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Geochemistry and Origin of Combustible Gas in Crested Butte, Gunnison County, Colorado

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GEOCHEMISTRY AND ORIGIN OF COMBUSTIBLE GAS IN CRESTED BUTTE, GUNNISON COUNTY, COLORADO

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INTRODUCTION

On March 6, 1990, an explosion killed three people, injured several others, and resulted in the destruction of the Crested Butte State Bank in the town of Crested Butte, Gunnison County, central Colorado. After a chemical explosion was ruled out as the cause of the explosion, gas samples were collected and analyzed from seeps and desorbed core in the area of the bank in an effort to determine the source of the combustible gas responsible for the explosion. The gas samples were collected from March 14 to 16, 1990 by James M. Soule. Based on geochemical data presented in this report, the hydrocarbon fraction of the gas from the seeps and desorbed core is similar in composition to that of the fuel line for the town.

METHODS

Gas samples were analyzed with a Perkin Elmer model 8500 thermal-conductivity gas chromatograph. Volume percent of the constituents methane (CH_4), ethane (C_2H_6), propane (C_3H_8), iso- and normal-butane (i- and n-C_4H_{10}), carbon dioxide (CO_2), and nitrogen and(or) air (N_2-air) were measured. The propane was prepared for isotopic analysis using methods similar to those described by Schoell (1980). The stable carbon isotope ratios were measured on a Nier-McKinney-type Finnigan MAT model 251 mass spectrometer and are reported in the ∂-notation ($\partial^{13}C_{propane}$, table 1) in parts per thousand (ppt) deviation, relative to the Peedee belemnite (PDB) marine carbonate standard.

RESULTS AND DISCUSSION

The analyses of gas samples collected from the town of Crested Butte are summarized in table 1. The volume percent of selected components is reported together with the carbon isotope value ($\partial^{13}C$) of the propane.

Table 1.--Analyses of gas collected in vicinity of Crested Butte State Bank. Methane, ethane, propane, iso- and normal-butane, nitrogen and (or) air, and carbon dioxide are given in volume percent. $\partial^{13}C$ values for propane are reported in parts per thousand (ppt) relative to Peedee beleminite (PDB) marine carbonate standard. See figure 1 for location of samples.

	Methane CH_4 (%)	Ethane C_2H_6 (%)	Propane C_3H_8 (%)	Iso-Butane $i\text{-}C_4H_{10}$ (%)	Normal-Butane $n\text{-}C_4H_{10}$ (%)	Nitrogen (N_2) and (or) air (%)	Carbon Dioxide CO_2 (%)	$\delta^{13}C_{propane}$ (ppt)
1. Fuel line supplying town	0.45	3.16	57.29	0.49	0.47	38.03	-	-30.31
2. Crested Butte State Bank foundation (seep)	-	0.29	2.88	0.20	0.17	96.01	0.44	-29.59
3. Bullion King Building basement (seep)	-	-	0.23	-	-	99.55	-	*
4. Crested Butte State Bank foundation (seep)	-	-	0.67	-	-	98.12	0.31	*
5. Crested Butte State Bank parking lot (drill hole no. 6) (seep)	-	-	0.31	-	-	99.49	0.12	-34.36
6. Antique Store (desorbed core from drill hole no. 10)	-	-	0.86	-	-	98.39	0.75	-29.19
7. Crested Butte State Bank vault (desorbed core from drill hole no. 3)	-	-	-	-	-	98.99	0.85	*

* Not measured

Sample 1 is from a fuel line that supplies the town. Except for the air contamination (about 38 percent), the main constituent of the gas is propane with minor and decreasing amounts of ethane, iso- and normal-butane, and methane. The carbon isotope value of the propane ($\partial^{13}C$) is -30.31 ppt.

Samples 2 through 7 are seep samples collected from the basement and foundation of the bank (samples no. 2 and 4), the basement of a nearby building (sample no. 3), and a shallow drill hole (sample no. 5), and desorbed from cores from two shallow drill holes (samples no. 6 and 7) (figure 1). The locations of these samples in relation to the buried fuel distribution lines is not known. These samples consist mainly of air (>96 percent). Excluding the air, the six seep and desorbed samples are mainly propane and carbon dioxide. Sample 7 contains no propane and sample 3 contains no carbon dioxide. Sample 2, the seep sample with the least amount of air contamination, also contains ethane and iso- and normal-butane. No methane was detected in the sample, but the amount of air contamination may have reduced any traces of methane to an undetectable level. $\partial^{13}C$ values of the propane of these seep and desorbed core samples, where obtainable, range from -29.19 to -34.36 ppt. The most reliable carbon isotope value is probably from sample 2 where the largest amount of propane was available for analysis.

As stated before, the gas in the fuel line supplying the town consists mainly of propane with minor amounts of other hydrocarbons. This distribution is the result of refining crude oil and(or) natural gas (Lom, 1973) which concentrates the propane component of the naturally occurring hydrocarbons. The resulting gas has a high calorific (Btu) value (Walmsley, 1973). Gases originating from naturally occurring hydrocarbon-generating processes always have methane as their major component with lesser amounts of both hydrocarbon and nonhydrocarbon gases (Tissot and Welte, 1984).

The seep and desorbed core samples consist mainly of air from contamination and minor amounts of propane and carbon dioxide. Sample 2 also contains ethane and iso- and normal-butane and has a distribution of hydrocarbon components similar to the sample from the fuel line. In samples 3 through 6, the hydrocarbon fraction of the total sample was so small that minor amounts of hydrocarbon gases, other than propane, would not be

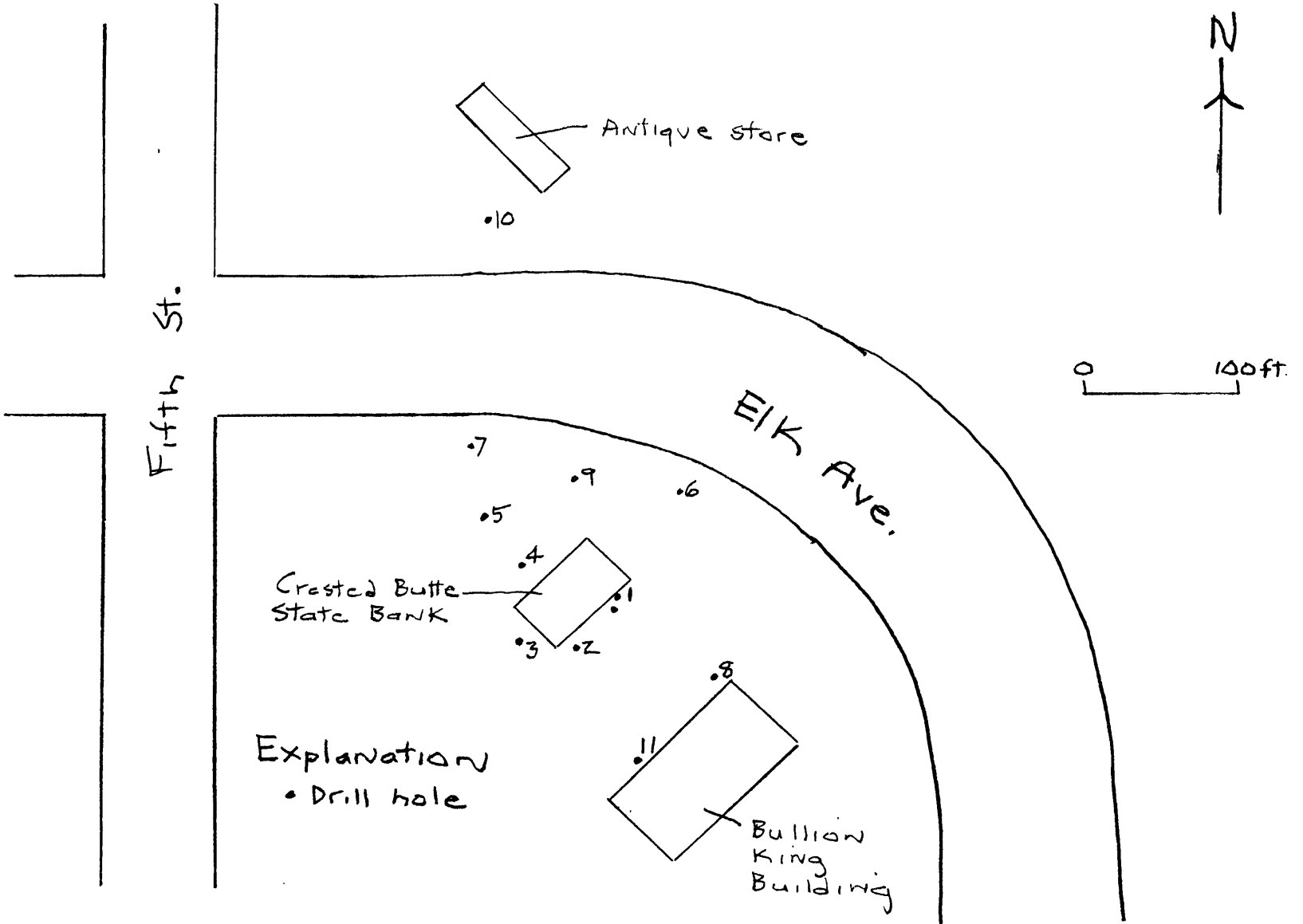

Figure 1.--Generalized map of a portion of Crested Butte showing locations of selected buildings and 11 shallow holes drilled under supervision of Colorado Geological Survey.

detectable, even if present. In sample 7, no measurable amount of propane was detected. In addition, the propane from the seep and desorbed samples has an isotopic signature similar to that from the fuel line. These geochemical data indicate that the combustible hydrocarbon gases from the fuel supply, seeps, and desorbed core are almost identical.

The occurrence of only propane in the seep and desorbed samples cannot be explained by migration of a deeper, naturally occurring gas. For example, in the LaSalle, Colorado area, gas vented to the surface along shallow abandoned water wells is identical in composition to gas produced from reservoirs at 7,000 ft (2,130 m) (Rice and others, 1984). The shallow gas is interpreted to be thermal in origin and was generated from the same deep, thermally mature petroleum source rocks as those associated with the deep producing reservoirs. The hydrocarbon fraction of gases from both shallow water wells and the deep producing wells is about 80 percent methane.

Minor amounts of carbon dioxide, such as those present in five of the six Crested Butte seep and desorbed core samples, are common in shallow sediments and probably result from bacterial activity at low temperatures. Carbon dioxide is not present and would not be expected in the fuel distribution lines.

Two other possible origins of gases causing the explosion in the bank have been suggested: (1) bacterial gas generated from a buried bog or abandoned dairy farm and (2) coal-bed gas released by nearby mining. However, both of these can be discounted for the following reasons. Bacterial gas consists mainly of methane; heavier hydrocarbon gases, such as propane, are not generated by anaerobic bacteria in shallow sediments (Rice and Claypool, 1981). For example, in southern Weld County, Colorado, natural gas in the ground water is mostly methane (C_1/C_{1-5} values >0.99) which is interpreted to be the result of decomposition of organic matter by bacteria within the aquifer (Rice and Threlkeld, 1982).

Bituminous coal in the Upper Cretaceous Mesaverde Formation was actively deep mined in the Crested Butte area until 1952 (Gaskill and others, 1986). In the Jokerville mine located less than 1 mile west of Crested Butte, 59

miners were killed by a gas explosion in 1884 and several other mines are reported to be gassy (Gaskill and others, 1986). However, this possible source of the propane-rich gas is discounted for two reasons. First, coal-bed gases consist mainly of methane and some CO_2 (Rice and others, 1989). Second, the coal beds and mines are structurally higher than the town of Crested Butte.

In conclusion, the hydrocarbon fraction of the seep and desorbed core gases recently collected and analyzed from the town of Crested Butte consists mainly of propane and is almost identical in composition to the gas in the fuel line supplying the town. The propane from the town fuel supply is the most likely cause of the bank explosion. However, the bank tragedy cannot be positively related to a leak in the fuel system because the seep and desorbed core gases were collected several days after the explosion and the conditions may not have been the same as those at the time of explosion. The possibility that the gas originated from bacterial activity or is related to coal mining is discounted because of the distinct, propane-rich composition of all but one of the analyzed gases. The one sample (no. 7) that contained no propane also contained no other hydrocarbon gas.

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