THE RESINITE RESOURCES OF SELECTED COAL SEAMS OF THE BOOK CLIFFS AND WASATCH PLATEAU COAL FIELDS OF CENTRAL UTAH

by

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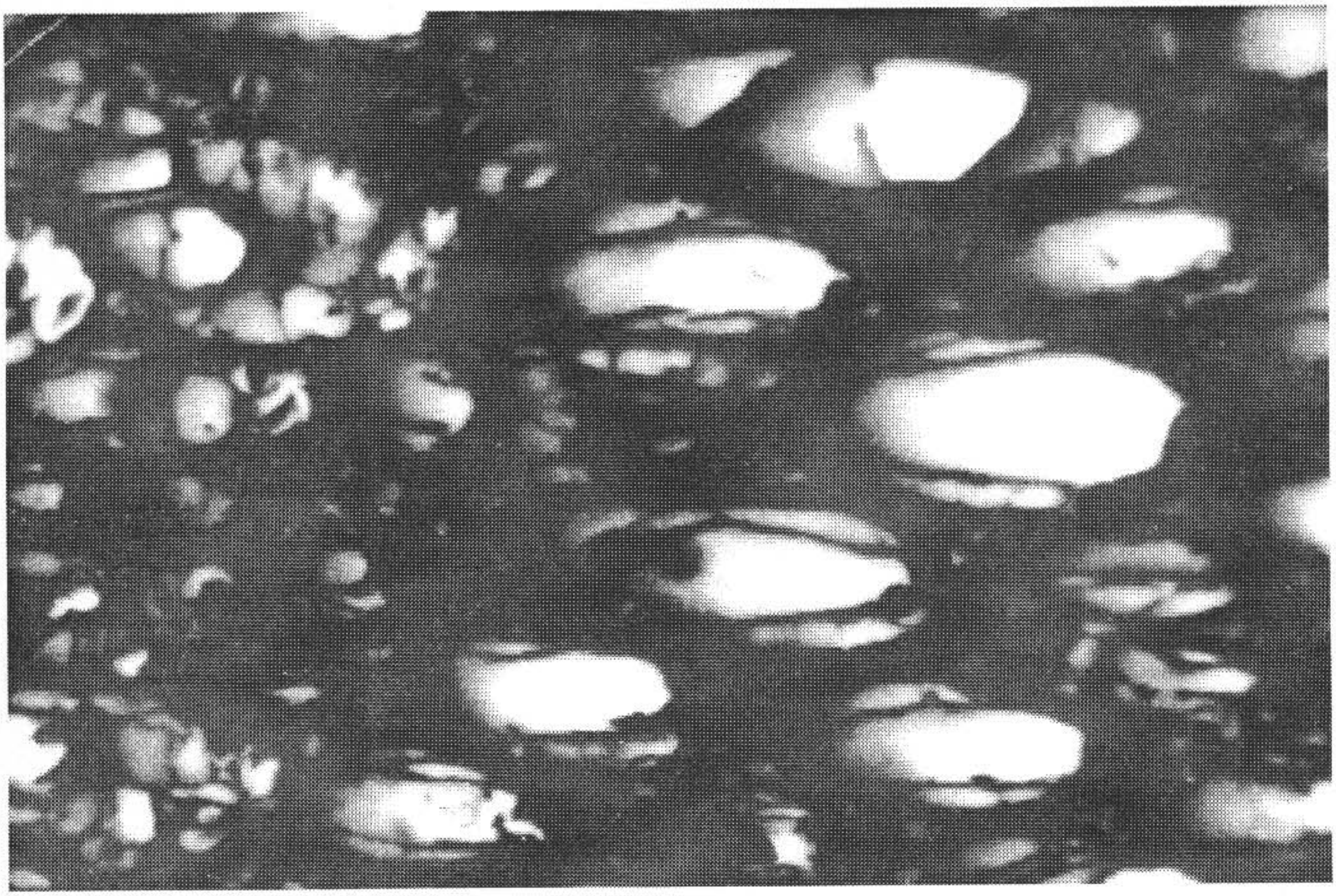

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COVER PHOTOGRAPH: Resinite (light areas) in cell lumens of coal from Utah.

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ABSTRACT

Coal seams in the Wasatch Plateau and western Book Cliffs coal fields of Utah have high resinite contents. Resinite, or coal resin, is most abundant in the seams above the Spring Canyon and Aberdeen Sandstone Members in the lower part of the Upper Cretaceous Blackhawk Formation. These coal seams average 2.5 to 3.0 percent resinite and locally contain more than 10 percent resinite. Recoverable resin resources in Utah's coal seams are estimated at 19.4 million short tons (38.8 billion pounds). This brittle, low-density coal constituent concentrates in the fine fraction of mined coal and can be recovered by flotation methods.

Recovery of high-value coal resin (resinite) as a by-product of coal can substantially increase the revenue to a coal operator. The removal of the resin does not significantly affect the quality of the coal because the resin makes up only a small fraction of the coal, and processing the coal for resin also removes ash- and sulfur-bearing constituents. Past flotation techniques removed only 50 percent of the coal resin; new flotation techniques can recover up to 90 percent.

Coal resin, a low-cost resin, has been widely used in the black-ink market and has applications in the colored-ink, adhesive, rubber, varnish, coatings, and plastics industries. Coal resin competes well with other natural and synthetic resins on a cost basis, but has no current share of the resin market due to the lack of a reliable supply and a shortage of resin refiners.

INTRODUCTION

The purpose of this study is to point out a potentially valuable product, coal resin, that could be produced as a by-product of coal mining in central Utah. This study examines the physical and chemical properties, and abundance of resinite in selected coal seams of the Wasatch Plateau and Book Cliffs coal fields of central Utah (figure 1). The resinite-bearing coal seams in the study area are found in the Upper Cretaceous Blackhawk Formation. The vertical stacking and intertonguing of the various resin-bearing coals and marine sandstones units of the Blackhawk Formation are shown in figure 2.

Coal is composed of macerals, which are components derived from the disaggregation of plant material. Macerals are classified into three major groups: vitrinite (woody material), inertinite (carbonized plant matter), and exinite (waxy or sticky plant coatings or secretions). The term resinite is used by coal petrographers for a subgroup of the exinite macerals. Poinar (1991) defines resinite as semi-fossilized or fossilized resin found in association with coal.

Although resinite, or coal resin, forms a small percentage of almost all coals, it is particularly abundant in coals from some western U.S. states, especially coals from Utah (Crelling and others, 1982). Resinite in coal generally occurs either as fine disseminated grains associated with the coaly matrix (occluded), or as coarse ovoid bodies and veins filling cleats (non-occluded) (Poinar, 1991). Cleat-filling resinite commonly shows flow structures and coal inclusions, and is thought to be secondary, mobilized by increased heat and pressure during the bituminous coalification step (Crelling and others, 1982). Resinite is rarely found in anthracite because the resinite macerals are unable to withstand the extreme heat and pressure necessary to form anthracite (Poinar, 1991).

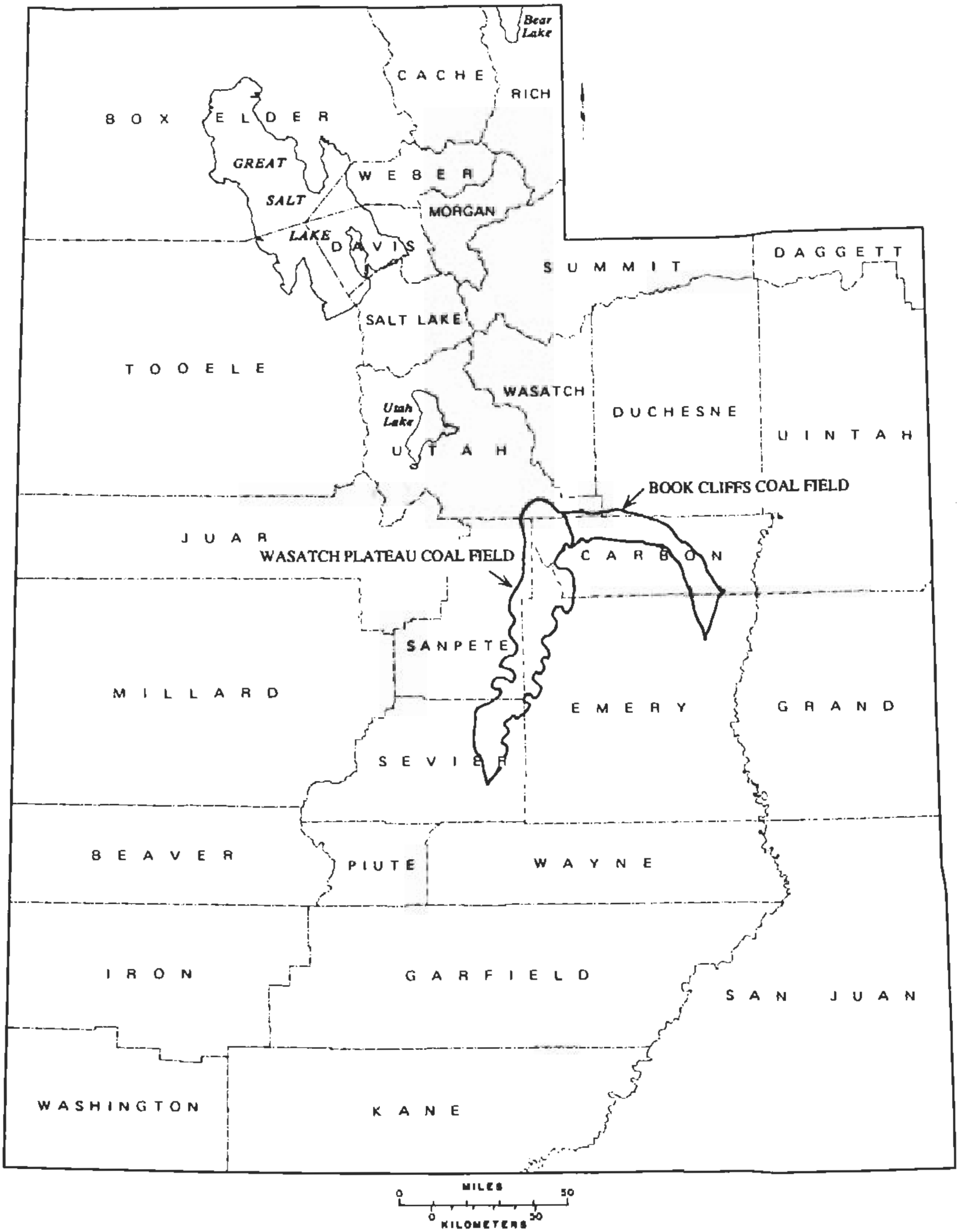

Figure 1. Location of central Utah coal fields studied for resinite.

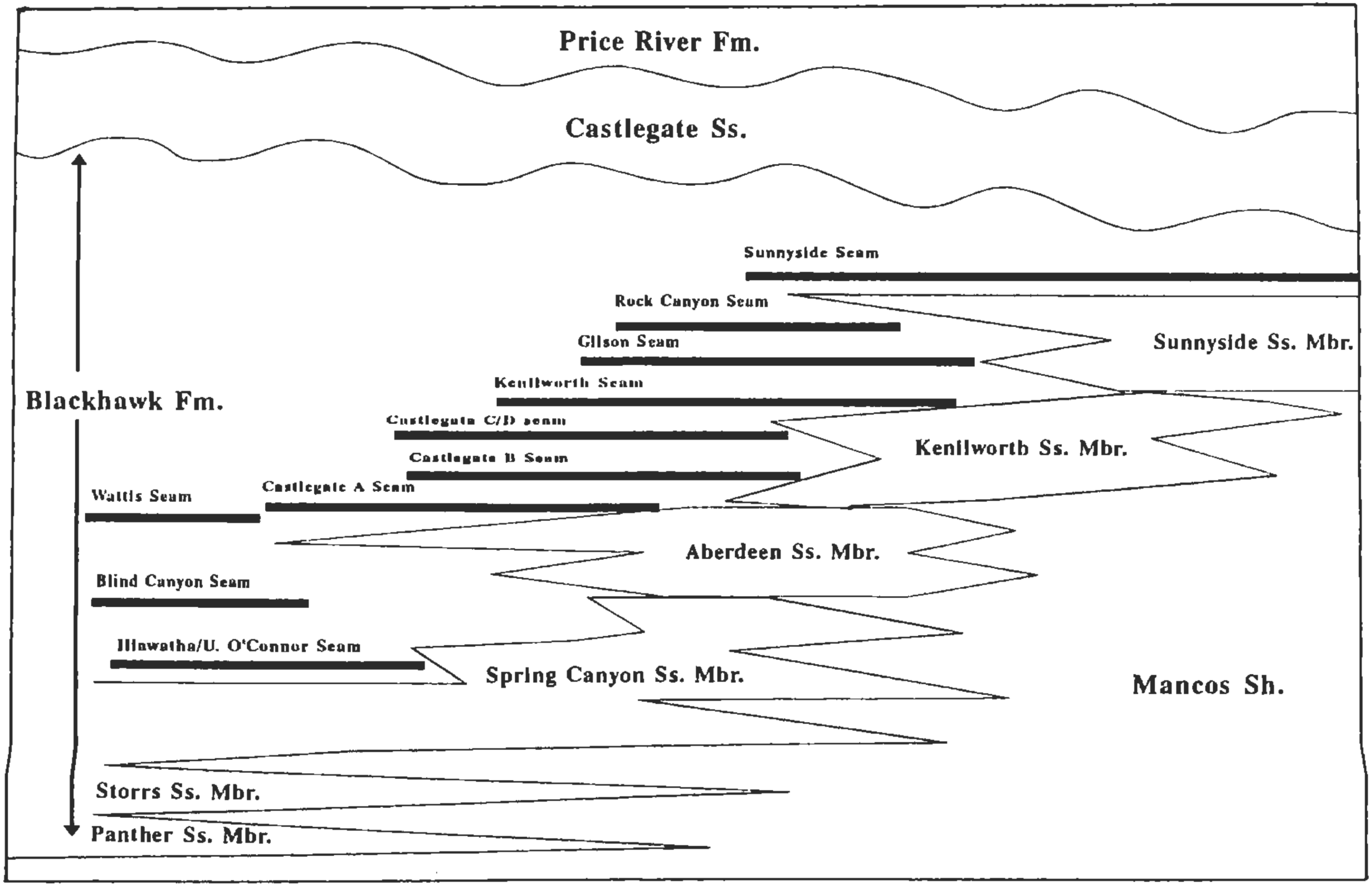

Figure 2. Diagrammatic cross section showing the stacking of sandstone bodies and coal seams of the Blackhawk Formation in central Utah.

PHYSICAL PROPERTIES OF RESINITE

Resinite is a heterogenous mixture of organic compounds derived from plant resin that varies in color in hand specimens from yellow, to amber, to light brown, to dark brown. Under microscopic examination in transmitted light, resinite ranges in color from green to dark orange. Yu (1991) concluded that the microscopic color of resinite darkens with increasing thermal alteration. He postulated that thermal alteration changed both the resinite chemistry and its light-absorption characteristics.

Resinite is a glassy, brittle substance with conchoidal fracture. It has a melting point of 150 to 200°C, and a hardness of about 2.5 on Mohs scale (Yu, 1991). In sub-bituminous and bituminous coals, resinite is characterized by a density of 62.43 to 79.91 lbs/ft^3, which is considerably lower than that of the other coal macerals (vitrinite 79.29 to 89.27 lbs/ft^3, and inertinite >96.64 lbs/ft^3). This density difference permits resinite to be separated from the coal using flotation or gravity methods.

Researchers have used two different techniques to divide resinite into four types based on color. Crelling and others (1982) used microscopic fluorescence (spectral) analysis, and Yu and others (1991) megascopically examined resinite under plain light to determine color types.

Crelling and others (1982) identified green-, yellow-, orange-, and red-brown-fluorescing types of resinite. They found that the green-fluorescing resinite was the most common type, making up 55 to 87 percent of the resinite in a sample, and occurs mainly as cleat or fracture fillings in the coal. The other three resinite fluorescence types range in abundance from 1.5 to 22 percent. Yellow- and orange-fluorescing resinites are found as fracture fillings, or as ovoid masses in the coal. The red-brown-fluorescing resinite was only found as ovoid masses, mainly in cell lumens (open spaces).

Yu and others (1991) divided resinite from the Hiawatha seam from the Wasatch Plateau coal field into yellow, amber, light-brown, and dark-brown types. They concluded that the color darkened as the resinite incorporated increasing amounts of micro-inclusions of coal particles. Dark-brown resinite was the most abundant resinite type in their concentrate sample, comprising 51.6 percent by weight. The abundance of each lighter colored resinite decreased progressively; the yellow resinite comprised only 8.2 percent of the concentrate by weight. Yu and others (1991) also examined the resinite concentrate using fluorescent-light microscopy and found that all four megascopic resinite types showed green-yellow fluorescence, and did not include any of the orange- or red-brown-fluorescing resinite types of Crelling and others (1982).

CHEMICAL PROPERTIES OF RESINITE

The resinite coal maceral is a hydrogen-rich, volatile-rich fraction of coal (Yu, 1991; Yu and others, 1991). Yu (1991) found that the lightest colored resinite (macroscopically) had the highest volatile-matter content, and that the darker colored resinites contained incrementally greater amounts of fixed carbon, but at most no more than a few percent. The averaged proximate analysis for two resinite samples from the Hiawatha seam show that this maceral fraction is almost completely composed of volatile matter (table 1). For comparison purposes, table 1 also lists proximate analyses for two raw coal samples (Buranek and Crawford, 1943; Yu and others, 1992) and for one sample of coal from which the resin was removed (Klepetko, 1947).

Table 1. Proximate analyses of various raw coal and coal fractions from the Wasatch Plateau coal field (first three reported on as-received basis, last sample reported on a dry basis).

Sample Type	Seam Name	Moisture(%)	Ash(%)	Volatile Matter(%)	Fixed Carbon(%)	Btu/lb
Resinite	Hiawatha	0.21	0.12	93.6	5.07	18,312
Raw coal	Hiawatha	1.45	11.51	44.4	42.64	15,538
Raw coal	Blind Canyon	4.6	5.3	40.1	49.9	13,290
Coal (minus resin)	Blind Canyon	---	8.33	42.59	49.08	13,132

An understanding of how the chemistry of the coal changes before and after resinite removal would ideally come from analyses of the differing coal products which are derived from a single source. Although the samples in table 1 should not be directly compared because they are not from a single source, the analyses show that the resinite is distinctly different in composition from the raw coal. Further, the various coal-quality parameters of the Blind Canyon seam are similar, both with and without the resin fraction. However, more sampling and testing is needed to determine more precisely how the coal quality changes when the resin fraction is removed.

Four ultimate analyses of the resinite from Utah coals are given in table 2. The first three resinite samples were analyzed in the 1920s (Steele, 1924; Benson, 1925), when the standard analytical procedures did not include testing for nitrogen and sulfur. The last resinite and the one "whole" coal analyses are from Yu and others (1991).

Table 2. Ultimate analyses of resinite and whole coal samples from the Wasatch Plateau coal field (reported on a dry, ash-free basis).

Sample Type	Seam Name	Carbon(%)	Hydrogen(%)	Oxygen(%)	Nitrogen(%)	Sulfur(%)	Density(g/cm^3)
Resinite	Castlegate A	80.4	9.4	10.2	----	----	0.99
Resinite	Hiawatha	82.62	10.14	6.81	----	----	1.03
Resinite	Hiawatha	83.61	10.10	5.86	----	----	1.03
Resinite	Hiawatha	85.21	10.72	3.50	0.37	0.20	1.04
Coal	Hiawatha	81.45	6.74	9.71	1.44	0.66	1.31

Comparison of the ultimate analyses for the "whole" coal and the extracted resinite samples show that the resinite is richer in hydrogen and generally depleted in oxygen. The resinite may also be depleted in nitrogen and sulfur in comparison with the "whole" coal.

RESINITE CONTENT OF UTAH COALS

The study of resinite in Utah coal began in the 1920s (Steele, 1924; Benson, 1925). Recently, the resinite content of coal from 27 mines was determined by the Utah Geological Survey (UGS) (Sommer and others, 1991) as part of a cooperative program with the University of Utah to establish a coal sample bank and are shown below.

Table 3. Resinite content and coal rank of 27 Utah mine samples (from Sommer and others, 1991).

Coal Field	Mine Name	Seam Name	Resinite (%)	Coal Rank
Wasatch Plateau	Star Point #2	Blind Canyon	3.2	hvCb
Wasatch Plateau	Deer Creek	Blind Canyon	4.4	hvCb
Wasatch Plateau	King #4	Blind Canyon	3.0	hvCb
Wasatch Plateau	Belina #1	U. O'Connor	1.2	hvCb
Wasatch Plateau	Skyline #1	U. O'Connor	0.7	hvCb
Wasatch Plateau	Skyline #3	L. O'Connor	0.8	hvCb
Wasatch Plateau	Belina #2	L. O'Connor	1.4	hvCb
Wasatch Plateau	Beaver Cr. #9	Hiawatha	3.3	hvCb
Wasatch Plateau	King #6	Hiawatha	2.9	hvCb
Wasatch Plateau	Crandall Cyn.	Hiawatha	1.4	hvCb
Wasatch Plateau	Bear Cyn. #1	Hiawatha	1.1	hvCb
Wasatch Plateau	Cottonwood	Hiawatha	1.8	hvCb
Wasatch Plateau	SUFCO	U. Hiawatha	2.1	hvCb
Wasatch Plateau	Bear Cyn. #1	U. Hiawatha	2.4	hvCb
Wasatch Plateau	Star Point #2	Wattis	7.3	hvCb
Wasatch Plateau	Gordon Cr. #7	Castlegate A	7.4	hvCb
Wasatch Plateau	Beaver Cr. #8	Castlegate A	6.8	hvCb
Book Cliffs	Aberdeen	Castlegate A	2.8	hvCb
Book Cliffs	Castlegate #3	Sub Seam #3	2.3	hvCb
Book Cliffs	Pinnacle	Pinnacle	1.4	hvCb
Book Cliffs	Pinnacle	Gilson	2.0	hvBb
Book Cliffs	Soldier Cyn.	Rock Canyon	1.4	hvBb
Book Cliffs	Apex	L. Sunnyside	0.9	hvBb
Book Cliffs	Sunnyside #1	L. Sunnyside	1.4	hvAb
Book Cliffs	Soldier Cyn.	Sunnyside	1.6	hvBb
Book Cliffs	Sunnyside #3	U. Sunnyside	1.1	hvBb
Emery	Emery	Upper I	2.5	hvBb

The resinite content of all 27 samples averages 2.5 percent, and varies from 0.7 to 7.4 percent. Resinite contents show much variability from mine to mine, and from samples taken from the same seam. In general, coal seams of lower rank tend to have higher resinite contents than those of higher rank. For example, the lower rank Wasatch Plateau field coals tend to have higher resinite contents (average of 3.01 percent) than coals from the Book Cliffs field (average of 1.66 percent). The highest resinite contents are generally 2.5 to 3 times the average value, and come from the Castlegate A, Blind Canyon, and Wattis seams of the Wasatch Plateau coal field (table 3).

Additional, previously unpublished resinite-content analyses have been compiled by the UGS in a comprehensive statewide coal petrographic database that includes data from drill core as well as mine samples. This database contains resinite analyses for 257 samples from the Wasatch Plateau and Book Cliffs coal fields. Table 4 presents basic resinite-content statistics for individual coal seams in the database with five or more analyses. The resinite contents from the UGS database (table 4) show differences from those reported by Sommer and others (1991)(table 3). Resinite contents in table 4 show a broader range of values, from 0.2 to 28.3 percent of the coal, and the average resinite content in table 4 (3.09 percent) is slightly higher. Coal seams from the UGS database that have above-average resinite contents are the Hiawatha, Upper Hiawatha, Blind Canyon, and all four Castlegate seams. The Wattis seam, which had a high resinite content in table 3, was not reported as such in table 4 because it had less than five analyses. However, the two analyses available for the Wattis seam both show greater than 3.09 percent resinite. Stratigraphic data for the Wattis seam also point to a high resinite content for that seam. According to Mercier (1982), the Wattis seam of the central Wasatch Plateau is found above the Aberdeen Sandstone Member of the Blackhawk Formation (figure 2), and this position would make it correlative with the highly resinous Castlegate A seam found farther to the north.

Because coal resin is brittle and easily crushed, it is preferentially concentrated with the fine-

Table 4. Statistics on resinite content (percent) of various seams in the Wasatch Plateau and Book Cliffs coal fields.

Field Area	Seam Name	Mean	Minimum	Maximum	Std. Dev.	Samples
		Wasatch Plateau coal field				
Entire	Hiawatha	3.23	0.6	28.3	3.88	49
Entire	U. Hiawatha	3.60	0.8	25.7	4.57	28
Central	Blind Canyon	5.33	0.9	14.5	3.87	16
North	U. O'Connor	1.24	0.6	4.0	0.80	15
North	L. O'Connor	1.92	0.2	5.8	1.51	19
North	Castlegate A	5.34	1.1	7.5	2.33	5
		Book Cliffs coal field				
West	Castlegate A	4.25	1.2	12.9	2.97	16
West	Castlegate B	5.74	1.7	16.2	4.59	7
West	Castlegate C	5.43	2.7	11.5	3.76	7
West	Castlegate D	5.31	1.7	17.8	4.05	14
West	Subseam 3	2.55	1.0	7.2	1.58	11
West	Kenilworth	2.09	1.1	3.5	0.77	7
Central	Rock Canyon	1.96	0.8	4.3	0.87	19
Central	Gilson	1.44	0.5	5.0	0.93	24
East	L. Sunnyside	1.24	0.8	2.1	0.40	10
East	U. Sunnyside	2.15	0.9	3.0	0.68	10
Both Fields	Weighted Avg.	3.09	0.9	13.8		257

sized coal fraction during mining. Consequently, the U.S. Fuel Company produced coal resin at its mine by processing only the coal fines. Coal fines from this mine contained 8 to 9 percent resin (Buranek and Crawford, 1943). The elevated concentration of resinite in the fine-coal fraction also appears in analyses of different size fractions from two grab samples collected by the UGS from the waste and coal stockpiles at the Star Point #2 mine of Cyprus Plateau Mining Company (table 5).

Table 5. Percent resinite in grab samples from waste pile and coal stockpile at the Star Point #2 mine, Wasatch Plateau coal field; stockpile combines production from the Wattis (85 percent) and Blind Canyon (15 percent) seams.

Resinite Type	Stockpile		Waste Pile	
	-20 mesh	+20 mesh	-20 mesh	+20 mesh
Green(primary)	12.8	4.8	7.3	3.3
Yellow(primary)	0.3	0.5	0.4	0.2
Orange(primary)	0.1	0.2	0.3	0.1
Exsudatinite(secondary)	0.2	0.2	0.3	0.0
Fluorinite(secondary)	0.0	0.0	0.0	0.1
Bituminite(secondary)	0.1	0.0	0.0	0.0
Total Resinite(%)	13.5	5.7	8.3	3.7

The elevated resinite concentration apparent in the fine fraction of the two grab samples suggest that: (1) simple screening could be useful in helping concentrate resinite, and (2) resinite could be produced from the coal waste piles as well as from mined coal.

POTENTIAL RECOVERABLE RESINITE RESOURCES

The seams of the lower Blackhawk Formation in the Wasatch Plateau and western Book Cliffs coal fields have the highest resinite content, and offer the most potential for resinite recovery. These include the Hiawatha, Upper Hiawatha, and Blind Canyon seams above the Spring Canyon Sandstone Member, and the Wattis and Castlegate A, B, C, and D seams above the Aberdeen Sandstone Member of the Blackhawk Formation. Coal resources for the above-mentioned seams have been estimated by Doelling (1972), Sanchez and others (1983a, 1983b), Sanchez and Brown (1983, 1986, 1987), and Brown and others (1987). Their estimates of coal resources and our estimate of the associated resinite resources are summarized in table 6.

Table 6. Coal and resinite resources of selected seams in the Wasatch Plateau and westernmost Book Cliffs coal fields (millions of short tons).

	Southern Wasatch Plateau		Northern Wasatch Plateau			Western Book Cliffs		
	Hiawatha	Upper Hiawatha	Hiawatha	Blind Canyon	Castlegate A	Spring Canyon Grp.	Castlegate Grp.	TOTAL
Original Resources	409.0	22.5	1,131.1	246.8	283.4	371.0	332.4	2,976.2
Resinite Content (%)	3.2	3.6	3.2	5.3	5.3	2.5	5.0	----
Original Resinite	13.1	0.8	36.2	13.1	15.0	9.3	16.6	104.1
Recoverable Resinite	3.3	0.2	9.0	3.3	3.7	2.3	4.1	25.9

In table 6 the recoverable resinite was assumed to be 25 percent of the total resinite contained in the in-place coal resources. This percentage was calculated based on the assumptions that only 50 percent of the in-place coal is recoverable by mining, and that the resinite recovered by traditional flotation methods from the mined coal is also 50 percent. Thus, the total recoverable resinite from the target seams is 25.9 million short tons (51.8 billion pounds). While froth flotation separation techniques have historically recovered 50 percent of the resinite from the coal (Benemelis, 1990), there are new flotation techniques which can recover 90 percent of the resinite (Miller and Ye, 1989; Yu, 1991). These new techniques could dramatically increase Utah's recoverable resinite resources, but to date they have not been demonstrated on a commercial scale.

Mining has occurred in areas underlain by the target seams for over a century, and has probably disturbed as much as 25 percent of the original coal reserves in those areas. Subtracting 25 percent for past mining from the original 25.9 million short tons of recoverable resinite leaves a remaining recoverable resinite resource of 19.4 million short tons (38.8 billion pounds). This resource estimate is made on a field-wide basis and does not represent resources in specific coal leases. Because the resinite contents of Utah coals show significant variation from sample to sample, coal seams within any specific lease area considered for resinite production should be sampled and analyzed to determine the expected range and average resinite content for that area.

RESINITE MARKET AND ECONOMIC CONSIDERATIONS

Benemelis (1990) summarized the potential markets for resinite. Resin from coal competes in the market place with other natural and synthetic resins, and gilsonite. A major market for resinite is the ink industry. The annual U.S. consumption of various types of black ink is about 750 million pounds (Benemelis, 1990). Resins used in making black ink may contain up to 15 percent coal resin which corresponds to 112.5 million pounds of coal resin that potentially could be sold annually for black-ink production in the U.S.

The resin market worldwide is large and expanding. Additional market potential for coal resin in the ink industry exists in international markets, and in some colored-ink markets. Other markets for coal resin are the adhesive, rubber, varnish, coatings, and plastics industries. Recently, it has been proposed that coal resin could be used as feedstock for high-density jet fuels (Miller, 1988), and for environmental clean-up and abatement work (F. Djahanguiri, U.S. Bureau of Mines, verbal communication, 1992). Yu (1991) states that the total annual U.S. consumption of various hydrocarbon resins in 1988 was 1.5 billion pounds, one third of the worldwide consumption of 4.5 billion pounds.

Resinite production from Utah is currently at an impasse because miners can not find resin-refiners to process their product for market, and resin-refiners are not likely to build new capacity without the guarantee of a large, steady supply of resin concentrate feedstock. When Utah resinite was available in the past, this low-cost resin was readily accepted as a substitute for other higher cost synthetic and natural resins by the market (Miller, 1988). For example, the U.S. Fuel Company formerly produced up to 80,000 pounds of resinite concentrate (55 percent resinite) per month as a by-product from its wash plant (Doelling, 1972). However, this plant was dismantled and the mine closed by 1993. From 1947 to 1979 Utah resinite also had a local resin-refining outlet until the solvent extraction plant at Bauer in Tooele County burned down and was not rebuilt. This lack of refining capacity lead to the early demise of a recent resin-production start-up effort by Cyprus Plateau Mining Company. During early 1993 the company added a coal resin recovery circuit to its wash plant, and was producing 10,000 pounds of resinite concentrate a month. Unfortunately resinite production by Cyprus Plateau Mining was curtailed shortly after inception when a resin refiner could not be found to purify the resin concentrate. Cyprus Plateau's attempts to find a refiner were probably hurt by the fact that the coal reserves at its current resin-rich mine are limited to about five years of production.

A Utah coal mine could substantially increase its revenue stream by recovering resin from the coal if the resinite could be refined and brought to market. Table 7 summarizes the revenue, with and without resin recovery, for a hypothetical mine producing 1.0 million short tons of coal per year. For this summary, a coal resinite content of 3.0 percent, and resinite flotation recovery of 50 percent are assumed.

Table 7. Hypothetical resinite production and revenue at a Utah coal mine producing 1.0 million short tons per year.

	With Resin Recovery	Only Coal Production
Annual coal production (tons)	1,000,000	1,000,000
Resinite content	3%	NA
Concentrate produced (tons)	30,000	0
Resinite recovered (tons)	15,000	0
Resinite recovered (pounds)	30,000,000	0
Coal(- resinite) produced	970,000	1,000,000
Coal revenue ($20/ton)	$19,400,000	$20,000,000
Resinite revenue ($0.50/lb)	$15,000,000	$0
TOTAL REVENUE	$34,400,000	$20,000,000

The above example shows that the production of by-product resinite would increase revenue to the coal operator by $14.4 million, or 72 percent. For each short ton of coal mined, the operator would produce 30 pounds of resinite with a value of $15.00, or 75 percent more value than that of the coal alone. This added revenue must be balanced against the costs of producing the by-product resinite to determine the overall economic benefit to the operator.

The 30 million pounds of resinite produced annually by this hypothetical coal operation represents 26.6 percent of the annual U.S. black-ink market, and 2 percent of the annual 1.5-billion-pound U.S. hydrocarbon resin market. At present, only two of the eight active Utah coal-mining companies have a wash plant with a fine-coal circuit that would be necessary to recover resinite. Most Utah coal operators ship unwashed, run-of-mine coal. If all of Utah's annual coal production (roughly 20 million short tons) was processed for resinite, and resinite recovery rates were similar to the example shown in table 7, then the total resinite production from Utah would be 600 million pounds or 40 percent of the annual U.S. hydrocarbon resin market. Because it is unlikely that all Utah coal-mining operations have coal suitable for resin recovery, or that all Utah coal mines will add wash plants to recover resin, then Utah resinite is likely to account for only a small share of the total resin market. Utah coal operators that could produce and refine resinite would probably find that their low-cost product could displace other high-cost resins in the market place. At present, a shortage of resin-refining, market middle-men poses a significant bottleneck in getting Utah resinite to the end users in the ink, plastic and varnish industries. To restart the coal resin industry in Utah will require a cooperative effort between the resin-supplying mining companies and a resin refiner so that the miners are assured an outlet for their resin concentrate and the refiner is assured a large, steady supply of feedstock material.

SUMMARY

In summary, of the coal seams studied, those in the lower part of the Blackhawk Formation just above the Spring Canyon and Aberdeen Sandstone Members generally have the highest resinite contents. Geographically these seams are in the Wasatch Plateau coal field and the westernmost part of the Book Cliffs coal field. The Hiawatha, Upper Hiawatha, Blind Canyon, and Castlegate target seams average above 3.0 percent resinite, and locally may contain more than 10 percent resinite. The Castlegate group of coal seams, found above the Aberdeen Sandstone, have the highest average resinite contents. The remaining recoverable resinite resources in the target seams are estimated to be 19.4 million tons (38.8 billion pounds).

When present, the resinite is preferentially concentrated in the fine fraction of the coal and waste material, and can be recovered using standard flotation methods. Historical flotation techniques recovered around 50 percent of a coal's resinite, but bench tests indicate that up to 90 percent recovery is possible using new flotation techniques. Resinite, in addition to being recovered from mined coal, could be recovered from coal waste piles, and thus help offset the cost of waste pile reclamation.

This report shows the potential economic benefit of resinite recovery and encourages Utah coal operators to include resinite analysis in their site-specific property evaluations. Few Utah coal operators have attempted to recover coal resin, but this by-product could add significantly to a mine's revenue stream. A preliminary market assessment indicates that the current resin market is sufficiently large to accommodate additional coal resin produced in Utah. Coal resin has traditionally been readily accepted by the market place as a low-cost resin supply. Its sale has been hampered only by the lack of a reliable supply and a shortage of resin refiners, not for lack of demand.

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