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Preliminary report on solid bitumens in Eocene rocks of Piceance Creek basin, northwestern Colorado

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INTRODUCTION

Solid hydrocarbons are present in numerous deposits in the Uinta Basin of Utah (fig. 1). The deposits are principally in veins in the Eocene Uinta Formation. The most important solid hydrocarbons are gilsonite and wurtzilite, black lustrous minerals, and ozokerite, a yellow, brown, or black mineral wax. Gilsonite is, by far, the most important. The amount of solid hydrocarbon produced in Utah from 1888 through 1961 is estimated to be about 3,880,000 short tons, valued at about $90,300,000 (Cashion, 1964, p. 63). The deposits in Utah have been described by Bell and Hunt (1963), Cashion (1964, 1967), and Hunt, Stewart, and Dickey (1954).

In Colorado, solid hydrocarbons are also found at localities in the Piceance Creek basin but all are unimportant and of small extent. This report briefly discusses some of these occurrences of solid hydrocarbons or bitumens in Colorado and briefly describes their nature.

BITUMENS IN PICEANCE CREEK BASIN

The solid hydrocarbons in the Piceance Creek basin are found at a number of scattered surface localities and in the subsurface in drill holes. All the occurrences are either in the Uinta Formation or in the Green River Formation in the Parachute Creek and underlying Garden Gulch Members (fig. 2). The solid hydrocarbons or bitumens are black to black-brown, vitreous and break with a conchoidal fracture. The bitumen is found as thin vertical to horizontal seams or veins, as inclusions, and as void fillings. The bitumen resembles gilsonite in general appearance but the physical and chemical characteristics show it is unlike any previously described hydrocarbon.

Solid hydrocarbons have been noted previously in the Piceance Creek basin. Winchester (1916, p. 169) noted "* * * small masses (some of them mere films between beds) of solid black hydrocarbon are found in the shale. Hydrocarbon occurring in this way in a small gulch east of Piceance Creek near its mouth possesses all the properties of elaterite, but in most places the material is similar to gilsonite. In sec. 14, T. 1 N., R. 97 W., this elaterite may be seen at a number of places between two beds of rather rich shale. In some places, such as Hay Gulch, in sec. 36, T. 1 N., R. 96 W., there are pockets of black material which have the shape of partly compressed stems but which show no woody structure, as would be expected if they were carbonized wood. The material contained in these pockets is not soluble in ether, chloroform, gasoline, or turpentine, the ordinary solvents of hydrocarbons."

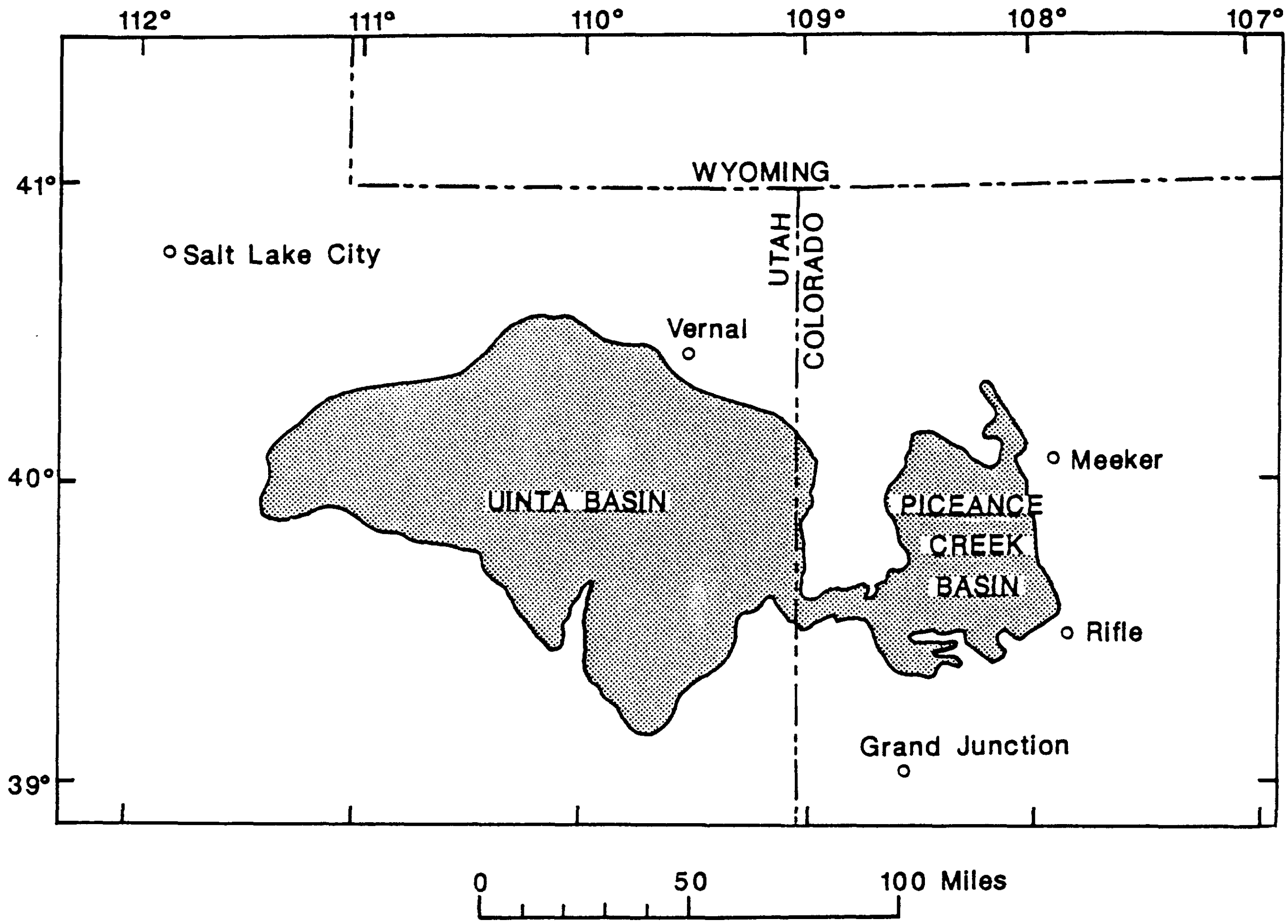

Figure 1. Map of northwestern Colorado and adjacent areas. Stippling indicates areas of Uinta and Piceance Creek Basins underlain by Green River Formation.

Later, Winchester (1923, p. 40) in describing Piceance Creek basin stated, "Very little faulting has taken place in this area, and such breaks as have been discovered are more in the form of cracks in which vertical displacement is not noticeable. Such cracks are usually filled with hydrocarbon materials which at one time may have been liquid. One of the most interesting occurrences of this type is in Jessup Gulch, a tributary of Piceance Creek on the west side of the Petrolite Hills. Here a fracture zone 2 or 3 feet wide is filled with a yellowish-brown hydrocarbon which is of low specific gravity and is entirely different in physical appearance from the ordinary asphaltite. The deposit may not be sufficiently extensive to be of economic importance, but its unusual characteristics make it of considerable scientific interest."

SUBSURFACE OCCURRENCES

Solid black hydrocarbons are present in the Atlantic Richfield Company core hole 2-B drilled in the SE 1/4, sec. 10, T. 3 S., R. 96 W. (fig. 3). The bitumens were discussed in an unpublished U.S. Geological Survey Core Description report for the well. In the report, the solid hydrocarbons are described as black and vitreous occurring as lenses as much as 1/8 inch thick, as inclusions in oil shale as much as 1 inch across, and as thin coats on fractures that cut the core at angles to bedding planes. The bitumens are found in the Parachute Creek and Garden Gulch Members over a vertical stratigraphic distance of 1,400 ft extending from within the Mahogany Zone to below the orange marker in the Garden Gulch (fig. 2). In the unpublished core description, the bitumen is usually referred to as gilsonite? or gilsonite because of its resemblance to the hydrocarbon in Utah. The solid hydrocarbon in the core has not been analyzed.

Solid bitumen is also found in cores of 3 other drill holes in the northern part of the Piceance Creek basin. The wells are the Pan American Peterson 1, in sec. 4, T. 2 S., R. 98 W., and the U.S. Geological Survey CR-1 and CR-2 drilled in sec. 31, T. 1 S., R. 96 W. and sec. 36, T. 1 N., R. 97 W. respectively. The cores of the 3 drill holes examined by V. F. Nuccio (oral commun., 1986) who reports that the bitumen resembled coal and occurred as thin laminae. The solid hydrocarbons extend from below the Mahogany zone of the Parachute Creek Member down to the level of the orange marker in the Garden Gulch Member. Nuccio (1985, p. 293) noted that it was difficult at times to distinguish vitrinite from solid bitumen.

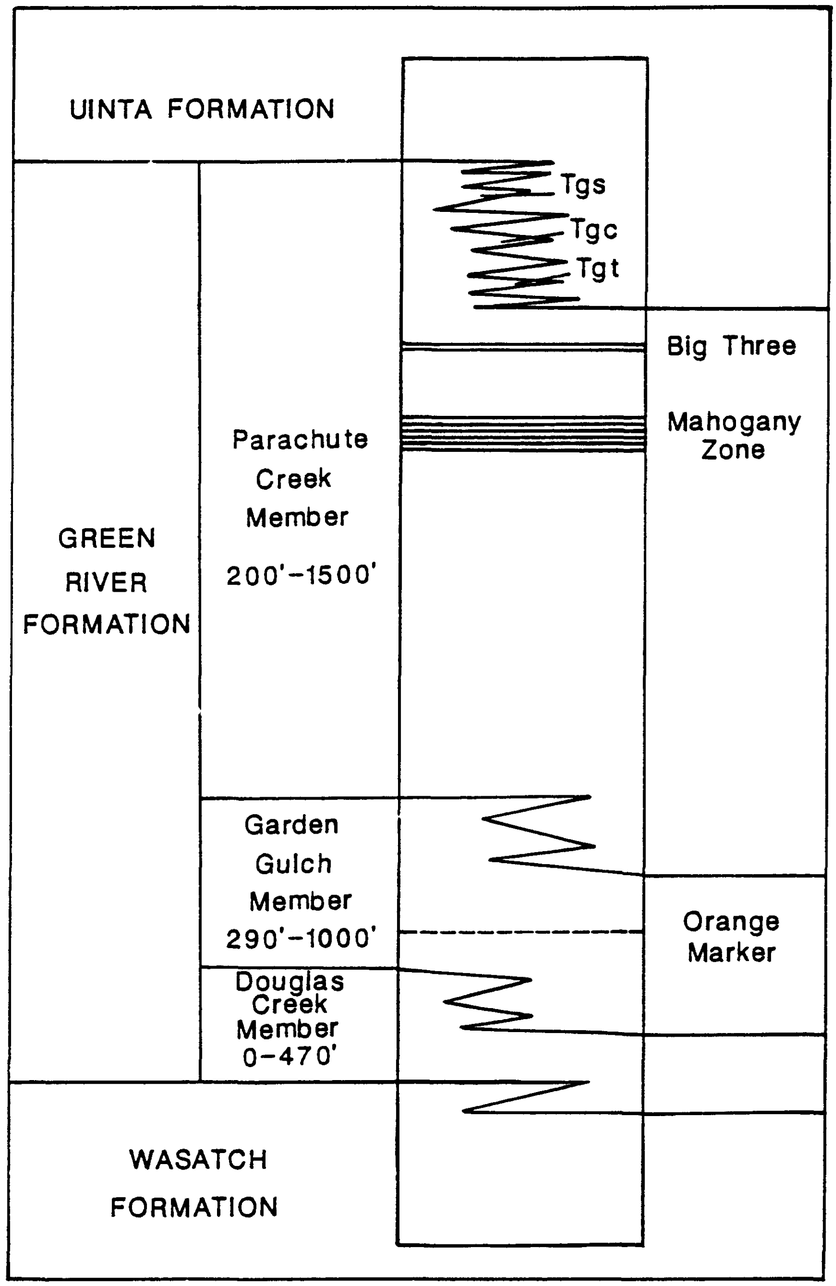

Figure 2. Generalized section of Green River and associated Formations. Only selected tongues, members and oil-shale zones are shown. Tongues of Green River Formation: Tgs--Stewart Gulch Tongue; Tgc--Coughs Creek Tongue; Tgt--Thirteenmile Creek Tongue. Orange marker is a conspicuous deviation on the geophysical response line of mechanical logs that denotes a widespread stratigraphic marker horizon in the Piceance Creek basin.

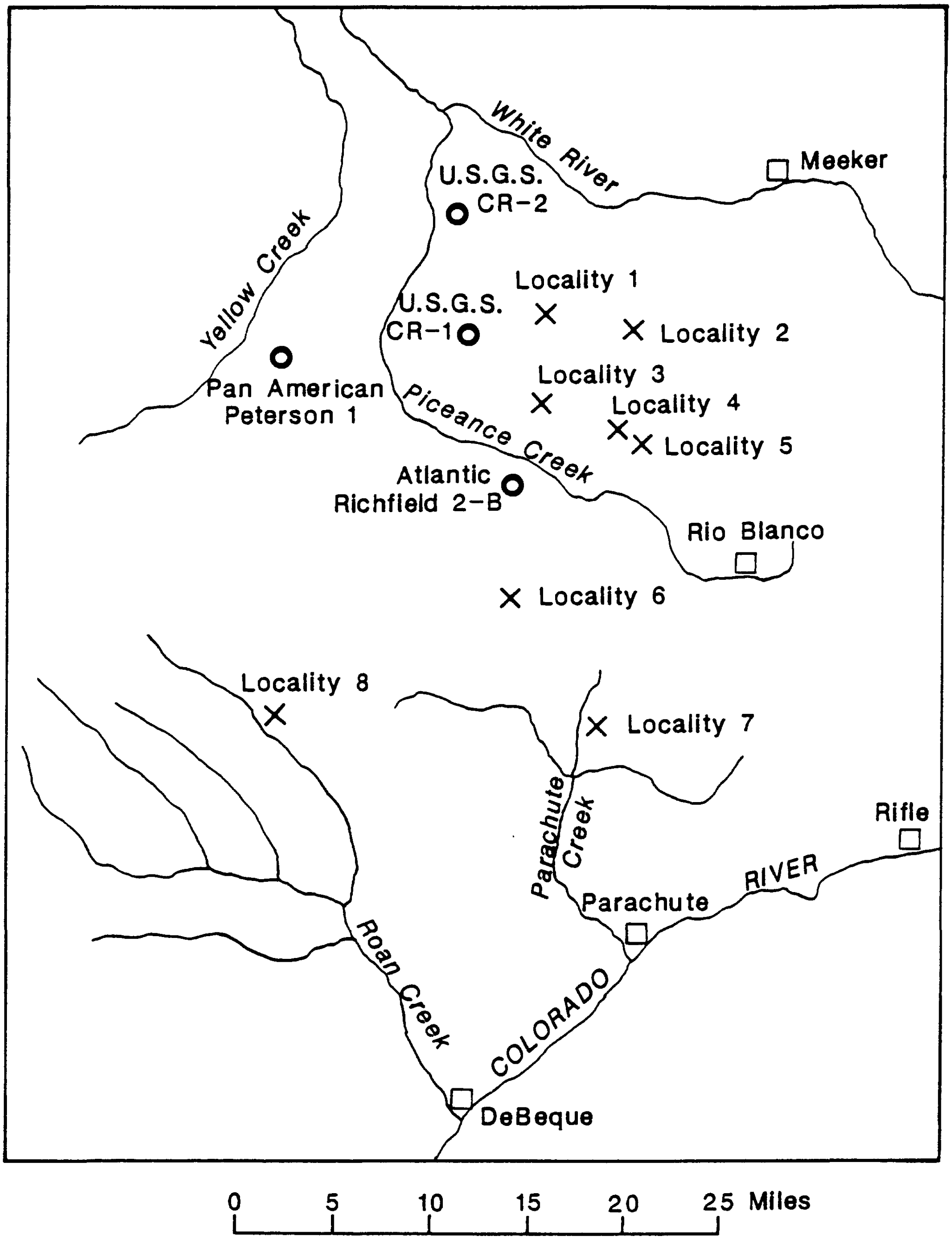

Figure 3. Index map of Piceance Creek basin.

SURFACE OCCURRENCES

Solid hydrocarbons were noted on the outcrop at 8 localities in the eastern and southern parts of the Piceance Creek basin (fig. 3). Some salient features of each locality are discussed below.

Locality 1

Locality 1 is on a short wash draining northeast into Dry Fork of Piceance Creek in the NE 1/4 NW 1/4 SE 1/4 sec. 25, T. 1 S., R. 96 W. The site is along a fault zone about 100 to 150 ft wide. The black vitreous solid hydrocarbons are in veins as much as 1/2 inch wide. At places the hydrocarbons contain small bits of marlstone as much as 1/4 inch across. All the veins are clustered in a zone, about 1/2 to 1 ft wide, which cuts the marlstone of the Thirteenmile Creek Tongue of the Green River Formation.

Locality 2

Locality 2 is found along a side wash draining southward into Joe Bush Gulch in the NW 1/4 SW 1/4 SW 1/4 sec. 34, T. 1 S., R. 95 W. The site is associated with 2 major faults about 450 ft apart which trend northwest. The solid black hydrocarbons are on the south fault where the fault cuts across marlstone of the Thirteenmile Tongue of the Green River Formation. The bitumens migrated up the fault and spread out on the surface. It then solidified in small irregular patches of vitreous hydrocarbon as much as 3 inches across. Nearly 200 ft to the north of the south fault are 2 short veins of black hydrocarbons each about 2 inches wide.

Locality 3

Locality 3 is situated on a short tributary draining southward into Jessup Gulch and is in the NW 1/4 SW 1/4 NE 1/4 sec. 23, T. 2 S., R. 96 W. The area is near the western end of a fault system about 20 ft wide which trends northwest. Black vitreous hydrocarbons are found in a short discontinuous vertical vein, about 2 inches wide, near the north end of the fault zone. Black bitumens also occur disseminated in a fine grained matrix in a vein, about 1 ft wide, which contains abundant angular bits of marlstone as much as 1 inch across and bits of calcite as much as 2 inches across. Small pits on the west bank and a small adit on the east bank, near stream level, indicate that some attempt was made to evaluate the vein system.

Locality 4

Locality 4 is on Charlie Earl Gulch near the CSW 1/4 SE 1/4 sec. 28, T. 2 S., R. 95 W. A fracture or fault zone about 16 ft wide in the Uinta Formation, with very little detectable displacement, trends southeast across the gulch. A gouge zone 2 to 3 ft wide bounds the fracture zone on the south side. Another gouge zone about 0.3 ft wide is present near the middle of the fracture zone. The gouge zones consist of subrounded boulders of brown sandstone less than 1 ft across set in a very fine grained matrix. The country rock adjacent to the gouge zones is highly fractured or jointed. The fracture zone aligns to the northwest with faults that show offset.

Solid black bitumens are in or associated with the south gouge zone. Some hydrocarbon is disseminated through the matrix rock and some is found as angular chunks as much as 1/2 inch across. Bitumens are also present intermixed with white calcite in thin patchy veneers on the fracture or joint face that marks the south border of the south gouge zone. An adit, 7 ft wide by 5 ft high by 30 to 40 ft deep, on the right bank of the gulch indicates that an attempt was made to mine the fracture zone.

Locality 5

Locality 5 is on Thirteenmile Creek in the NW 1/4 NW 1/4 NE 1/4 sec. 34, T. 2 S., R. 95 W. The locality is along the same fracture zone as locality 4 on Charlie Earl Gulch. The site is a low mound of highly jointed Uinta Formation surrounded by alluvium. A breccia zone about 1 ft wide is associated with the jointed country rock. The breccia zone consists of broken bits of calcite as much as 1/2 inch across set in a very fine grained clastic matrix. Calcite fills part of the breccia and resembles the calcite filled dike described by Verbeek (1981) about 15 mi northwest of locality 5. Bitumens are present in the breccia zone either disseminated sparsely through the matrix rock or in angular chunks as much as 1/4 inch across.

Locality 6

Locality 6 is along Middle Fork of Stewart Gulch in the NE 1/4 SW 1/4 NE 1/4 sec. 9, T. 4 S., R. 96 W. The site is at an adit which is 5 to 6 ft wide, 15 ft high and about 100 ft deep. The adit is in the Uinta Formation about 60 ft above the Coughs Creek Tongue of the Green River Formation (Hail, 1975). Near the adit are 2 vertical veins 5 inches and 1 ft wide. The veins contain solid black bitumens and small chunks of very fine grained sandstone. The veins trend to the west. Other thin veins in the area trend to the north or are parallel to bedding. Faults have not been mapped in the area and the veins appear to be related to joints. Calcite fills some joints in the area.

Locality 7

Locality 7 is on the south facing cliffs above East Middle Fork of Parachute Creek in the NW 1/4 SE 1/4 NE 1/4 sec. 18, T. 5 S., R. 95 W. Black, vitreous hydrocarbons are found in cavities in the Parachute Creek Member of the Green River Formation. The cavities are in a bed of marlstone and oil shale, about 13 ft thick, whose base is 39 ft above the Big Three rich oil shale zones (fig. 2). The cavities are generally 1 to 1.5 ft across and 0.5 to 0.7 ft high and are probably the result of nahcolite dissolution. Some, but not all, of the cavities are filled or partly filled with black bitumens. Some cavities are filled with a mixture of black hydrocarbons and broken bits of marlstone.

Locality 8

Locality 8 is along Clear Creek in the SE 1/4 sec. 8, T. 5 S., R. 98 W. According to R. C. Johnson (oral commun., 1986), black hydrocarbons are in vugs in calcareous concretions. The concretions are as much as 1 ft across and they can be traced laterally for some distance. However, the bitumens have been noted in the concretions only at one locality. The concretions are in the upper part of the Parachute Creek Member of the Green River Formation in strata equivalent to the Stewart Gulch Tongue (fig. 2). The Stewart Gulch Tongue of the Green River Formation cannot be separately recognized at locality 8 because the underlying tongues of the Uinta Formation have wedged out north of the area.

CHARACTERISTICS OF THE SOLID BITUMENS

Three samples of solid bitumens collected in the field were examined and analyzed. Samples 1, 2, and 3 described below are from localities 2, 4, and 7 respectively.

The physical and chemical properties of the samples are summarized in table 1. Samples 1 and 3 were large and uncontaminated; sample 2 consisted of organic blebs in a calcite and sandstone matrix. Consequently the purity of sample 2 is reflected in the high ash content compared to samples 1 and 3. Specific gravity of sample 2 could not be determined because the proper equipment was unavailable.

The solubility of each sample in carbon disulfide was tested and estimated to be greater than 95 percent. This solubility, low fusibility (below $110^{o}C$), limited solubility in petroleum ether, and the bitumen fractionation data indicate that the samples should be classified as asphalts (Bell and Hunt, 1963).

Infrared spectra (fig. 4) of the carbon disulfide-soluble bitumens show the same functional groups present in each sample. Absorptions due to various carbon-hydrogen vibrations are found in the region 3000-2800 cm^{-1}, peaks at 1465, 1380, and 725 cm^{-1}. The peak at 1710 cm^{-1} is due to carbonyl carbon oxygen (>C=O) stretching. The broad absorptions at 3410 and 1635 cm^{-1} are probably due to atmospheric moisture absorbed by the potassium bromide matrix used to hold the sample in the infrared beam. The infrared spectrum of sample 3 show a few more details than the other two spectra. The shoulders in the region 3100-3000 cm^{-1} are due to aromatic and olefinic carbon-hydrogen stretching. The peak at 1035 cm^{-1} may be due to aryl-alkyl ether linkages (alkyl C-O-Ø stretching), while the sharp peak at 675 cm^{-1} is attributed to substitutions on aromatic ring systems.

Liquid-solid chromatograms of bitumen fractionation are shown in figure 5. The first two partially resolved peaks are the petroleum ether-soluble fraction, sometimes called the saturated hydrocarbon fraction, although not all components in this fraction are saturated hydrocarbons. The next peak is the benzene-soluble or aromatic hydrocarbon fraction. The last two partially resolved peaks are the benzene-methanol-soluble or asphaltic fraction.

Only the petroleum ether-soluble fractions were analyzed by gas chromatography (fig. 6). These chromatographs indicate the fractions are comprised mostly of branched and cyclic hydrocarbons, with very few n-alkanes present. The absence of n-alkanes indicates either that these samples may have been subjected to microbial degradation, a process which selectively consumes normal paraffins, or that the samples are immature and have not been exposed to conditions necessary to generate an homologous series of n-alkanes. Gas chromatograms of samples 2 and 3 show broad unresolved peaks in the C_{40} range, tentatively identified as carotenoid hydrocarbons; confirming evidence is not available at this time.

None of the physical and chemical data of these samples correspond to the characteristics previously found for solid bitumens from the Uinta Basin (Bell and Hunt, 1963; Douglas and Grantham, 1973; Carman and Bayes, 1961).

Table 1.--Some physical and chemical properties of bitumen samples from Piceance Creek basin

	Sample 1	Sample 2	Sample 3
Color	black	blackish-brown	blackish-brown
Fracture	conchoidal	conchoidal	conchoidal
Luster	glossy	glossy	glossy
Specific gravity	1.03	----	1.04
Melting (fusing) point °C	96	93	104
% Solubility in:			
Chloroform	99	99	99
Petroleum ether	60	55	36
% Ash	0.66	2.95	0.29
% Carbon[1]	80.11	79.11	81.65
% Hydrogen	10.84	10.56	10.69
% Nitrogen	1.25	1.20	1.31
% Sulfur[2]	1.30	1.16	1.54
% Oxygen (by difference)	5.84	5.02	4.52
Carbon/hydrogen atomic ratio	1.61	1.59	1.56
Bitumen fractionation[3]			
% Saturated hydrocarbons	3.09	3.54	2.40
% Aromatic hydrocarbons	5.15	21.98	18.54
% Resins	78.77	71.51	63.70
% Unrecovered (by difference)	12.99	2.97	15.36

[1]Carbon, hydrogen, and nitrogen contents were determined on a Perkin-Elmer Elemented Analyzer Model 240.

[2]Sulfur contents were determined on a Leco Sulfur Analyzer Model 532 by Paul H. Briggs.

[3]Bitumen fractionation was performed on silica gel using petroleum ether, benzene and 50/50 (v/v) benzene-methanol to elute the various fractions, which were dried and weighed by Sister Carlos M. Lubeck.

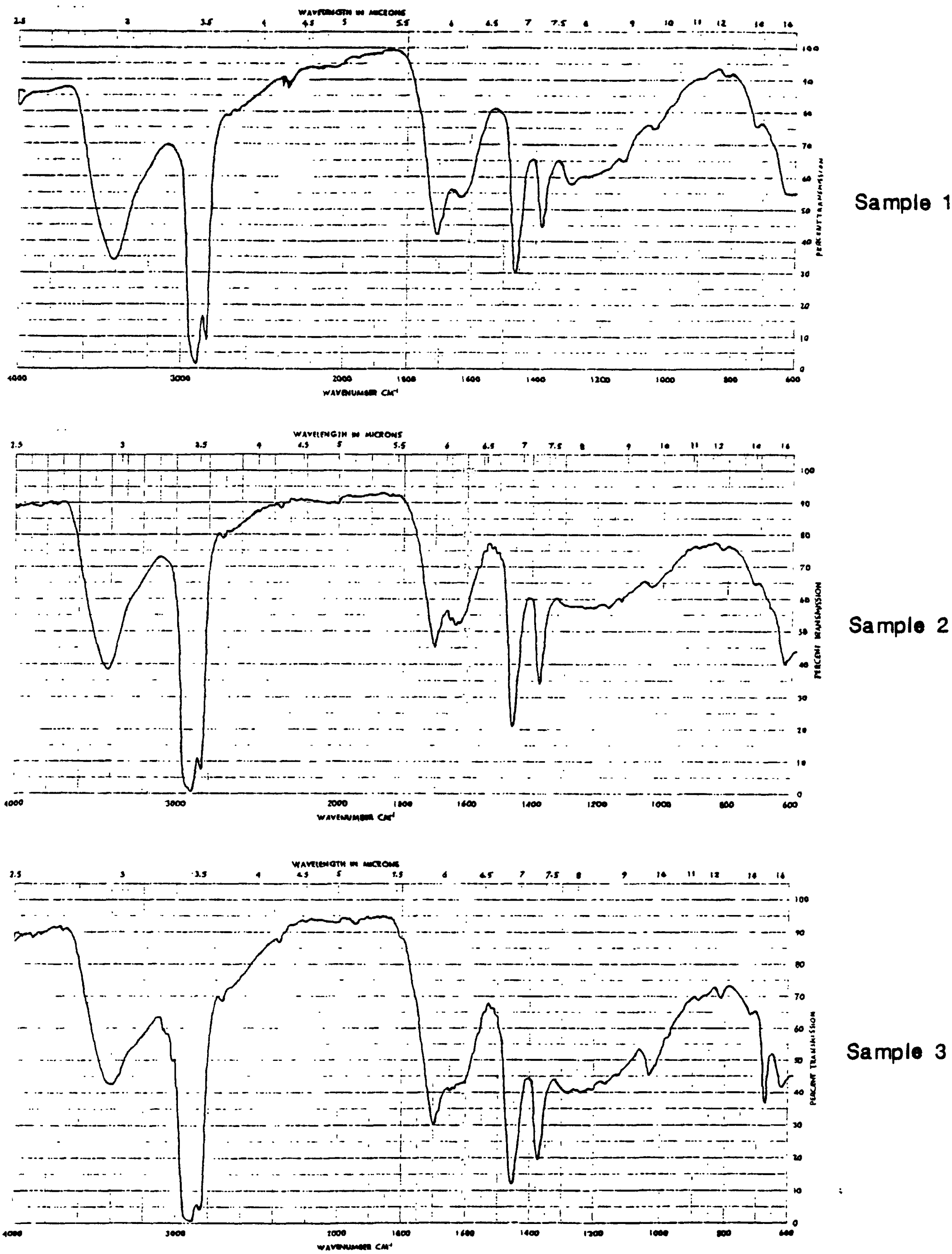

Figure 4. Infrared spectra of carbon disulfide-soluble bitumens. Each sample, 0.5 mg, was mixed with 10 mg potassium bromide after evaporation of the solvent. The mixture was then pelletized into a 3 mm diameter disk and scanned on a Beckman Acculab 4 Infrared Spectrophotometer.

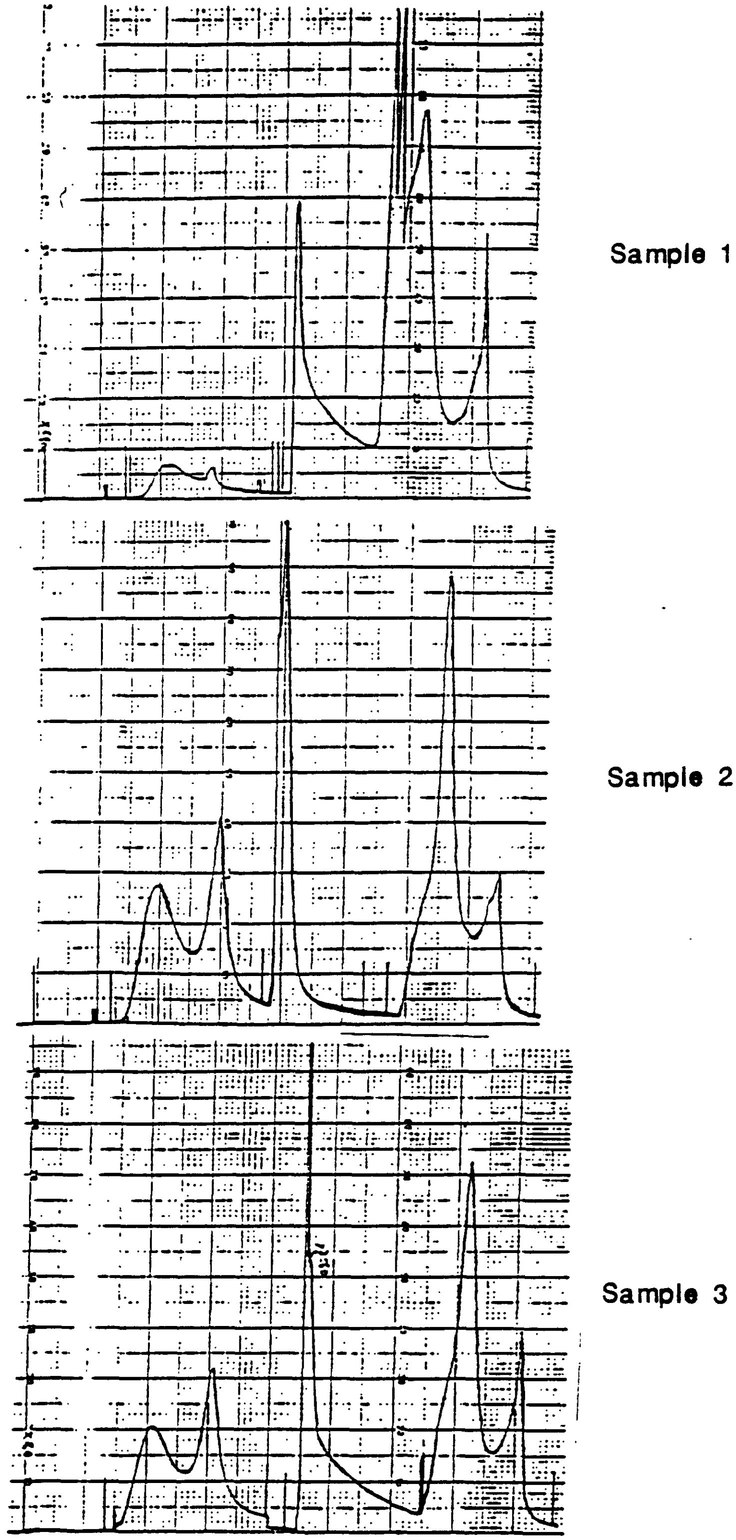

Figure 5. Bitumen fractionation by silica gel column chromatography. The columns consisted of 4.6 mm lD x 250 mm long stainless steel tube filled with Davison Grade 62 silica gel, connected to 4.6 mm lD x 500 mm long stainless steel tube filled with Davison Grade 923 silica gel. Fractions were eluted by solvents flowing at 2 ml/min. Column effluents were monitored by Pye Unicam Moving Wire Flame Ionization Detector Model LCM2.

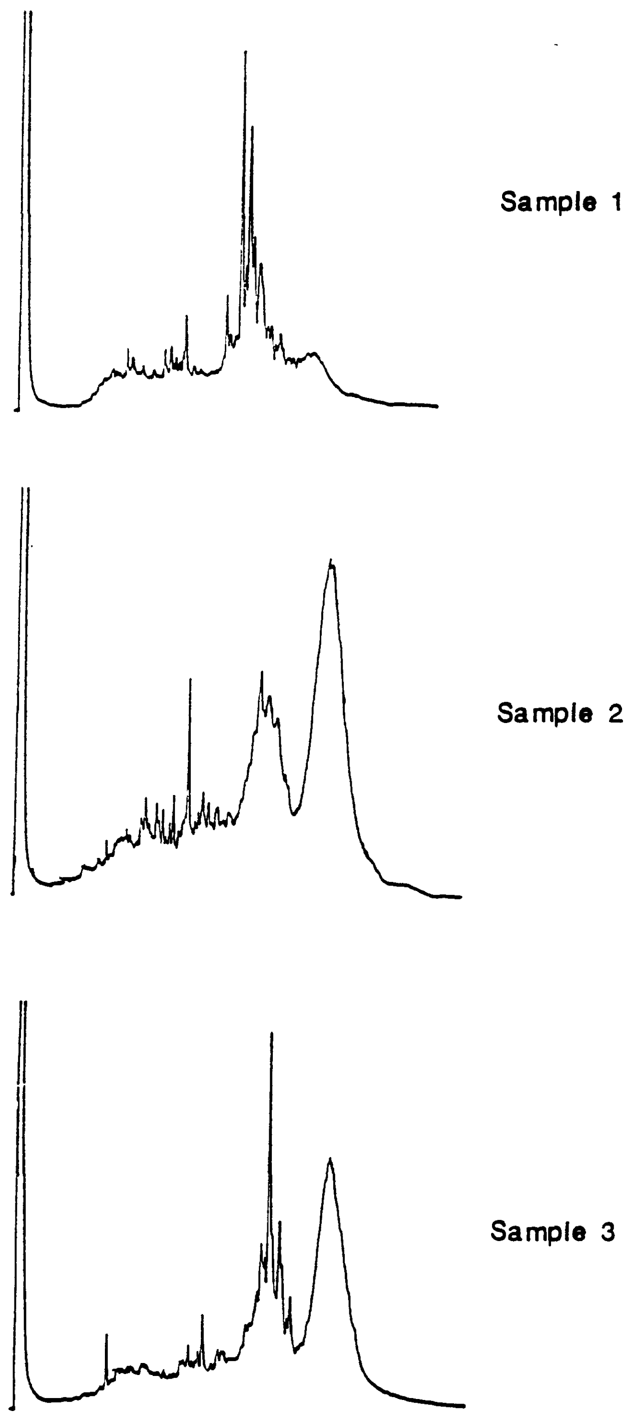

Figure 6. Gas chromatograms of saturated hydrocarbon fractions. Analyses were performed with a 3% GC-SE-30 on 100-200 mesh Gas Chrom Q column mounted in a Varian Gas Chromatograph Model 2000. Temperature programmed from 80° to 322°C. Analyst was John M. Patterson.

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