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Halloysite Deposits of Western North Carolina

BY

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LETTER OF TRANSMITTAL

Raleigh, North Carolina
April 22, 1949

To His Excellency, Hon. W. Kerr Scott
Governor of North Carolina

Sir:

I have the honor to submit herewith manuscript for publication as Bulletin 58, "Halloysite Deposits of Western North Carolina." This bulletin is another in the series being made possible by the cooperation of the Tennessee Valley Authority.

Halloysite is a mineral close to kaolin in composition and physical properties. North Carolina has been, for many years, an important producer of residual kaolin. During the past six years it has been demonstrated that some of the residual kaolin deposits of the State contain important amounts of halloysite. It has also been found that five to ten per cent of halloysite in a ceramic body improve its whiteness and gloss.

This report indicates that the halloysite reserves of western North Carolina are of commercial importance, and it is believed that the information contained herein will be of value to those interested in developing the deposits.

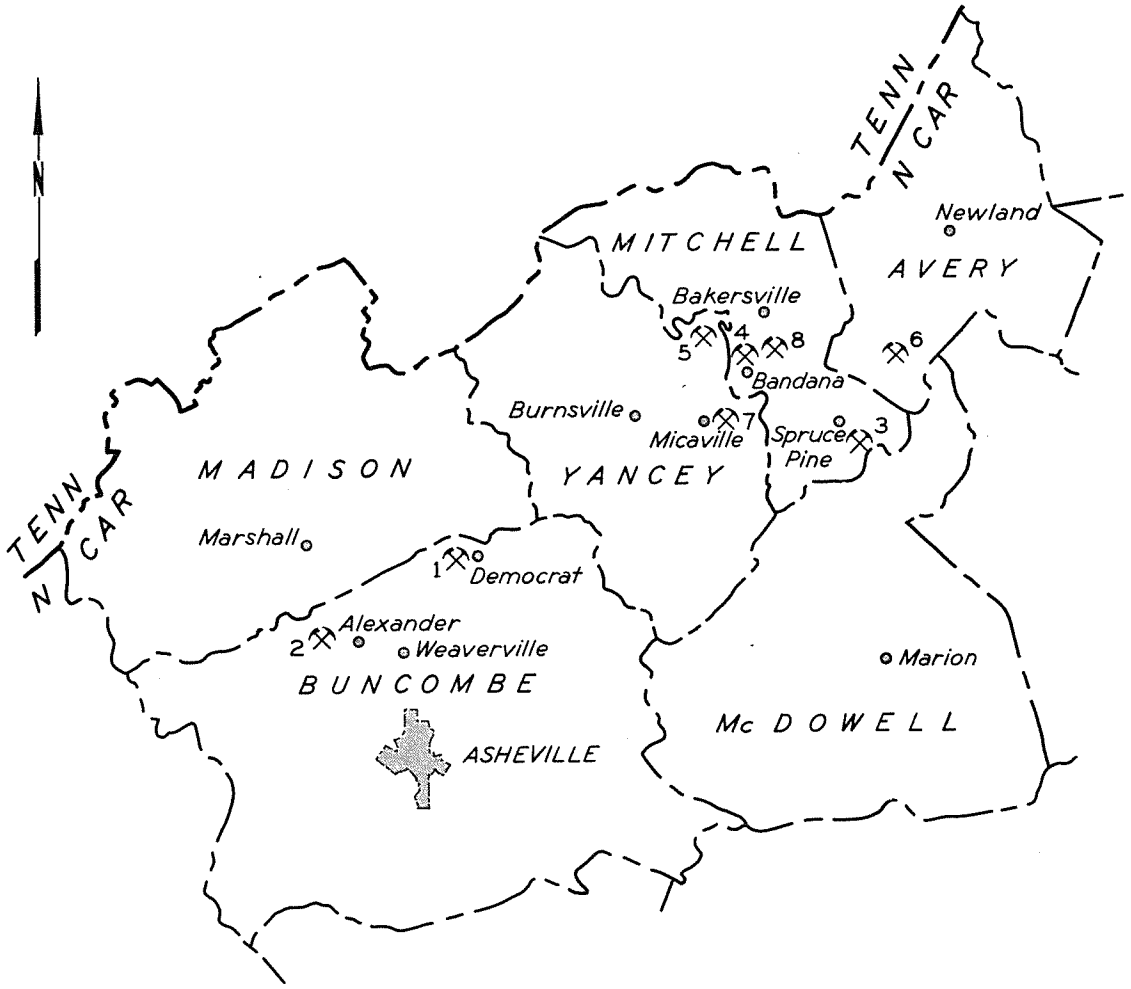
Respectfully submitted,

R. BRUCE ETHERIDGE
Director

CONTENTS

CONTENTS—Continued

PLATES



HALLOYSITE MINES

1 Arrowood Mine
2 Alexander Mine
3 Carter Ridge Mine
4 Johnson Mine
5 Green Mountain Mine
6 Gusher Knob Mine
7 Micaville Mine
8 Fluken Ridge Mine

LOCATION OF PRINCIPAL HALLOYSITE MINES OF WESTERN NORTH CAROLINA

10 0 10 20
Scale in Miles

PLATE 1

HALLOYSITE DEPOSITS OF WESTERN NORTH CAROLINA

By

CHARLES E. HUNTER* AND LEWIS J. HASH*

SUMMARY

Halloysite is a white clay mineral very similar to kaolinite in chemical composition, physical properties, and appearance.

The first domestic use of halloysite in this area (about 1913) was in the manufacture of aluminum sulphate from ore mined in the vicinity of Gore, Georgia.[1] In recent years this clay mineral has become commercially important as an ingredient in ceramic products. Its unusual properties give a glossy whiteness to porcelain containing from 5 to 10 percent halloysite in the ceramic body. Interest in halloysite as a ceramic material is increasing and several potteries are actively experimenting with it at present. The mining of halloysite in western North Carolina, which began in 1943, has been intermittent and usually of limited extent. Although the demand is not great at the present time, production has increased in recent years and there is reason to believe it will continue to rise.

The halloysite deposits described in this report consist of a mixture of halloysite and kaolinite which were formed by the alteration of feldspar in pegmatites and alaskites (type of granite). These residual deposits occur in weathered pegmatites and weathered alaskite bodies from Clay County northeastward to Avery County. Accordingly, two principal types of deposits are here recognized; namely, block halloysite, occuring in weathered pegmatites, and halloysite deposits found in weathered alaskite bodies. The former type is freer from intimately mixed quartz, feldspar, and other undesirable minerals.

At most of the operations, the overburden is removed with bulldozers or other powered equipment. Selective mining with picks and shovels is practiced to obtain halloysite in block form. Undesirable minerals and stained portions are trimmed from the blocks before the clay is transferred to a drying shed. The principal production and largest reserves are in Buncombe, Avery, and Mitchell Counties. It is estimated that 28,000 tons of block halloysite could be recovered from the five major deposits described in detail, with a possible recovery of 36,000 tons. The other deposits, observed in the field but not studied in detail, contain an estimated 45,000 to 65,000 tons, which would give an over-all tonnage of from 75,000 to 100,000 tons of block halloysite. In addition, there are over 100,000 tons of halloysite occurring in weathered alaskite deposits that could be recovered by refining, in existing clay plants in the area.

[1] Watkins, J. H., New Occurrences and Use of Halloysite. Min and Engr. World, vol. 38, 1913.

* Geologists, Regional Minerals Section, Division of Chemical Engineering, Tennessee Valley Authority.

INTRODUCTION

PURPOSE AND SCOPE OF REPORT

The purpose of this survey was to locate the halloysite deposits in western North Carolina, determine their quality and probable tonnage, and to make this information available. Accordingly, five major deposits are described in detail, together with tonnage estimates, chemical analysis, detailed geology and maps. In addition to showing the locations, outlines, and related geology of the larger and better known halloysite deposits, the maps contain data useful in determining the reserve tonnages and, in many cases, making estimates of the overburden to be removed. It is believed that these detailed maps will be of great advantage in helping producers to plan their mining operations. The report also describes numerous other occurrences and locations of areas believed to contain halloysite deposits. Because of the limited time for field studies, thorough investigations could not be carried out in these areas. However, the favorable geological conditions observed, and the occurrences found, are good indications of the existence of workable deposits. The authors wish to point out that they are aware of several known occurrences in the Piedmont area of the state--principally in Cleveland and Catawba Counties.

HISTORY

The first record of clay being produced in North Carolina and sold as halloysite was in 1943. During that year, Marshall Mills, president of the Victor Mica Company, Spruce Pine, North Carolina, mined from a deposit about two miles south of Spruce Pine, and made a few small trial shipments. At that time the occurrence was known as the Grassy Creek deposit. Later this deposit was obtained by the Spruce Pine Mining Company, and the halloysite produced from it has become known as the Carter Ridge type.

In 1944 the Harris Clay Company, Spruce Pine, North Carolina, obtained the clay mining rights on the Sluder farm near Alexander, Buncombe County. From that date until late 1946 halloysite was produced from a deposit there and sold to the trade as the Buncombe, or Alexander type. This operation was under the direction of Fred E. Smith, general manager of the Harris Clay Company. The production from the Alexander deposit stopped shortly after Mr. Smith's death in 1946.

From 1947 until the present, the principal producer of halloysite in North Carolina has been the Spruce Pine Mining Company, under the direction of Paul Henline. Their principal production has been from the Carter Ridge deposit in Mitchell County and the Arrowood deposit in Buncombe County. The present producers are the Spruce Pine Mining Company and the Harris Clay Company, Spruce Pine, North Carolina.

Halloysite production in western North Carolina and its use in the ceramic industry is relatively new. It is believed that the demand will increase when more

potential users become aware of its desirable properties and availability. An increased demand will stimulate the local mining industry to produce a more uniform product which may eventually promote the use of some beneficiation equipment.

FIELD WORK AND ACKNOWLEDGMENTS

The field work was done by staff members of the Regional Minerals Section of the Division of Chemical Engineering, Tennessee Valley Authority, and extended from July 1, 1948 to December 1, 1948. (Continuous field work on halloysite during this period was not possible, because the personnel working on this project carried out numerous other mineral assignments simultaneously with the halloysite study.) The survey was under the general supervision of Mr. H. S. Rankin, Mining Engineer, Tennessee Valley Authority.

The authors greatly appreciate the help and cooperation given them by local residents of western North Carolina, and especially that of Paul Henline, Spruce Pine Mining Company, Spruce Pine; S. W. Enloe, Sr., President and Roy Weld, General Superintendent, Harris Clay Company, Spruce Pine; and Bradley Johnson, Asheville. The North Carolina State College Minerals Research Laboratory, Asheville, made tests on halloysite samples and furnished chemical analyses used in this report.

GEOLOGY

Halloysite in western North Carolina occurs in weathered feldspar pegmatites and weathered alaskite bodies. The pegmatites vary from a few inches to nearly 100 feet in width and from a few feet to over 300 feet in length. Although some of the alaskite bodies are several thousand feet in length, only certain areas in them contain workable deposits of halloysite. The known workable occurrences of halloysite in North Carolina are restricted almost entirely to the mountainous western part of the state. The rock formations in the mountain province, in which the halloysite occurs, are mostly crystalline schists, gneisses and granites, and are considered to be pre-Cambrian in age. There are, however, several granites and numerous pegmatite intrusions of much younger age, some of which are thought to be Carboniferous. In general, these formations have a prevailing northeast-southwest strike, and southeast dip, although locally these may vary considerably. This area has undergone considerable uplift, continued and deep weathering, with subsequent erosion. This erosion has exposed the pegmatites with which this report is concerned.

Pegmatites are difficult to classify. If a classification must be made, the halloysite producing pegmatites fall in the category of the feldspar type. By this, it is meant that the predominating mineral in the formation is feldspar, usually of the large crystal, or blocky type. It is the weathering and subsequent alteration of these feldspar rich zones that produced halloysite. The largest pegmatites of this type have been intruded into massive country rock types, such as serpentine, hornblende gneiss, and the more gneissic formations of the schists. Usually these pegmatites were intruded along a structure, such as the contact between

two of these formations; however, in some cases, they parallel the foliation of of enclosing schists. It is possible that these intrusions may have followed some structural feature not apparent at the present time.

The halloysite pegmatites are composed of clay, quartz, and feldspar. They are unusually low in the percentage of accessory minerals such as garnet, muscovite, tourmaline, and the rare minerals such as beryl and zircon that are sometimes found in pegmatites. These pegmatites invariably contain some quartz core material, usually making up perhaps 15 percent of the formation. Zones of microcline feldspar were observed in all deposits, usually being more pronounced adjacent to or near, the quartz-rich part. This microcline, being more resistant to weathering or kaolinization, has remained hard, and frequently stands out in a conspicuous way. In the deposits described in this report, only microcline feldspar is found near the surface, but both microcline and plagioclase are found at depth. It is possible that halloysite results from the weathering of soda-lime feldspar, and that kaolinite results from the weathering of potash feldspar, thus accounting for the intimately mixed kaolinite and halloysite found in these deposits.

The halloysite pegmatites examined in this survey were found to vary in width from a few inches up to 90 feet. In general, their length is from three to four times their width. Halloysite mining has not disclosed the depth at which these pegmatites pinch out; however, judging from feldspar mining operations in this area, it can safely be predicted that they will extend in depth from between 1/3 and 1/2 their length.

In addition to the pegmatites there are many rather large alaskite occurrences in Avery, Mitchell, and Yancey Counties that contain workable deposits of halloysite. The alaskites were intruded into the same general types of rocks as those that are associated with the pegmatites. Alaskite deposits are much larger than the pegmatites, many of them being several thousand feet long and several hundred feet wide. The feldspar in the alaskite, where the topographic and other conditions were favorable, has been weathered and changed chemically into kaolin and halloysite. The halloysite is more plentiful in the alaskite in areas that contain the greatest number of pegmatite intrusions and pegmatite replacements. Several halloysite zones are well exposed in the kaolin pits of the area. On an average, these occurrences contain a higher percentage of quartz intermixed with the clay than is found in the pegmatite types.

Very little field data could be obtained concerning the geological conditions under which halloysite was formed. It is logical to assume that ordinary kaolinization processes[2] acted upon the feldspar to produce kaolin. After this, it is thought, some unusual condition converted from 20 to 60 percent of the kaolin to halloysite. The details of this action are not clear.

[2]Hunter, C. E. Residual Alaskite Kaolin Deposits of North Carolina, Bull. Amer. Ceram. Soc., vol. 19, no. 3, 1940. p. 100.

Clarence S. Ross has suggested that in some cases kaolinite and halloysite may have been formed simultaneously.[3] It was observed that all of these halloysite deposits occurred at well drained points; that is, they occurred near the top or along the side of a steep slope. It is suggested that alternate wetting and drying, with the possibility of aeration, may have been influential in the conversion of kaolinite to halloysite.

Weathering, or halloysitization, of these pegmatites extends to a depth of from a few feet up to 80 feet, the depth of weathering often depending on the pegmatite's topographic location. Below the zone of complete alteration the clay becomes harder and gradually grades into feldspar.

In all deposits examined, the clay was iron stained to a depth of approximately five feet, and all deposits contained numerous schist inclusions which usually made up from 10 to 20 percent of the volume of the deposit. The halloysite is usually iron stained near these inclusions, and also along joints or slip seams in the body.

MINERALOGY

Halloysite was first indentified in 1826 from the locality Angleur, Liege, Belgium.[4] It is a white clay mineral very similar to kaolinite in chemical composition, physical properties, and appearance. The hardness varies from 1 to 2 and specific gravity from 2.0 to 2.2. Although compact or friable when dry it become semi-plastic when wet.

According to Shearer,[5] "Halloysite is a hydrated silicate of aluminum, having the theoretical composition $Al_2O_3 \cdot 2SiO_2 \cdot 3H_2O$, that is 43.5 percent silica, 36.9 percent alumina, and 16.9 percent water. It contains one more molecule of combined water than kaolinite, and the elements seem to be less closely combined than in kaolins and ordinary clays." The water present is, in part, held mechanically since it is given off very readily. The resulting partially dehydrated material is near kaolin in composition. Humbert[6] has proven by the use of the electron microscope that halloysite is composed of rod shaped crystals, rather than hexagonal plate shaped crystals as found in kaolinite. It has the same type of aluminum silicate layers as kaolinite, but the layers are usually superimposed in a less orderly manner.[7]

The type of halloysite covered by this survey is invariably mixed with kaolinite and thus it is difficult to distinguish between the two. The halloysite is unusually white in color--generally much whiter than kaolinite. A simple procedure was discovered for identifying halloysite in the field. Halloysite is distinguished

[3] Ross, Clarence S. and Kerr, Paul F., Halloysite and Allophane, U. S. Geol. Survey, Professional Paper 185-G, 1934-35.

[4] Berthier, P., Analyse de L'halloysite: Annalis Chemic Phys., vol. 32, 1826.

[5] Shearer, H. K., A Report on the Bauxite and Fullers Earth of the Costal Plain of Georgia. Ga. Geol. Survey, Bull. 31, 1917, pp. 330-332

[6] Humbert, R. P., Particle Shape and the Behavior of Clay as Revealed by the Electron Microscope, Ceram. Abs., vol. 21, no. 11, 1942, pp. 260-263.

[7] Alexander, L. T., Faust, G. T., Hendricks, S. B., Insley, H., McMurdie, H. F., Relationship of the Clay Minerals Halloysite and Endellite. Amer. Mineralogist, vol. 28, no. 1, 1943, pp. 1-18.

from kaolinite by its ability to roll when sliced very thin with a knife, whereas kaolinite crumbles and powders in front of the knife blade. Also, dry halloysite adheres strongly when touched with the tongue. These tests were found to be reasonably accurate and of great assistance in rapid field determinations.

X-RAY DETERMINATIONS

Samples from various halloysite deposits in Western North Carolina were submitted to the Electrotechnical Laboratory, U. S. Bureau of Mines, Norris, Tennessee for X-ray determinations. The mineralogic compositions of the samples, as determined by this examination, are as follows:

Deposit	Halloysite	Meta-Halloysite	Kaolinite	Mica (Muscovite)
Alexander	trace?	90	5	5
Bethel	5	80	15	none
Arrowood	80	20	none	trace
Green Mountain	15	80	none	5
Carter Ridge	none	90	trace?	10(Biotite)
Webster	25	75	none	trace

This work was performed by Drs. Wilhelm Eitel and R. A. Hatch, who report that:

"The distinction between meta-halloysite and kaolinite is very difficult due to the remarkable similarity of their X-ray spectra. Compounds distinguished by the X-ray study are halloysite, $Al_2O_3 \cdot 2SiO_2 \cdot 4H_2O$; meta-halloysite, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$; kaolinite, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, and muscovite and biotite micas. Many near coincidences exist in the X-ray spectrograms of these compounds. As an aid in distinguishing between them, each sample was X-rayed a second time after first being dehydrated at 110°C for about 36 hours. Meta-halloysite forms readily from halloysite with this treatment thereby permitting a clear distinction between mica and halloysite. The distinction between halloysite mnd meta-halloysite presumes that the samples as received are unchanged from their original condition as mined."

CHEMICAL ANALYSES

The following chemical analyses of representative samples from the major halloysite deposits were made at the North Carolina Minerals Research Laboratory, Asheville.[8]

Location	SiO_2	R_2O_3	Fe_2O_3*	CaO	K_2O	Na_2O	Ign Loss**	
Arrowood Deposit	47.3%	37.9%	0.25%	Nil	0.13%	0.90%	13.8%	100.0
Alexander Deposit	45.0	39.9	0.29	Nil	0.46***		14.7	100.1
Carter Ridge Deposit	44.8	41.2	0.18	Nil	0.34***		13.9	100.2
Green Mountain Deposit	45.7	40.0	0.27	Nil	0.40***		14.0	100.1
Gusher Knob Deposit	49.6	37.0	0.27	Nil	1.06	0.48	12.3	100.4
Micaville Deposit	47.0	38.9	0.11	Nil	0.22***		13.8	99.9

* Total alkalies. ** Samples dried at 140°C. for 2 hours. *** Included in R_2O_3. $R_2O_3 - Fe_2O_3 = Al_2O_3$ for practical purposes.

[8] Chemical Analyses and Moisture Investigations by Philip N. Sales, Chemist, North Carolina Minerals Research Laboratory, Asheville, North Carolina.

MOISTURE INVESTIGATIONS

Tests were made at the Asheville Laboratory to determine moisture losses at elevated temperatures and moisture gains at room temperature after desiccation. The following data were obtained in these tests.

Moisture Losses	Arrowood Halloysite	Alexander Halloysite	Green Mountain Halloysite
% loss at 60° C. in 24 hours	2.2	2.1	1.2
% loss at 110° C. in 24 hours	2.7	2.5	1.5
% loss at 140° C. in 24 hours	2.7	2.5	1.5
Moisture Gain*			
% gain in weight in 1 hour	0.59	0.60	0.41
% gain in weight overnight	0.84	0.83	0.64

*Sample dried at 140° C. for 24 hours, desiccated for 1 hour in $CaSO_4$ desiccator. Allowed to stand 1 hour and overnight at room conditions.

MINING METHODS AND PROCESSING

At the time this survey was made the methods of mining and processing were similar at all operations. The principal production has come from open cuts, drifts, and rooms in the halloysite pegmatites. Of these, open cut mining predominates; however, tunnels are often driven from the face of an open cut into the purer zones of halloysite. Some room and pillar mining has been started at the Arrowood mine, Buncombe County. There the zones of pure halloysite have been mined, leaving halloysite that is stained or high in quartz and/or feldspar as pillars.

Overburden and stained halloysite are removed by a dragline or bulldozer. The clay is then broken down into blocks from 1 inch to 18 inches in diameter with picks and shovels because the use of explosives would shatter the clay until it could not be recovered in lump form. Stained halloysite and undesirable minerals, such as quartz, feldspar, mica, are trimmed from the blocks with knives or hatchets. The relatively pure blocks are then hoisted and transported to a drying shed where they remain two weeks or longer. The dry halloysite is then ready for shipment to the ceramic user.

At numerous localities halloysite is intimately mixed with quartz, mica, and sometimes feldspar. This condition was found at many of the pegmatites examined and in all of the kaolin pits in alaskite in the Spruce Pine area. In most instances deposits of this type contain larger tonnages than those of the pure block type. It is believed that in some of these deposits the halloysite which is mixed with quartz and other minerals could be mined mechanically and refined in a clay reclaiming plant similar to those operating in the Spruce Pine area. One company is now experimenting with procedures for recovering halloysite

from this type of deposit. If the demand and the market price could sustain such operations, selective mining and mechanization would greatly increase the production of halloysite in western North Carolina

RESERVES

The major deposits of pegmatite (block type) halloysite are the Arrowood and Alexander deposits in Buncombe County, and the Carter Ridge and Fluken Ridge deposits in Mitchell County. Of these, the Arrowood deposit contains the greatest tonnage, and it is believed that more block halloysite could be recovered there than at any other known deposit in western North Carolina. Smaller deposits in Avery, Mitchell, Yancey, Haywood, Jackson, Swain, Macon and Clay Counties are also described in this report. These deposits, some of which are relatively small, do not represent large tonnages individually; however, when taken as a whole, they increase the reserves in western North Carolina a great deal. Due to the present methods of mining block halloysite, some of these smaller deposits can be worked as efficiently as the larger deposits. Zones of halloysite are often found in pegmatites being worked for feldspar, and recovery of halloysite in these mines would be relatively inexpensive. This applies particularly to the Fluken Ridge deposit, Mitchell County, and also to some of the other mines in Mitchell and Yancey Counties. Undoubtedly, some halloysite could be recovered from mica mining operations in the Piedmont area.

The major occurrences of alaskite halloysite are the Gusher Knob deposit, Avery County, and Micaville deposit, Yancey County. Because quartz and clay are intimately mixed in these deposits, very little halloysite could be recovered by hand sorting and trimming; however, they represent a large potential supply of halloysite that could be recovered by selective mining and processing in a kaolin recovery plant.

The method used for calculating tonnage reserves of individual deposits was as follows.

The volume of the deposit was computed from measurements of the areal extent and assumed depth of weathering. From this was subtracted the sum of the estimated volumes of stained halloysite, schist inclusions, and quartz. The resulting figure represented the volume which, in the writers' opinions, could be worked by selective mining. Estimated losses due to necessary trimming of the mined material were substracted from this figure to obtain the tonnages representing recoverable reserves.

Although it was not practical to prepare detailed estimates for the occurrences in weathered alaskites, the total reserves of this type in Avery, Mitchell, and Yancey Counties are estimated at 100,000 tons.

The estimated reserves of block halloysite occurring in weathered pegmatites are given below. The classes of these reserves may be defined as follows:

Measured reserves are those calculated from dimensions exposed in outcrops and workings, and conservative estimates of the depth weathering.

Indicated reserves are those computed partly from specific measurements, and partly from interpretations of geologic evidence projected for a reasonable distance.

Inferred reserves are those which are based largely on interpreptations of the geologic character of the deposit and assumed continuity of conditions in adjacent concealed areas.

Estimated Reserves Block Halloysite

Deposits	Measured (Tons)	Indicated (Tons)	Inferred (Tons)	Total (Tons)
Arrowood	6,000	8,500	3,000	17,500
Alexander	4,000	4,000	2,000	10,000
Carter Ridge	2,000	1,500	2,000	5,500
Johnson	1,000	500		1,500
Green Mountain	1,000		500	1,500
Total	14,000	14,500	7,500	36,000

Counties	Probable (Tons)	Possible (Tons)
Avery	6,500	10,000
Mitchell	15,000	20,000
Yancey	1,500	2,500
Buncombe	22,000	27,000
Haywood	2,500	3,500
Jackson	15,000	20,000
Swain	5,000	6,500
Macon	5,000	6,500
Clay	2,500	4,000
Total	75,000	100,000

DESCRIPTIONS OF DEPOSITS

BLOCK TYPE HALLOYSITE IN PEGMATITES

Avery County

Beech Deposit

This deposit includes a series of pegmatites at Beech Bottom Settlement in Avery County, located 11 miles northeast of Spruce Pine, and from 300 to 500 feet north of U. S. Highway 19E.

Some of these pegmatites have been producing feldspar for about twenty years, and are active producers of feldspar at the present time. The main feldspar producing pegmatite is about 300 feet north of the highway. This pegmatite contains some halloysite near the surface; however, the principal halloysite-bearing pegmatites are on the adjoining hill, east of the main mine.

For the most, part these pegmatites were intruded into, and near the contact of a rather large alaskite body; the eastern-most one, however, was intruded into hornblende gneiss. These pegmatites are relatively large, averaging perhaps 50 feet wide. They strike from N 60°W to N 80°W and dip rather steeply to the southwest. They contain a very low percent of accessory minerals, and produce a good grade of block feldspar.

About 200 feet east of the main feldspar producing deposits, numerous shafts and tunnels were driven into a pegmatite in search of feldspar. Halloysite was encountered in this development work, however, it was impossible to determine the size of the deposit from the workings. This pegmatite contains some halloysite that could be recovered by hand trimming, and apparently a larger tonnage that is intricately mixed with small angular pieces of quartz and feldspar.

On the crest of a ridge about 300 feet to the east is a similar deposit which was prospected for feldspar many years ago. Recently the Harris Clay Company put down several drill holes to determine its possibilities as a producer of halloysite. The drill holes were put down at random over an area about 100 feet square, and halloysite was encountered in most of these holes. It was impossible to tell the quality of halloysite from this drilling, but from the nature of other deposits in the area, it should prove to be a good grade of halloysite. It is believed that both of the above described occurrences are worthy of further prospecting, and that they have good possibilities as producers of halloysite.

Mitchell County

Carter Ridge Deposit

Location

The Carter Ridge halloysite deposit is located in the southeast part of Mitchell

County, 1-1/2 airline miles S 35°E of Spruce Pine. It can best be reached by following N. C. Highway 26, 1 mile south of Spruce Pine, turning left at the recreation lake, and following a gravel road one mile northeast.

History

In 1942, while searching for additional scrap mica deposits, Marshall Mills of the Victor Mica Company, Spruce Pine, uncovered some unusual clay. He immediately became interested in the economic possibilities of this clay and sent a number of samples to numerous possible users. Following this, he became aware that the clay contained an appreciable amount of halloysite. During the latter part of that year, Mr. Mills made a few shipments of hand picked white halloysite to be used in ceramic mixtures.

A few years ago, the Spruce Pine Mining Company acquired the Carter Ridge deposit. During the past few years, this company, under the direction of Paul Henline, has intermittently mined and sold halloysite from this deposit.

General Geology

The rock types in the immediate vicinity of the Carter Ridge deposit consist of muscovite-biotite gneiss, muscovite schist, and a pyroxenite dike. In general, the foliation of these rocks strikes approximately N 5°W, and dips from nearly vertical to less than 15 degrees to the northeast. Several folds in the mica gneiss strike parallel to the above foliation and plunge approximately 30° to the northeast. In the area of these folds, a small amount of the rocks have a foliation dip to the southeast. The mica schist is not as well exposed; therefore, the details of its structure were not obtainable. A single basic dike, varying from a few inches to perhaps six feet in width and striking essentially north-south, cuts through the mica gneiss in the area observed to contain the greatest number of folds. This pyroxenite dike, with nearly vertical dip at the points of exposure, shows a considerable amount of alteration to biotite and chlorite. All of these rock types are deeply weathered.

Pegmatite

The Carter Ridge deposit consists essentially of two parts; one of these is an unusually large quartz vein and the other an irregular shaped tongue of pegmatite material. The quartz vein, which is a rather pure milky quartz, that does not contain any feldspar or mica, appears to be a quartz core. Some feldspar and halloysite were observed along the northeast side of this quartz body which strikes N 25°W, and is approximately 225 feet long and 25 feet wide. The boundaries of this quartz vein are not well exposed but it is highly probable that pegmatite material extends at least 20 or 25 feet on both sides of the outcrop. The second part of the above pegmatite is of principal concern here, as it is from this part that halloysite has been produced. This part of the pegmatite has apparently been injected into a fold in the country rock, and has a contact with mica schist on the west and with mica gneiss and a basic dike on the east. It was impossible to trace the contacts outside of the boundaries of the present workings. The pegmatite varies in width from 30 to 60 feet, and the present workings show it to have a length of 90 feet; however, it is believed that it

underlies an area much larger than is shown on the map. It is highly probable that the halloysite extends along the northeast side of the quartz core, and connects with the halloysite exposed in the road cut (see plate 2). If this condition exists, a large tonnage of halloysite can be recovered between the present workings and the road. This area in doubt is covered with a considerable amount of float quartz. It was reported that halloysite was encountered in drilling to the south of the present workings and it is logical to assume that the pegmatite extends from 30 to 60 feet, or a greater distance, in that direction.

The pegmatite strikes north on the southern end but makes an irregular curve and strikes N 40°W on the northern end. It dips approximately 40° to the west on the southern end, 30° northeast along the center, and 45°to the southwest on the northwest end.

The pegmatite contains numerous schist inclusions, varying up to four or five feet in width and up to twenty-five feet in length. The feldspar has altered to halloysite to a depth of 60 feet, and probably to a depth of 80 feet in places. There is no feldspar exposed but in places the clay contains a relatively high percentage of quartz and is badly stained. There are numerous seams along which there has been slight movement, and the halloysite is usually very badly iron stained along these seams.

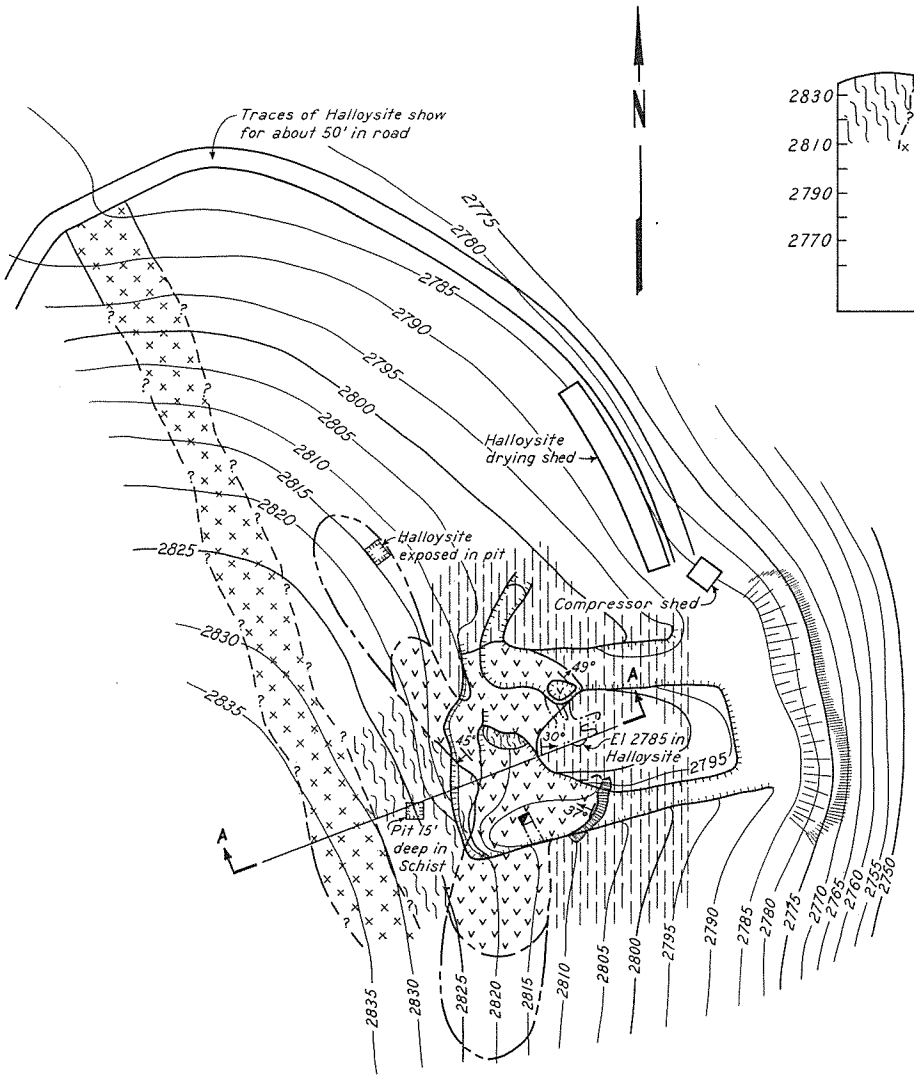
Halloysite

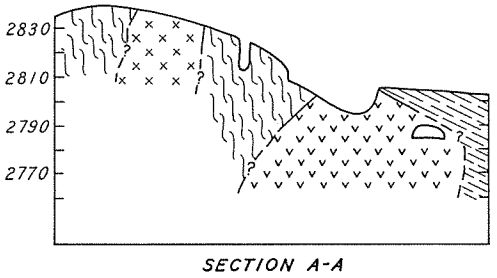
It is estimated that 50 percent of the halloysite is too ironstained for commercial use. This will increase mining costs, because the halloysite will require more trimming. It is reasonable to assume that the amount of stained halloysite will greatly decrease with depth. Some zones of halloysite are exposed in which the clay is mixed with small angular pieces of quartz. The quartz pieces average about 1/4 inch in diameter, and make up about 5 percent of the pegmatite volume. It is not believed this quartz will interfere greatly with mining and trimming or marketing of the product.

The unstained halloysite is very white and semi-plastic when wet, but becomes relatively hard and holds together well when dry. It has been reported that manufacturers prefer this halloysite to that from other deposits in the area.

Mining Methods

The workings (see plate 2) consist of a very irregular open cut, two prospect pits, and numerous tunnels (most of which are inaccessible). The main cut is about 90 feet long, 30 to 40 feet wide, and varies from 5 to 30 feet deep. It is deepest at the two ends of the cut where most of the mining has been done. There are two roads to the pit, one joining each end of the pit. Recently, halloysite has been mined from the west side of the open cut and from the tunnel on the east side of the cut. A bulldozer was used to remove the stained overburden part of the deposit and some of the weathered country rock. The best halloysite was mined from small underground rooms and from tunnels and drifts. A drag line pan, worked by a double drum hoist is used to clean out the open cut and to deliver halloysite to the entry of the drying shed.





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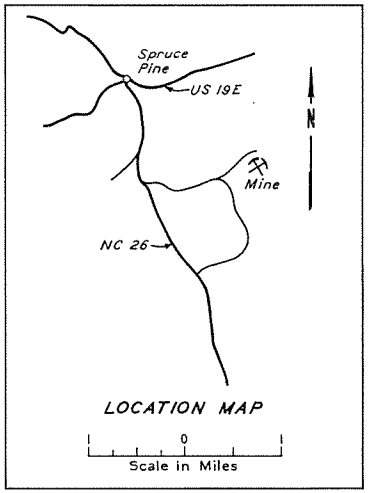


EXPLANATION

- Pegmatite (Mostly Halloysite)
- Quartz
- Weathered Hornblende Dike
- Mica Gneiss
- Mica Schist
- Pegmatite Contact
- 45° Strike and Dip of Pegmatite
- Underground workings
- Rim of Open Cut
- Dump
- —2780— Contour
- Indicated Pegmatite
- Inferred Pegmatite
- Contact, Approximate Location

CARTER RIDGE HALLOYSITE MINE

MITCHELL COUNTY, NORTH CAROLINA

40 0 40 80
Scale in Feet

Mapped by L.J. Hash
Geology by C.E. Hunter and L.J. Hash
September 1948

PLATE 2

Future Mining

It is believed that mining would be most efficient by removing the high ground between the two entry cuts where the pegmatite dips 30° to the northeast. This work should expose a worthwhile tonnage of halloysite. Elsewhere the pegmatite dips to the southwest into the ridge, and a considerable amount of overburden will have to be removed to expose the pegmatite, and eventually underground mining methods will have to be employed. It is believed that further prospecting at the ends of the pegmatite, either by drilling or with a bulldozer, would possibly disclose a sufficient quantity of halloysite to permit more efficient mining on a larger scale. The steep slope east of the present workings affords ample dumping ground for any mining operation there. It is strongly recommended that ample prospecting be carried out to determine if there is a workable body of halloysite along the large quartz core exposed west of the present workings. Halloysite can be observed along this quartz core where the road crosses it near its northern end.

Tonnage Estimate

It is believed that the pegmatite is weathered to a depth of 60 feet, probably 80 feet; that 15 percent of the deposit is schist inclusions; and that 50 percent of the deposit is stained halloysite not of commercial grade. On the basis of these assumptions the reserves are estimated to be: 2,000 tons, measured ore; 1,500 tons, indicated ore; and 2,000 tons, inferred ore, or a total of 5,500 tons. The reserves may be much greater if it is found that the pegmatite extends along the quartz body to the road.

Johnson Deposit

Location

This deposit is located in the western part of Mitchell County, 7-1/2 airline miles N 55°W of Spruce Pine, and 1 mile N 10°W. of Bandana. It is on the Johnson Farm on the side of a steep ridge, 1/8 mile west of the gravel road from Bandana to Boonford.

History

The Johnson mine was first worked between 10 and 15 years ago for feldspar. A small amount of feldspar was produced from several crosscut adits and underground rooms extending along the strike of the pegmatite. In 1947, C. P. Randolph, and Bradley Johnson, mined a small amount of halloysite from these old underground workings. It has been reported that the Harris Clay Company owns the clay rights on this property, and is considering bringing this deposit into production.

General Geology

The country rock is mica schist on the north side of the pegmatite and mica gneiss on the south side. The foliation strikes approximately N 80°E, and dips very steeply to the northwest. Outcrops of hornblende gneiss were observed in the mica gneiss. Some relatively hard outcrops of rock were observed near the pegmatite; however, the rock exposed in tunnels was highly weathered, and it

is believed that most of the wall rock is relatively soft to a much greater depth than the bottom of the workings.

Pegmatite

The pegmatite strikes N 70°E and dips from 60° to 70° northwest into the ridge. It has a maximum width of seventy feet, and is approximately 250 feet long. The width increases uniformly from both ends, the maximum being near the center of the pegmatite. A small tongue, approximately 50 feet long, projects from the north end in a northeast direction (see plate 3).

The Johnson pegmatite is weathered to a depth of from 35 to 45 feet. Local zones of hard microcline feldspar were observed in the tunnels; however, the greater part of the feldspar has been altered to clay to a depth of about 40 feet. Large boulders of float quartz were observed immediately south of the pegmatite, but no indication of a quartz core was seen in the deposit. Small stringers and pods of quartz were observed occurring at random in the exposures. Small schist inclusions are present, and it is estimated they make up approximately 15 percent of the deposit. The halloysite contains a rather high percentage of quartz, muscovite, and biotite; and is iron stained near contacts, fracture seams, and around schist inclusions. The quartz is relatively fine, varying up to 1/2 inch in diameter but is disseminated through the clay, and therefore will make recovery of block halloysite very difficult. Also, the mica and feldspar occur in such quantities as to greatly reduce the amount of recoverable block halloysite. The clay will have to be recovered in small blocks (1/2'' to 4'' diameter) and will require considerable trimming.

Mining Methods

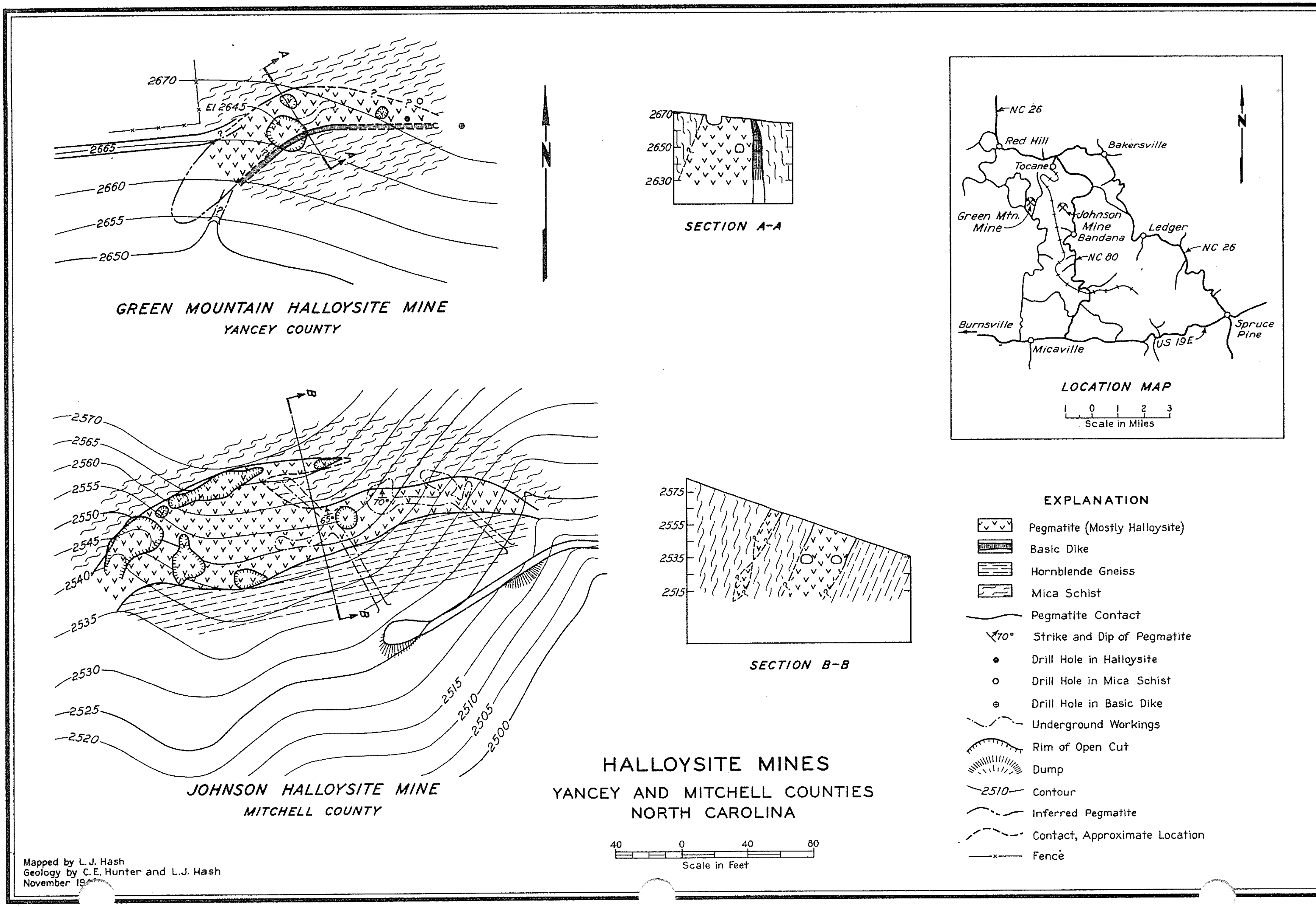
The present workings consist of two tunnels (see plate 3) and numerous pits. These pits seldom exceed 10 feet in depth, and all are caved, thus obscuring the pegmatite in most places. Two tunnels have been driven through the country rock on a horizontal plane, and intersect the pegmatite at a depth of from 15 to 30 feet. Where they intersect the pegmatite, drift mining has been done as well as a small amount of stoping.

Future Mining

The topographic location and dip of this pegmatite will make mining on a large scale difficult. Since the pegmatite dips very steeply into the ridge, open cut mining would not be economical at depths greater than 20 or 25 feet, and additional mining would have to be underground. The steep slope below the outcrop affords ample dumping ground for open cut or underground mining.

Tonnage Estimate

It is estimated that the pegmatite contains approximately 50 percent quartz, 15 percent stained halloysite, 15 percent schist inclusions, and that weathering extends to a depth of from 35 to 45 feet. Assuming these conditions the reserves of block halloysite are estimated to be 1,000 tons of measured ore, and 500 tons of indicated ore, or a total of 1,500 tons. If the quartz could be removed mechanically a much larger tonnage of halloysite could be recovered.


HALLOYSITE MINES
YANCEY AND MITCHELL COUNTIES
NORTH CAROLINA
GREEN MOUNTAIN HALLOYSITE MINE
YANCEY COUNTY
JOHNSON HALLOYSITE MINE
MITCHELL COUNTY
SECTION A-A
SECTION B-B
LOCATION MAP
Scale in Miles
Scale in Feet
EXPLANATION
Pegmatite (Mostly Halloysite)
Basic Dike
Hornblende Gneiss
Mica Schist
Pegmatite Contact
Strike and Dip of Pegmatite
Drill Hole in Halloysite
Drill Hole in Mica Schist
Drill Hole in Basic Dike
Underground Workings
Rim of Open Cut
Dump
Contour
Inferred Pegmatite
Contact, Approximate Location
Fence
NC 26
Red Hill
Bakersville
Tocane
Green Mtn. Mine
Johnson Mine
Bandana
Ledger
NC 80
Burnsville
Micaville
US 19E
Spruce Pine
El 2645
Mapped by L. J. Hash
Geology by C. E. Hunter and L. J. Hash
November 19

Fluken Ridge Deposit

This deposit is located in the western part of Mitchell County, two miles from the Yancey County line. It is 6.7 airline miles N 45° W of Spruce Pine, 1.2 airline miles N 45°E of Bandana, 0.3 mile southwest of Mine Creek, on farm of W. A. Howell.

This deposit has been worked extensively in the past by the Harris Clay Company for kaolin and is being worked for feldspar at the present time.

The deposit consists of a fairly large body of alaskite into which several pegmatites have been intruded. The largest pegmatite in which halloysite occurs strikes N 65°E and dips approximately 40° to the southeast. Dump material and back-filling obscure the pegmatite at numerous places, making it very difficult to determine its extent; however, a zone of halloysite, approximately 50 feet wide, is exposed at the northeast end of the deposit. Prospect pits and shafts at the northeast end of the deposit indicate that the pegmatite extends at least 75 feet to the northeast. The central and southwest portions of the pegmatite are not well exposed, but the pegmatite is believed to have a length of approximately 250 feet, and probably contains a considerable quantity of halloysite which is not exposed at present.

This deposit contains small pockets of feldspar, but is relatively free of quartz, mica, stain, and schist inclusions. The halloysite is white and appears to be of high quality. Large blocks of halloysite could be mined and trimming would be at a minimum, with very high recovery.

The mine at present consists of an irregular open cut with numerous small pits and shafts around the edges. The main open cut is approximately 250 feet long, up to 75 feet wide, and up to 40 feet deep. It is reported that this pit has been much deeper in the past and that there are extensive underground workings on this deposit.

A considerable quantity of block halloysite could be recovered by stripping and open cutting on the northeast end of the pegmatite. In addition, some halloysite could be produced from the mixed zones if the material could be put through a plant which would remove the quartz and feldspar.

Bandana Deposits

These deposits were discovered by the presence of float halloysite on the surface. Since no development work has been done, the exact boundaries, quality, and commercial possibilities of the deposits are not known. It is believed that some of these and the areas adjacent to them warrant future prospecting.

The best deposit is located 0.5 mile N 30°W of Bandana and 0.3 mile southwest of the old Sink Hole mica mine, from which the first sheet mica in the United States was produced. No work has been done on this deposit, but it is plainly marked by float halloysite which extends over an area about 20 feet

wide and 40 feet long. The float halloysite occurs in small cubes varying in size from 1/4'' to 1/2'' in diameter. Several auger holes were drilled in this deposit and encountered a good grade of halloysite, relatively free from stain and grit. Since the deposit occurs on top of a ridge (elevation 2,700 feet) it is not believed that weathering extends to as great a depth as in some of the other deposits. Although the exact boundaries of this deposit have not been determined, it is believed to be one of the best in the area, and it is strongly recommended that it be considered for future exploration.

Halloysite float was discovered 0.1 mile northeast of Bandana in the side of a road cut leading to Gouge Cemetery. This float was very white and free from grit, but could be traced for only a few feet. Similar deposits were found southeast of this locality along the old road to Gouge Cemetery, all of which appeared to be relatively small. Due to the undergrowth and leaves, it was impossible to examine this area thoroughly, but it is believed to be a likely area for more thorough prospecting.

Halloysite was found in some old mica mine dumps along a ridge trending NE, 0.5 mile northeast of Bandana. These mines are all old and badly caved; therefore, it was impossible to determine the boundaries of any of the pegmatites. It is reported that most of them are relatively narrow. Halloysite float was found on top of this ridge, about 0.2 mile northeast of the mica mines. This float was found over an area about 20 feet in diameter. Some of it occurred in chunks up to 2 inches in diameter and appeared to be of good quality.

Norman Deposit

The Norman deposit is located in the western part of Mitchell County 0.8 mile from the Yancey County line. It is 5.8 miles N 23°E of Micaville, 1 mile N 5°E of Bandana, on the property of Walter Norman.

This pegmatite strikes approximately north, and small pits show its length to be about 100 feet, or possibly a little greater. Its width is not known, but approximately 15 feet of halloysite and quartz core are exposed in a tunnel, and it is believed the pegmatite may have a width of approximately 30 feet. The quartz core shows imprints of feldspar crystals up to a foot in diameter. The halloysite found here was very white, free from quartz, and appeared to be of good quality. This deposit occurs on the side of a steep ridge, therefore, it is believed that weathering extends only to a depth of about 30 feet. It is believed that this deposit contains a considerable quantity of grade-A feldspar at depth, which would be relatively easy to recover after the halloysite is removed.

No halloysite has been produced from this deposit; however, it is believed that it should be considered for further prospecting.

Ledger Deposit

A small amount of prospecting has been done on a halloysite pegmatite in Mitchell County, 6 airline miles N 45°W of Spruce Pine. This deposit is located

1-1/10 miles west of Ledger, and 3/4 mile southwest of Snow Hill Church, on the north side of the road between Snow Hill Church and Wing. Very little work has been done on this deposit; however, there are a few shallow pits along the strike which indicate that it has a length of between 200 and 300 feet. The road cut exposure shows that the halloysite is principally restricted to a pegmatite about 30 feet wide, which was intruded along the southeast contact of a fairly large alaskite body. This occurrence contains angular pieces of quartz, but it is believed that block halloysite could be mined from the deposit. This deposit is thought to be worthy of further investigation.

Yancey County

Green Mountain Deposit

Location

This deposit is located 500 feet east of Pleasant Grove Baptist Church, in the northeastern part of Yancey County. It is 5.3 airline miles N 2°E of Micaville, 2.7 miles S 60°E of Green Mountain, and 1.5 miles west of the Mitchell County line.

History

The Harris Clay Company acquired the property in 1946, and produced halloysite from it for approximately one year thereafter. It is reported that this deposit has recently been acquired by the Spruce Pine Mining Company.

General Geology

The country rock surrounding this pegmatite is mica schist. The foliation of the schist strikes N 66°E and dips 66° southeast. The schist is highly weathered at the surface and in the open cut, and it is not likely that hard rock would be encountered for a depth of 50 or 60 feet. The pegmatite was intruded on the northwest side, and along the contact of a basic dike. This dike, which is highly weathered, is five feet wide at the bottom of the cut, but is considerably narrower at the rim of the cut. The surface outcrop is lens shaped, and is not continuous.

Pegmatite

The pegmatite is approximately 30 feet wide at the cut; however, it is considerably narrower on the east end. Its width may exceed 30 feet on the west side of the cut where it is not well exposed. The pegmatite strikes N 50°E on the southwest end, but makes a broad curve and strikes approximately east on the east end (see plate 3). In the open cut the pegmatite strikes N 65°E and dips 62° southeast. From drill holes, it is apparent that the pegmatite narrows considerably on the east end; but there are no indications of its extent at the southwest end. The lower tunnel has caved and is inaccessible at present (see plate 3); however, dump material from this tunnel indicates that the old workings penetrated halloysite.

Halloysite

The feldspar has been altered to halloysite and kaolin to a depth of 45 feet and possibly to 60 feet. The clay contains graphic growths of quartz and about 5 percent scrap mica, which is unusual in a halloysite-bearing type of pegmatite. Schist inclusions were found that vary from a few inches up to 4 or 5 feet in width, but no feldspar was observed in the deposit. The halloysite is iron stained for about five feet below the surface, but the main body is relatively free of stain. Selective mining would be necessary at this deposit due to the disseminated quartz and mica, and considerable trimming would be required to keep the quartz and mica content down to meet market specifications.

Mining Methods

The present workings consist of an open cut, about 20 feet in diameter and 20 feet deep, and two smaller pits about 5 feet deep (see plate 3). In addition, there are two drifts extending from the bottom of the open cut along the strike of the pegmatite, and one cross cut tunnel, 55 feet southwest of the open cut. Only the drift extending northeast from the open cut is accessible (see plate 3).

Future Mining

It is believed that the best mining practice here would be to remove the five feet of stained halloysite with a bulldozer. This would expose the southwest portion of the pegmatite, and make mining possible by open cut methods.

Tonnage Estimate

It is believed that the pegmatite is weathered to a depth of 45 feet, that 15 percent of the deposit is schist inclusions, and that quartz and mica will render 35 percent of the deposit unsatisfactory. On the basis of these assumptions the reserves are estimated to be: 1,000 tons measured ore and 500 tons inferred ore, or a total of 1,500 tons. The reserves may be much greater if the pegmatite extends farther on the southwest end than is shown in plate 3.

Buncombe County

Arrowood Deposit

Location

The Arrowood halloysite deposit is located in the northern part of Buncombe County, 12.7 airline miles N 13°E of Asheville, 1.1 airline miles southwest of Democrat, and adjacent to North Carolina Highway No. 197.

History

The deposit was first worked for feldspar in 1934 by John Rice of Barnardsville and there was intermittent production by various operators from that year until 1941. In 1947 the Spruce Pine Mining Company acquired the mine, and, under the

direction of Paul Henline, President, produced perhaps 15 carloads of halloysite during 1947 and 1948. The Arrowood mine is an active producer of halloysite at the present time.

General Geology

The pegmatite of the Arrowood deposit was intruded in the contact and across part of a dunite formation. This dunite, for the most part, is altered to serpentine and contains numerous small seams of nickel silicate minerals, as well as talc and vermiculite. The southern part of the pegmatite, which is not well exposed, is in and along the east contact of the dunite formation. The central and northern parts of this pegmatite are well within the dunite (see plate 4).

Pegmatite

This pegmatite is exposed for a length of 390 feet and varies in width from 40 to 90 feet. The southern part of the pegmatite strikes north, but the central and northern outcrops strike about N 40°W. The northern part dips about 50° northeast and the southern part dips about 20° to the east.

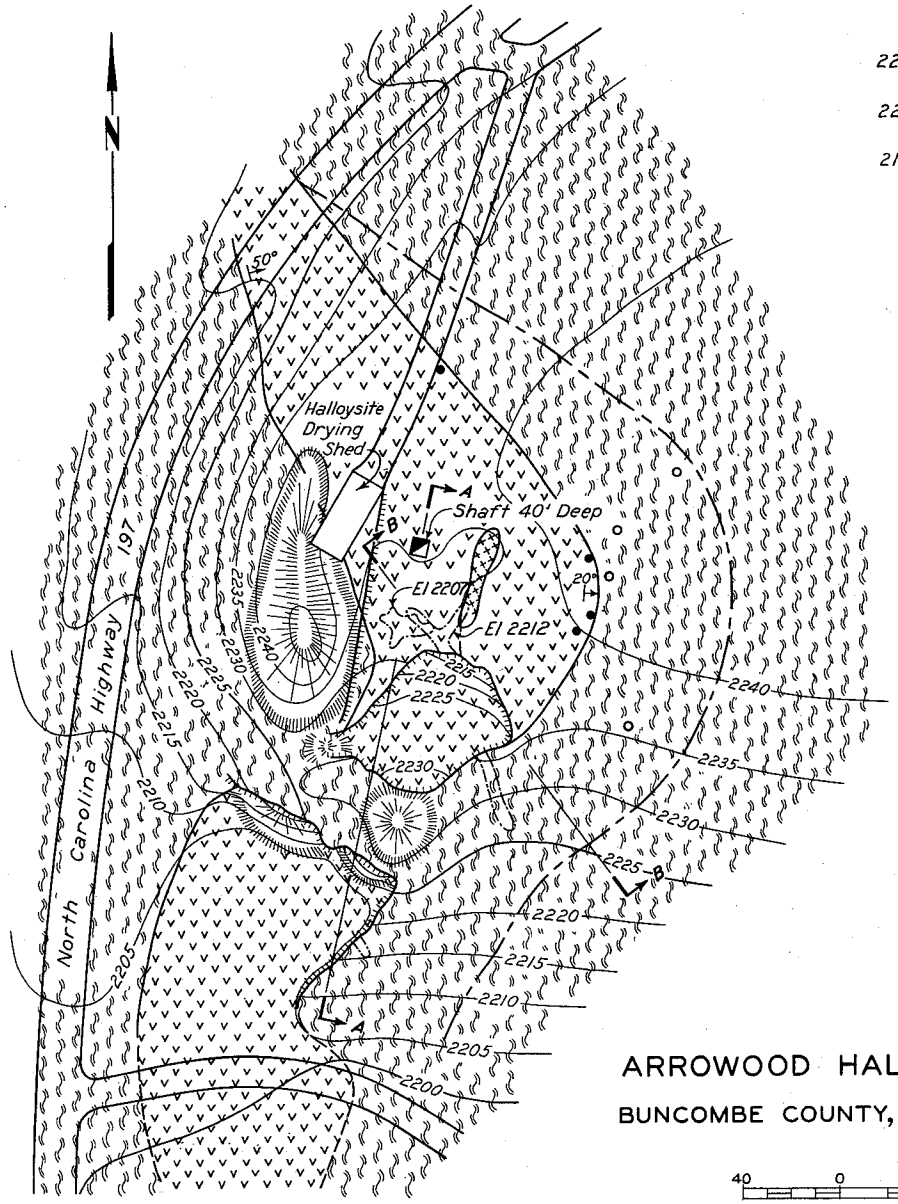
Zones of rather hard plagioclase feldspar are exposed near the surface. Weathering has proceeded to depths of from 25 to 50 feet and, apparently, the greater part of the feldspar has been weathered into clay for a depth of at least 45 feet. Local weathering to greater depth is known. A small part of a quartz core is exposed just northwest of the thicker central part of the dike. There are a few small inclusions of serpentine in the pegmatite, and parts of some of these inclusions have been partially altered to vermiculite. At a few places small lenses of muscovite mica were observed which, for the most part, are near the quartz core.

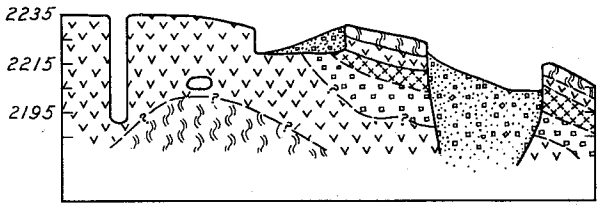
The pegmatite shows numerous fractures along which there has been slight movement. Perhaps this slight displacement was caused by the volume change when the clay was formed and during the time the dunite was changed into serpentine.

Halloysite

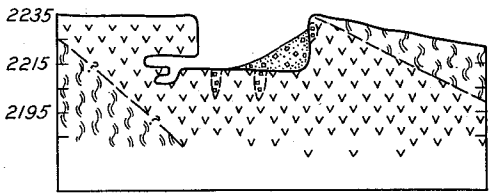
The halloysite in this deposit is unusually white in color. It is yellow or red stained only along the larger fractures and near the contacts with the serpentine. There are two general types of halloysite in this deposit. One is rather pure clay, and the other is mixed with small angular pieces of quartz. The quartz pieces average about 1/4 inch in diameter and make up about 10 percent of the pegmatite volume. The division line between the clay with quartz and the clay without quartz is well defined.

The clay is semi-plastic when damp but very hard for a clay when dry. The mined material, as seen in the drying shed, ranged from about 1/2 inch pieces to blocks up to 18 inches across.





SECTION A-A



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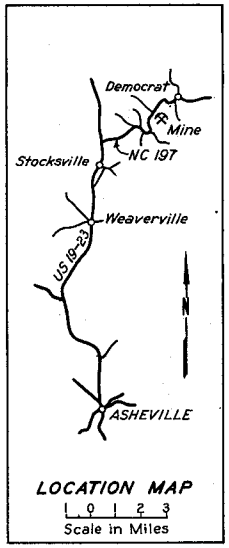


ARROWOOD HALLOYSITE MINE

BUNCOMBE COUNTY, NORTH CAROLINA

40 0 40 80
Scale in Feet

EXPLANATION

- Dump (In Section)
- Pegmatite (Mostly Halloysite)
- Quartz
- Microcline Pegmatite
- Serpentinized Dunite
- Pegmatite Contact
- 50° Strike and Dip of Pegmatite
- Hand Auger Holes in Pegmatite
- Drill Holes that hit Pegmatite at 5' to 15'
- Underground Workings
- Rim of Open Cut
- Dump
- 2215 Contour
- Area to be Stripped to Recover Indicated Halloysite
- Contact, Approximate Location

Mapped by L.J.Hash
Geology by C.E. Hunter and L.J. Hash
August 1948

PLATE 4

Mining Methods

An open cut has been made in the weathered part of the pegmatite near the widest part of the outcrop. Halloysite was removed from this cut until a depth of about 30 feet was reached. At this depth some feldspar and inclusions were encountered. Then drifts were driven into the banks of the cut, and halloysite was produced from these drifts. When the drifts were in far enough to permit room and pillar mining, the working face area was expanded. The pillars were left in stained halloysite or clay containing too much free quartz to meet market requirements. Recently an area was stripped just north of the present open cut. The stained overburden here was about 3 feet thick.

The halloysite is broken down by picks into lumps which are trimmed free of stain and other undesirable impurities, and then placed in hoisting buckets. The clay is raised to the surface with a single drum hoist, and stacked in a drying shed where it is air-dried for about 12 days before it is shipped.

Future Mining

It has been stated before that this pegmatite dips to the northeast and east, the average dip being about 20° to the east. There is an area east of the present cut where the overburden is less than 20 feet thick, which offers possibilities for another open cut. After the clay has been removed from the cut, drift mining could be continued down the dip without removing the remaining overburden.

Tonnage Estimate

It is estimated that the quartz core, stained halloysite, and schist inclusions make up 30 percent of the deposit, and that the pegmatite is weathered to a depth of 45 feet. On the basis of these assumptions, the reserves are estimated to be: 6,000 tons measured, 8,500 tons indicated, and 3,000 tons inferred, or a total of 17,500 tons. Feldspar mining several years ago proved that in places this pegmatite is weathered to 80 feet in depth. If this greater depth is used in calculations, then the total tonnage is much greater.

Alexander Deposit

Location

The Alexander halloysite deposit is located in the northwest part of Buncombe County, on the Sluder farm. It is 9.3 airline miles N 38°W of Asheville, 2 airline miles N 81°W of Alexander, and on the crest of a ridge approximately 1,000 feet south of a concrete road, running from Alexander to Cedar Hill Church.

History

This pegmatite was first mined for sheet mica during 1917-1918, and was reopened for sheet mica in 1943. At that time a shaft was sunk to a depth of about 50 feet near the center of the present open cut. At several levels, drifts were made from the shaft in search of sheet mica. All of these operations encountered

what was considered an unusual clay.

Mr. Sluder, on whose farm the deposit occurred, submitted samples of the clay to the Harris Clay Company of Spruce Pine. Fred E. Smith of that company identified it as halloysite. In 1944 the Harris Clay Company obtained mining rights on the deposit and produced halloysite from an open cut and drifts until Mr. Smith's death in 1946. Shortly thereafter mining was stopped.

Between 1946 and 1948 two attempts were made at halloysite mining from this deposit. During 1948 Bradley Johnson and others, stripped the overburden and stained halloysite from part of the deposit. No mining was done and the deposit is still in excellent shape for production.

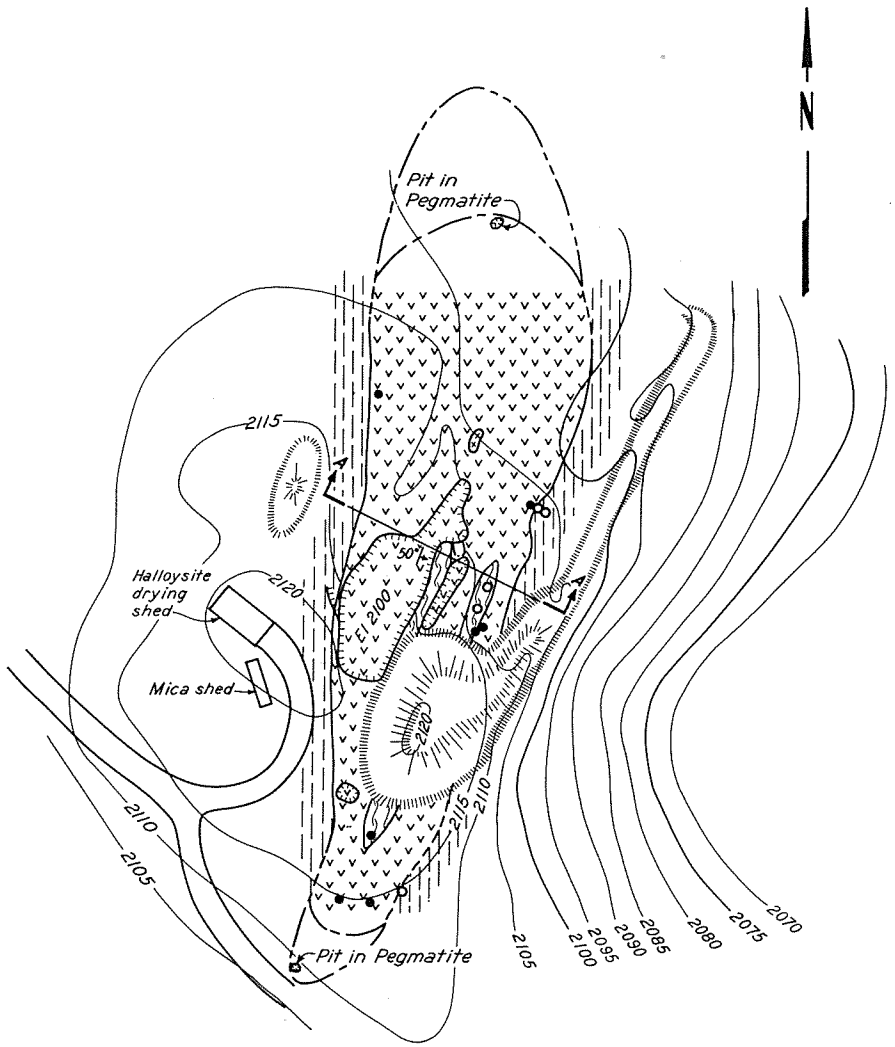
General Geology

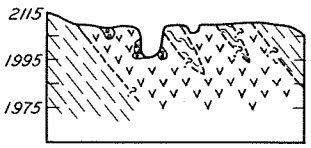
The country rock at the Alexander deposit is mica gneiss, the foliation of which strikes from N 10°E to N 15° E and dips approximately 65° to the southeast. This gneiss is composed principally of muscovite, biotite and quartz, and has numerous pegmatite stringers largely composed of feldspar and quartz. These stringers seldom exceed one inch in width or more than 18 inches in length. In the vicinity of the mine the mica gneiss is deeply weathered and it is believed that it could be removed relatively easily with a bulldozer to a depth as great as mining would permit.

Pegmatite

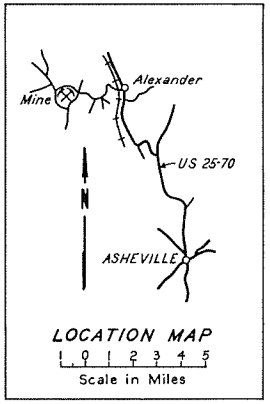
The pegmatite has a strike parallel to the foliation of the gneiss; however, its dip appears to cut across the foliation at an angle from 30° to 50° to the southeast. It is exposed for a length of approximately 225 feet, and varies in width from approximately 30 feet on the south end to over 90 feet on the north end (see plate 5). It is believed that the pegmatite may extend a greater distance farther to the north than is indicated on the map. This area is concealed by a clay cover, and the prospect pits are not deep enough to penetrate it. Because of overburden and dump material it was difficult to trace the pegmatite any farther north than is shown.

This pegmatite is weathered to a depth of over 30 feet and may be weathered to a depth of 45 feet in places. There are several zones of hard microcline feldspar, seldom exceeding three feet in width and of very limited extent, which appear to be more numerous near the quartz core. A small portion of the quartz core is exposed 10 feet north of the open cut, and small stringers of fractured quartz are exposed in the halloysite near the core. Schist inclusions account for approximately 15 percent of the volume of the pegmatite. These inclusions are more numerous along the hanging wall, and vary in size from a few inches to ten feet in width, with a maximum length of seventy feet (see plate 5). Around and adjacent to some of these schist inclusions are pockets of sheet mica, containing books up to 8 inches in diameter. Part of this mica is ruled, or of the ribbon type, but it is believed a considerable quantity of punch and sheet mica could be recovered economically during a halloysite mining operation. Since this mica occurs in pockets, it is impossible to give an accurate estimate of the amount that might be recovered.





SECTION A–A



EXPLANATION

- Pegmatite (Mostly Halloysite)
- Massive Quartz
- Microcline Pegmatite
- Mica Gneiss
- Mica Schist
- Pegmatite Contact
- 50° Strike and Dip of Pegmatite
- Drill Holes in Halloysite
- Drill Holes in Schist or Gneiss
- Underground Workings
- Rim of Open Cut
- Dump
- 2105 Contour
- Indicated Pegmatite
- Inferred Pegmatite
- Contact, Approximate Location

ALEXANDER HALLOYSITE MINE

BUNCOMBE COUNTY, NORTH CAROLINA

40 0 40 80
Scale in Feet

Mapped by L.J. Hash
Geology by C.E. Hunter and L.J. Hash
August 1948

PLATE 5

Halloysite

The halloysite in this deposit is very white and free from impurities. It contains a reddish stain for about five feet below the surface and near schist inclusions. The stain seldom extends over five or six inches from the inclusions. This deposit contains zones of rather pure halloysite, which are essentially quartz and mica free. In general, this halloysite could be mined in relatively large pieces, averaging perhaps 10 inch cubes, with a minimum of trimming. The part of the pegmatite near the quartz core appears to contain a high percentage of fine grained angular quartz. Some clay could be recovered from the quartz-rich zones, but would require more selective mining and considerably more trimming. Small lenses of relatively hard feldspar occur at random throughout the halloysitized part of the pegmatite. These feldspar lenses are distinct and could be easily excluded from the clay as mined.

A considerable part of the dumps at this mine consist of material produced during the time that the deposit was worked for sheet mica. At that time halloysite was not recovered; therefore, the dumps contain about 30 percent halloysite, much of which is in recoverable pieces, averaging perhaps 3 inches in diameter.

Mining Methods

The present workings consist of an open cut and smaller pits at both ends of the cut (see plate 5). The cut is 90 feet long, has a maximum width of 30 feet, and varies in depth from 10 to 25 feet. The walls of the cut have caved considerably, thus concealing the entries to several of the cross cuts and tunnels. Part of this cut, at one time, was about 35 feet deep. Forty-five feet south of the cut there is a shaft 10 feet in diameter and about 30 feet deep. The other pits are about four feet deep, and evidently are prospects. Immediately north and northwest of the open cut, an area approximately 50 feet square has been stripped to minable halloysite. This stripped area appears to offer excellent possibilities for production of halloysite by open cut methods.

Future Mining

Due to topograhpic conditions here, mining would be relatively easy by the open cut method. Since the northern part of the pegmatite is the widest part of the formation, and is also between 10 and 15 feet lower in elevation than the southern end, it is believed mining would be more economical by starting an incline from the northern end and working southward. Additional prospecting should be done to determine the northern extent of the pegmatite, and the most advantageous point for the beginning of a new open cut entry. The waste material could conveniently by dumped down the steep slope from this point.

Tonnage Estimate

It is estimated that the pegmatite is weathered to a depth of 30 feet, probably 45 feet; that 15 percent of the deposit is composed of schist inclusions and 10 percent is composed of quartz. On the basis of these assumptions, the reserves

are estimated to be: 4,000 tons measured, 4,000 tons indicated, and 2,000 tons inferred, or a total of 10,000 tons.

Haywood County

Bethel Deposit

This deposit, located on the property of Marvin Long, is 6-1/2 miles southeast of Waynesville, and one mile southeast of Bethel.

The Bethel mine was formerly worked for kaolin by Harris Clay Company, but was abandoned in 1918 and no appreciable work has been done since.

The old workings consist of an open cut between 500 and 600 feet long, varying in width from 50 to 75 feet, and varying in depth from 40 to 75 feet. The walls of the open cut have caved considerably, and small trees and underbrush are growing in the center of the cut; however, halloysite is exposed in a few places on the sides of the cut.

It is reported that when the mine was abandoned, there was a 50 foot shaft in kaolin in the bottom of the pit, and also that there was a rather large deposit of clay near the south end of the workings. The kaolin at the bottom and on the south end of the pit was reported to be very white, soft, and free of quartz.

One thousand feet west of this mine, halloysite was encountered while a well was being dug at a farm house. This halloysite was stained and contained considerable quartz; however, it was reported that the halloysite was much purer at the bottom of the well, and apparently would be of much better quality at depth.

It is reported that kaolin was encountered in numerous drill holes put down by the Harris Clay Company on a hill about 1/8 mile long, 1/4 mile west of the mine. This deposit was not considered to be of sufficient interest to be worked at that time.

A halloysite pegmatite, approximately 20 feet thick, outcrops about 300 feet west of the village of Retreat. The exposed portion of this deposit is badly iron stained, but it is believed the amount of stain will decrease at depth.

Little field work was done in the vicinity of Bethel and Retreat. Because of the lack of exposures it was thought more advisable to concentrate on other areas where data were more readily obtainable. However, on the basis of the deposits described above and the presence of numerous stringers of halloysite in the country rock, the authors believe that with thorough field investigation, the possibilities of discovering new deposits of halloysite in this area are very good.

Jackson County

Little Savannah Creek Area

About 50 years ago the Harris Clay Company began producing kaolin from a group of deposits on Little Savannah Creek, 1-1/2 miles southwest of Webster.

It is now known that a substantial part of that clay was halloysite. Among these deposits is the famous mine known as the Hog Rock deposit. At that time the clay was mined from open cuts and timbered shafts some of which were well over 100 feet deep. Most of the workings are now caved, thus obscuring the greater part of the pegmatite; however, at most of these occurrences some halloysite can be seen in the walls of the cuts, or mixed in with the old dump material. It is believed that halloysite could be produced at several of these mines. This is especially true of the Hog Rock occurrence.

Cullowhee Group

Several pegmatites occur 3/4 mile west of Cullowhee College, most of which are on the estate of Tom Coxe. Many years ago these deposits were worked for kaolin, and more recently, they have been reopened for sheet and scrap mica production. Some halloysite is visible in these abandoned workings. It is believed that halloysite could be produced from some of these deposits; however, an appreciable amount of trimming would be necessary because of the close association of scrap mica with the white clay.

Coxe Cove Deposit

This deposit is 1-1/4 miles southwest of Cullowhee, 1-1/4 miles northwest of of Speedwell near the headwaters of Coxe Cove Branch. The pegmatite outcrops adjacent to and along the north side of the branch.

About twenty years ago the deposit was prospected for kaolin by driving a series of drifts and cross cuts in the decomposed part of the pegmatite. The development work disclosed that this was nearly a vertical dipping pegmatite, about 200 feet long and from 50 to 75 feet wide. The pegmatite contains some areas of scrap mica concentration as well as some quartz-rich zones. There is an appreciable amount of white clay in the formation, of which perhaps 1/3 is recoverable halloysite.

Swain County

Several pegmatites occur in Swain County, on the headwaters of Bryson and Hallow Creeks, from 1-1/2 to 1-3/4 miles northwest of Bryson City.

Most of these pegmatites have been prospected rather thoroughly for feldspar and kaolin. Kaolin was produced from one of the larger pegmatites for many years, and feldspar is being produced from two of the deposits at the present time. Some halloysite occurs in all these pegmatites, and it is believed that two contain halloysite in commercial quantities.

Whitehall Deposit

The Whitehall deposit is an unusually large pegmatite from which feldspar is being produced at the present time. The pegmatite strikes N 60°E and dips from 65° to 70° to the northwest. It contains zones of biotite, feldspar and clay which are badly iron stained near the surface. On the south end of this deposit, approx-

imately 100 feet south of the main workings, halloysite outcrops in the side of a small open cut. This halloysite outcrop is about 30 feet wide, and approximately 60 feet long. The clay is unusually hard and, although it would require a considerable amount of trimming, it is believed that it has possibilities for the production of halloysite.

Thompson Deposit

About half way between the Coxe and McCraken feldspar mines, a 100 foot tunnel and numerous crosscuts have been driven in a pegmatite, but apparently no mining has been done. This pegmatite strikes from N 50°E to N 80°E, has a nearly vertical dip, and has a width of 60 feet, as exposed in the tunnel. Much of the material is badly stained and has quartz and feldspar intimately mixed with the clay; however, there are zones of rather pure halloysite. It is believed that approximately half of this deposit could be worked by selective mining. Considerable trimming would be necessary, but it is thought the deposit has good possibilities for the production of halloysite, and it is suggested that more prospecting be done to further determine its possibilities.

Macon County

Most all of the mica pegmatites in the Franklin area, Macon County, contain some halloysite. The active mica production in this area for the most part has destroyed the possibilities of halloysite production; however, the Chalk Hill mine is one possible exception to this.

Chalk Hill Deposit

The Chalk Hill deposit is located 3-1/4 miles southwest of Iotla Bridge and on the east side of Carson Cove Branch, which flows into Iotla Creek. Roy Fouts, owns the deposit and is now mining it for scrap mica. The deposit consists of several pegmatites, some of which contain lenses of rather pure white halloysite. These lenses appear to be of workable size, and it is suggested that halloysite recovery be considered along with the mica production.

Clay County

Numerous pegmatites occur in Clay County from 1 to 2 miles southwest of Hayesville. Auger holes and test pits show that some of these pegmatites contain relatively pure halloysite.

Bumgarner Deposit

This pegmatite is located on the Bumgarner property along the side of a ridge overlooking Blair Creek. Several auger holes and small test pits show this halloysite to be of uniform grade with few impurities. The deposit is approximately 90 feet wide and 300 or more feet long. Because of its uniformity and elevation above creek level, this deposit would be one of the easiest to work in the Hayesville area. Halloysite should be found to a depth of 50 feet, and it is believed

that 25 percent of the halloysite could be recovered from this deposit.

There are several other occurrences similar to the Bumgarner deposit in the Hayesville area, and it is believed that they are worthy of further prospecting and that they have good possibilities for the production of halloysite.

DEPOSITS IN ALASKITE

Avery, Mitchell and Yancey Counties

It has been recognized recently that the weathered alaskite deposits in Mitchell, Avery, and Yancey Counties contain appreciable amounts of halloysite. Very little work has been done on this type of halloysite occurrence because of the limited demand and because of the fact that block halloysite can not be produced from these deposits by the customary mining methods.

In this type of occurrence, the halloysite is so intimately mixed with quartz, feldspar and mica that it could not be commercially recovered by trimming these undesirable minerals from the clay. However, if the halloysite could be recovered in a manner similar to the recovery of kaolin, these deposits would represent a very large reserve tonnage of halloysite.

All alaskite bodies of this area contain numerous pegmatites which apparently were derived from the alaskite magmas and were formed in the late stages of the magma crystallization. These pegmatites, when found near the alaskite boundaries often reach a hundred feet in width, but when found within the alaskite body are much smaller and more numerous. These small pegmatites vary in width from a few inches up to 20 feet, and sometimes occur only a few feet apart. It is in and near these weathered pegmatites that the greatest concentrations of halloysite are found.

This halloysite is very white and pure, but will require mechanical separation to remove the small disseminated pieces of quartz, feldspar, and mica. A similar separation of kaolin is being made by Harris Clay Company and there is no reason to believe that halloysite could not be recovered by the same method.

In some deposits, halloysite occurs in sufficient quantities to be mined with a power shovel, but in others it occurs in such small zones that some selective mining and hand sorting will be required to prepare the clay for a concentrating plant.

Because of the nature of these occurrences and the large areas covered by the alaskite, it would be impossible to give an accurate estimate of the reserve tonnages from these deposits; however, they represent sufficient tonnages to supply the ceramic industry with high grade halloysite for many years.

Gusher Knob Deposit

The Gusher Knob deposit is located in Avery County, 5-1/2 airline miles N 40°E of Spruce Pine, and 1/2 mile northeast of Ingalls.

The Harris Clay Company has been producing kaolin from this weathered alaskite deposit for about six years. The material is mined with a power shovel and trucked to their nearby concentrating plant. Several large open cuts have been made and zones of halloysite are exposed at numerous places in these cuts.

The largest concentration of halloysite is found in the northernmost of these cuts. Sufficient work has not been done to disclose the extent of the halloysite there; however, exposures and material from old workings indicate that it extends over an area from 50 to 75 feet in width. Much of this material occurs in sufficient quantities to be mined with a power shovel. This applies particularly to the small pegmatites in the alaskite. All the halloysite in this alaskite body will require more selective mining.

Micaville Deposit

The Micaville mine is located in Yancey County 6-3/4 miles west of Spruce Pine, 1/2 mile east of Micaville, and 1/4 mile south of U. S. Highway No. 19E.

Fred Deneen has been producing scrap mica from this weathered alaskite deposit for about three years. Recently a zone of halloysite approximately 75 feet wide was uncovered at the northeast side of the open cut. The length of this zone is not known, but it is thought to be at least 200 or 300 feet.

This halloysite is very white, but approximately 20 percent of the deposit is composed of small angular pieces of quartz which are disseminated through the clay. This deposit contains a rather low percent of mica in the halloysite zone. The occurrence is unusual in that no red stain was observed in the clay except in the material two or three feet below the overburden.

The clay in this alaskite body could not be trimmed to meet present market specifications; however, it is thought that it would be relatively easy to remove the quartz in a concentrating plant, and very high recovery of halloysite could be expected. The halloysite could be mined easily with a power shovel, and it is believed that little or no hand sorting would be required.

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