fuels Engineering.

Physical Examination

Pellet Preparation

Two pellets for each sample were prepared by crushing the coal to a -20 mesh and setting the coal powder in a cold epoxy medium. These pellets were then polished to allow petrographic analysis in reflected light.

Reflectance Analysis

To determine the rank of the coal, 100 random vitrinite reflectance measurements were made with a Leitz Orthoplan MPV II microscope at 500X magnification using a 50X oil immersion objective. In general, the procedure outlined in the American Society for Testing and Materials (ASTM) standards was used (ASTM, 1978) except that readings on pseudovitrinite were also recorded. The mean maximum reflectance values (R_o) are reported in table 2.

Maceral Analysis

White-light analysis: Maceral composition was determined using a Leitz Orthoplan microscope. Crushed-particle pellets were recorded at 500X with 10X oculars and a 50X oil immersion objective using oil having a refractive index of 1.5180. The following macerals were counted

(1,000 points per sample): vitrinite, pseudo-vitrinite, sporinite, cutinite, resinite, micrinite, fusinite, macronite, semifusinite, and sclerotinite. The occurrence of pyrite, mineral matter, voids, and epoxy under counting points were not included in the total.

Fluorescent-maceral analysis: The fluorescent-maceral analysis was made at 500X magnification using a 100 watt Hg lamp with a BG 23 filter and a BG 12 blue-light filter. In this procedure, light is passed through the microscope to a vertical illuminator adapted with a TK 400 mirror. Light to the 10X oculars is filtered through a K510 barrier filter. Because ultraviolet light excitation reveals resinite subtypes and aids in the identification of the other liptinites, it is possible to count the following: sporinite, cutinite, green resinite, yellow resinite, orange resinite, exudatinite, fluorinite, bituminite, and alginite. The non-fluorescing macerals were totalled and then compared to the white- light analysis and adjusted to reflect the correct liptinite value. The maceral analyses are reported in table 2.

Microlithotype Analyses

Microlithotype and combined maceral-microlithotype analyses procedures were performed in accordance with Stach (1975) on all but the last four samples (UGS samples 715, 718, 719, and 720 [table 1]) because of the unavailability of the ocular. The results of this analysis comprise the seam and maceral groups analyses (table 3), the microlithotypes (table 4), and the rock and carbominerite analyses (table 5).

Density and Porosity

Density and porosity were determined using a Beckman Model 930 air comparison pycnometer. Crushed samples were dried in an oven during a four-hour period at 110°C and then measured for density. Bulk samples were measured for apparent porosity using paraffin to seal

the pores. The density and porosity values are reported in table 2.

Coking Analysis

Coking characteristics were determined using the observed vitrinite reflectance values, ash content, and percentage of inertinites. The composition balance index (C.B.I.) was then calculated and plotted against the rank index (R.I.) to determine the stability factor. The stability factor indicates coking potential of the coal. The values for the above categories are in table 2.

Coal Chemistry

The Fossil Fuels Characterization Laboratory at the University of Utah performed the chemical analyses of the samples. The instruments used in the analyses were: LECO model CHN-600 for elemental analyses, LECO model MAC-400 for the proximate analyses, LECO model SC-132 for sulfur amounts, and LECO model BC-300 for the heating value in British thermal units (BTUs) . Because samples are stored in water the moisture results do not correspond to bed moistures. The elemental and proximate analyses, and the caloric heating values are in table 6.

RESULTS AND SIGNIFICANCE

Table 2 summarizes the maceral analyses, the mean of the maximum reflectance value, rank, density, porosity, and coking data, table 3 summarizes the chemical character of the coal samples. Coal quality and certain favorable characteristics are shown in the tables. For instance,

a good coal for power generation is one that has high vitrinite content, low inertinites, low ash, and a reflectance between 0.47 and 1.10 percent. All the coal samples except the Wasatch coal seam meet these criteria. The Wasatch coal would have good steam generation potential without the high moisture content which lowers the heating value.

The tables can also be used to determine the suitability of a particular coal for coking or blending with other coals for coking. Coal with a stability factor above 40 and a C.B.I. value near 1.0 is the most suitable for coking. The Lower Sunnyside seam has a composition balance index of 0.40 (table 2) which is suitable for coking, but its rank index of 2.7 (table 2), vitrinite reflectance of less than 0.85 percent (table 2), and high volatile content make it unsuitable by itself as a coking coal, but it can be blended with other coals for use as coke. In the past Geneva Steel Company used this coal blended with a medium-volatile coal from Colorado for coke.

There has been increased interest in Utah coals as a source of resin for printers ink. Table 2 can be used to evaluate the suitability of Utah coal for this purpose. For instance, a good quality coal for printers ink must have a resin value greater than 4 percent and must be high in green resinite type. The Blind Canyon seam from the Deer Creek mine, the Castlegate A seam from the Gordon Creek No. 7 mine, and the Wattis seam from the Star Point No.2 mine fit these criteria.

The microlithotype analyses is important because it supplements the maceral analyses for better characterization of the nature and properties of the seams. Companies use this analysis to categorize different grades of coking coals. However, the seam analysis can also provide insights regarding coal quality. For instance, the coal containing the greatest percentage of rock is the Upper "I" seam (4.0 percent, table 4) and the seam with the highest carbominerite (coal incorporated in minerals) is the Upper Sunnyside (3.4 percent, table 4), which would have the

highest ash value. The highest quality coal has the least amount of inertinite and minerals. The Upper O'Connor, for instance, has 3.0 percent inertinite and 3.0 percent minerals (table 4); the lowest for all the samples in the sample bank. In general, this coal would have the highest caloric value if dry. The breakdown of microlithotypes (maceral associations) is in table 5. In general, coals with the highest vitrite and clarite values are the "cleanest" coals; the cleanest, in this sampling, is the Upper O'Connor. Rock analyses of the coal (table 6) identifies minerals which must be removed by washing in order to improve quality. For example, the Wasatch seam has 4.9 percent minerals (table 6) and can be significantly improved by density separation of the quartz and clays that make up most of the mineral content. The carbominerite (already defined on the previous page) composition of coal (table 6) is also used to determine coal quality. High concentrations of carbominerites (dirty coal) such as pyrite can be removed by washing. For example, from table 4, the Upper Sunnyside seam from the Sunnyside No. 3 mine has the highest carbominerite content (3.4 percent). From table 6, 96.7 percent of the carbominerite is "tied up" with clays (argilite) and 3.3 percent with quartz. Generally the quality of this coal cannot be improved unless it is finely pulverized and washed.

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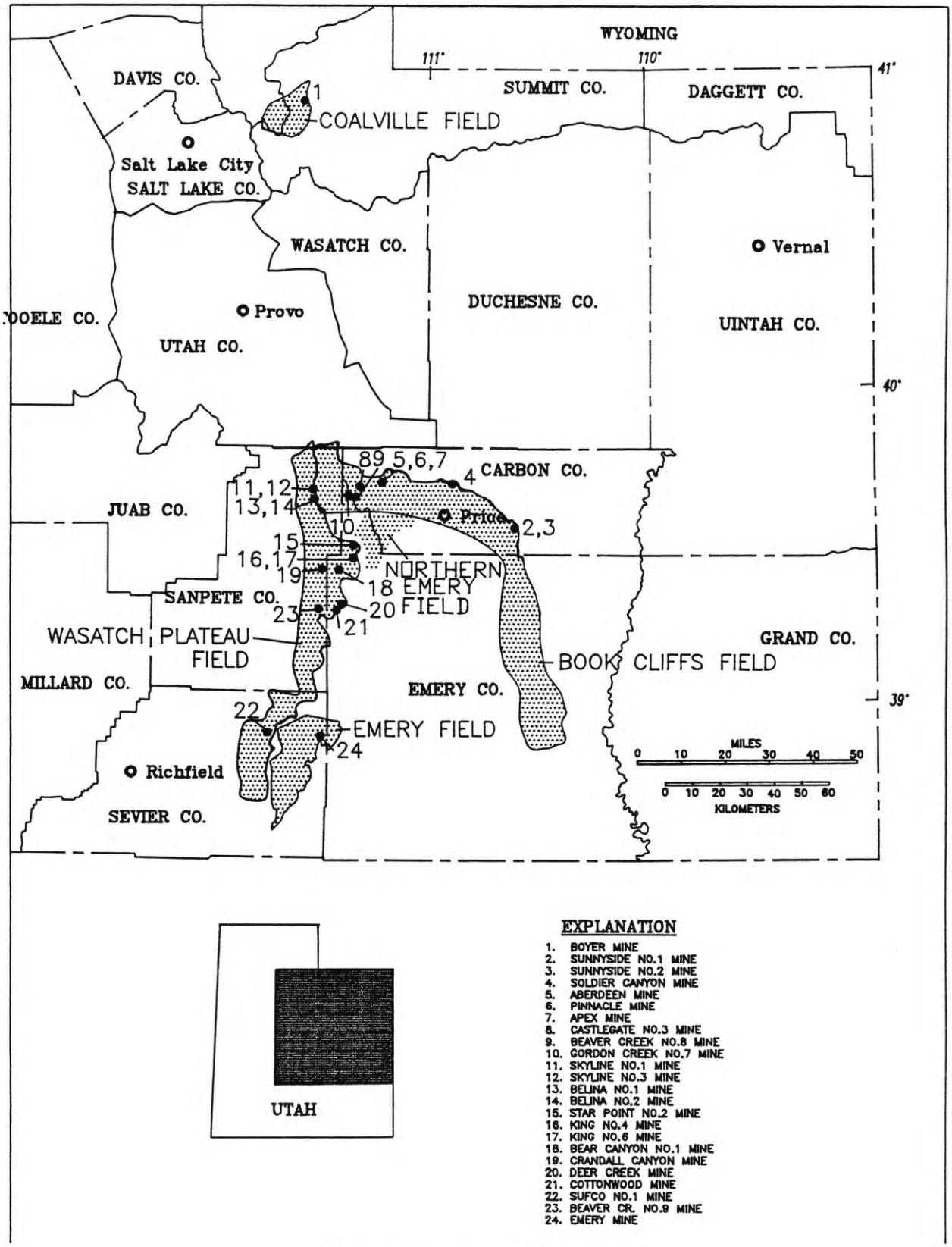


Figure 1. Coal sample locations.

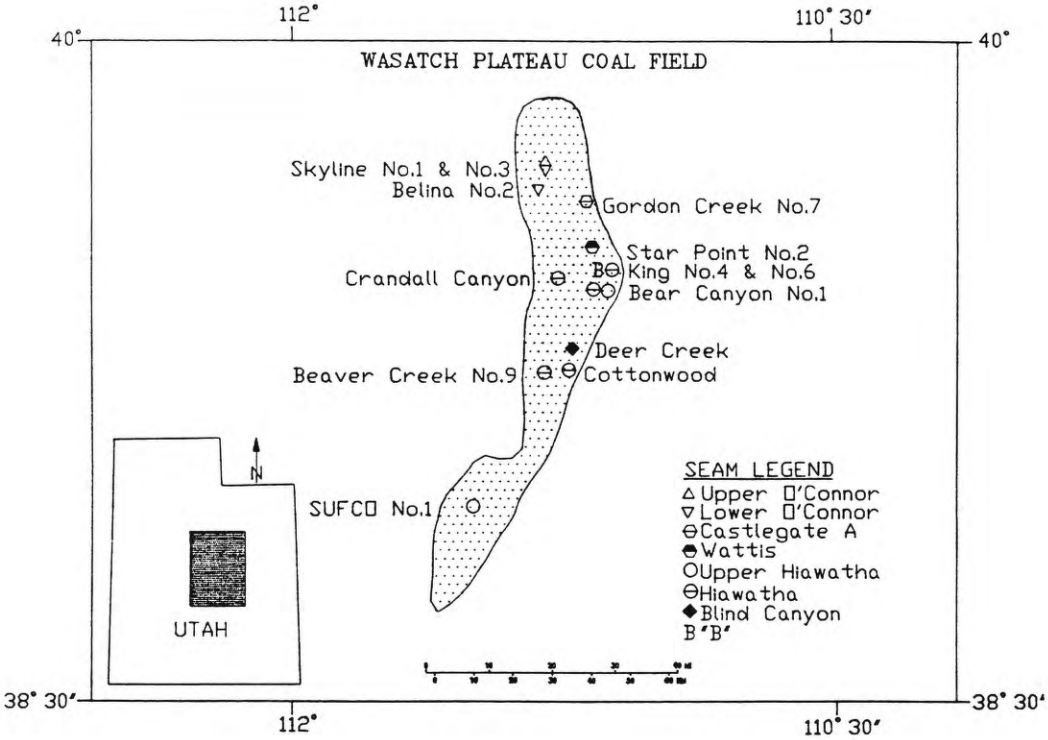


Figure 2a. Coal sample locations in the Wasatch Plateau coal field.

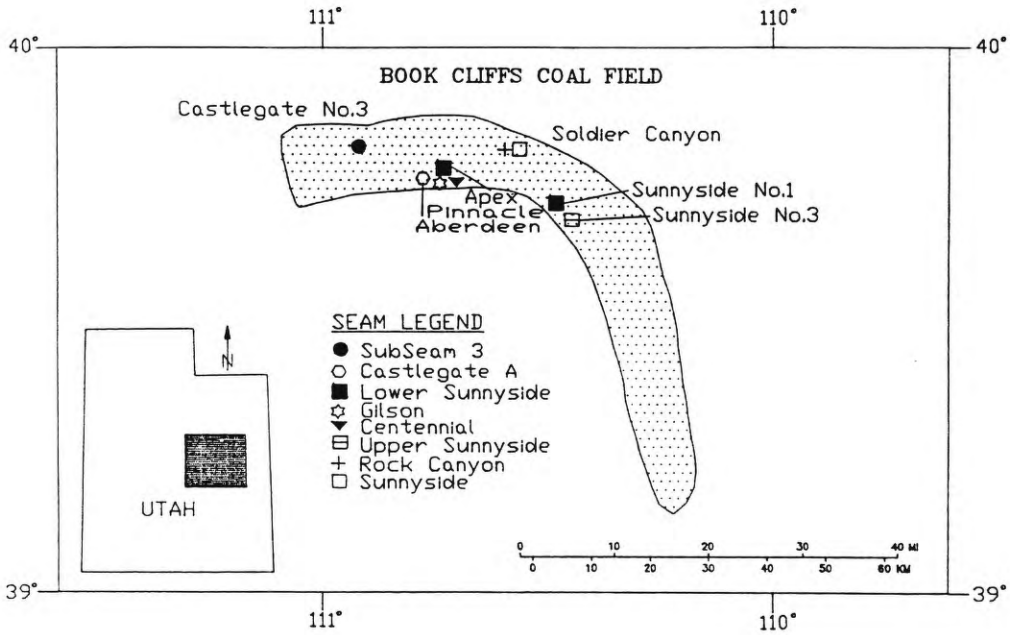


Figure 2b. Coal sample locations in the Book Cliffs coal field.

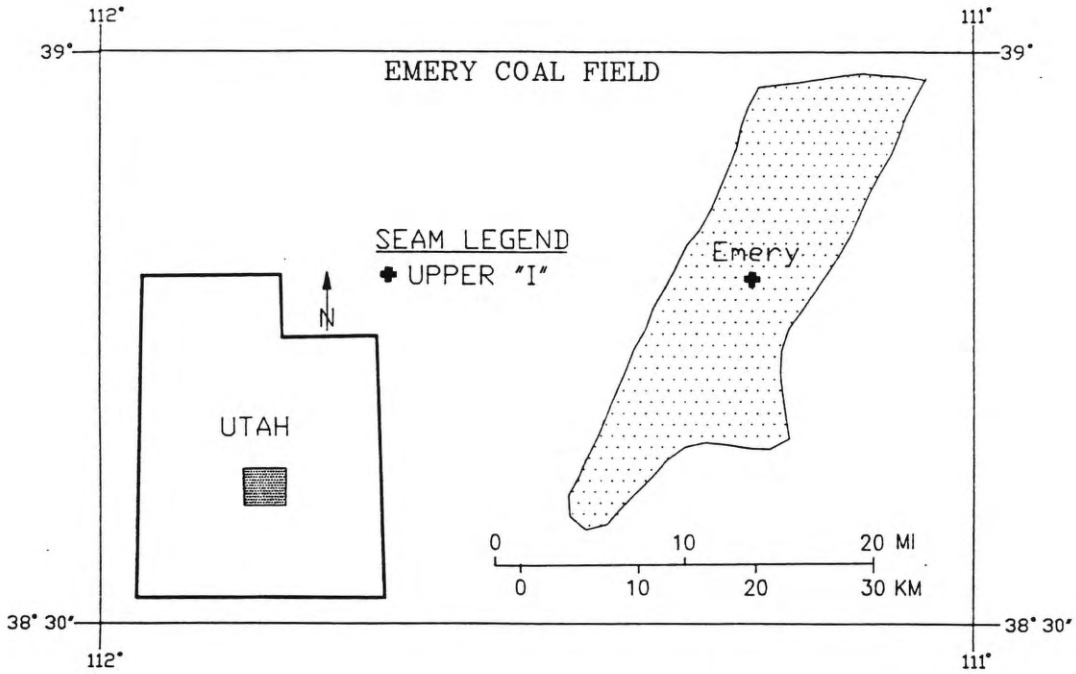


Figure 3a. Coal sample locations in the Emery coal field.

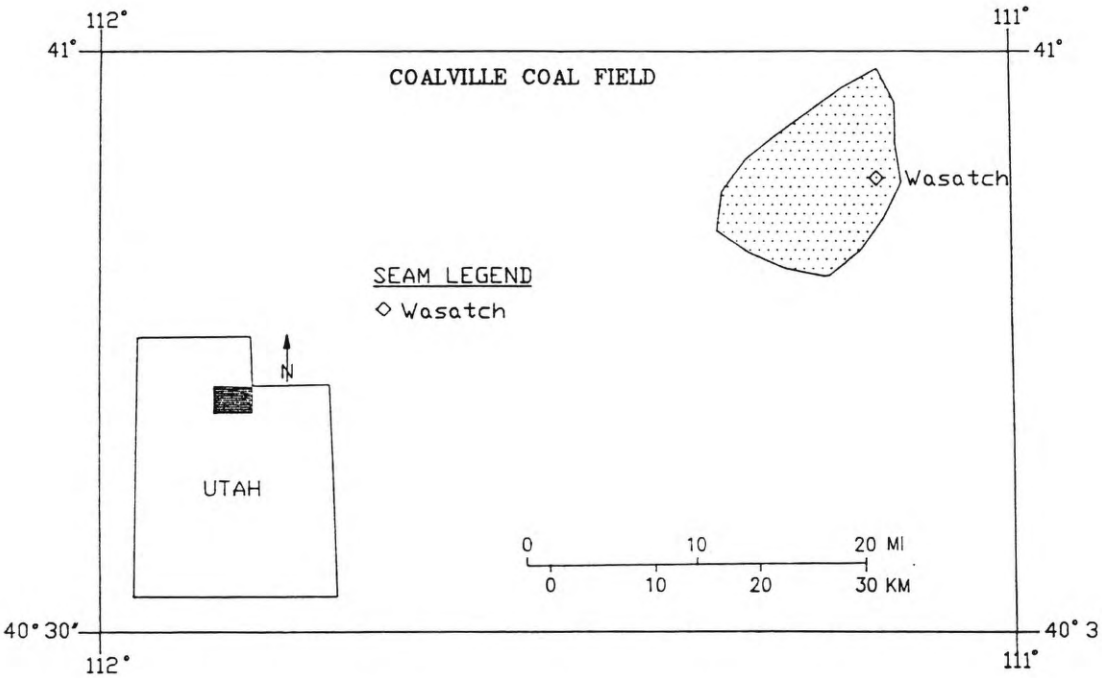


Figure 3b. Coal sample locations in the Coalville coal field.

UGS No.	CHEM No.	MINE	OPERATOR	SEAM	COALFIELD	FORMATION
619	AC-SCF-A062	Belina No.1	Valley Camp of Utah	Upper O'Connor	Wasatch Plateau	Blackhawk
717	AC-MHP-A042	Beaver Creek #9	Beaver Creek Coal Co.	Hiawatha	WasatchPlateau	Blackhawk
621	AC-SCF-A061	Skyline No.3	Southern Utah Fuel Co.	Lower O'Connor	Wasatch Plateau	Blackhawk
628	AC-ACL-A031	SUFCO No.1	Southern Utah Fuel Co.	Upper Ivie	Wasatch Plateau	Blackhawk
629	AC-HWT-A090	King No.6	U.S. Fuel Company	Hiawatha	WasatchPlateau	Blackhawk
630	AC-HWT-A035	King No.4	U.S. Fuel Company	"B"	Wasatch Plateau	Blackhawk
637	AC-WTS-A032	Star Point No.2	Plateau Mining Company	Third	WasatchPlateau	Blackhawk
648	AC-STN-A105	Castlegate No.3	Castlegate Coal Co.	SubSeam 3	Book Cliffs	Blackhawk
649	AC-SCF-A063	Belina No.2	Valley Camp of Utah	Lower O'Connor	Wasatch Plateau	Blackhawk
650	AC-PNC-A236	Soldier Canyon	Soldier Creek Coal Co.	Rock Canyon	Book Cliffs	Blackhawk
651	AC-RDC-A015	Crandall Canyon	Genwal Coal Company	Hiawatha	Wasatch Plateau	Blackhawk
652	AC-HWT-A094	Bear Canyon No.1	Co-op Coal Company	Upper Hiawatha	Wasatch Plateau	Blackhawk
653	AC-HWT-A098	Bear Canyon No.1	Co-op Coal Company	Hiawatha	Wasatch Plateau	Blackhawk
654	AC-MHP-A046	Cottonwood	Utah Power & Light Co.	Hiawatha	Wasatch Plateau	Blackhawk
655	AC-MHP-A050	Deer Creek	Utah Power & Light Co.	Blind Canyon	Wasatch Plateau	Blackhawk
656	AC-WKF-A046	Emery	Consolidation Coal Co.	Upper "I"	Emery	Ferron
657	AC-SCF-A072	Skyline No.1	Southern Utah Fuel Co.	Upper O'Connor	Wasatch Plateau	Blackhawk
658	AC-PTH-A044	Sunnyside No.3	Kaiser Steel Corp.	Upper Sunnyside	Book Cliffs	Blackhawk
659	AC-DDC-A048	Pinnacle	Andalex Resources Co.	Gilson	Book Cliffs	Blackhawk
660	AC-DDC-A052	Apex	Andalex Resources Co.	Lower Sunnyside	Book Cliffs	Blackhawk
661	AC-PTH-A048	Sunnyside No.1	Kaiser Steel Corp.	Lower Sunnyside	Book Cliffs	Blackhawk
662	AC-UPT-A001	Boyer	Summit Coal Company	Wasatch	Coalville	Frontier
663	AC-JPC-A013	Gordon Creek No.7	Beaver Creek Coal Co.	Castlegate "A"	Wasatch Plateau	Blackhawk
664	AC-WTS-A022	Star Point No.2	Plateau Mining Company	Wattis	Wasatch Plateau	Blackhawk
715	AC-DDC-A056	Aberdeen	Andalex Resources Co.	Castlegate "A"	Book Cliffs	Blackhawk
718	AC-JPC-A014	Beaver Creek No.8	Beaver Creek Coal Co.	Castlegate "A"	Wasatch Plateau	Blackhawk
719	AC-DDC-A057	Pinnacle	Andalex Resources Co.	Centennial	Book Cliffs	Blackhawk
720	AC-PNC-A240	Soldier Canyon	Soldier Creek Coal Co.	Sunnyside	Wasatch Plateau	Blackhawk

Table 1. Coal samples collected
(UGS No.= index number used by Utah Geological Survey, Chem No.= UGS chemical data base number).

MINE	Belina#1	Beaver Ck.#9	Skyline#3	SUFCO#1	King#6	King#4	Star Point#2	Castlegate#3	Belina#2	Soldier Cyn	Candall Cyn	Bear Cyn#1	Bear Cyn#1	Cottonwood
SEAM	Upper O'Connor	Hiawatha	Lower O'Connor	Upper Ivie	Hiawatha	"B"	Third	SubSeam 3	Lower O'Connor	Rock Canyon	Hiawatha	Upper Hiawatha	Hiawatha	Hiawatha
Maceral Analysis														
(white light)	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Vitrinite	85.4	77.3	82.2	62.9	67.8	76.3	74.5	82.2	83.3	67.5	77.7	78.2	80.9	78.0
Pseudovitrinite	5.4	4.3	10.1	0.9	11.8	9.7	8.9	3.7	4.2	7.1	4.3	2.5	4.7	2.1
Fusinite	0.9	2.1	0.9	5.8	3.2	0.8	1.6	1.4	1.6	3.9	1.6	0.5	1.0	3.0
Macronite	0.1	0.4	0.0	0.0	0.1	0.5	0.2	0.1	0.3	0.4	0.6	1.2	0.2	0.1
Semifusinite	2.9	7.1	2.5	24.8	8.8	4.9	5.6	5.3	5.9	15.9	8.3	10.4	4.6	10.6
Sclerotinite	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.0	0.1	0.1	0.1	0.2	0.1	0.1
Micronite 0.4	1.1	0.5	1.3	1.4	1.7	1.0	1.7	1.7	1.8	2.1	1.2	2.3	1.7	
Resinite	1.2	3.3	0.8	2.1	2.9	3.0	3.2	2.3	1.4	1.4	2.8	2.4	2.3	1.8
Sporinite	2.5	3.5	2.1	2.1	3.4	2.8	3.6	2.9	1.2	1.5	1.8	3.0	3.1	1.5
Cutinite	1.1	0.7	0.8	0.0	0.5	0.1	1.3	0.4	0.3	0.4	0.7	0.4	0.8	1.1
Liptinite Analysis Total	6.0%	10.8%	4.5%	6.3%	9.7%	8.9%	11.3%	7.9%	4.3%	4.7%	8.1%	8.2%	8.5%	6.2%
(UV light) %	%	%	%	%	%	%	%	%	%	%	%	%	%	
Sporinite	2.5	3.5	2.1	2.1	3.4	2.8	3.6	2.9	1.2	1.5	1.8	3.0	3.1	1.5
Cutinite	1.1	0.7	0.8	0.0	0.5	0.1	1.3	0.4	0.3	0.4	0.7	0.4	0.8	1.1
Resinite	1.2	3.3	0.8	2.1	2.9	3.0	3.2	2.3	1.4	1.4	2.8	2.4	2.3	1.8
Green	0.5	1.9	0.2	0.7	1.5	1.9	2.1	0.9	0.2	0.0	1.4	1.7	1.1	0.6
Yellow	0.0	0.5	0.0	0.1	0.2	0.1	0.3	0.2	0.7	0.1	0.4	0.3	0.3	0.1
Orange	0.4	0.2	0.3	1.2	0.4	0.3	0.5	0.8	0.5	0.9	0.3	0.0	0.3	0.8
Exudatinite	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.0
Bituminite	0.0	0.1	0.0	0.0	0.7	0.7	0.1	0.0	0.0	0.2	0.3	0.2	0.3	0.0
Fluorinite	0.1	0.3	0.2	0.0	0.1	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.1	0.1
Alginite	0.2	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.3	0.1	0.2	0.2
Reflectance %	0.48	0.48	0.55	0.49	0.57	0.58	0.54	0.50	0.50	0.63	0.56	0.51	0.54	0.55
Rank	HvBc[1]	HvBc	HvBc	HvBc	HvBc	HvBb[2]	HvBc	HvBc	HvBc	HvBb	HvBc	HvBc	HvBc	HvBc
Density g/cc	1.31	1.31	1.31	1.39	1.35	1.31	1.32	1.32	1.34	1.37	1.30	1.30	1.33	1.35
Porosity %	1.37	0.88	3.12	3.00	3.44	2.01	3.47	1.51	2.51	2.06	1.63	2.12	1.67	1.26
Coking Data														
Composition Balance Index	0.23	0.63	0.18	0.88	0.71	0.40	0.31	0.43	0.47	0.87	0.51	0.58	0.50	0.70
Rank Index	2.20	2.50	2.40	3.10	2.60	2.40	2.50	2.50	2.40	2.75	2.60	2.50	2.50	2.60
Stability Factor	0	5	0	37	20	1	0	7	5	28	14	13	10	20

[1] HvBc= High volatile bituminous C

[2] HvBb= High volatile bitumimous B

Table 2. Physical characteristics of the samples.

MINE	Deer Creek	Emery	Skyline#1	Sunnyside#3	Pinnacle	Apex	Sunnyside#1	Boyer	Gordon Ck#7	Star Point#2	Aberdeen	Beaver Ck#8	Pinnacle	Soldier Cyn
SEAM	Blind Cyn	Upper "I"	Upper O'Connor	Upper Sunnyside	Gilson	Lower Sunnyside	Lower Sunnyside	Wasatch	Castlegate "A"	Wattis	Castlegate "A"	Castlegate "A"	Centennial	Sunnyside
Maceral Anlysis														
(white light)	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Vitrinite	74.3	60.8	93.3	68.1	68.0	71.2	68.6	82.2	75.5	78.3	64.8	74.9	72.0	73.6
Psuedovitrinite	3.2	4.2	0.7	16.9	8.2	11.4	16.4	10.1	4.8	1.0	4.2	5.1	3.8	2.7
Fusinite	2.6	5.9	0.4	2.1	4.2	5.3	2.5	0.9	1.2	1.6	5.0	1.4	5.3	3.3
Macronite	0.2	0.6	0.0	0.4	0.8	0.8	0.3	0.0	0.4	0.4	0.4	0.2	0.4	0.4
Semifusinite	10.1	18.6	1.8	7.7	12.2	8.0	7.5	2.5	5.0	5.3	16.3	5.5	11.7	13.7
Sclerotinite	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1
Micronite 2.3	3.2	0.4	1.6	1.6	0.9	1.1	0.5	0.9	1.3	2.3	0.5	1.5	1.4	
Resinite	4.4	2.5	0.7	1.1	2.0	0.9	1.4	0.8	7.4	7.3	2.8	6.8	1.4	1.6
Sporinite	2.6	2.7	2.3	1.5	2.1	1.1	1.7	2.1	4.4	4.1	3.3	4.6	2.8	2.7
Cutinite	0.2	1.4	0.4	0.6	0.9	0.4	0.5	0.8	0.3	0.7	0.8	0.9	1.1	0.5
Liptinite Analysis Total	11.6%	9.1%	4.1%	4.3%	7.0%	3.3%	5.0%	4.5%	19.5%	19.4%	9.7%	19.1%	6.7%	6.4%
(UV light) %	%	%	%	%	%	%	%	%	%	%	%	%	%	
Sporinite	2.6	2.7	2.3	1.5	2.1	1.1	1.7	2.1	4.4	4.1	3.3	4.6	2.8	2.7
Cutinite	0.2	1.4	0.4	0.6	0.9	0.4	0.5	0.8	0.3	0.7	0.8	0.9	1.1	0.5
Resinite	4.4	2.5	0.7	1.1	2.0	0.9	1.4	0.8	7.4	7.3	2.8	6.8	1.4	1.6
Green	2.7	0.2	0.4	0.1	0.1	0.4	0.0	0.2	4.7	5.6	1.3	3.4	0.3	0.1
Yellow	0.5	0.4	0.0	0.4	0.4	0.1	0.3	0.0	1.2	0.2	0.3	0.1	0.3	0.2
Orange	0.2	0.7	0.0	0.2	0.5	0.2	0.7	0.3	0.3	0.9	0.3	1.0	0.2	0.3
Exudatinite	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.6	0.4	0.2	0.6	0.2	0.1
Bituminite	0.3	1.0	0.0	0.1	0.0	0.0	0.1	0.0	0.2	0.0	0.0	1.1	0.3	0.2
Fluorinite	0.5	0.0	0.2	0.2	0.4	0.1	0.1	0.2	0.4	0.1	0.2	0.3	0.1	0.6
Alginite	0.1	0.1	0.1	0.1	0.6	0.1	0.1	0.0	0.0	0.1	0.5	0.3	0.0	0.1
Reflectance %	0.54	0.60	0.51	0.68	0.60	0.62	0.72	0.41	0.51	0.51	0.56	0.48	0.53	0.59
Rank	HvBc[1]	HvBb[2]	HvBc	HvBb	HvBb	HvBb	HvBa	SuBb[3]	HvBc	HvBc	HvBc	HvBc	HvBc	HvBb
Density g/cc	1.32	1.40	1.32	1.35	1.32	1.35	1.32	1.38	1.30	1.28	1.33	1.32	1.36	1.33
Porosity %	2.57	0.95	2.59	2.81	2.94	1.54	2.06	2.38	1.52	2.65	2.98	3.29	1.86	0.94
Coking Data														
Composition Balance Index	0.70	1.10	0.20	0.50	0.76	0.55	0.40	0.60	0.40	0.30	1.07	0.56	0.94	0.82
Rank Index	2.60	2.70	2.30	2.70	2.70	2.60	2.70	2.40	2.40	2.40	2.60	2.40	2.60	2.66
Stability Factor	20	24	0	18	25	15	13	10	0	28	21	8	22	26

[1] HvBc= High volatile bituminous C
[2] HvBb= High volatile Bituminous B
[3] SuBb= Subbituminous

Table 2. (continued) Physical characteristics of the samples.

MINE	SEAM	SEAM ANALYSES			MACERAL GROUPS			
		Coal	Rock	Carbominerite	Vitrite	Exinite	Inertite	Minerals
Apex	Lower Sunnyside	98.7	0.7	0.6	71.1	13.6	14.3	1.0
Bear Canyon No.1	Upper Hiawatha	98.9	0.7	0.4	61.0	18.5	19.0	1.5
Bear Canyon No.1	Hiawatha	99.4	0.4	0.2	64.0	18.0	15.0	1.5
Beaver Creek No.9	Hiawatha	99.1	0.0	0.9	67.5	14.0	16.0	2.5
Belina No.1	Upper O'Connor	98.7	0.2	1.1	78.0	16.0	3.0	3.0
Belina No.2	Lower O'Connor	98.0	0.6	1.4	67.5	15.5	14.5	2.5
Boyer	Wasatch	94.0	2.7	3.3	65.5	20.0	9.6	4.9
Castlegate No.3	Sub Seam 3	99.6	0.0	0.4	68.0	16.5	14.0	1.5
Crandall Canyon	Hiawatha	99.2	0.2	0.6	60.5	21.0	17.0	1.5
Cottonwood	Hiawatha	99.0	0.0	1.0	63.5	15.0	19.5	2.0
Deer Creek	Blind Canyon	98.0	0.8	1.2	67.5	16.5	15.0	1.0
Emery	Upper "I" Bed	93.2	4.0	2.8	58.0	15.1	22.0	4.9
Gordon Creek No.7	Castlegate "A"	98.2	1.1	0.7	61.7	24.6	12.1	1.6
King No. 4	"B" Seam	99.3	0.35	0.35	71.0	15.0	12.0	2.0
King No. 6	Hiawatha	99.2	0.0	0.8	65.0	15.5	16.5	3.0
Pinnacle	Gilson	98.9	0.0	1.1	65.8	15.3	18.2	0.7
Skyline No.1	Upper O'Connor	99.6	0.2	0.2	76.3	17.0	6.4	0.3
Skyline No.3	Lower O'Connor	97.0	1.6	1.4	70.2	19.2	8.2	2.9
Soldier Canyon	Rock Canyon	99.8	0.0	0.2	57.0	18.5	23.0	1.5
Star Point No.2	Third	98.2	1.5	0.3	64.0	18.5	14.0	3.5
Star Point No.2	Wattis	97.8	0.3	1.8	63.6	20.3	14.2	1.9
SUFCO No.1	Upper Hiawatha	96.2	0.7	3.1	64.6	17.8	14.7	2.9
Sunnyside No.1	Lower Sunnyside	97.7	1.4	0.9	67.4	17.3	13.6	1.7
Sunnyside No.3	Upper Sunnyside	95.9	0.7	3.4	67.5	15.1	14.6	2.8

Table 3. Seam analyses and maceral groups.

MINE	SEAM	Vitrite	Liptite	Inertite	Clarite	Durite	Vitrinertite	Trimacerite	Carbominerite
Apex	Lower Sunnyside	27.2	0.2	1.9	20.6	2.2	4.0	43.0	0.9
Bear Canyon No.1	Upper Hiawatha	17.0	1.0	3.5	23.5	4.5	8.5	41.0	1.0
Bear Canyon No.1	Hiawatha	25.5	1.0	2.0	22.5	7.5	8.0	33.0	0.5
Beaver Creek No.9	Hiawatha	18.0	1.0	2.0	17.0	5.0	6.0	50.0	1.0
Belina No.1	Upper O'Connor	21.5	0.5	0.5	34.0	1.5	4.5	36.0	1.5
Belina No.2	Lower O'Connor	18.0	0.5	1.5	29.5	1.0	10.5	38.0	1.0
Boyer	Wasatch	23.2	0.8	2.1	33.8	3.1	5.4	28.0	3.6
Castlegate No.3	Sub Seam 3	24.0	0.5	1.0	24.5	7.5	8.0	34.0	0.5
Crandall Canyon	Hiawatha	13.0	1.0	2.0	28.0	5.0	9.0	41.5	0.5
Cottonwood	Hiawatha	17.5	0.5	2.5	28.0	8.5	7.5	34.5	1.0
Deer Creek	Blind Canyon	14.5	1.0	2.0	24.0	3.0	5.5	48.0	2.0
Emery	Upper "I" Bed	14.8	0.5	6.8	20.2	7.4	4.4	40.4	5.5
Gordon Creek No.7	Castlegate "A"	14.5	1.9	0.8	21.3	9.5	3.8	47.0	1.2
King No. 4	"B" Seam	27.0	1.0	2.0	21.0	4.5	8.0	36.0	0.5
King No. 6	Hiawatha	21.5	1.0	3.0	24.0	3.0	8.5	38.5	0.5
Pinnacle	Gilson	16.6	0.8	3.1	19.4	1.4	4.9	52.9	0.9
Skyline No.1	Upper O'Connor	19.7	0.5	0.1	46.1	4.7	1.7	26.8	0.4
Skyline No.3	Lower O'Connor	22.0	1.5	0.8	32.8	3.7	2.3	34.6	2.3
Soldier Canyon	Rock Canyon	15.9	0.4	4.0	18.0	7.0	7.0	47.5	0.2
Star Point No.2	Blind Canyon	18.0	0.5	1.5	30.0	7.0	5.0	36.0	2.0
Star Point No.2	Wattis	14.7	2.9	1.0	22.4	4.2	4.1	50.1	0.6
SUFCO No.1	Upper Hiawatha	15.8	0.3	1.6	26.0	2.8	3.6	48.5	1.4
Sunnyside No.1	Lower Sunnyside	19.5	0.3	1.5	26.8	0.7	3.0	46.4	1.8
Sunnyside No.3	Upper Sunnyside	23.7	0.2	1.5	18.6	8.8	4.7	40.7	1.8

Table 4. Microlithotypes.

MINE	SEAM	ROCK ANALYSES					CARBOMINERITE ANALYSIS				
		Quartz	Clays	Carbonates	Pyrite	Other minerals	Quartzite	Argilite	Ankerite	Pyrite	Polyminerite
Apex	Lower Sunnyside	17.0	17.0	33.0	33.0	0.0	20.0	40.0	20.0	20.0	0.0
Bear Canyon No.1	Upper Hiawatha	16.0	17.0	50.0	17.0	0.0	0.0	50.0	25.0	25.0	0.0
Bear Canyon No.1	Hiawatha	0.0	33.0	0.0	67.0	0.0	0.0	50.0	0.0	50.0	0.0
Beaver Creek No.9	Hiawatha	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Belina No.1	Upper O'Connor	0.0	0.0	100.0	0.0	0.0	22.0	22.0	11.0	45.0	0.0
Belina No.2	Lower O'Connor	20.0	0.0	80.0	0.0	0.0	9.1	27.3	54.6	9.0	0.0
Boyer	Wasatch	29.2	25.0	0.0	4.1	41.7	0.0	100.0	0.0	0.0	0.0
Castlegate No.3	Sub Seam 3	0.0	0.0	0.0	0.0	0.0	33.0	34.0	33.0	0.0	0.0
Crandall Canyon	Hiawatha	0.0	50.0	50.0	0.0	0.0	0.0	80.0	20.0	0.0	0.0
Cottonwood	Hiawatha	0.0	0.0	0.0	0.0	0.0	0.0	50.0	25.0	0.0	25.0
Deer Creek	Blind Canyon	0.0	29.0	71.0	0.0	0.0	14.0	14.0	29.0	43.0	0.0
Emery	Upper "I" Bed	0.0	64.0	33.0	3.0	0.0	0.0	50.0	45.0	0.0	5.0
Gordon Creek No.7	Castlegate "A"	33.0	0.0	0.0	0.0	67.0	50.0	33.0	17.0	0.0	0.0
King No.4	"B" Seam	33.0	67.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
King No.6	Hiawatha	0.0	0.0	0.0	0.0	0.0	0.0	33.0	50.0	17.0	0.0
Pinnacle	Gilson	0.0	0.0	0.0	0.0	0.0	11.0	67.0	22.0	0.0	0.0
Skyline No.1	Upper O'Connor	0.0	50.0	0.0	50.0	0.0	0.0	0.0	50.0	50.0	0.0
Skyline No.3	Lower O'Connor	0.0	0.0	36.0	21.0	43.0	17.0	25.0	8.0	25.0	25.0
Soldier Canyon	Rock Canyon	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Star Point No.2	Blind Canyon	31.0	69.0	0.0	0.0	0.0	0.0	67.0	0.0	33.0	0.0
Star Point No.2	Wattis	67.0	33.0	0.0	0.0	0.0	6.0	7.0	6.0	6.0	75.0
SUFCO No.1	Upper Hiawatha	17.0	33.0	33.0	0.0	17.0	14.0	57.0	0.0	4.0	25.0
Sunnyside No.1	Lower Sunnyside	33.0	50.0	17.0	0.0	0.0	0.0	50.0	50.0	0.0	0.0
Sunnyside No.3	Upper Sunnyside	33.0	34.0	0.0	0.0	33.0	3.3	96.7	0.0	0.0	0.0

Table 5. Rock and carbominerite analyses.

MINE	Belina No.1		Beaver Creek No.9		Skyline No.3		SUFCO No.1		King No.6		King No.4		Star Point No.2	
SEAM	Upper O'Connor		Hiawatha		Lower O'Connor		Upper Ivie		Hiawatha		"B"		Third	
Elemental Analysis %														
(DAF[1] basis weight)	AD*	ND*	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND
Carbon	79.12	80.08	n/a	n/a	79.97	80.44	80.21	80.65	81.17	81.35	80.74	81.04	80.48	80.59
Hydrogen	5.85	5.98	n/a	n/a	5.84	5.98	5.35	5.46	5.97	6.03	5.80	5.92	5.82	5.93
Nitrogen	1.53	1.48	n/a	n/a	1.70	1.64	1.40	1.38	1.69	1.66	1.70	1.75	1.66	1.65
Sulfur	0.55	0.58	n/a	n/a	0.72	0.72	0.39	0.40	0.72	0.74	0.52	0.53	0.76	0.77
Oxygen	12.94	11.89	n/a	n/a	11.76	11.22	12.65	12.11	10.44	10.21	11.24	10.77	11.27	11.06
Proximate Analysis %														
(as received by weight)														
Moisture	1.55	6.42	n/a	n/a	1.80	2.63	2.61	4.51	2.20	1.46	1.64	1.88	2.04	8.23
(dry basis weight)														
Volatile Matter	49.32	50.30	n/a	n/a	47.13	47.62	43.98	44.22	45.02	45.35	45.19	45.99	46.32	47.15
Fixed Carbon	44.78	43.66	n/a	n/a	46.83	46.35	47.61	47.31	45.26	44.92	48.77	47.98	47.03	46.04
Ash	5.90	6.04	n/a	n/a	6.04	6.03	8.41	8.47	9.72	9.73	6.04	6.03	6.65	6.81
BTUs (Dry)	13170		n/a		13176		12572		12840		13295		13114	
(DAF)	14017		n/a		14021		13735		14224		14148		14072	
Dry Basis Weight %														
Carbon	74.45	75.24	n/a	n/a	75.14	75.59	73.47	73.82	73.28	73.43	75.86	76.15	75.13	75.10
Hydrogen	5.50	5.62	n/a	n/a	5.49	5.62	4.90	4.99	5.39	5.45	5.45	5.57	5.43	5.53
Nitrogen	1.44	1.39	n/a	n/a	1.60	1.54	1.28	1.27	1.52	1.50	1.60	1.64	1.55	1.54
Sulfur	0.52	0.54	n/a	n/a	0.68	0.68	0.35	0.36	0.65	0.67	0.49	0.49	0.71	0.72
As Received %														
Carbon	73.3	70.41	n/a	n/a	73.79	73.60	71.55	70.49	71.67	72.36	74.62	74.72	73.60	68.92
Hydrogen	5.59	5.97	n/a	n/a	5.59	5.76	5.06	5.27	5.52	5.53	5.54	5.67	5.55	5.99
Nitrogen	1.42	1.30	n/a	n/a	1.57	1.50	1.25	1.21	1.49	1.48	1.57	1.61	1.52	1.41
Sulfur	0.51	0.51	n/a	n/a	0.66	0.66	0.35	0.35	0.64	0.66	0.48	0.49	0.70	0.66

* AD=air dried
* ND=nitrogen dried
[1] Dry ash free

Table 6. Elemental and proximate analyses data.

MINE	Castlegate No.3		Belina No.2		Soldier Canyon		Crandall Canyon		Bear Canyon No.1		Bear Canyon No.1		Cottonwood	
SEAM	SubSeam 3		Lower O'Connor		Rock Canyon		Hiawatha		Upper Hiawatha		Hiawatha		Hiawatha	
Elemental Analysis %														
(DAF basis weight)	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND
Carbon	81.27	81.57	79.67	80.14	82.15	82.46	81.94	82.22	82.08	82.43	81.29	81.87	81.56	81.88
Hydrogen	6.08	6.17	5.66	5.80	5.56	5.67	6.04	6.12	6.20	6.25	6.12	6.14	5.84	5.94
Nitrogen	1.79	1.79	1.49	1.38	1.77	1.63	1.73	1.70	1.59	1.59	1.72	1.66	1.67	1.56
Sulfur	0.52	0.54	0.57	0.59	0.45	0.46	0.53	0.54	0.64	0.66	0.75	0.77	0.50	0.51
Oxygen	10.34	9.93	12.61	12.08	10.08	9.78	9.76	9.42	9.49	9.07	10.12	9.56	10.43	10.11
Proximate Analysis %														
(as received by weight)														
Moisture	1.42	1.69	2.06	3.51	1.35	1.07	1.39	1.48	1.57	5.22	1.91	7.16	2.15	2.48
(dry basis weight)														
Volatile Matter	44.86	45.33	47.91	48.72	42.17	42.82	45.88	46.02	48.95	49.64	46.60	47.44	43.97	44.37
Fixed Carbon	44.10	43.76	46.12	45.20	50.64	49.94	47.67	47.58	44.40	43.70	44.82	43.97	47.81	46.45
Ash	11.04	10.91	5.97	6.08	7.19	7.24	6.45	6.40	6.65	6.66	8.58	8.59	8.22	8.18
BTUs (Dry)	12848		12958		13284		13585		13808		13234		13090	
(DAF)	14421		13797		14321		14514		14793		14478		14256	
Dry Basis Weight %														
Carbon	72.30	72.67	74.91	75.27	76.24	76.49	76.66	76.96	76.62	76.94	74.32	74.84	74.86	75.18
Hydrogen	5.41	5.50	5.32	5.45	5.16	5.26	5.65	5.73	5.79	5.83	5.59	5.62	5.36	5.45
Nitrogen	1.59	1.60	1.40	1.30	1.64	1.52	1.62	1.59	1.48	1.49	1.57	1.52	1.53	1.44
Sulfur	0.47	0.48	0.54	0.55	0.42	0.43	0.49	0.50	0.60	0.62	0.69	0.70	0.46	0.47
As Received %														
Carbon	71.27	71.44	73.37	72.63	75.21	75.67	75.59	75.82	75.42	72.92	72.90	69.48	73.25	73.32
Hydrogen	5.49	5.59	5.44	5.65	5.24	5.32	5.73	5.81	5.87	6.11	5.70	6.01	5.48	5.59
Nitrogen	1.57	1.57	1.37	1.25	1.62	1.50	1.60	1.57	1.46	1.41	1.54	1.41	1.50	1.40
Sulfur	0.50	0.48	0.53	0.53	0.41	0.42	0.49	0.50	0.60	0.58	0.67	0.65	0.47	0.46

Table 6. (continued) Elemental and proximate data.

MINE	Deer Creek		Emery		Skyline No.1		Sunnyside No.3		Pinnacle		Apex		Sunnyside No.1	
SEAM	Blind Canyon		Upper "I"		Upper O'Connor		Upper Sunnyside		Gilson		Lower Sunnyside		Lower Sunnyside	
Elemental Analysis %														
(DAF basis weight)	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND
Carbon	81.91	81.83	81.87	82.45	79.12	80.02	83.42	84.65	80.67	81.22	80.45	80.90	84.06	84.36
Hydrogen	6.16	6.24	5.80	5.92	5.75	6.01	5.78	5.74	5.43	5.60	5.33	5.51	5.61	5.73
Nitrogen	1.57	1.53	1.51	1.55	1.83	1.69	1.90	1.91	1.61	1.60	1.63	1.71	1.99	1.89
Sulfur	0.49	0.50	0.42	0.42	0.63	0.64	0.82	0.86	0.65	0.67	0.62	0.63	0.48	0.49
Oxygen	9.86	9.90	10.39	9.65	12.67	11.65	8.08	6.83	11.64	10.92	11.96	11.26	7.87	7.53
Proximate Analysis %														
(as received by weight)														
Moisture	2.27	1.33	1.93	2.00	1.25	3.24	1.34	8.07	1.57	2.26	1.53	2.06	1.11	1.14
(dry basis weight)														
Volatile Matter	50.72	51.08	43.62	43.61	48.89	49.91	40.99	41.99	41.15	42.19	41.93	43.34	39.99	40.66
Fixed Carbon	42.88	42.47	47.47	47.65	46.18	45.15	51.78	50.76	50.58	49.38	53.85	52.47	55.66	54.96
Ash	6.40	6.45	8.91	8.74	4.93	4.94	7.23	7.25	8.27	8.43	4.22	4.19	4.35	4.38
BTUs (Dry)	13469		12964		13221		13780		12799		13275		14174	
(DAF)	14398		14206		13908		14857		13977		13856		14823	
Dry Basis Weight %														
Carbon	76.67	76.55	74.58	75.24	75.22	76.06	77.39	78.52	74.00	74.37	77.06	77.51	80.40	80.67
Hydrogen	5.77	5.84	5.29	5.41	5.47	5.72	5.36	5.32	4.98	5.12	5.11	5.28	5.37	5.48
Nitrogen	1.47	1.43	1.38	1.42	1.74	1.60	1.76	1.77	1.47	1.46	1.56	1.63	1.90	1.81
Sulfur	0.46	0.47	0.38	0.39	0.60	0.61	0.76	0.80	0.60	0.61	0.59	0.60	0.46	0.47
As Received %														
Carbon	74.93	75.53	73.14	73.74	74.28	73.60	76.35	72.18	72.84	72.69	75.88	75.91	79.51	79.75
Hydrogen	5.89	5.91	5.40	5.52	5.54	5.89	5.44	5.79	5.08	5.26	5.20	5.40	5.43	5.54
Nitrogen	1.44	1.41	1.35	1.39	1.72	1.55	1.74	1.63	1.45	1.43	1.54	1.60	1.88	1.79
Sulfur	0.45	0.46	0.37	0.38	0.59	0.59	0.75	0.74	0.59	0.60	0.58	0.59	0.45	0.46

Table 6. (continued) Elemental and proximate analyses data.

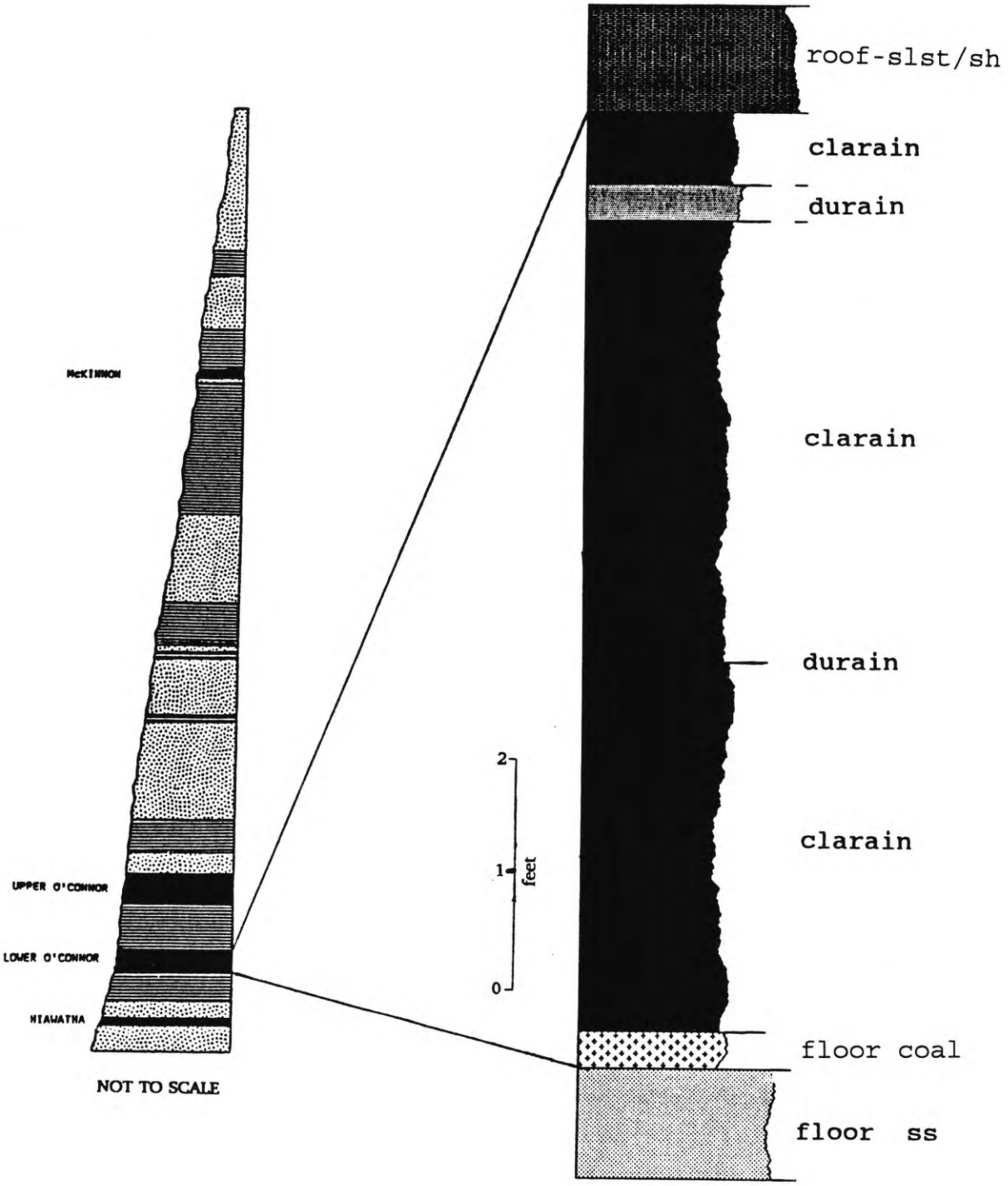
MINE	Boyer		Gordon Creek No.7		Star Point No.2		Aberdeen		Beaver Creek No.8		Pinnacle		Soldier Canyon	
SEAM	Wasatch		Castlegate "A"		Wattis		Castlegate "A"		Castlegate "A"		Centennial		Sunnyside	
Elemental Analysis %														
(DAF basis weight)	AD*	ND*	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND	AD	ND
Carbon	75.65	76.30	80.03	80.53	80.97	81.45	83.42	84.65	80.67	81.22	80.45	80.90	84.06	84.36
Hydrogen	5.07	5.45	6.27	6.39	6.32	6.46	5.78	5.74	5.43	5.60	5.33	5.51	5.61	5.73
Nitrogen	1.76	1.74	1.69	1.68	1.62	1.68	1.90	1.91	1.61	1.60	1.63	1.71	1.99	1.89
Sulfur	1.13	1.15	0.56	0.58	0.61	0.63	0.82	0.86	0.65	0.67	0.62	0.63	0.48	0.49
Oxygen	16.39	15.37	11.45	10.82	10.47	9.78	8.08	6.83	11.64	10.92	11.96	11.26	7.87	7.53
Proximate Analysis %														
(as received by weight)														
Moisture	6.12	8.18	1.75	2.05	1.41	2.70	1.34	8.07	1.57	2.26	1.53	2.06	1.11	1.14
(dry basis weight)														
Volatile Matter	48.25	49.00	48.93	49.53	51.73	52.58	40.99	41.99	41.15	42.19	41.93	43.34	39.99	40.66
Fixed Carbon	44.54	43.74	41.81	41.09	43.15	42.22	51.78	50.76	50.58	49.38	53.85	52.47	55.66	54.96
Ash	7.21	7.26	9.26	9.38	5.12	5.20	7.23	7.25	8.27	8.43	4.22	4.19	4.35	4.38
BTUs (Dry)	11610		12934		13828		n/a		n/a		n/a		n/a	
(DAF)	12519		14273		14586		n/a		n/a		n/a		n/a	
Dry Basis Weight %														
Carbon	70.20	70.76	72.62	72.98	76.82	77.21	77.39	78.52	74.00	74.37	77.06	77.51	80.40	80.67
Hydrogen	4.71	5.05	5.69	5.79	6.00	6.13	5.36	5.32	4.98	5.12	5.11	5.28	5.37	5.48
Nitrogen	1.63	1.61	1.54	1.52	1.54	1.59	1.76	1.77	1.47	1.46	1.56	1.63	1.90	1.81
Sulfur	1.04	1.06	0.51	0.52	0.58	0.60	0.76	0.80	0.60	0.61	0.59	0.60	0.46	0.47
As Received %														
Carbon	65.90	64.97	71.35	71.48	75.74	75.13	76.35	72.18	72.84	72.69	75.88	75.91	79.51	79.75
Hydrogen	5.10	5.55	5.78	5.90	6.07	6.26	5.44	5.79	5.08	5.26	5.20	5.40	5.43	5.54
Nitrogen	1.53	1.48	1.51	1.49	1.52	1.55	1.74	1.63	1.45	1.43	1.54	1.60	1.88	1.79
Sulfur	0.98	0.98	0.50	0.51	0.57	0.58	0.75	0.74	0.59	0.60	0.58	0.59	0.45	0.46

Table 6. (continued) Elemental and proximate analyses data.

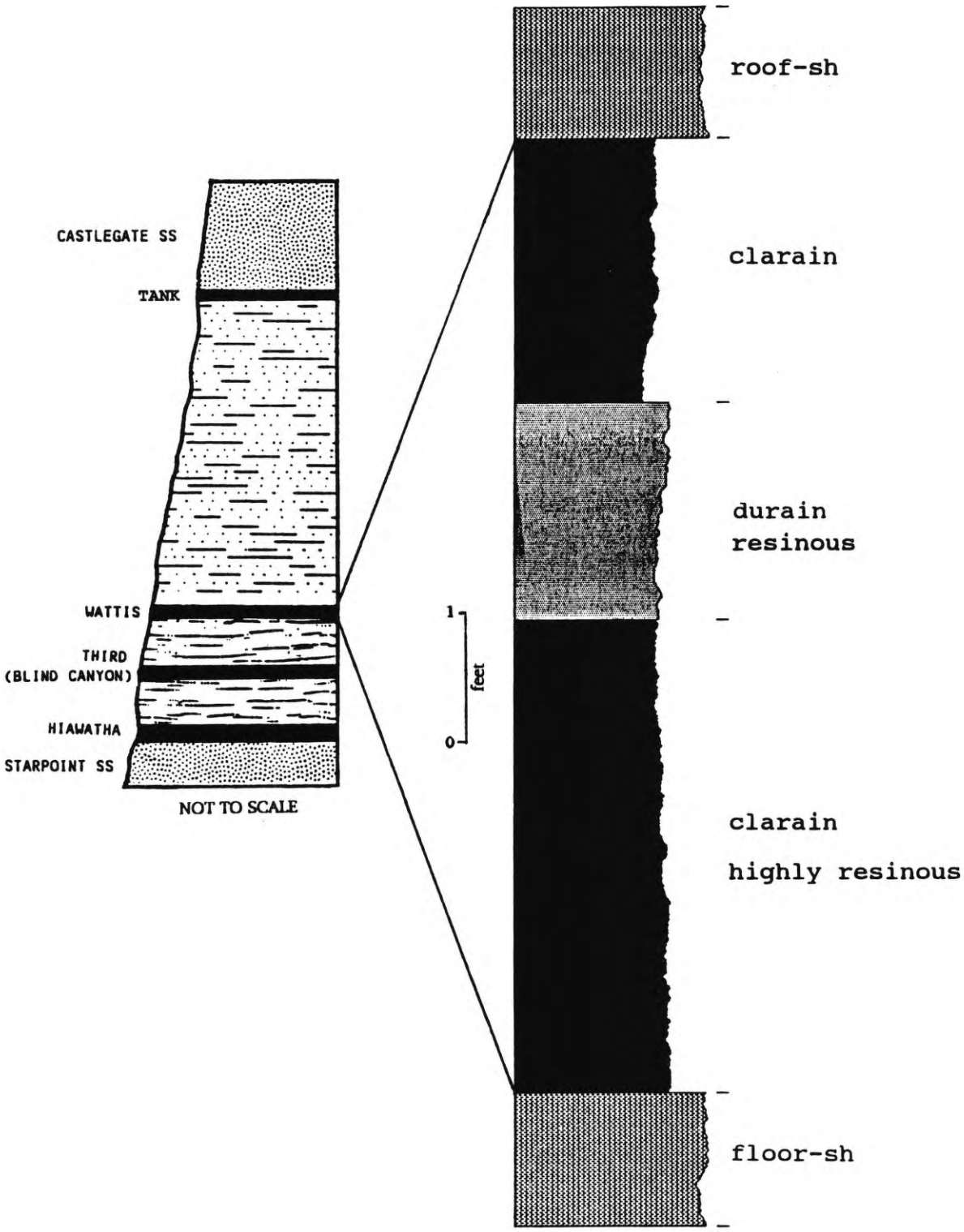
APPENDIX A

The material illustrated in this appendix is the UGS macroscopic interpretation of the coal seam in the coal mine correlated with a generalized formation stratigraphic column. The descriptions (vitrain, clarain, durain, and fusain) are from universally recognized coal manuals. The rock types (ss=sandstone, slst=siltstone, sh=shale, carb sh=carbonaceous shale) are from recognized geology rock manuals.

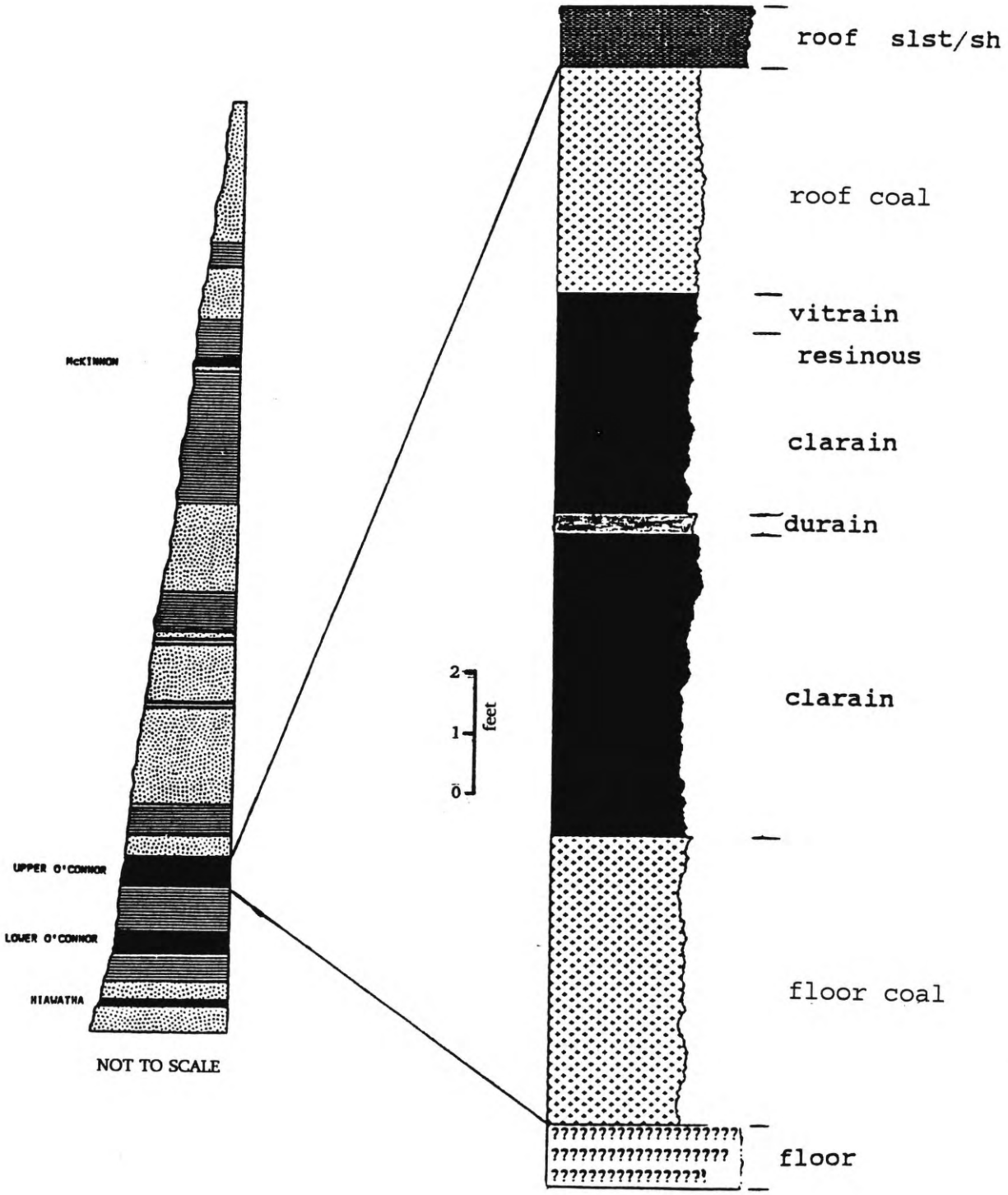
The arrangement of columns depicts the chronological order of the coal sampling. The source of this information is from a field book logged at the time of the sampling.



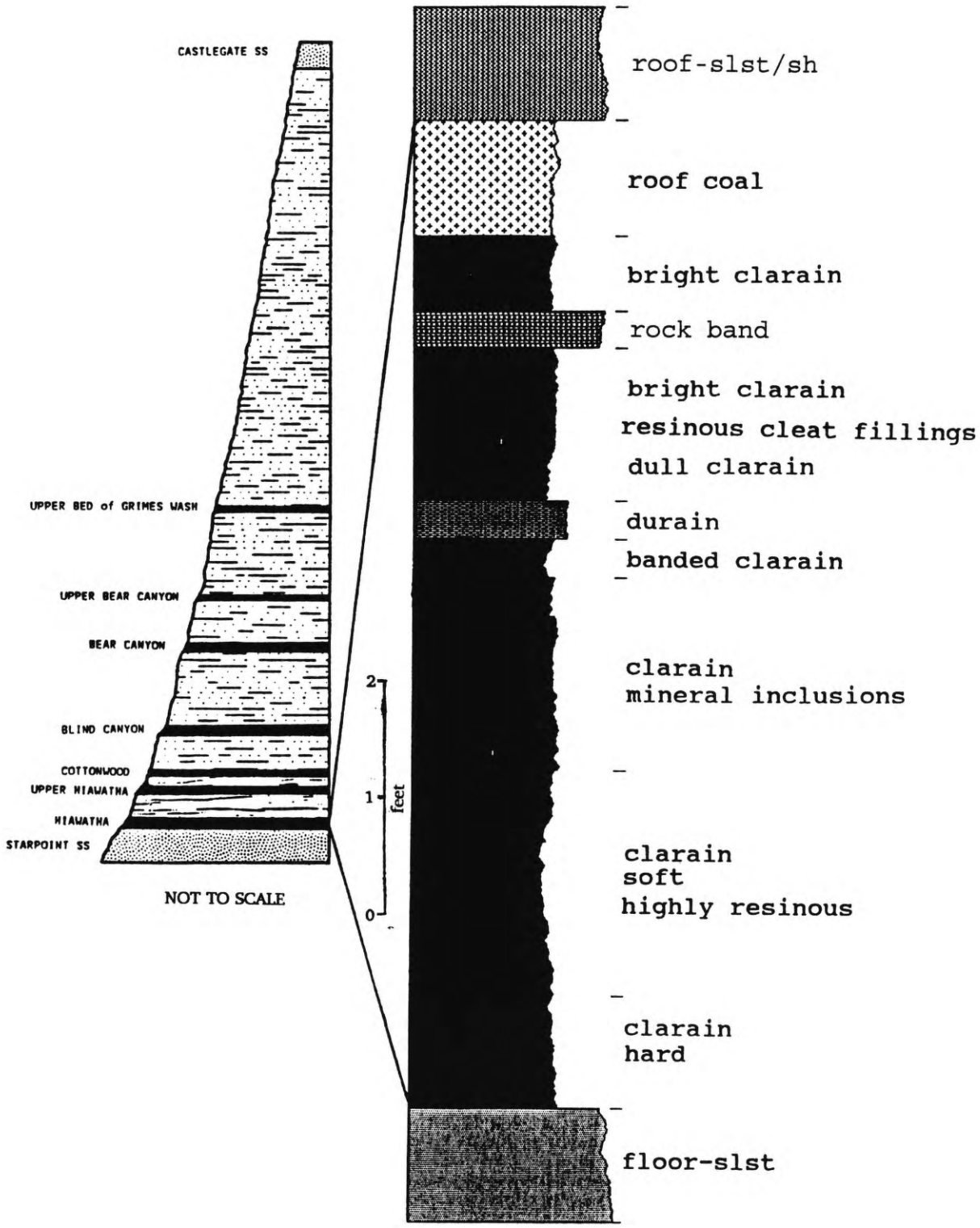
A1. Macroscopic description of the Lower O'Conner seam in the Skyline No. 3 mine, Carbon County, Utah.



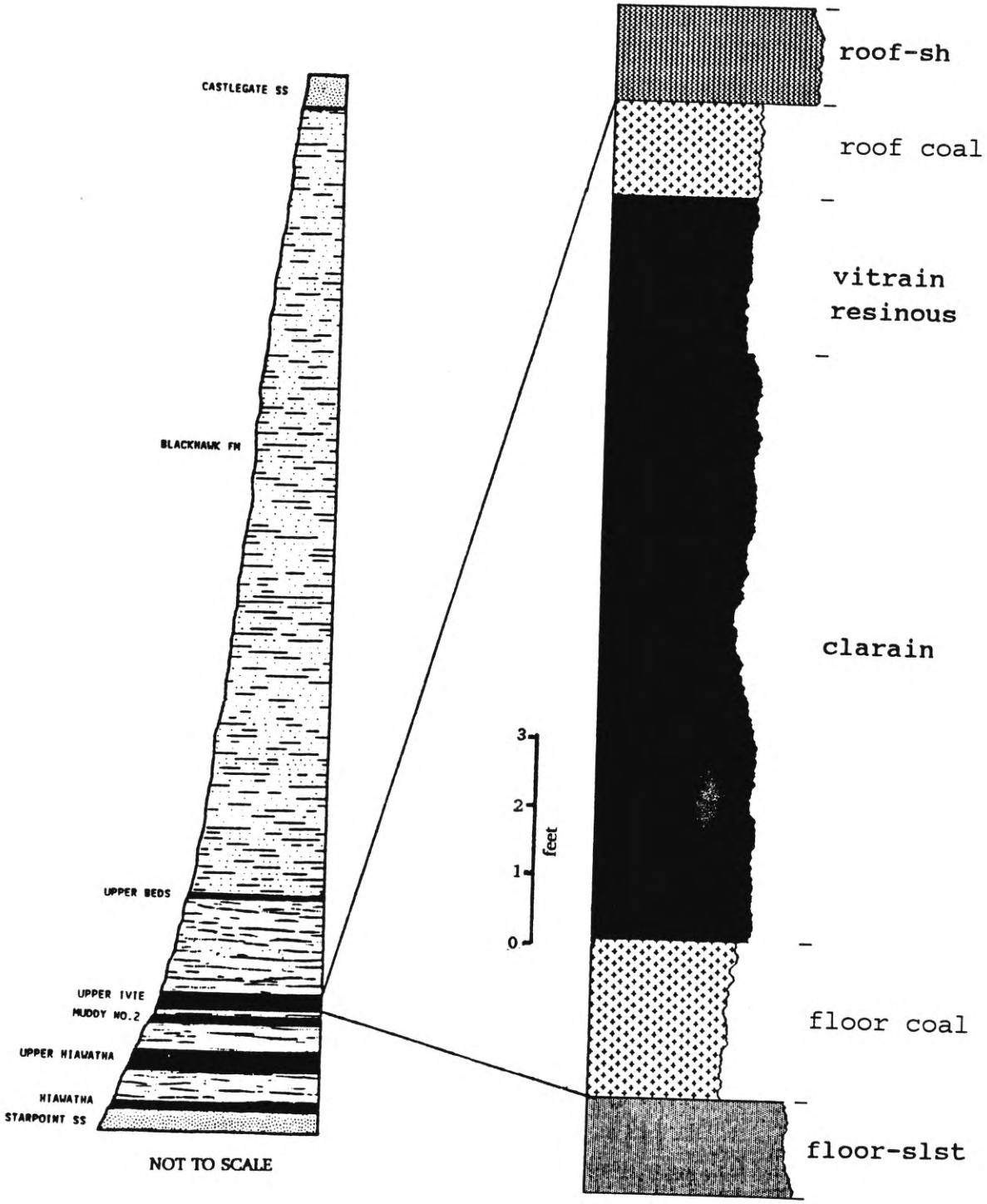
A2. Macroscopic description of the Wattis seam in the Star Point No. 2 mine, Carbon County, Utah.



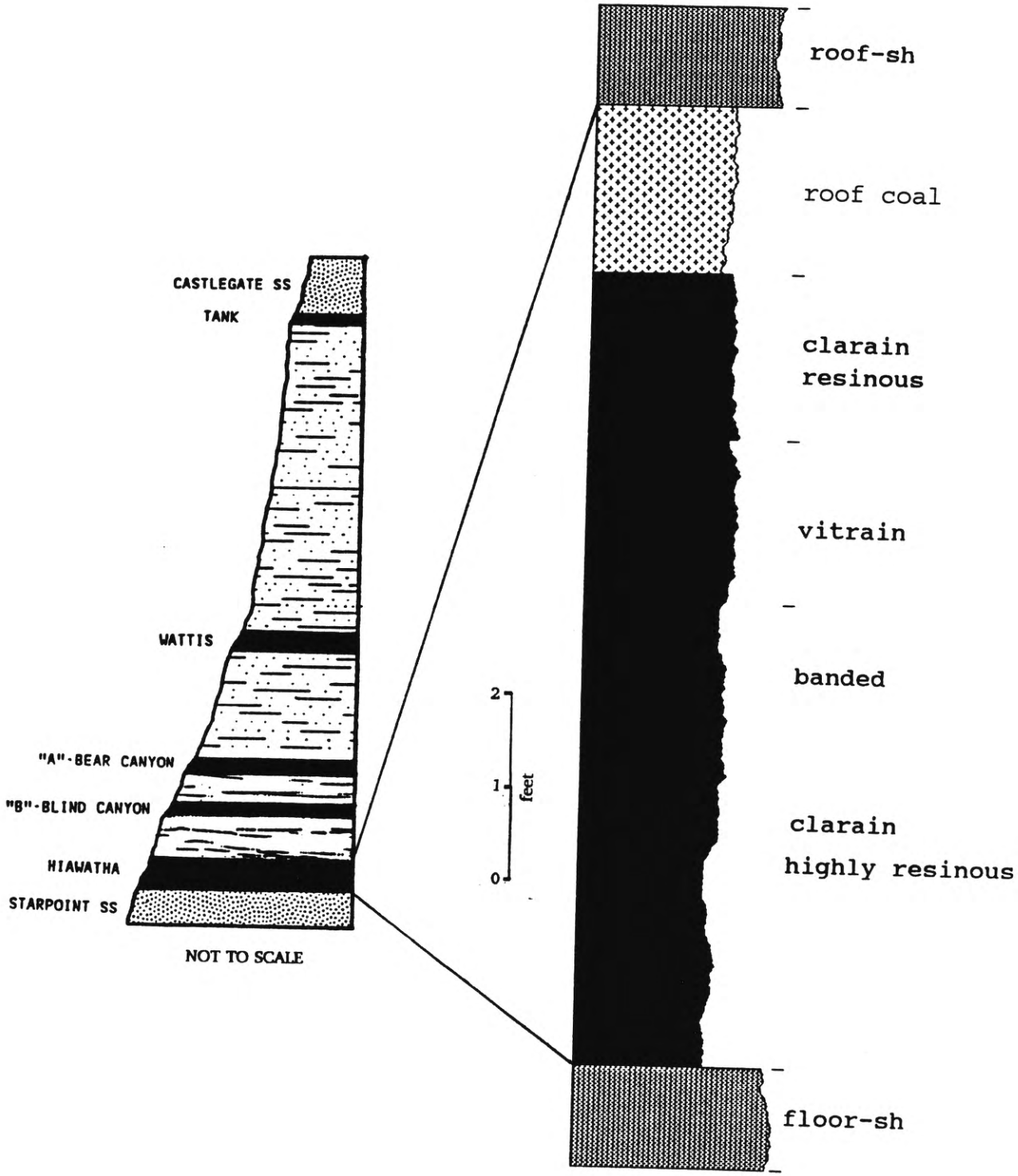
A3. Macroscopic description of the Upper O'Conner seam in the Belina No. 1 mine, Carbon County, Utah.



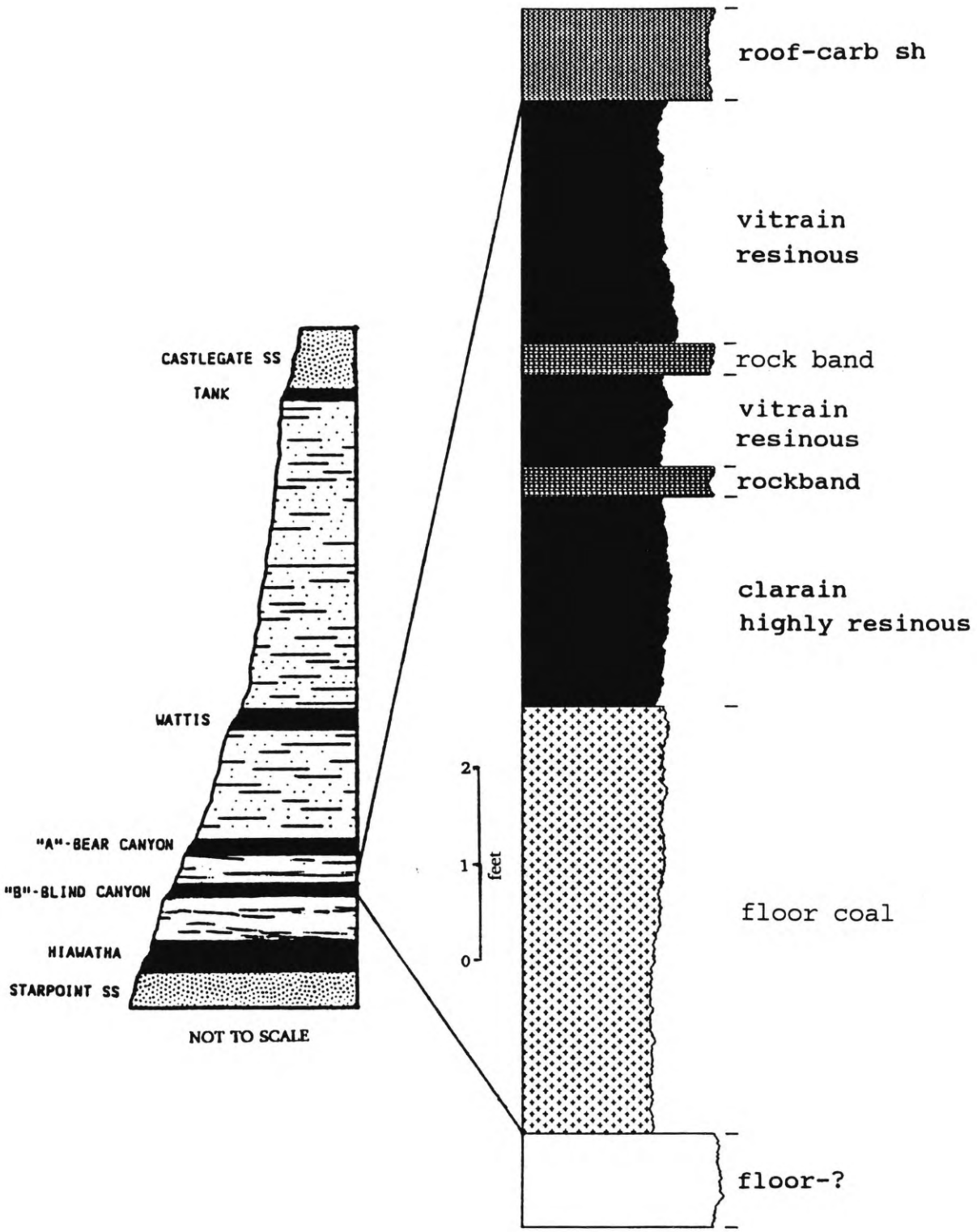
A4. Macroscopic description of the Hiawatha seam in the Beaver Creek No. 9 mine, Carbon County, Utah.



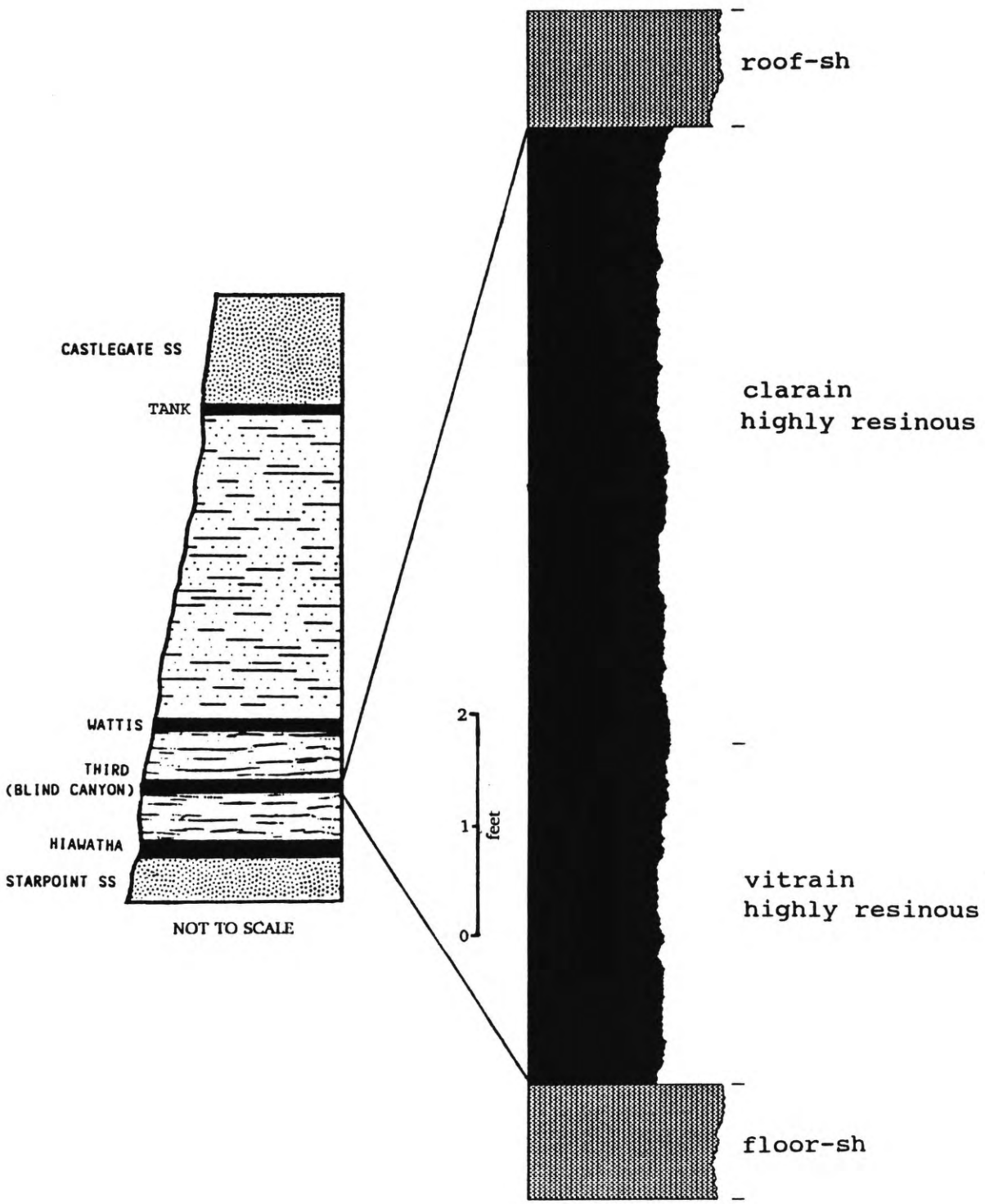
A5. Macroscopic description of the Upper Ivie seam in the SUFCO No. 1 mine, Carbon County, Utah.



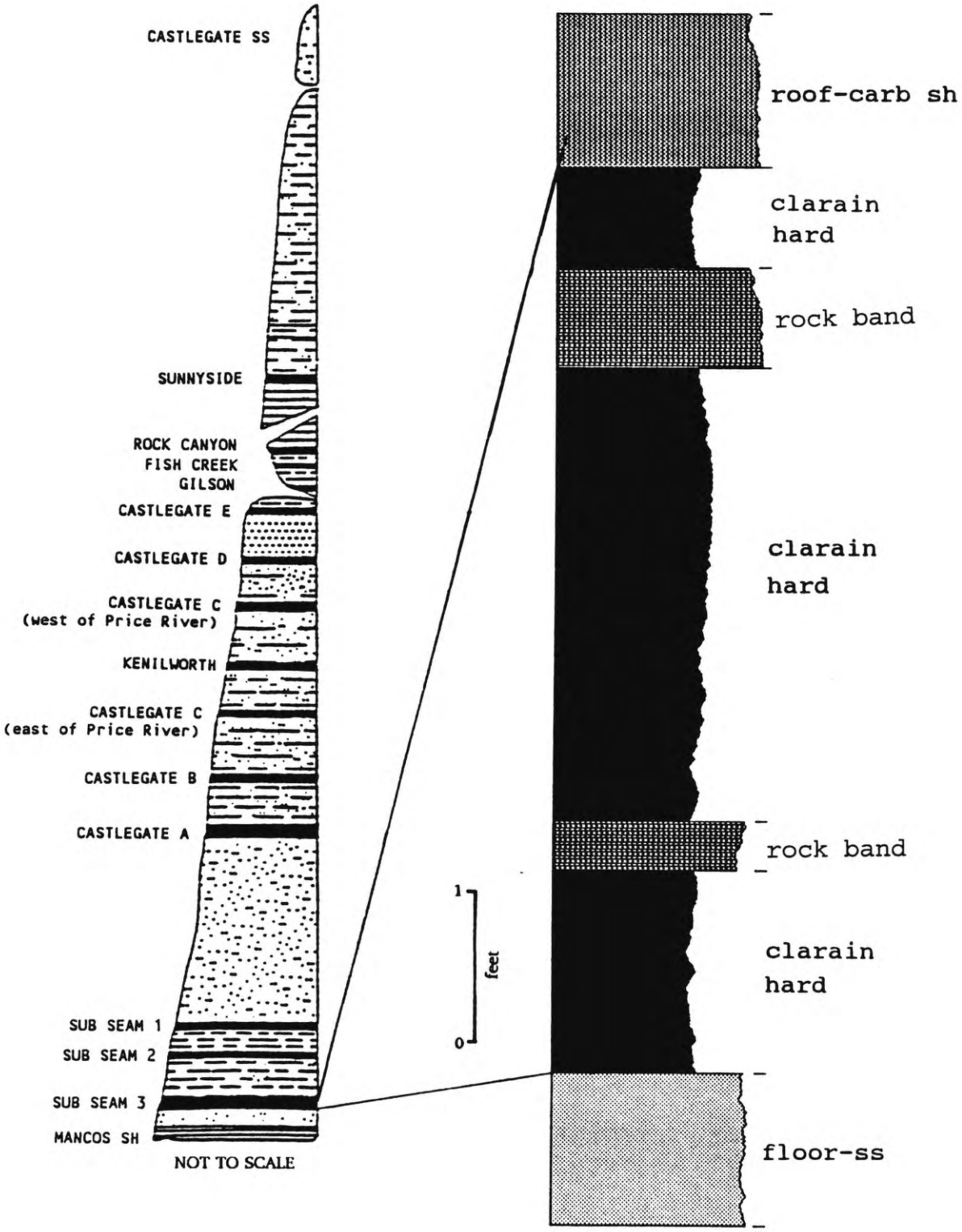
A6. Macroscopic description of the Hiawatha seam in the King No. 6 mine, Carbon County, Utah.



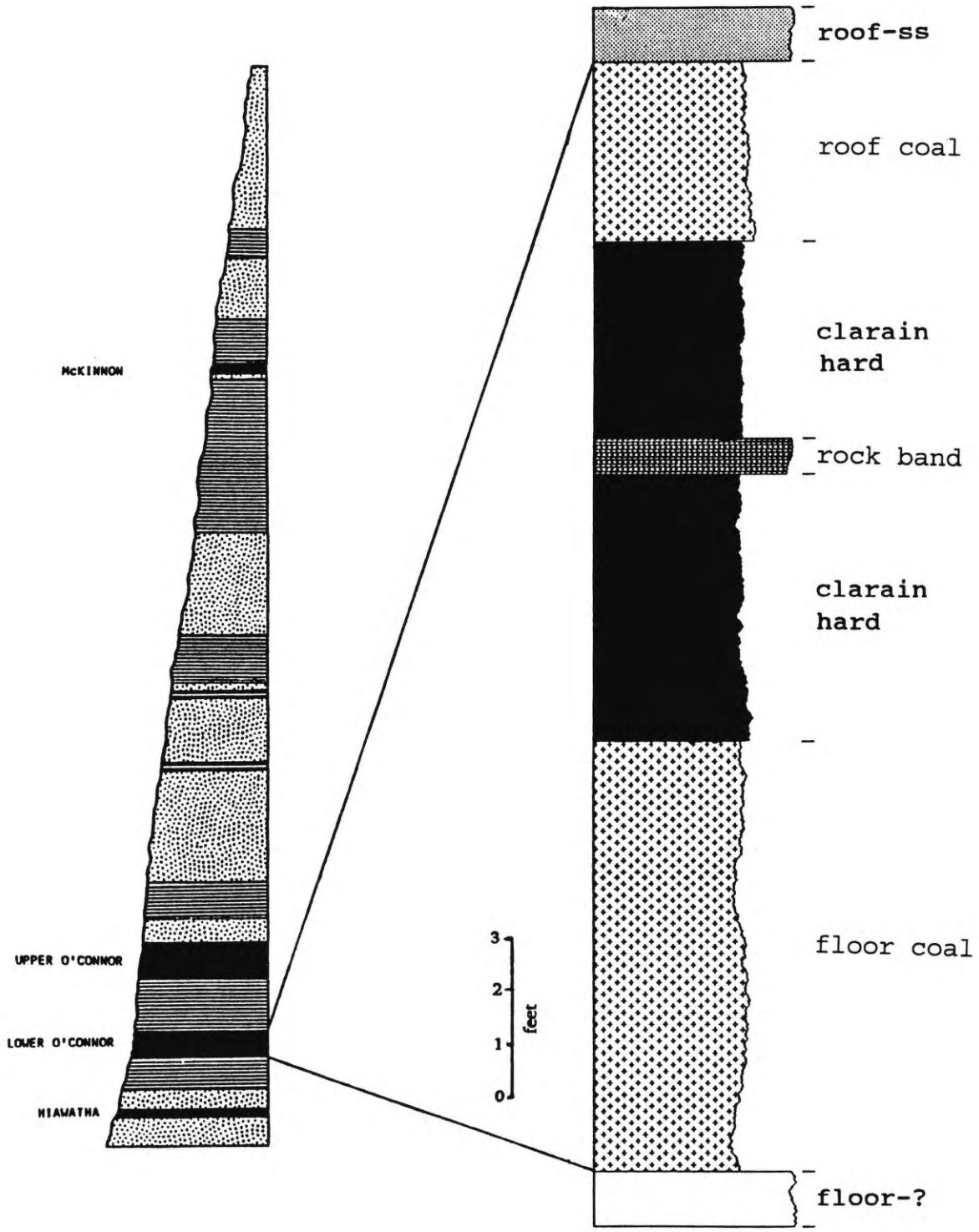
A7. Macroscopic description of the "B" seam in the King No. 4 mine, Carbon County, Utah.



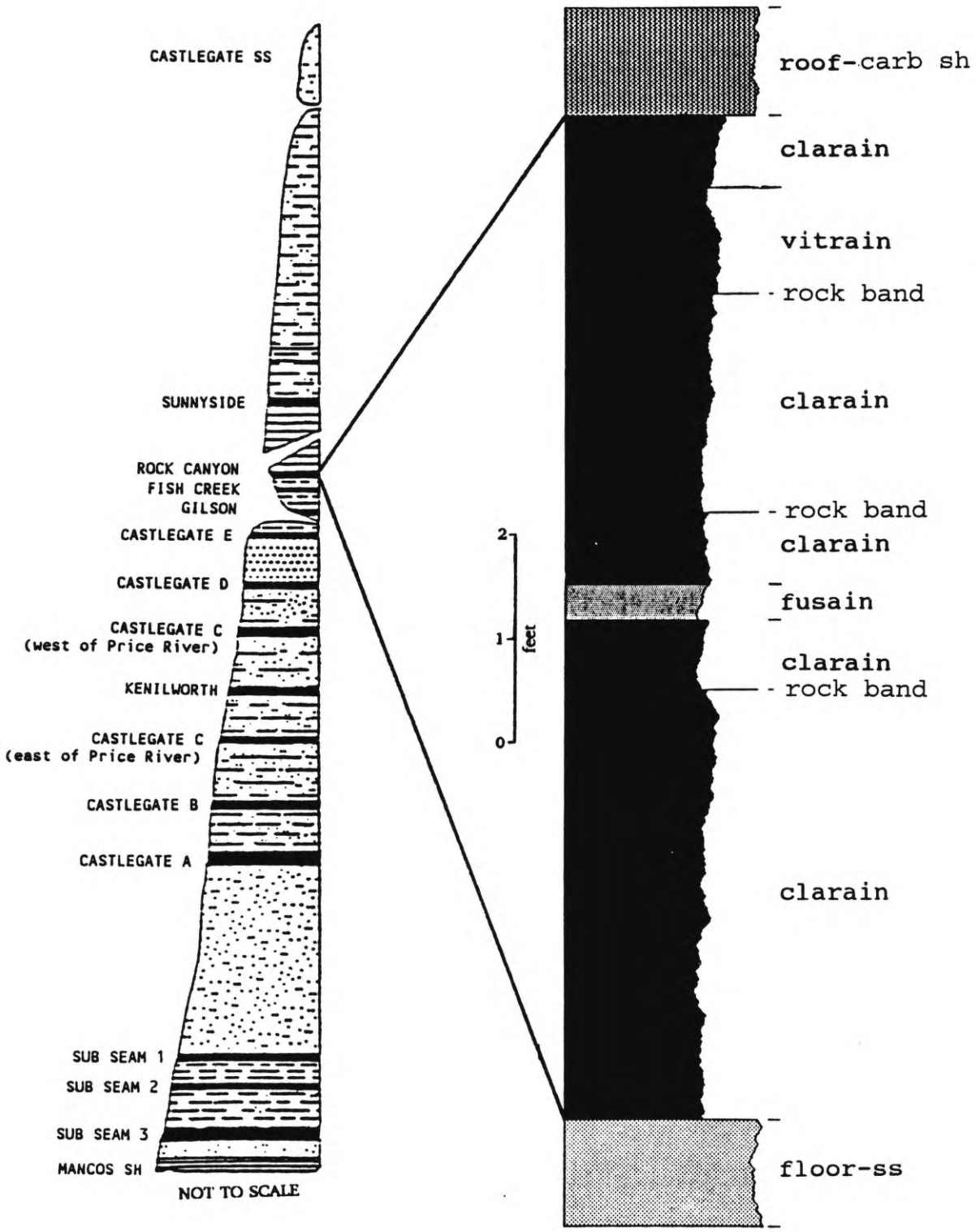
A8. Macroscopic description of the Third seam in the Star Point No. 2 mine, Carbon County, Utah.



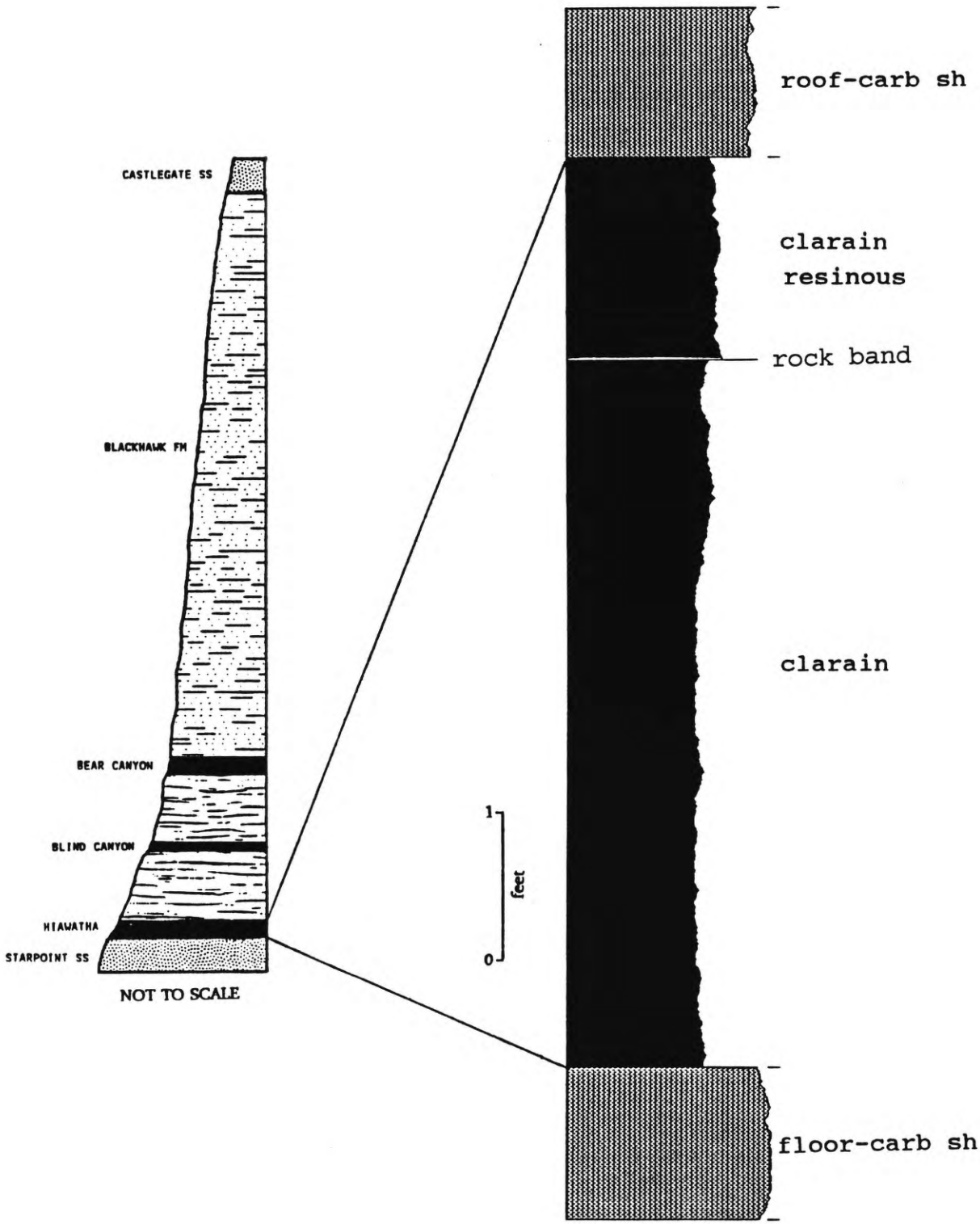
A9. Macroscopic description of the Sub Seam 3 seam in the Castlegate No. 3 mine, Carbon County, Utah.



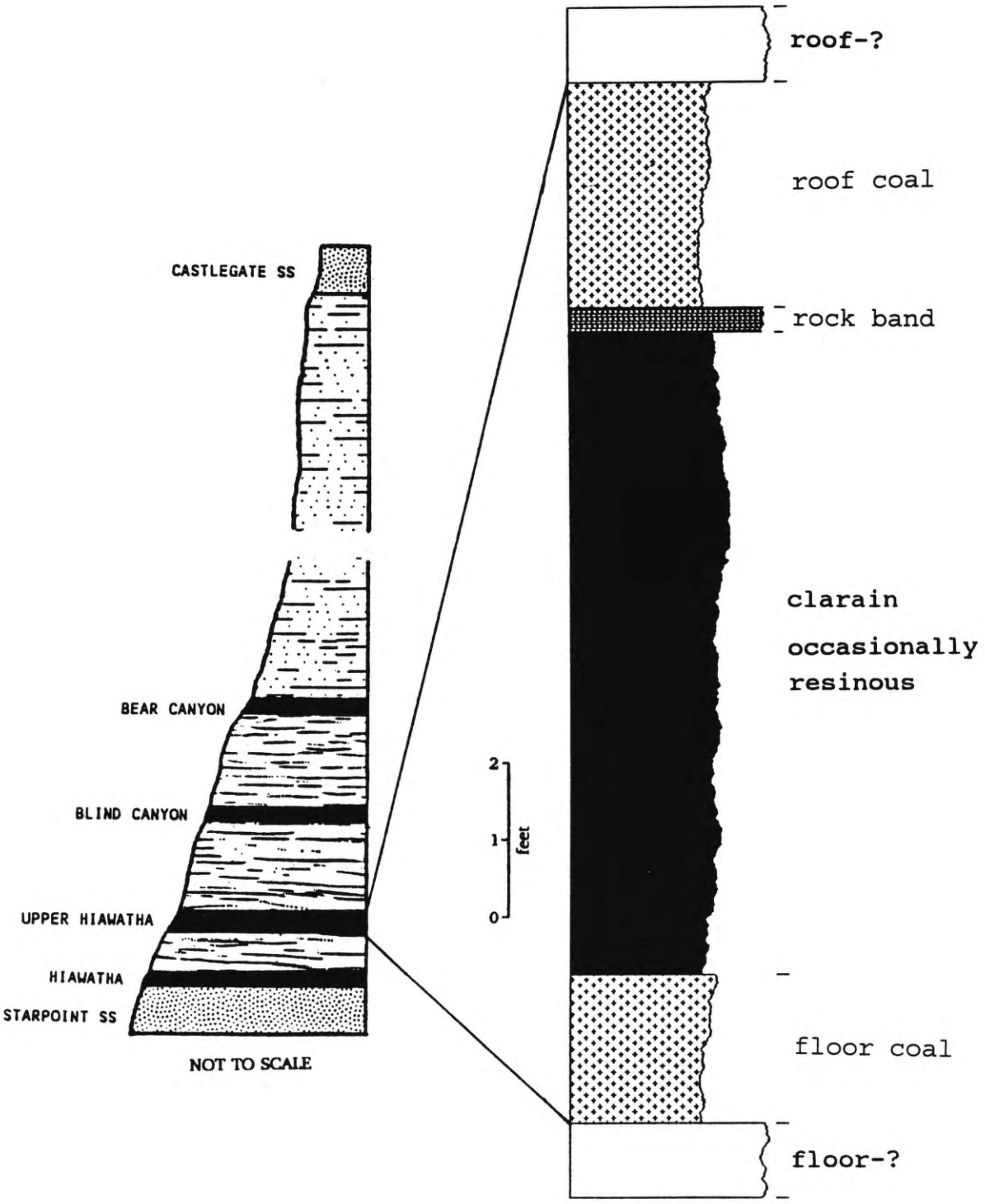
A10. Macroscopic description of the Lower O'Conner seam in the Belina No. 2 mine, Carbon County, Utah.



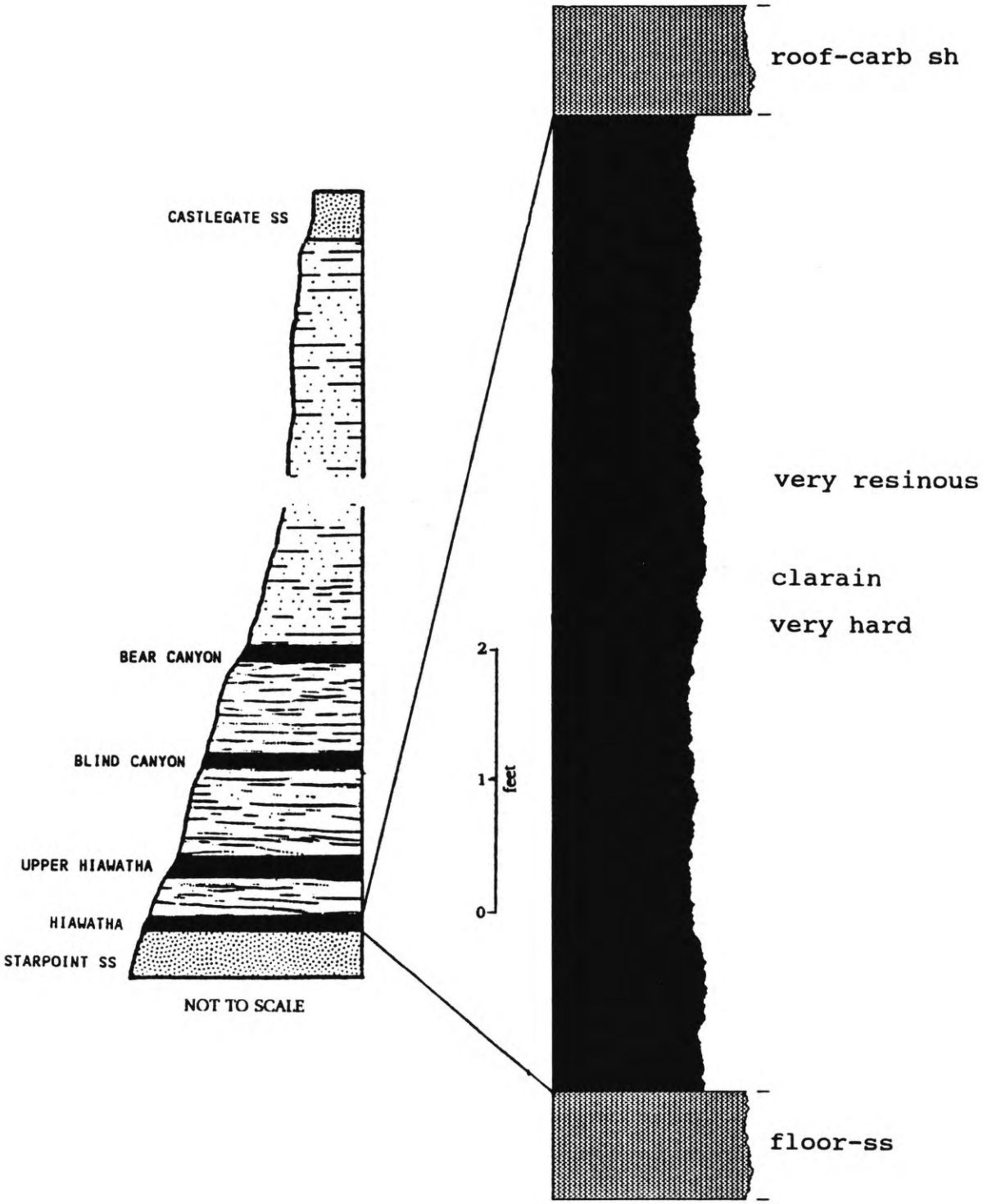
A11. Macroscopic description of the Rock Canyon seam in the Soldier Canyon mine, Carbon County, Utah.



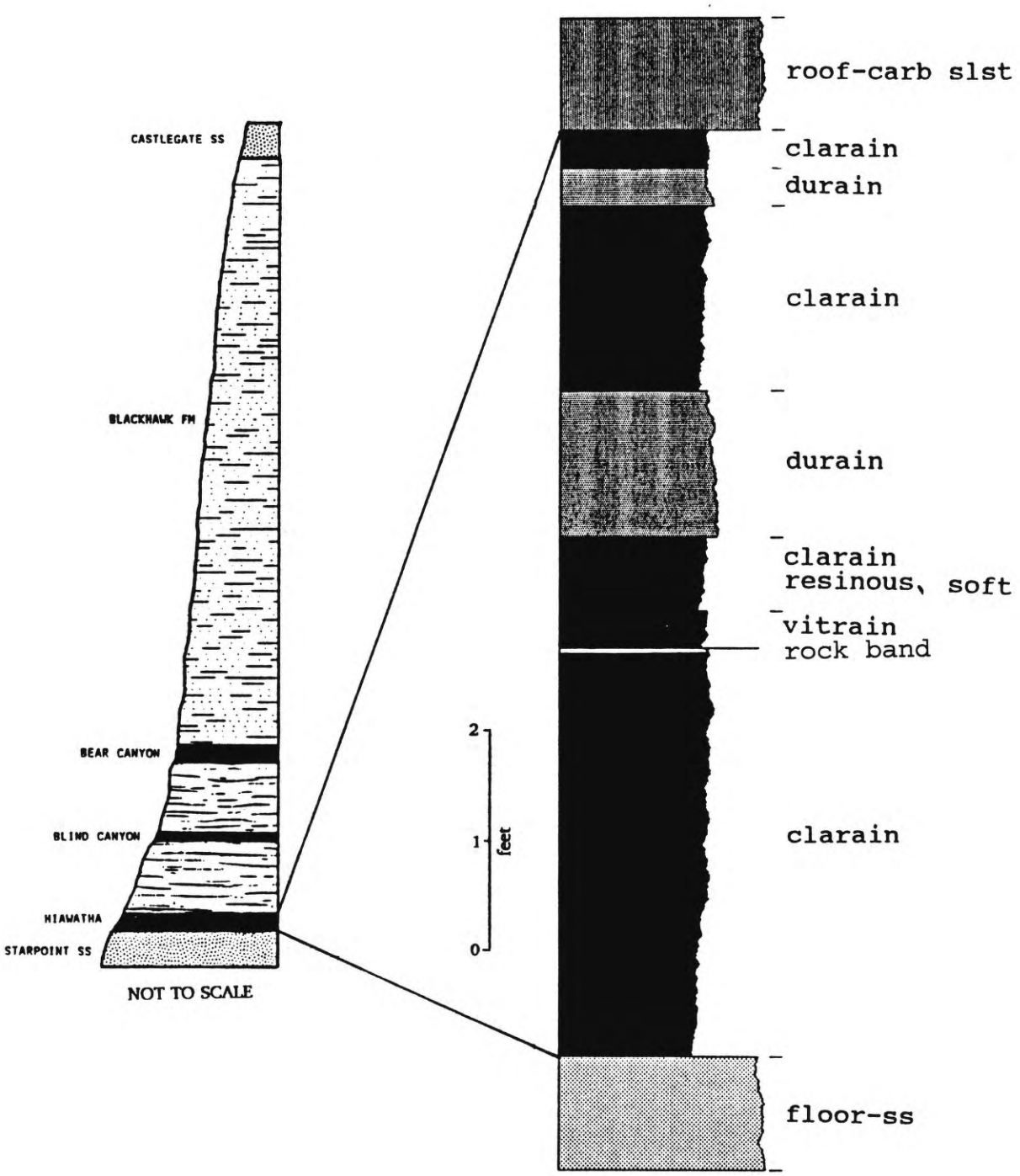
A12. Macroscopic description of the Hiawatha seam in the Crandall Canyon mine, Carbon County, Utah.



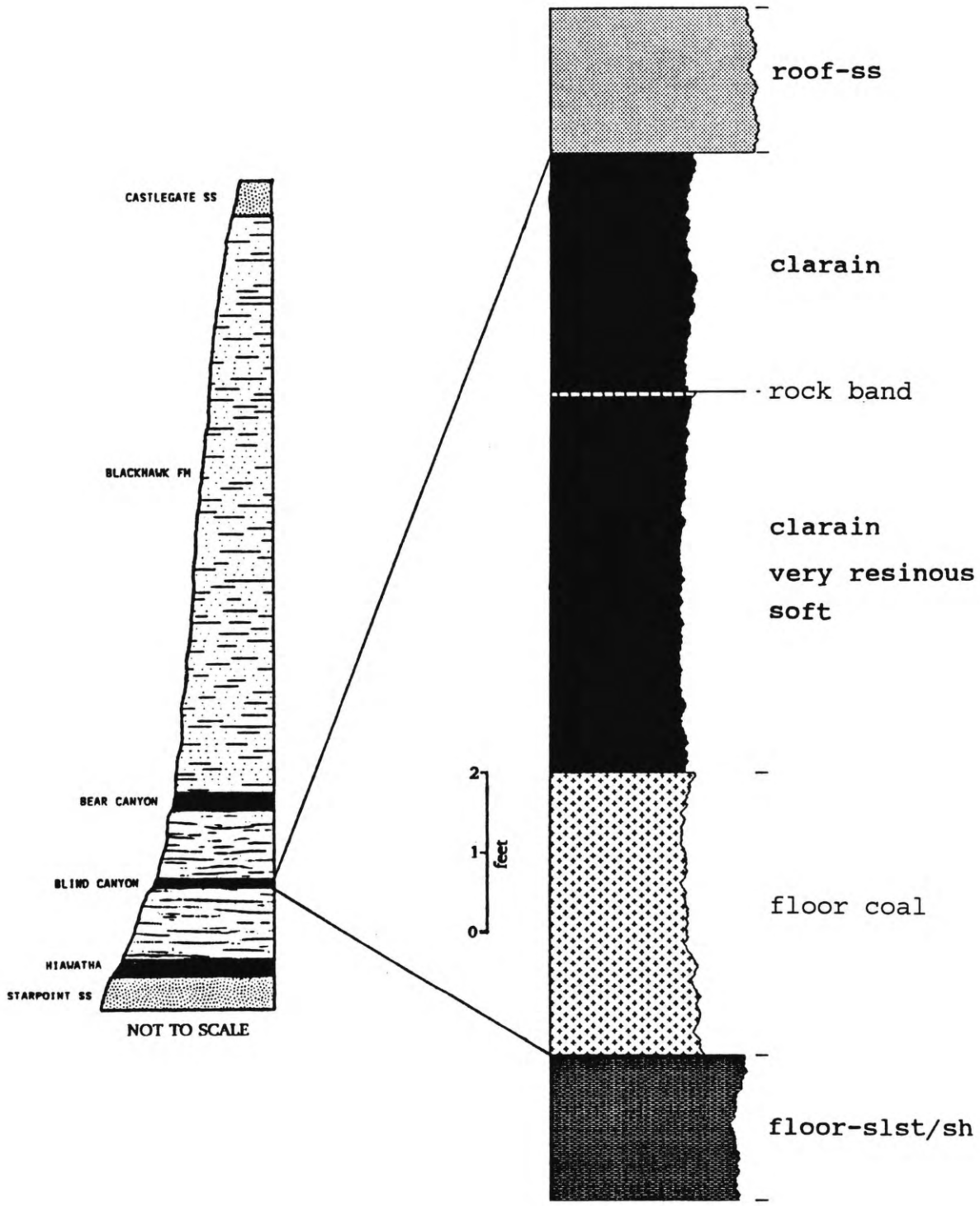
A13. Macroscopic description of the Upper Hiawatha seam in the Bear Canyon No. 1 mine, Carbon County, Utah.



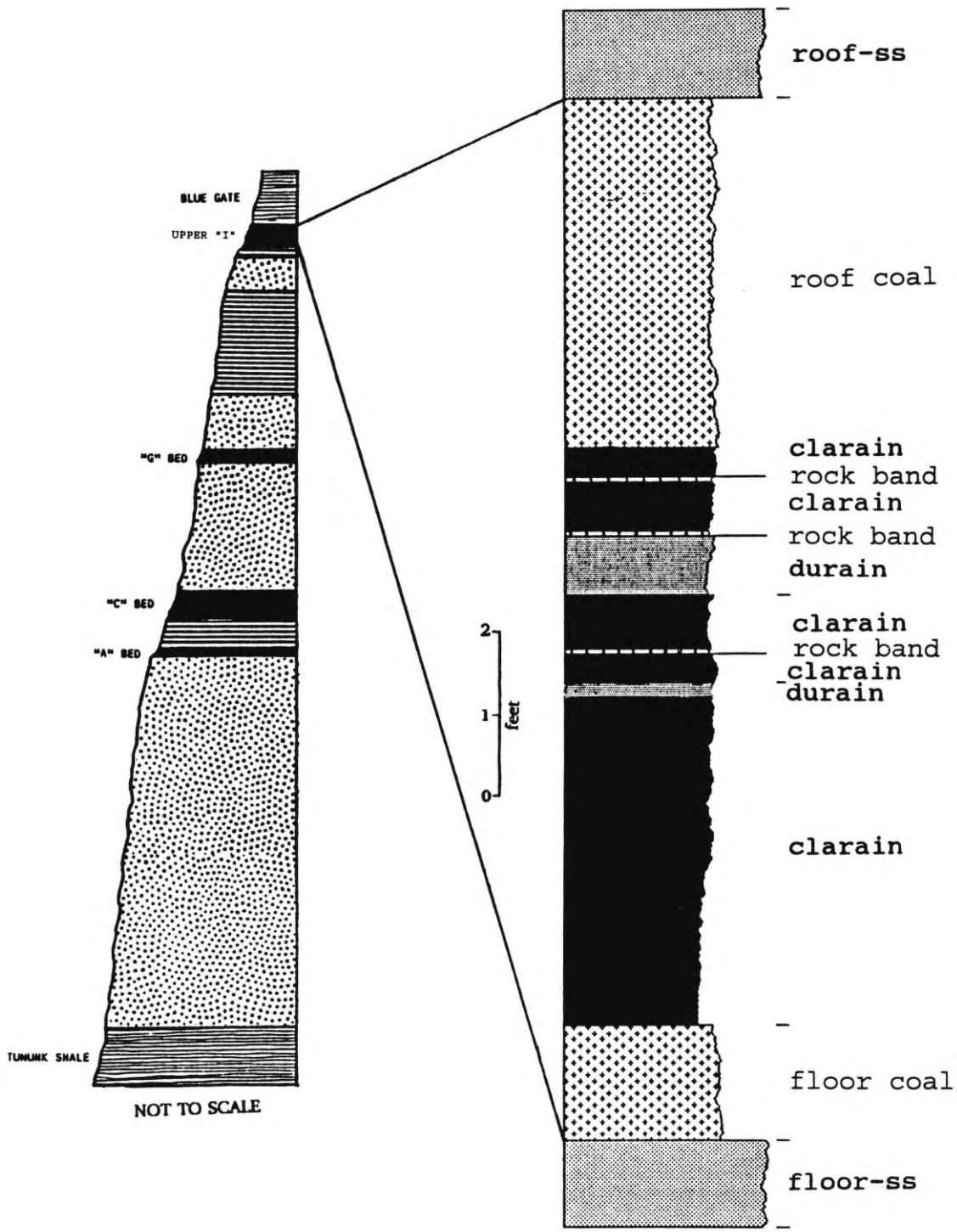
A14. Macroscopic description of the Hiawatha seam in the Bear Canyon No. 1 mine, Carbon County, Utah.



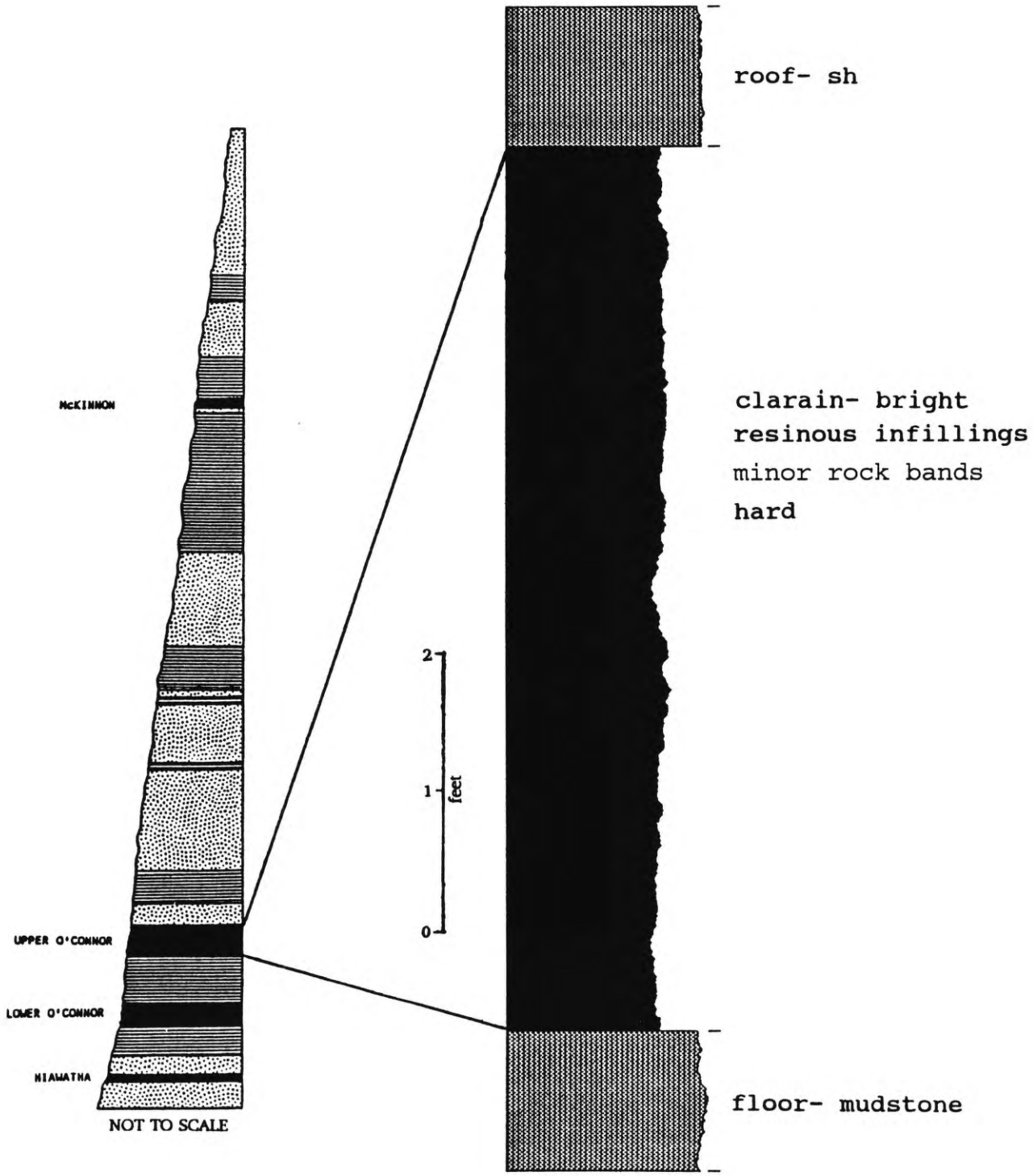
A15. Macroscopic description of the Hiawatha seam in the Cottonwood mine, Carbon County, Utah.



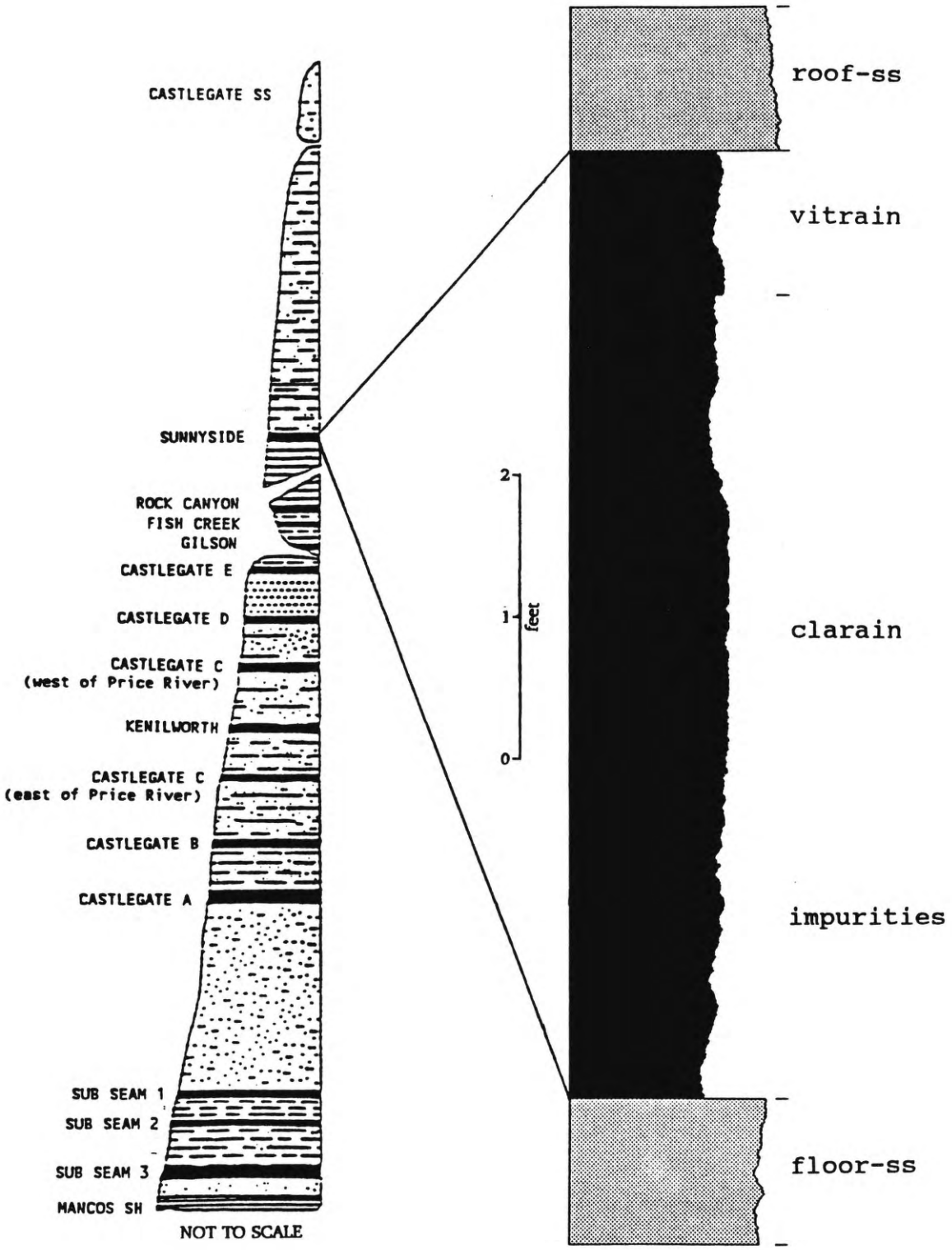
A16. Macroscopic description of the Blind Canyon seam in the Deer Creek mine, Carbon County, Utah.



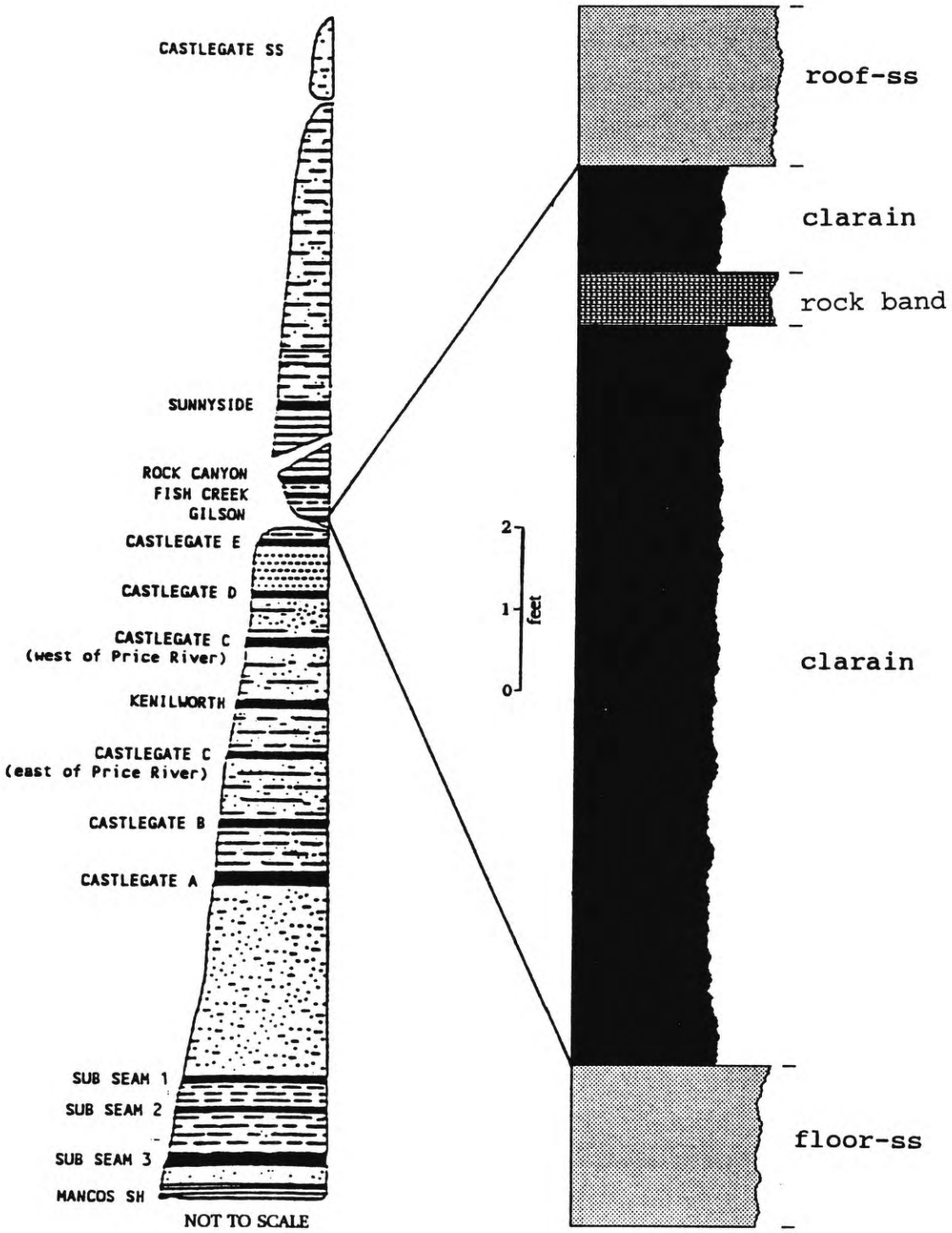
A17. Macroscopic description of the Upper "I" seam in the Emery mine, Emery County, Utah.



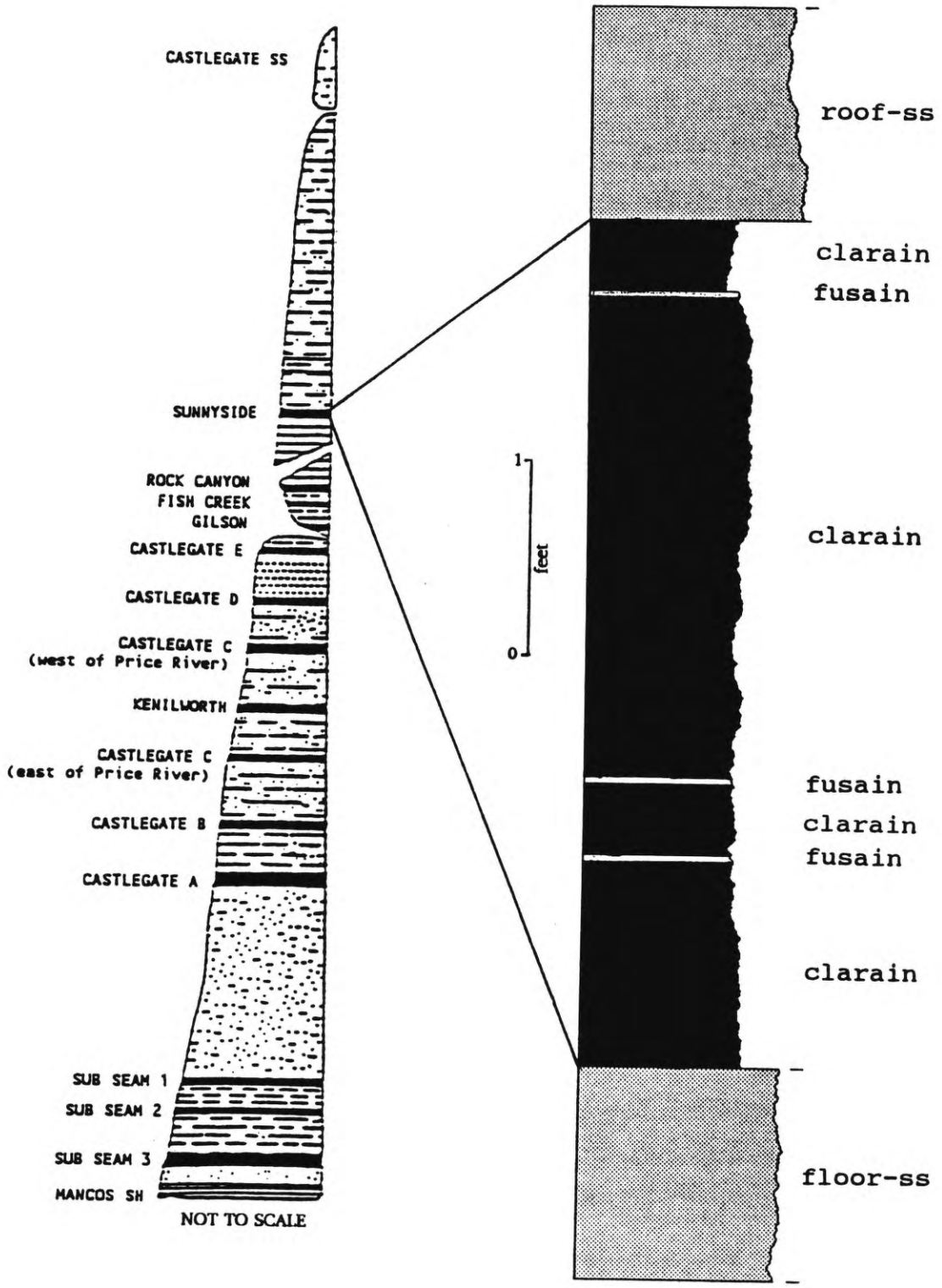
A18. Macroscopic description of the Upper O'Conner seam in the Skyline No. 1 mine, Carbon County, Utah.



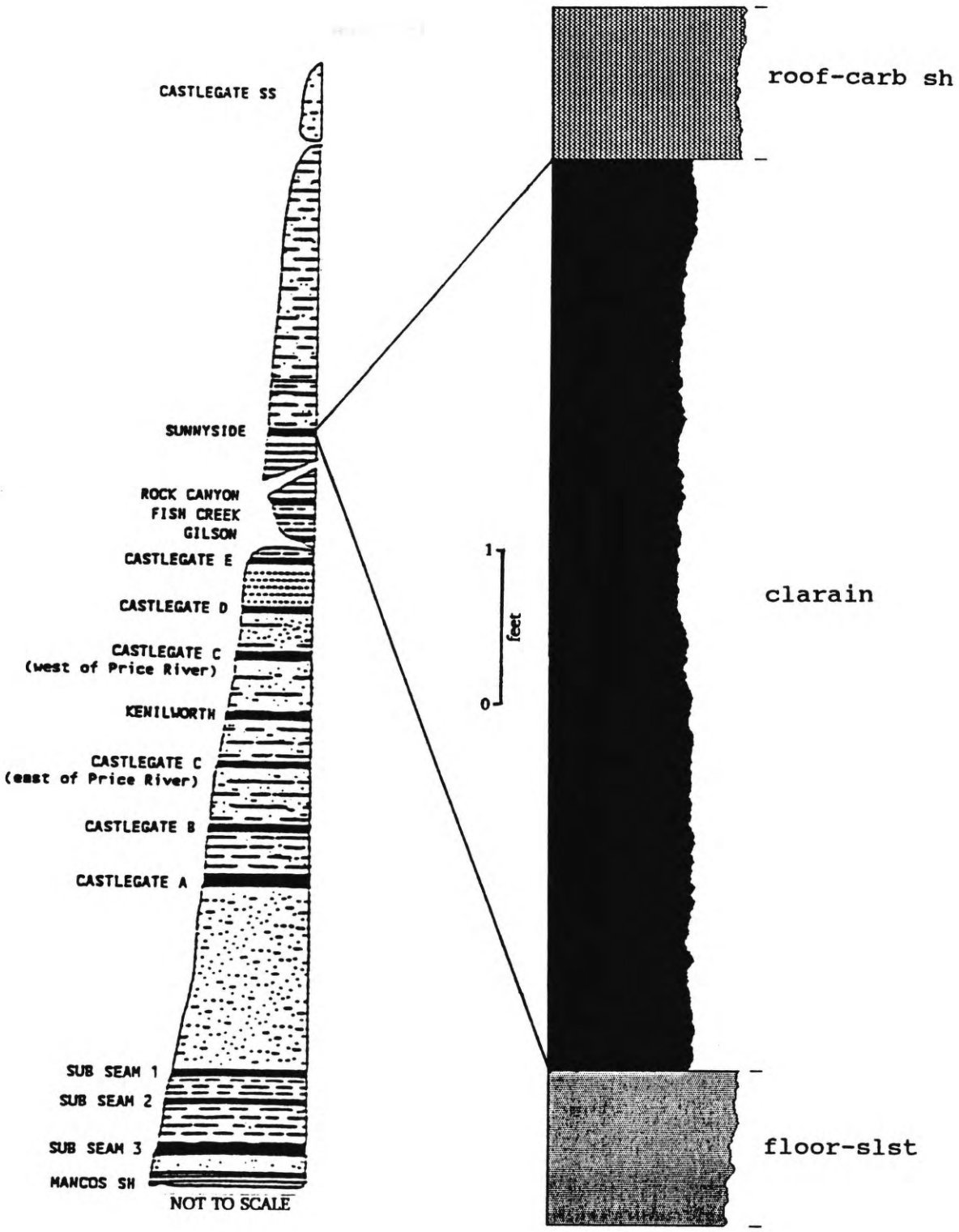
A19. Macroscopic description of the Upper Sunnyside seam in the Sunnyside No. 3 mine, Carbon County, Utah.



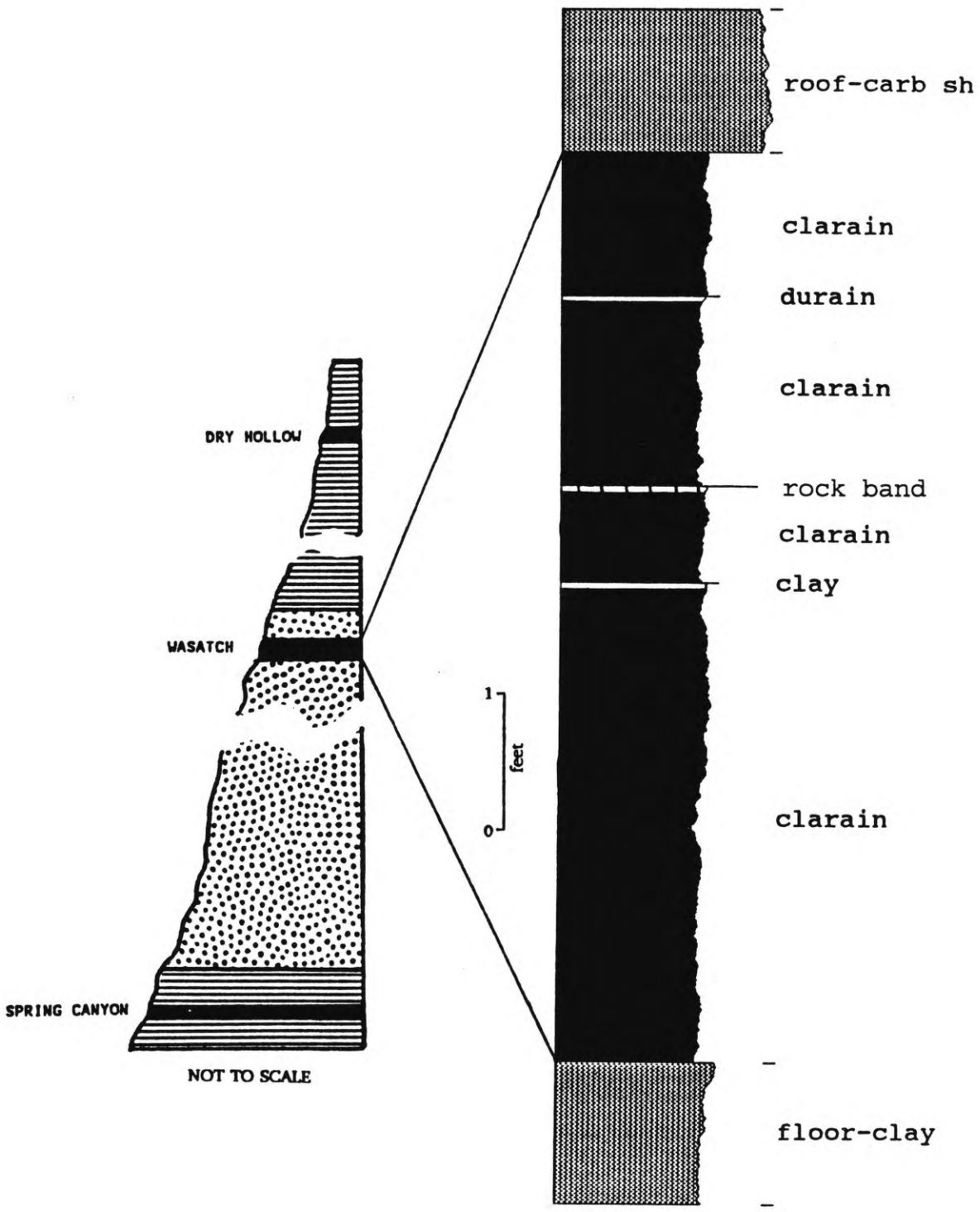
A20. Macroscopic description of the Gilson seam in the Pinnacle mine, Carbon County, Utah.



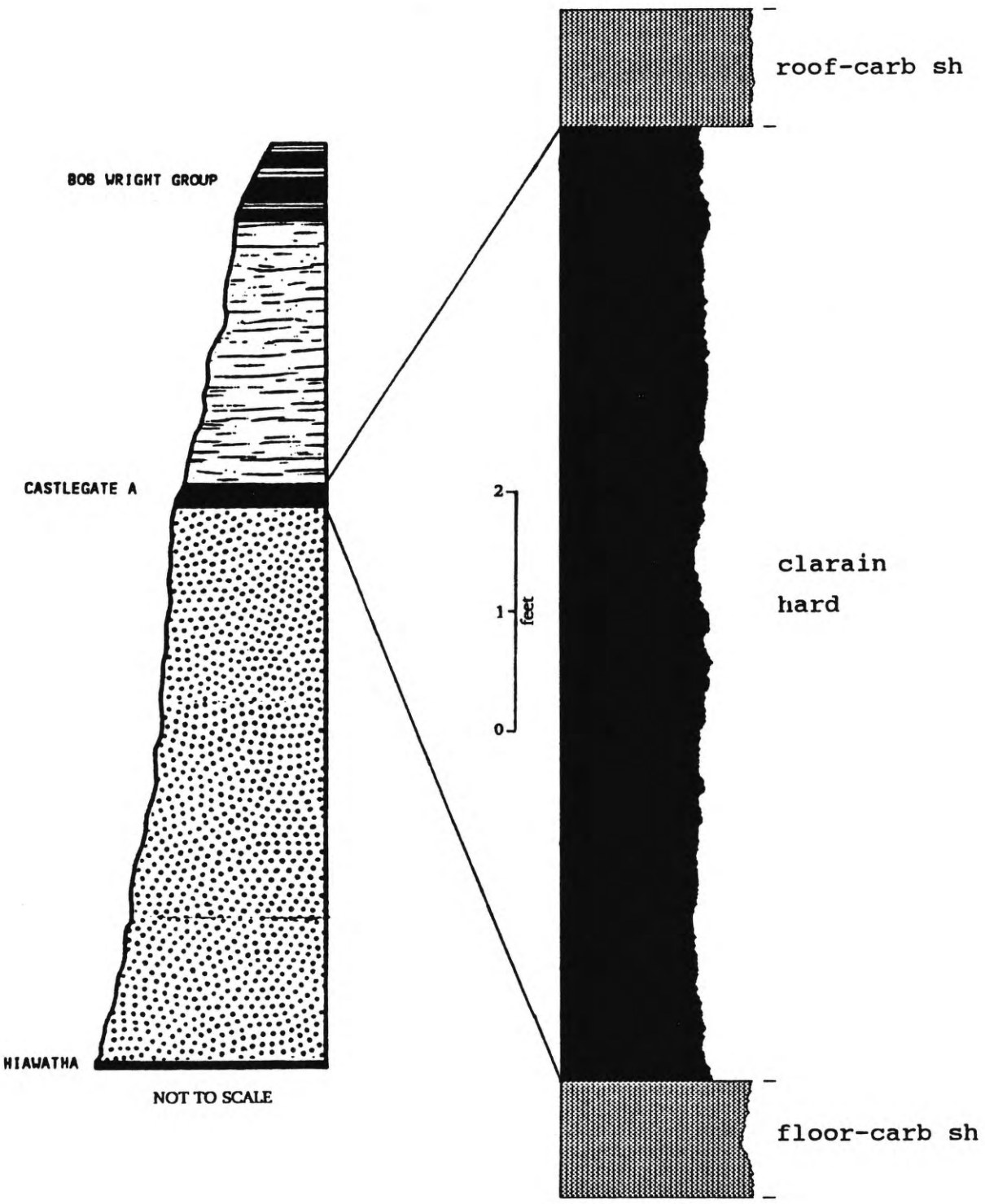
A21. Macroscopic description of the Lower Sunnyside seam in the Apex mine, Carbon County, Utah.



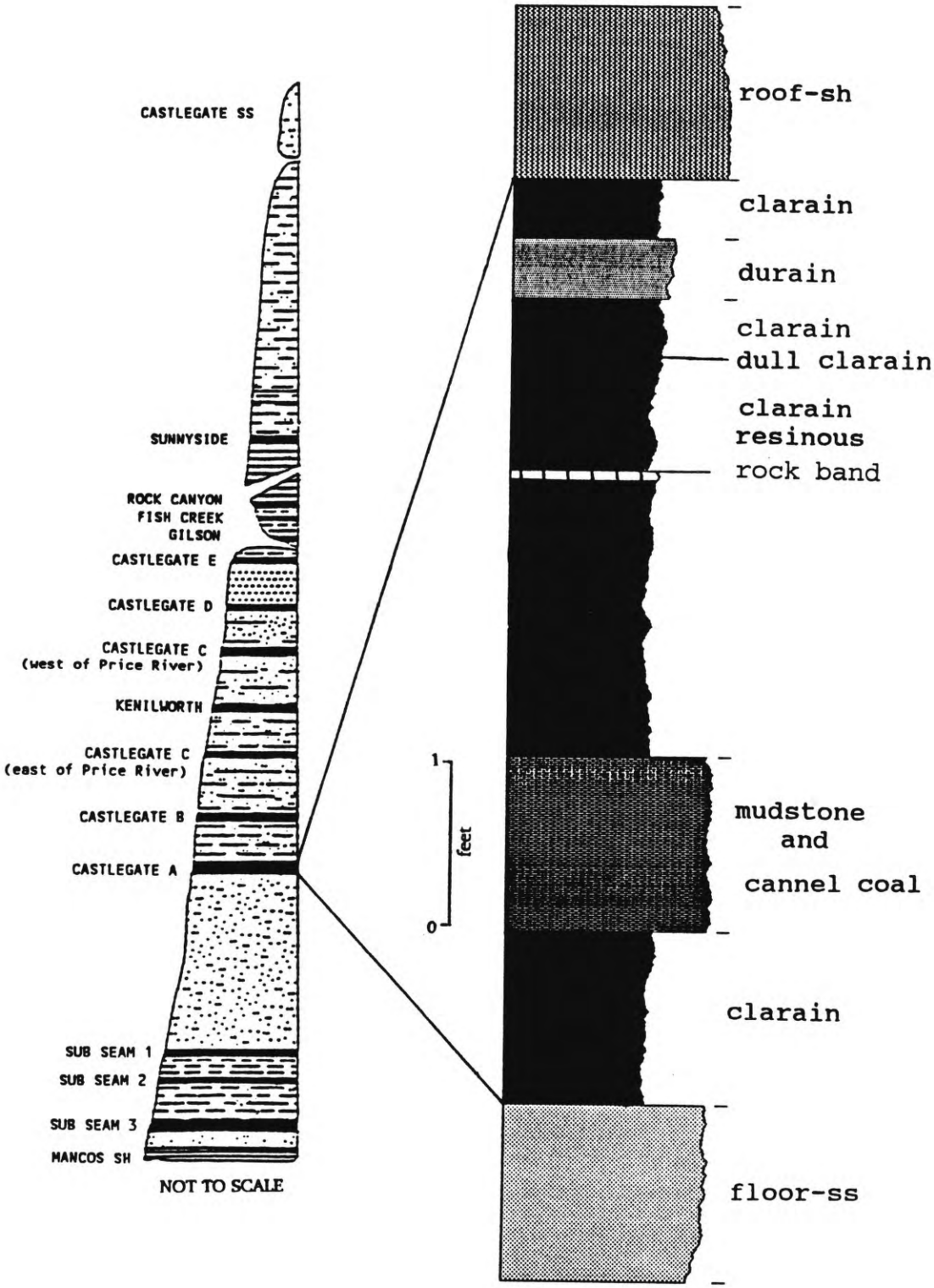
A22. Macroscopic description of the Lower Sunnyside seam in the Sunnyside No. 1 mine, Carbon County, Utah.



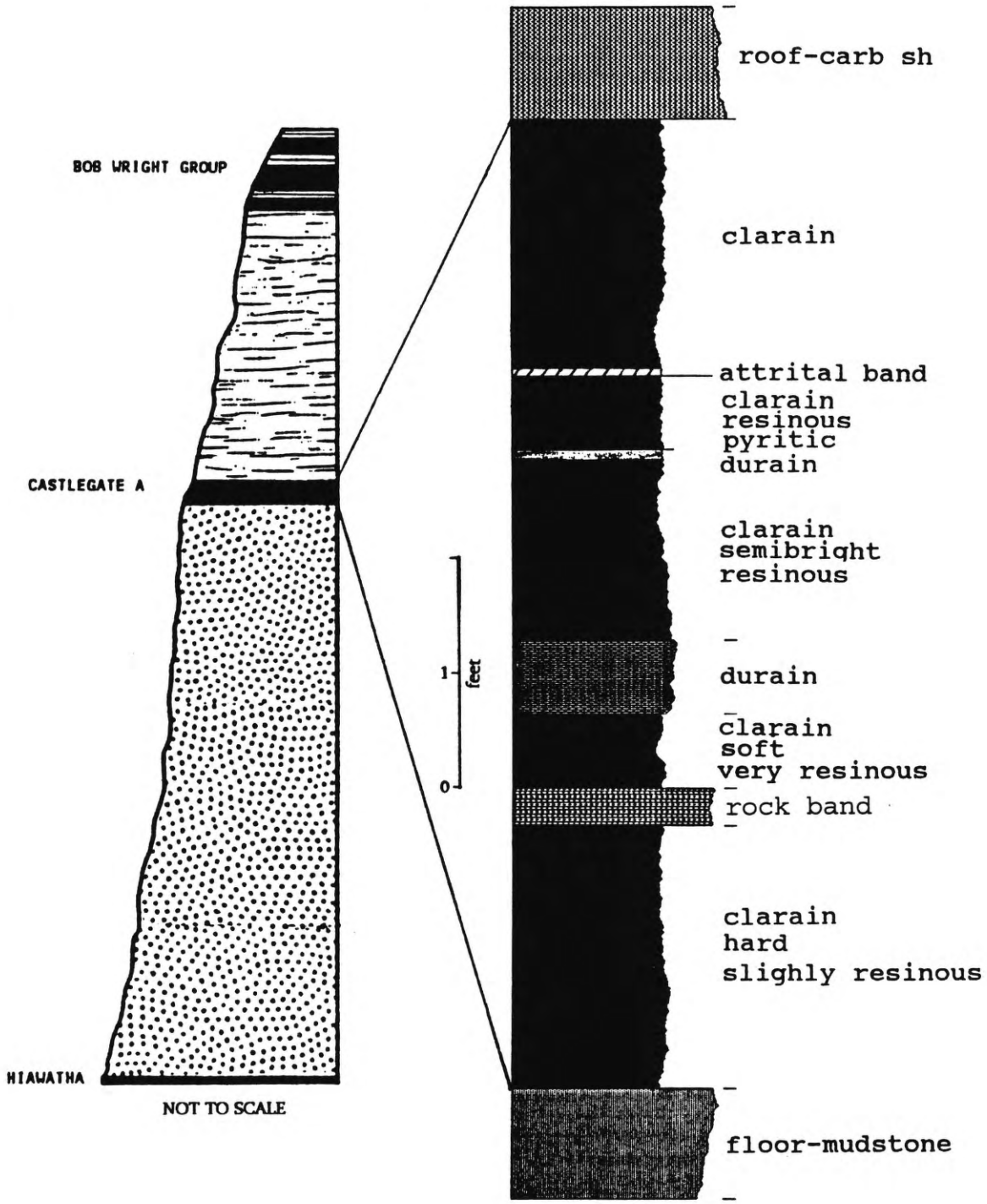
A23. Macroscopic description of the Wasatch seam in the Boyer mine, Wasatch County, Utah.



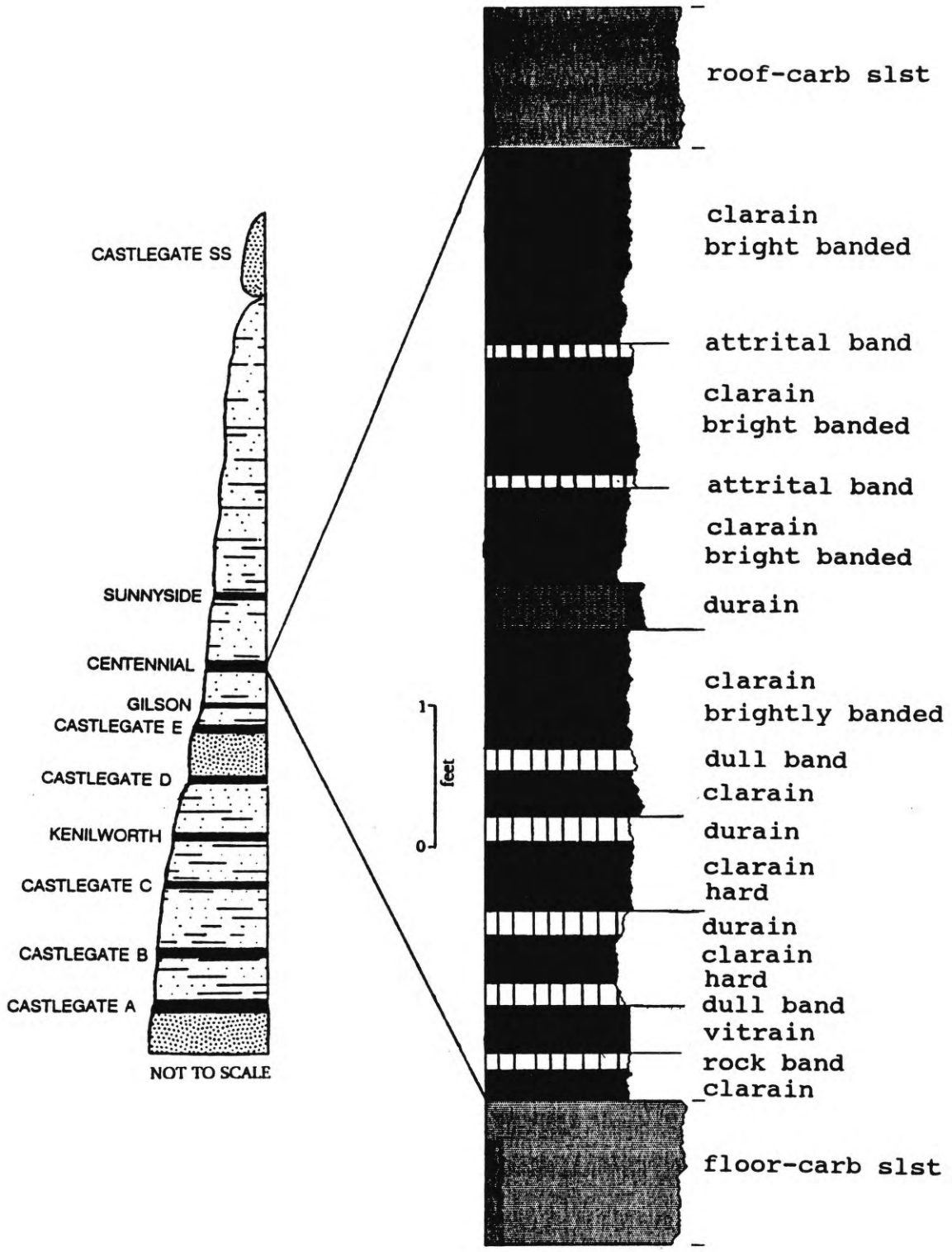
A24. Macroscopic description of the Castlegate A seam in the Gordon Creek No. 7 mine, Carbon County, Utah.



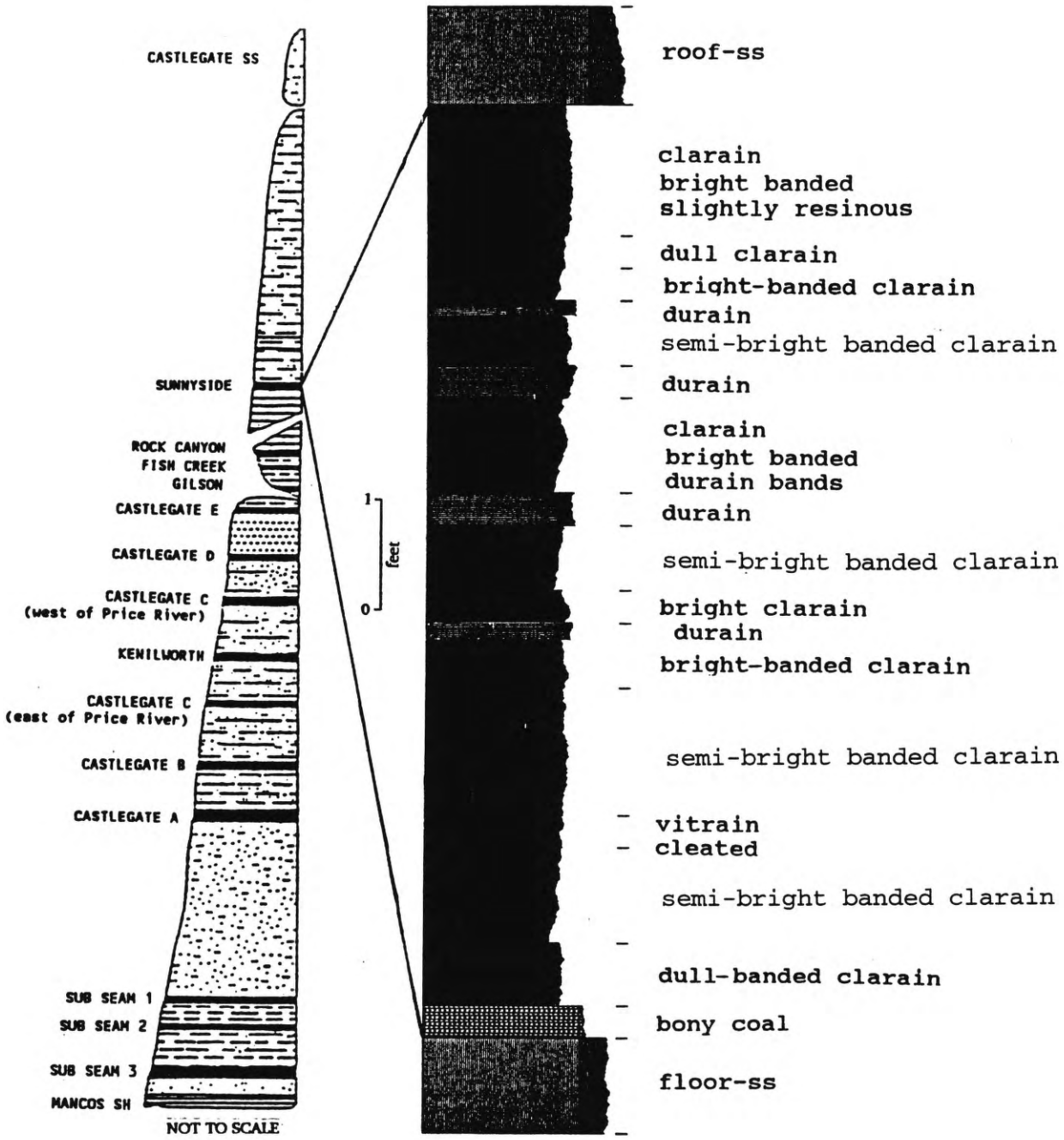
A25. Macroscopic description of the Castlegate A seam in the Aberdeen mine, Carbon County, Utah.



A26. Macroscopic description of the Castlegate A seam in the Beaver Creek No. 8 mine, Carbon County, Utah.



A27. Macroscopic description of the Centennial seam in the Pinnacle mine, Carbon County, Utah.



A28. Macroscopic description of the Sunnyside seam in the Soldier Canyon mine, Carbon County, Utah.