

# FLUORESCENT SODALITE AND HACKMANITE FROM MAGNET COVE, ARKANSAS<sup>1</sup>

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## ABSTRACT

Two varieties of fluorescent sodalite are found in the tinguaita rocks of Magnet Cove, Arkansas: a blue sodalite that fluoresces a purplish-blue to violet-red, and a white variety, hackmanite, which strongly fluoresces a reddish-orange. The hackmanite also exhibits the peculiar phenomenon of evanescence; that is, change of color from rose to colorless and back again with alternate exposures to light and darkness. It shows also the property of photosensitivity; that is, the phenomenon of induced reappearance of the rose color by exposure to ultra-violet radiation and the disappearance of the color in daylight.

## OCCURRENCE

Magnet Cove, or "The Cove" as it was known to the early travelers, is situated in Hot Spring County, about 12 miles east of Hot Springs, in southwest-central Arkansas, near the boundary between the Coastal Plain Province and the Ouachita Plateau. The igneous complex at Magnet Cove occupies an area of about 5 square miles and is elliptical in shape. It is basin-like in form due to an encircling rim of the more resistant peripheral zone of intrusive rocks around a depression left by erosion of the softer rocks in the center. The igneous rocks belong mostly to the nepheline-syenite group, and were intruded—apparently in Upper Cretaceous time—into closely folded Paleozoic sedimentary rocks, novaculite, sandstone, and shale.

There are exposures of several different types of alkalic rocks; including nepheline-mica syenite, nepheline syenite dike rock, nepheline tinguaita, leucite tinguaita, and alkalic pegmatite with which are associated a large group of minerals. Among these is natural lodestone which gives Magnet Cove its name.

A comprehensive description of the petrology and geology of Magnet Cove is contained in the classical work of J. Francis Williams.<sup>2</sup> The petrogenesis of Magnet Cove is discussed in an article by H. S. Washington,<sup>3</sup> and a paragenetic classification of the Magnet Cove minerals has

<sup>1</sup> Published by the permission of the Director, U. S. Geological Survey, Department of the Interior, Washington, D. C.

<sup>2</sup> Williams, J. Francis, The igneous rocks of Arkansas: vol. II, *Annual Report of the Geological Survey of Arkansas for 1890*.

<sup>3</sup> Washington, H. S., Igneous complex of Magnet Cove, Arkansas: *Bull. Geol. Soc. Am.*, 11, 389-416 (1900).

been made by K. K. Landis.<sup>4</sup> A brief account of the geomorphology and regional geology is given by Landis, Parks, and Scheid.<sup>5</sup>

Microscopic grains of sodalite were recognized in thin sections of rocks from Magnet Cove by Williams<sup>6</sup> and by others, but recent quarry operations revealed the first material visible to the unaided eye. Specimens of blue sodalite and the evanescent white variety hackmanite, were first obtained through Lawton D. Kimzey and Joe W. Kimzey by Hugh D. Miser during his visit to Magnet Cove, Arkansas, in 1936. Much additional material has been obtained since—some from Lawton D. Kimzey, and the remainder during visits to the locality in 1937 by Lawton D. Kimzey, Hugh D. Miser, C. S. Ross, and W. T. Schaller; and in 1938 by Jewell J. Glass and Mr. Kimzey. This is believed to be the first occurrence of hackmanite to be identified in the United States.

The sodalite and the variety hackmanite occur in two quarry pits opened by Joe W. Kimzey on the south border of Magnet Cove about three-fourths of a mile northeast of Cove Creek Station and about one and a half miles southwest of Magnet Post Office. One pit is 60 feet long in an east-west direction, and as much as 35 feet wide and 12 feet deep, and the other 100 feet east of the first, is 50 feet long in a southeast-northwest direction, 10 feet wide and 6 feet deep. The rock of the area is a fine-grained dark greenish-gray dike type of tinguaitite. At this locality the tinguaitite contains a few widely separated irregular masses and veins of sodalite and hackmanite, varying from small white specks to masses as much as 4 inches in diameter. Another occurrence of similar material has been discovered by Lawton D. Kimzey on the north side of the Cove 2 miles northwest of the first locality, and was visited by Miss Glass and Mr. Kimzey in 1938.

The hackmanite variety of sodalite is another addition to the increasing list of minerals from Magnet Cove. Taeniolite, a rare mica, was recently described by Miser and Stevens,<sup>7</sup> molybdenite has just been reported,<sup>8</sup> and a crystal of emerald-green sphalerite about 4 mm. in diameter emplaced in a cavity on a felted mass of dark brown acmite with aegirite and orthoclase was collected recently by Russell S. Henderson of the U. S. Forest Service.

The blue sodalite occurs either alone in lenses, or as rounded or irreg-

<sup>4</sup> Landis, Kenneth K., A paragenetic classification of the Magnet Cove minerals: *Am. Mineral.*, **16**, [No. 8], 313 (1931).

<sup>5</sup> Landis, K. K., Parks, Bryan, and Scheid, Vernon E., Mining districts of the eastern states: *XVI International Geol. Congress, Guidebook 2, Excursion A-E*.

<sup>6</sup> Williams, J. F., *op. cit.*

<sup>7</sup> Miser, H. D., and Stevens, R. E., Taeniolite from Magnet Cove, Arkansas: *Am. Mineral.*, **23**, [No. 2], 104 (1938).

<sup>8</sup> Sleight, V. G., Molybdenite at Magnet Cove, Arkansas: *Am. Mineral.*, **26**, 132 (1941).

ular masses, or more commonly in close association or as an intergrowth with hackmanite, similar to the occurrence from Kishengarh State, Rajputna, India, described by Vredenburg<sup>9</sup> in 1904, and from Kola Peninsula, U.S.S.R., by Fersman<sup>10</sup> in 1926.

The blue sodalite contains pyrite, calcite, black biotite, and purple fluorite which sometimes forms a rim around the edges. The most common alteration product of the blue sodalite is thomsonite. The colorless

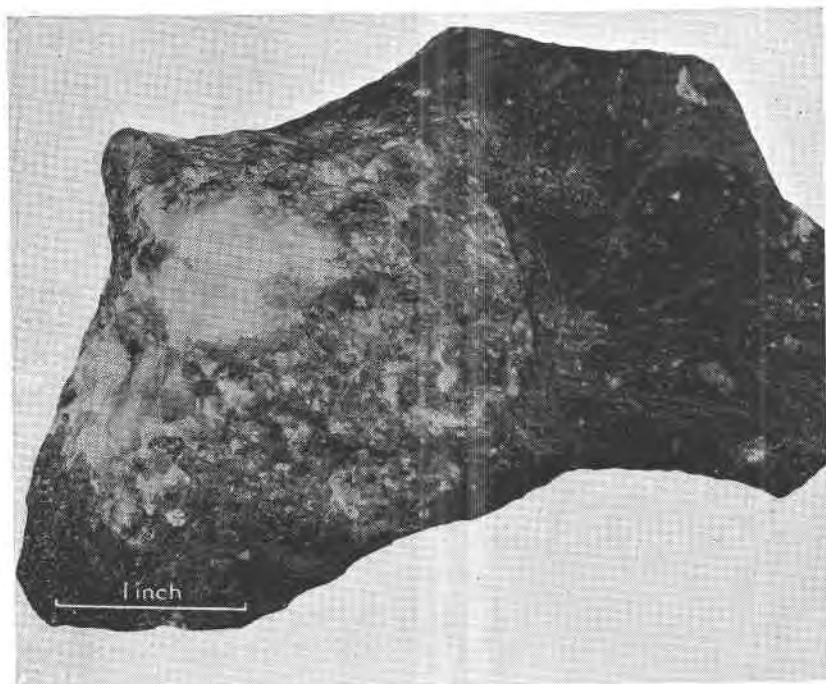


FIG. 1. Photograph showing a sodalite-hackmanite mass in tinguaitite dike rock from Kimzey quarry, Magnet Cove, Arkansas. The white almost circular center is evanescent hackmanite surrounded by a mottled zone of blue sodalite interspersed with patches of hackmanite. Both minerals are fluorescent. Scale in inches.

sodalite (hackmanite) in general is free from inclusions, only a little intergrown calcite having been noted. The hackmanite is usually surrounded by a zone of blue sodalite interspersed with patches of white hackmanite or intimate intergrowth without distinguishable boundaries (Fig. 1).

<sup>9</sup> Vredenburg, E., Elaeolite and sodalite-syenite in Kishengarh State: *Records of Geol. Survey of India*, **31**, 43-44 (1904).

<sup>10</sup> Fersman, A. E., Minerals of the Kola Peninsula: *Am. Mineral.*, **11**, [No. 11], 289-299 (1926).

## FLUORESCENCE AND EVANESCENCE

Sodalite was discovered and named by Dr. Thomas Thomson<sup>11</sup> at Edinburgh in 1810. The material was obtained from Mr. Thomas Allan, who had purchased a collection of minerals from west Greenland. Dr. Thomson gives the following description of the original material: "Sodalite occurs in a primitive rock mixed with sahlite (diopside-hedenbergite), augite, hornblende, and garnet. It occurs massive, and crystallized in rhombic dodecahedrons. Its colour is intermediate between celandine and mountain green . . . particles of [green] sahlite doubtless modify the colour. . . . No mineral has hitherto been found containing nearly so much soda as this, hence the reason for the name by which I have distinguished it."

Dr. Thomson makes no mention of the color change of the sodalite from Greenland. Robert Allan,<sup>12</sup> the son of Thomas Allan, however, states in his *Manual of Mineralogy*, published in 1834, that the mineral from West Greenland "is associated with feldspar, arfvedsonite, eudyalite, and augite, . . . its colour is green unless newly fractured, when it presents a brilliant pink tinge, but this on exposure to light goes off in a few hours." Since this is the material analyzed by Dr. Thomas Thomson and named sodalite by him, the original sodalite was evanescent, and was no doubt the same variety of sodalite as that described later from Kola and given the name hackmanite by Borgström.<sup>13</sup>

No color change was noted in the fluorescent sodalite from New Jersey and from New Hampshire described by Smith.<sup>14</sup>

Under ultra-violet light the blue sodalite from Magnet Cove fluoresces a purplish-blue to violet-red; but it is the white hackmanite that displays a magnificent show of fluorescence, glowing so brightly that the duller fluorescence of the blue sodalite can hardly be seen. The fluorescence is bright golden-yellow under a Nico lamp, deep rose to reddish-orange under some mercury vapor lamps, firefly-yellow under the iron arc, and pink under the argon lamp. No phosphorescence nor thermoluminescence was noted.

The white hackmanite, in addition to its spectacular fluorescence, also shows the phenomenon of evanescence. By daylight it is white and translucent to colorless and transparent. Some of these specimens when kept in the dark for two or three weeks assume a lilac-rose color which disap-

<sup>11</sup> Thomson, Thomas, Chemical analysis of sodalite, a new mineral from Greenland: *R. Soc. Ed. Tr.*, [6], 5, 387 (1810).

<sup>12</sup> Allan, Robert, *A Manual of Mineralogy*, Edinburgh, 1834.

<sup>13</sup> Borgström, L. H., Hackmanit ett nytt mineral i sodalitgruppen: *Geol. För. Stockholm*, 23, 563 (1901).

<sup>14</sup> Smith, Lawrence L., Fluorescent sodalite: *Am. Mineral.*, 22, [No. 4], 304 (1937).

pears rapidly (within two minutes) on exposure to daylight and almost instantly in direct sunlight. The restoration of the rose color is greatly accelerated by exposure to ultra-violet rays. Exposed to ultra-violet rays for two to five minutes the colorless hackmanite assumes a brilliant lilac-rose color which fades rapidly in daylight. The color seems to reappear more completely in some of the specimens than in others and not at all in some.

The induced color change of hackmanite when exposed to ultra-violet light was first observed by O. Ivan Lee<sup>15</sup> on hackmanite from Bancroft, Ontario, which changed from pink to a raspberry shade or deep violet on exposure to ultra-violet light. The induced color faded rapidly and nearly completely on exposure to a strong light.

Hackmanite from a sodalite-aegerite rock (tawite) from Kola Peninsula, Lapland (U.S.S.R.) was described as a new variety of sodalite by Borgström.<sup>16</sup>

At nearly the same time (work published in 1904) Vredenburg,<sup>17</sup> who was working in India, discovered a peculiar sodalite which exhibited a bright red color on the freshly broken surface of the rock in which it occurred. He observed that the red color disappeared rapidly on being exposed to bright daylight and that the colorless mineral then would resume a pink color when kept in darkness for a fortnight or three weeks. This phenomenon, he stated, had not previously been recorded for any mineral.

The third recorded occurrence of this peculiar variety of sodalite is at Bancroft, Ontario, and was described by Walker and Parsons<sup>18</sup> in 1925, who proposed the term "evanescent" to describe this color change. The evanescent hackmanite at Bancroft is associated with cancrinite, nepheline, and calcite as it is at the other three localities. An occurrence of the hackmanite variety of sodalite from Korea is described by Iwase,<sup>19</sup> and an unrecorded occurrence of hackmanite has been observed in the Ice River region in British Columbia.<sup>20</sup>

The fluorite and calcite associated with the sodalite from Magnet Cove

<sup>15</sup> Lee, O. Ivan, A new property of matter: Reversible photosensitivity in hackmanite from Bancroft, Ontario: *Am. Mineral.*, **21**, [part 1, No. 12], 764-776 (1936).

<sup>16</sup> Borgström, L. H., Hackmanit ett nytt mineral i sodalitgruppen: *Geol. För. Stockholm*, **23**, 563 (1901).

<sup>17</sup> Vredenburg, E., Elaeolite and soda syenites in Kishengarh State, Rajputana, India: *Records of Geol. Survey of India*, **31**, 43-44 (1904).

<sup>18</sup> Walker, T. L., and Parsons, A. L., Evanescent pink sodalite or hackmanite from Bancroft, Ontario: *Am. Mineral.*, **10**, [No. 3], 66 (1925).

<sup>19</sup> Iwase, Ei-ichi, Über die photochemischen Eigenschaften des Sodaliths von Kisshu, Korea: *Zeits. Krist.*, **99**, 314 (1938).

<sup>20</sup> Personal letter from Dr. A. L. Parsons.

are both thermoluminescent. When heated, the fluorite (chlorophane variety) glows with a yellowish-green color, and the calcite, like all the calcite from Magnet Cove that was tested, emits a brilliant yellow, almost flame-colored light.

#### PROPERTIES

All of the sodalite collected at Magnet Cove is massive, but a few traces of hexagonal outline were observed under the microscope. The sodalite is seen to contain numerous dust-like inclusions. The bright blue sodalite has a specific gravity of 2.278 and index of refraction of 1.483. The white or colorless hackmanite has a specific gravity of 2.287 and index of refraction of 1.487, and frequently shows weak birefringence probably due to strain.

#### COMPOSITION

An analysis of the deep blue sodalite from Magnet Cove is shown in column I of Table 1. For comparison, the analysis of the blue sodalite from India, associated with the evanescent hackmanite, is given in column II, and of the original green sodalite from Greenland in column III.

A sample of the purest, more transparent, and colorless hackmanite from Magnet Cove was analyzed with the following results, column I, Table 2. When dissolved in dilute hot hydrochloric acid,  $H_2S$  was evolved, showing the presence of a sulphide. For comparison the analysis of hackmanite from the Kola Peninsula is given in column II, and of that from Bancroft, Ontario, in column III.

TABLE 1. BLUE SODALITE FROM MAGNET COVE, ARKANSAS (I), COMPARED CHEMICALLY WITH BLUE SODALITE ASSOCIATED WITH HACKMANITE FROM RAJPUTANA, INDIA, AND WITH THE ORIGINAL SODALITE FROM GREENLAND.

	I Magnet Cove, Ark.	II Rajputana, India	III Greenland	
SiO <sub>2</sub>	36.36	38.055	38.52	
Al <sub>2</sub> O <sub>3</sub>	32.09	31.300	27.48	
Fe <sub>2</sub> O <sub>3</sub>	0.07	trace	—	
FeO	none	—	—	
TiO <sub>2</sub>	none	—	—	
MnO	0.06	—	—	
MgO	none	—	—	
Na <sub>2</sub> O	24.73	24.77	23.50	
K <sub>2</sub> O	0.12	—	—	
H <sub>2</sub> O-110° C.	0.12	} 0.82	loss on ign.	1.70
H <sub>2</sub> O+110° C.	0.86		muriatic acid	3.00
Cl	6.79	7.18		
S	none	—		
SO <sub>3</sub>	trace	trace	volatile matter	2.10
CaCO <sub>3</sub> <sup>1</sup>	0.50	0.001 (CaO)		
	<hr/> 101.70			<hr/> 100.00
Less oxygen equiv. for Cl	1.53	1.618		
Total	<hr/> 100.17	<hr/> 100.508		
Sp. gr.	2.278 <sup>2</sup>	2.27		2.378

I. Blue sodalite from Magnet Cove, Arkansas. J. J. Fahey, analyst.

II. Blue sodalite from Rajputana, India. E. Vredenburg, analyst.

III. Green sodalite from Greenland. Thomas Thomson, analyst.

<sup>1</sup> Identified as calcite in thin section.

<sup>2</sup> Sp. gr. determined by the Berman precision balance.

TABLE 2. ANALYSIS OF HACKMANITE FROM MAGNET COVE, ARKANSAS (COLUMN I), COMPARED WITH THE ORIGINAL ANALYSIS OF THE HACKMANITE FROM KOLA PENINSULA (COLUMN II), AND WITH HACKMANITE FROM BANCROFT, ONTARIO, CANADA (COLUMN III).

	I Magnet Cove, Ark.	II Kola Peninsula, U.S.S.R.	III Bancroft, Ont.
SiO <sub>2</sub>	36.70	36.99	37.08
Al <sub>2</sub> O <sub>3</sub>	32.01	31.77	32.58
Fe <sub>2</sub> O <sub>3</sub>	0.07	0.17	—
FeO	none	—	—
TiO <sub>2</sub>	none	—	—
MnO	none	—	trace
MgO	none	none	0.03
Na <sub>2</sub> O	24.79	25.84	22.26
K <sub>2</sub> O	0.17	0.16	.53
H <sub>2</sub> O-110° C.	none	—	} 0.67
H <sub>2</sub> O+110° C.	0.36	—	
Cl	7.00	6.44	6.82
S	trace	0.39	—
SO <sub>3</sub>	trace	—	—
CaCO <sub>3</sub> <sup>1</sup>	0.29	—	(CO <sub>2</sub> ) 0.32
	<hr/> 101.39	<hr/> 101.81	<hr/> 100.79
Less oxygen equiv. for Cl	1.58	1.64	1.53
Total	<hr/> 99.81	<hr/> 100.17	<hr/> 99.26
Sp. gr.	2.286 <sup>2</sup>	2.32-2.33 <sup>3</sup>	

I. Hackmanite from Magnet Cove, Arkansas, J. J. Fahey, analyst.

II. Hackmanite from Kola Peninsula. L. H. Borgström, analyst.

III. Hackmanite from Bancroft, Ontario, Canada. H. C. Rickaby, analyst.

<sup>1</sup> Identified as calcite.

<sup>2</sup> Specific gravity determined on the Berman balance.

<sup>3</sup> Specific gravity 3.32 to 3.33 originally given is a misprint. In a letter from Leon H. Borgström, dated Nov. 20, 1925, written to Prof. T. L. Walker, Toronto, he says, "We made a new determination of the specific gravity of this mineral and found 2.33 (not 3.33). 3.33 is a misprint."



The analyses show that the two varieties of sodalite at Magnet Cove have almost the same chemical composition. A trace of sulphide was found in the hackmanite and none in the blue sodalite, which, however, contains a small quantity of manganese. The specific gravity of the two varieties is nearly the same. A comparison of the analyses of the variously colored sodalites (blue, pink, and colorless) shows that the composition is essentially the same; that is, the variation between the different colored varieties is no greater than the variation in different analyses for the same colored varieties. The assumption that manganese is probably accountable for the evanescent phenomenon does not hold for the Magnet Cove hackmanite which shows none.

The most noticeable difference aside from the color change is the difference in index of refraction. The blue sodalite from Magnet Cove shows  $n = 1.483$ , and for hackmanite  $n = 1.487$ . A study of the indices of refraction for sodalities made by Iwase<sup>21</sup> shows that the colorless and blue varieties have consistently  $n = 1.483$ , and that the rose colored (hackmanite) variety has  $n = 1.485$  to  $1.487$ . It is difficult to account for this constant difference in indices on the basis of the chemical analyses alone.

<sup>21</sup> Iwase, *op. cit.*