SODIUM BICARBONATE (NAHCOLITE) FROM COLORADO OIL SHALE[1]

TELL ERTL[2]

ABSTRACT

Sodium bicarbonate (nahcolite) was found in the high-grade oil-shale zone of the Parachute Creek member of the Eocene Green River formation in the underground development openings of the Bureau of Mines Oil-Shale Demonstration Mine at Anvil Points, 10 miles west of Rifle, Colo. It occurs as concretions varying up to five feet in diameter and as layers up to four inches thick, intercalated between rich oil-shale beds. It is suggested that the concretions were formed while the ooze, which had been deposited in the bottom of the former Uinta Lake, was still soft and plastic.

INTRODUCTION

Natural sodium bicarbonate ($NaHCO_3$) was reported first by P. Walther[3] from Little Magadi dry lake, in British East Africa, but no confirmatory evidence was given. F. A. Bannister,[4] who reported natural sodium bicarbonate in an efflorescence from an old Roman underground conduit from hot springs at Stufe de Nerone, near Naples, gave the mineral the name "nahcolite." Later the mineral was reported by E. Quercigh[5] as an incrustation in a lava grotto, apparently mixed with thenardite and halite. Large quantities of nahcolite were found in a well core-drilled below the central salt crust of Searles Lake and described by William F. Foshag.[6]

The presence of saline phases in the eastern part of the Uinta Basin in the high-grade oil-shale facies of the Parachute Creek member of the Eocene Green Eiver formation was noted by W. H. Bradley.[7] He states that ellipsoidal cavities whose major axes range from a fraction of an inch to more than five feet in length contained molds of radial aggregates of a saline mineral that could not be determined because of the complex intergrowth of the crystal molds.

The Bureau of Mines now is developing an underground oil-shale mine at Anvil Points, 10 miles west of Rifle, Colorado. A number of underground openings have penetrated the high-grade oil-shale facies that contain the salt cavities. As the openings were advanced deeper into the

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[1] Published by permission of the Director of the Bureau of Mines.

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[3] Walther, P., *Am. Mineral.*, **7**, 86–88 (1922).

[4] Bannister, F. A., *Mineral. Mag.*, **22**, 53–64 (1929).

[5] Quercigh, E., *Rend. Acad. Sci.* (Naples), (4) **7**, 19–25 (1937).

[6] Foshag, W. F., *Am. Mineral.*, **25**, 769–778 (1940).

[7] Bradley, W. H., Origin and microfossils of the oil shale of the Green River Formation of Colorado and Utah: *U. S. Geol. Survey, Prof. Paper* **168**, 33–37 (1931).

cliffside and away from the outcrop some of the cavities were found to be unleached and to contain a soluble crystalline mineral.

The mineral was found to occur in crystalline, cleavable masses in concretions as large as five feet in diameter and as small as a pea. It also was found in layers up to four inches thick intercalcated between oil-shale beds. The mineral in the concretions varies in color from colorless, through white, yellow, brown, and black. Most often the color is a dirty brown because of the bitumen dispersed throughout the mineral. Clear pieces one inch square and one-quarter inch thick have been broken from the concretions.

The mineral occurring in the layers is pure white, translucent, and occurs as fibrous crystals at right angles to the bedding. It has a pearly opalescence and resembles the satin spar variety of gypsum.

IDENTIFICATION

The mineral was taken to the Colorado School of Mines for identification. Professor Richard Merriam of the geology department, Mr. Eugene Staritzky, Associate Director of the Experimental Plant, and the writer determined by optical and crystallographic means that the mineral was nahcolite. Cursory spectrographic analyses, made by Mr. Staritzky, showed no important impurities.

Chemical tests on the mineral were made at the Bureau of Mines Petroleum and Oil-Shale Experiment Station, Laramie, Wyoming. Analyses on two specimens show:

$NaHCO_3$ (calculated from total HCO_3)	88.29%*	91.90%
Na_2CO_3 (calculated from total CO_3)	4.78	6.62
H_2O insoluble	6.77	0.14
Material unaccounted for	0.16	1.34
Total	100.00%	100.00%
Acid insoluble	4.47%	0.14%
CaO (acid soluble)	1.16%	0.14%
Al_2O_3 and Fe_2O_3	None	None

* This sample contained considerable bituminous material.

PARAGENESIS

Nahcolite in the Green River formation occurs in concretions and layers in the high-grade oil-shale bed. Each concretion seems to be composed of just a few large crystal growths since the cleavage is parallel throughout most of the concretion. The oil-shale beds on each side of the concretions are distorted for a short distance above and below, but the beds a few feet above and below the concretion appear in all cases to be flatlying. (See figure 1.) The highgrade oil shale is an extremely fine-grained, compact rock. It seems doubtful that solutions could move in the oil shale freely enough after lithification to produce these nahcolite concretions.

Therefore, the writer concludes that at the time of formation of the rich oil-shale beds, the lake was supersaturated with sodium salts. The sodium salts were precipitated as sodium bicarbonate concurrently with the marly mud rich in organic matter that later became oil shale. On lithification of the deposited material, the sodium bicarbonate began to crystallize along certain planes and as the crystals of nahcolite grew the surrounding oil shale was distorted while still soft and plastic. Nevertheless, as the growing crystals of nahcolite crowded the laminae of oil shale away from them both above and below, the mud was stiff enough to maintain its original laminate structure.

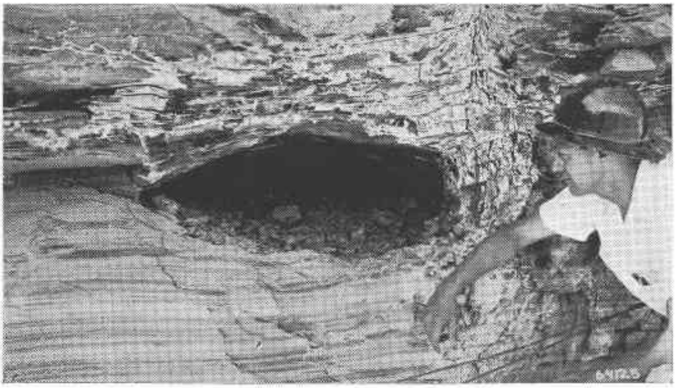

FIG. 1. Leached nahcolite concretions on fresh face of oil-shale cliff, showing distortion of beds immediately above and below the concretion. Note nahcolite efflorescence.

Foshag states that sodium bicarbonate, in open solutions, loses CO_2 and eventually passes to trona ($Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$), therefore it is not often found in nature. He states further that its occurrence in Searles Lake may be caused by an interaction of trona and calcium bicarbonate under conditions that did not allow the escape of carbon dioxide gas. The action of carbon dioxide and water vapor on trona is known to produce sodium bicarbonate. Because the organic-bearing mud that now is oil shale was putrifying on deposition, the lake readily could have had an excess of carbon dioxide that could have caused the deposition of nahcolite rather than trona.

On the other hand it is known that in the system $Na_2CO_3 \cdot NaHCO_3 \cdot H_2O$, trona is not stable below 21.26° C.; $NaHCO_3$ (nahcolite) and

$Na_2CO_3 \cdot 10H_2O$ (natron) are the stable phases. Bradley indicates that the former Uinta Lake must have been 75 to 100 feet deep during long periods of time while the rich oil-shale beds were being deposited. He also believes that the water toward the bottom of the lake was stagnant, and strongly reducing, and distinctly unfavorable for bottom-dwelling animals. In addition he has evidence that the mean annual temperature of the region, and therefore of the stagnant deeper portion of the lake. was of the order of 18° C. The evidence then favors the deposition of the nahcolite directly from a solution rich in sodium salts whose lower layers were stagnant, strongly reducing, and at a constant temperature below 21° C.