minerals was a group from the well known geyser area, Sonoma County, California. These specimens were collected by J. B. Nichols and the late M. Vonsen from Petaluma, California. One specimen consisted of a matte of tiny transparent flakes that had the same optical properties as the Steamboat Springs sassolite. The presence of boron was confirmed by flame test. The same group of specimens contained boussingaltite and mascagnite and other minerals well known from the Sonoma County locality. The specimen of sassolite was retained as part of Mr. Nichols' collection. The disposition of the collection after Mr. Nichols' death a few years ago, is not known to the author.

NORRIS GEYSER BASIN, YELLOWSTONE NATIONAL PARK

In 1954, the author examined a number of mineral specimens submitted by the National Park Service to the Geological Survey for identification. These specimens were collected in the Norris Geyser Basin and consisted predominantly of water soluble sulphates and other solfataric and hot spring deposits. One sample consisted of small nodular growths of halite intimately intergrown with at least three unidentified minerals. Sassolite occurred in tiny, curved, transparent flakes coating the other minerals. The optical properties, presence of boron, and its solubility in water and alcohol serve to identify the mineral as sassolite. This material has been retained by the author pending identification of the unidentified minerals.

These three localities, and the presence of boron-bearing waters in each, are of interest in that they are all areas of geyser activity.

REFERENCES

ALLEN, R. D. AND KRAMER, HENRY (1957), Ginorite and sassolite from Death Valley, California: *Am. Mineral.*, **42**, 56–61.

LARSEN, E. S., JR. AND BERMAN, HARRY (1934), Microscopic determination of the non-opaque minerals, 2d ed.: *U. S. Geol. Survey Bull.*, **848**, 149.

SMITH, GEORGE I., ALMOND, HY AND SAWYER, DWIGHT L. (1958), Sassolite from the Kramer Borate District, California: *Am. Mineral.*, **43**, 1068.

THE AMERICAN MINERALOGIST, VOL. 43, NOVEMBER-DECEMBER, 1958

NATROJAROSITE FROM NEAR THE MONTANA-WYOMING LINE

RICHARD S. MITCHELL AND WILLIAM F. GIANNINI,
University of Virginia, Charlottesville, Virginia

The purpose of this paper is to report an occurrence of natrojarosite, $NaFe_3(SO_4)_2(OH)_6$, near the Montana-Wyoming line. The senior writer first noticed this material in August of 1954, but was not able to study it adequately until more material was collected in September of 1957. Other American localities of this relatively uncommon mineral are Lawrence County, South Dakota (Headden, 1893), Soda Springs Valley, Nevada (Hillebrand and Penfield, 1902), Kingman, Arizona (Shannon and Gonyer, 1927), and Luna County, New Mexico (Ford, 1932).

The natrojarosite occurs in sediments of the Gypsum Spring anticline in an exposure in Sec. 21, T. 9 S., R. 27 E., Carbon County, Montana, about 3 miles north of the Montana-Wyoming line (Fig. 1). Natrojarosite is associated with fragments of carbonized wood and gypsum in a fine-grained gray sandstone which is about $2\frac{1}{2}$ feet thick and is in sequence with other sandstones. The beds here dip eastward and have been transected by an intermittent creek. The specimens were collected several yards downstream from where the road crosses the creek. Sediments containing the natrojarosite apparently belong to the Morrison formation of the Upper Jurassic. This material is overlain by other sandstones and greenish-gray shales containing dinosaur (?) bones. The stratum is underlain by sandstones, including a greenish-gray cross-bedded glauconitic type characteristic of the Upper Sundance formation of the Jurassic. Numerous belemnite remains are found immediately below this glauconitic sandstone. The general stratigraphy and structure of this area have been outlined by Blackstone (1940).

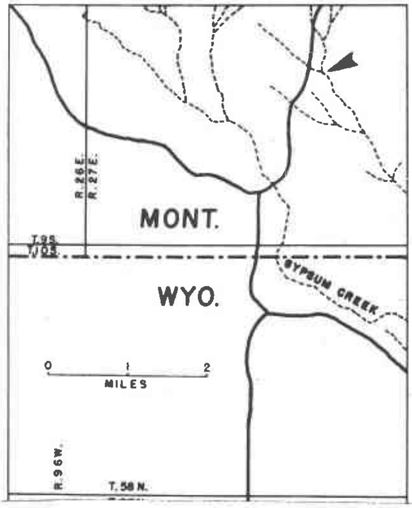

FIG. 1. Map showing natrojarosite locality. Chevron points to area where mineral is exposed. The town of Cowley (on U.S. 310) lies about 8 miles south of the Montana-Wyoming line on the road shown.

The natrojarosite occurs as a very fine-grained bright-yellow powder.

For a tentative identification some simple chemical tests were performed. The powder readily dissolved in warm hydrochloric acid to give a yellow solution. The addition of barium chloride to this solution formed a white cloudy precipitate indicating the presence of sulfate. When fused with charcoal and sodium carbonate and placed on a clean silver coin a dark stain resulted, thus indicating the presence of sulfur. An excellent test for ferric iron was obtained upon the addition of potassium ferrocyanide to a solution in hydrochloric acid. A flame test showed the intense persistent yellow coloration for sodium. In boiling water the mineral was apparently insoluble.

A semiquantitative spectrographic analysis* confirmed the fact that sodium is the major alkali metal present. The ratio of sodium to potassium determined by this method is 3 to 1. This analysis also detected the presence of considerable silica (up to 25%). That silica is present as an intermixed impurity was shown by a study of insoluble residues and by x-ray diffraction patterns. Small amounts of the following elements were also detected by the spectrographic analysis: Al, Ca, Sr, Ba, Ti, Mg, Zr, Mn and Cu. Although these elements are probably due to impurity compounds, it should be noted that Al (1.75% Al_2O_3 was detected) could substitute isomorphously for some of the Fe, and Ca, Sr and Ba could substitute for Na (Kulp and Adler, 1950).

For a final check on the identification of this substance six samples, taken from different specimens and associations, were studied by the x-ray powder method. The measured x-ray data listed in Table 1, represent an average of values obtained for these six films made with FeK_α radiation in cameras with a diameter of 11.46 cm. Using data available in the literature the films were partially indexed using the Davey charts (Davey, 1922). From the powder data the unit cell values obtained are $a_0 = 7.34$ Å and $c_0 = 16.72$ Å, with $a_0 : c_0 = 1 : 2.278$. Using these values all possible d spacings down to 1.35 Å were calculated. The excellent correlation obtained between these calculated values and the observed values is presented in Table 1. Observed values correspond only with d values for reflections which are allowed by an $R3m$ space group and this is the reported space group for natrojarosite. The structure cell dimensions for the Montana natrojarosite are slightly larger than those reported by Hendricks (1937) for this mineral. Perhaps the slight isomorphous replacement of sodium by potassium would contribute to this difference.

Because of the intimate association of the natrojarosite powder with other minerals, occasional impurity lines were noticed on some of the x-ray films. The most consistent impurity lines were from the quartz

---

* This analysis was performed by the American Spectrographic Laboratories, Inc., San Francisco, California.

TABLE 1. *X*-RAY POWDER DATA ON NATROJAROSITE FROM CARBON COUNTY, MONTANA. $a_0=7.34$ Å; $c_0=16.72$ Å; $a_0:c_0=1:2.278$. FeKα RADIATION

hk·l	$d_{(\text{calc.})}$ Å	$d_{(\text{obs.})}$ Å	$\text{I}_{(\text{obs.})}$
10·1	5.94	5.94	w
00·3	5.57	5.57	mw
01·2	5.06	5.06	vs
11·0	3.67	3.67	vw
10·4	3.49	3.49	vw
02·1	3.12	3.12	ms
11·3	3.07	3.06	s
20·2	2.97		
01·5	2.96	2.96	vw
00·6	2.79	2.78	vw
02·4	2.53	2.53	w
21·1	2.38		
12·2	2.31		
20·5	2.30		
10·7	2.24	2.24	m
11·6	2.22		
30·0	2.12	2.13	vw
21·4	2.08		
01·8, 30·3	1.98	1.98	m
12·5	1.95		
02·7	1.91	1.91	vvw
00·9	1.86		
22·0	1.84	1.83	mw
13·1, 20·8	1.75		
22·3	1.74	1.74	vvw
31·2	1.73	1.72	vvw
21·7, 30·6	1.69		
11·9	1.66		
13·4, 10·10	1.62		
12·8	1.58	1.57	vw
31·5	1.56		
22·6	1.53	1.54	vw
02·10, 01·11	1.48	1.48	vw
13·7	1.42		
30·9	1.40		
00·12, 14·0	1.39		
21·10, 20·11	1.37		
31·8, 41·3	1.35	1.34	vvw

10·0 (4.26 Å) and 10·1 (3.34 Å) reflections. The intensities of these, relative to natrojarosite, varied on five of the films and on a sixth one they were completely missing.

Because microscopic examination revealed no evidence of single crystals, it was virtually impossible to obtain optical data.

The matrix rock with which the natrojarosite is associated is a gray to buff fine-grained sandstone showing an apparently ripple-marked structure. An *x*-ray study of the sandstone revealed a composition of quartz and illite. Scattered throughout the rock are irregularly shaped fragments of black carbonaceous matter averaging about an inch or less across. Most of these black fragments resemble common charcoal, but a few were noted with a brilliant pitchy luster and good conchoidal fracture. Small splinters of each type of carbonaceous matter were *x*-rayed using the powder method. In addition to the broad diffuse bands typical of amorphous solids, lines for natrojarosite were observed. A light-brown earthy powder in small cavities and crusts is associated with the rock. An excellent correlation was obtained between *x*-ray powder data for this earthy powder and goethite. Also brown stains streak the gray sandstone. Selenite gypsum commonly occurs in the specimens as thin crusts. Two fossil bone fragments, the largest measuring three by four inches, were noted in the deposit. These are cellular, and vary in color from yellow-brown to dark red-gray. A typical apatite pattern was obtained from these by the diffraction method, but an exact categorization of the apatite mineral was not achieved.

Natrojarosite is associated with all the minerals in the deposit. Cavity fillings and discontinuous crusts rarely thicker than 1/16 inch were found in the sandstone. The yellow powder commonly surrounds the carbonaceous fragments and frequently veins them. In one specimen natrojarosite has almost completely replaced the carbonaceous material leaving only a woody structure and a few black streaks in a yellow irregular patch. *X*-ray study revealed natrojarosite even in apparently pure black splinters of the carbonaceous material. The relationship between goethite powder and natrojarosite suggests that goethite may result from the alteration of this sulfate. Crusts of the two minerals seem to grade into each other and most of the natrojarosite has some brown stains. Natrojarosite fills some cavities between crystals in the selenite crusts, but an intimate relationship between these sulfates, like one might expect, does not seem to exist. The bone fragments also contain thin coatings of natrojarosite on their outer surfaces. This association was verified by *x*-ray data. Of all these minerals it appears that natrojarosite is most intimately associated with the carbonaceous material of the rock.

After the completion of this study the writers received samples of a yellow mineral collected in Big Horn County, Wyoming, about 40 miles from the locality described above. This material is identical to that already described. *X*-ray films have identical *d* values and show the material is of exceptional purity. Crusts up to $\frac{1}{2}$ an inch wide are associated with a gray-brown sandstone. Much carbonized wood and gypsum are also present. The total thickness of these sediments, which belong to the

Morrison formation, is about 6 feet. The material described is from a uranium claim, owned by Mr. Irvin Asay, which is located 4 miles east of U. S. 310 on a turn-off about 13¼ miles southeast of Lovell, Wyoming.

The discovery of this second locality suggests that natrojarosite may be of widespread occurrence in the Morrison formation within and around the Big Horn Basin.

The writers wish to express their gratitude to Mr. C. F. Mitchell, of Lovell, Wyoming, for his assistance in checking certain field data included in this paper, and for collecting specimens from the Asay property.

References

Blackstone, D. L., Jr. (1940), Structure of the Pryor Mountains, Montana: *Jour. Geol.*, **48,** 590–618.

Davey, W. P. (1922), A New *X*-ray Diffraction Apparatus: *Gen. Elect. Rev.*, **25,** 565–580.

Ford, W. E. (1932), *Dana's Textbook of Mineralogy*, 4th ed., New York, p. 769.

Headden, W. P. (1893), Kehoeite, a New Phosphate from Galena, Lawrence Co., S. D.: *Am. Jour. Sci.*, **46**(3), 22–25.

Hendricks, S. B. (1937), The Crystal Structure of Alunite and the Jarosites: *Am. Mineral.*, **22,** 773–784.

Hillebrand, W. F. and Penfield, S. L. (1902), Some Additions to the Alunite-Jarosite Group of Minerals: *Am. Jour. Sci.*, **14**(4), 211–221.

Kulp, J. L. and Adler, H. H. (1950), Thermal Study of Jarosite: *Am. Jour. Sci.*, **248,** 475–487.

Shannon, E. V. and Gonyer, F. A. (1927), Natrojarosite from Kingman, Arizona: *Wash. Acad. Sci., Jour.*, **17,** 536–537.

THE AMERICAN MINERALOGIST, VOL. 43, NOVEMBER-DECEMBER, 1958

X-RAY DATA FOR DOLOMITE AND ANKERITE

R. A. Howie and F. M. Broadhurst, *Geology Department, The University, Manchester, England.*

Although the structure of dolomite was determined by Wyckoff and Merwin (1924) and by Wasatjerna (1924), the effect of the replacement of magnesium by iron on the cell parameters has remained in doubt. Wyckoff and Merwin examined various specimens of dolomite, two of them having over 10% FeO by weight, and using single crystal photographs they found that the cell sizes were identical within experimental error. Schoklitsch (1935), however, using the powder method, gave values for dolomite with 1.17% FeO of a_{rh} 6.007 Å,* α 47°32′ or a 4.843, c 15.95 Å on hexagonal axes and for ankerite with 16.43% FeO a_{rh} 6.062 Å, α 46°58′ or a 4.832, c 16.14 Å; these results indicating that the

* Original values given in kX units have been converted to Å.