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DEPARTMENT OF CONSERVATION AND DEVELOPMENT

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Information Circular 17

BERYL OCCURRENCES IN NORTH CAROLINA

BY

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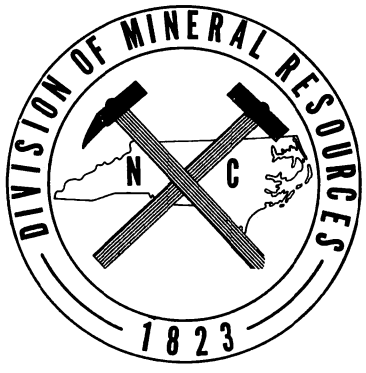

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INTRODUCTION

Beryllium, the fifth lightest metal possessing many unique physical properties, is now receiving considerable industrial attention. The "space age" has created renewed interest in this metal for its use in supersonic aircraft, missiles and space vehicles. New technical and economic developments are now underway, and in 1961, total sales of beryllium and beryllium metal products increased more than 34 percent over the past year. Several major companies with large financial resources are initiating extensive exploration programs and have adopted metallurgical research programs.

New domestic sources of beryllium ore have been found in Utah and exploration is continuing in the states of Nevada and Colorado.

North Carolina, long known for its wide variety of minerals and rocks has been prospected for the mineral beryl since before 1900, mostly for use as gem material. Although North Carolina is not actively mining beryl, U.S. Geological Survey reports indicate that there are important potential reserves present in the tin-spodumene pegmatites of the Kings Mountain Belt (Griffitts, 1954). Recently, an experimental flotation plant was set up by the U.S. Bureau of Mines to develop methods to recover beryl from flotation tailings of a commercial spodumene mill in North Carolina. Substantial progress was made in the Bureau's experiment which may lead to extensive beryl recovery.

PURPOSE AND SCOPE

This report is not intended to be a detailed scientific discussion and evaluation of beryllium and its ore minerals. Rather, its purpose is to introduce interested persons to, and make them aware of beryllium, its unique properties, mode of occurrence, consumption and uses, and the distribution of its ore minerals in North Carolina. It is hoped that this report will answer some questions on beryllium arising in the minds of its readers, and will help give them incentive to search further into these and others subjects dealing with the mineral resources of our State and our Nation.

ACKNOWLEDGEMENTS

This report was authorized and prepared under the direction of Dr. J.L. Stuckey, State Geologist.

In compiling information for this circular, numerous publications of the Division of Mineral Resources, Department of Conservation and Development and the old North Carolina Geological and Economic Survey were examined. These publications are too numerous to cite here, but appear in the bibliography.

Grateful acknowledgment is also extended to S.G. Conrad, Assistant State Geologist for his helpful suggestions in the reports overall preparation.

HISTORY

Beryllium, the metal with many unique properties, which was first called "earth of beryl", later glucinum, and finally beryllium, was discovered in 1797 by a Frenchman, Vanquelin, while making a chemical analyses of the mineral beryl. Thirty-one years later, in 1828, Wohler (in Germany) and Bussy (in France) almost simultaneously and independently prepared the

first metallic beryllim by reducing the oxide with potassium. Beryllium of high purity however, was not prepared until 1898, seventy years later by the French chemist Le Bau. In Germany during the year 1913, Fichter produced the first workable quantity of relatively pure beryllim and three years later, Oesterheld published the equilibrium diagram of several beryllium alloys. The United States had also adopted a program of scientific research on the new metal, and in 1916 Hugh S. Cooper produced the first sizeable ingot of beryllium and two years later patented the beryllium-aluminum basic alloy. In 1926, Michael G. Corson, a metallurigist of the Electro Metallurgical Corporation, discovered beryllium's ability to harden copper and shortly thereafter, beryllium found a place in industry.

MODE OF OCCURRENCE

Beryllium minerals occur principally in granitic and syenitic intrusive igneous rocks, chiefly pegmatites, granites, nepheline syenites and in a few sediments derived from these rocks. Some quartz veins and pegmatites rich in quartz contain the element.

The world's principal sources of beryl, the major beryllium ore, are heterogeneous granite pegmatites. In these deposits, some of which contain only a few thousand tons of pegmatite rock and others which contain a million tons or more of rock, the beryl occurs in enriched zones, filled fractures and replacement bodies.

Recently (about 1960) a new beryllium-bearing ore of an unusual and unique nature was discovered in beds of rhyolite and lapilli tuff in the Topaz Mountain area of Utah. In this deposit, the beryllium occurs as a complex mineral containing silica and fluorine. The host rock is a generally highly-altered rhyolite and lapilli tuff. The mineral occurs in association with clays, silicate minerals, fluorine, iron, manganese, magnesium and lime.

Nepheline syenites and other nepheline rocks have been reported to contain small quantities of beryllium.

Certain granites and sediments, such as clays derived from granite and syenitic rocks, sometimes contain beryllium minerals. Also, a few alluvial deposits derived from pegmatites have been mined in some parts of the world.

Some beryllium minerals have also been found in quartz veins occurring in schists and granites in association with the minerals cassiterite, wolframite and molybdenite. However, these are considered unusual sources.

Emerald, the gem variety of beryl, has been found to occur in cavaties in a bituminous limestone in Muso, Columbia.

BERYL - COMPOSITION AND APPEARANCE

About 30 minerals contain beryllium and in 50 others the occurrence of the element is sporadic. However, of these 80 minerals, beryl by far is the most abundant. Until a beryllium-bearing ore was recently found in the Topaz Mountain area of Utah, beryl had been the only mineral of sufficient quantity and concentration to qualify as an ore mineral of beryllium. The others are so rare that they will only infrequently be encountered.

Beryl is a beryllium aluminum silicate mineral having the chemical formula $Be_3Al_2Si_6O_{18}$, and containing approximately 14.0 percent BeO, 19.0 percent Al_2O_3 and 67.0 percent SiO_2. The mineral occurs in very distinctive hexagonal crystals, some of which have been known to weigh several tons. Beryl's most common color is green, but it may be blue, pink, yellow or white. Beryl is comparatively light, having a specific gravity of 2.7.

It is also one of the harder known minerals possessing a hardness on the Mohs scale of 7.5-8, which is only softer in hardness than corundum and diamond. Its hardness and glassy appearance result in the gem quality of certain varieties. Emerald, ranking among the most valuable of precious stones, is a green beryl and aquamarine is a blue-green semiprecious gem of beryl. Beryl is associated with the typical pegmatite minerals and is usually mined together with mica, feldspar, columbite, tantalite or spodumene.

DOMESTIC BERYLLIUM PRODUCTION AND CONSUMPTION 1950-1959

During the 10 year period from January 1950 to December 1959, the beryllium industry in the United States experienced rapid and expanded growth. Tables I and II, indicate the rise in tonnage and market value of beryllium ore during this 10 year period.

Table I. GROWTH OF BERYLLIUM INDUSTRY IN U.S. 1950 through 1959

Year	Sales	Investment in Plant & Equipment	Beryl Consumption Short Tons
1950	$ 9,485,992	$ 3,392,843	3,007
1951	10,783,261	4,442,400	3,388
1952	12,619,411	5,809,202	3,476
1953	12,000,503	6,742,493	2,661
1954	9,519,484	8,008,598	1,948
1955	15,838,870	8,838,014	3,860
1956	23,155,753	10,176,504	4,431
1957	24,123,260	17,896,010	4,309
1958	27,448,189	17,205,831	6,002
1959	39,312,774	20,739,085	8,173

Source: "Beryllium Ore Market", paper presented by D.H. Hershberger, Treasurer, Brush Beryllium Company, before the National Western Conference, April 23, 1960, Denver, Colorado.

TABLE II. BERYLLIUM PRODUCTION AND CONSUMPTION - 1950 THROUGH 1959

	1950-1953 Avg.	1954	1955	1956	1957	1958	1959
United States beryl, approx. 10-12% BeO. Domestic mine shipment short tons	557	669	500	445	521	463	328
Value	$214,545	$303,649	$267,927	$231,126	$275,855	$238,017	$170,523
Approx. price per unit BeO. Dom.	$39	$45	$49	$47	$48	$47	$47
World beryl production 10-12% BeO	6,800	7,700	8,900	12,900	12,900	7,000	7,300

Source: "Beryllium", U.S. Bureau of Mines Minerals Yearbook, Donald Ealertsen, Commodity Specialist.

USES

Over 90 percent of the beryllium consumed in the United States is used as a hardening agent in alloys, mostly those of copper. Beryllium, when alloyed with copper, gives this metal many special qualities which are ordinarly absent. Qualities such as high strength, excellent castability, high electrical and thermal conductivity; resistance to corrosion and fatigue and antisparking and nonmagnetic properties are added with the union of beryllium. These and other properties make beryllium copper a widely used alloy in the production of electrical contacts, aircraft engine parts, marine propellers and precision castings. It also has applications too numerous to mention in miniature electrical and electronic components.

Beryllium is also alloyed with zinc to improve its corrosion resistance and to increase its tensil strength. Nickel alloyed with beryllium has an increased tensil strength, ductility and improved grain refinement. The beryllium - nickle alloy is used for diamond-drill-bit matrix metal, watch balance wheels and certain airplane parts.

In recent years, considerable interest in beryllium has increased in the fields of nuclear energy, supersonic aircraft, missiles and space vehicles. In nuclear reactors, the element is used as a moderator material to lessen the speed of fission neutrons and as a reflector material to reflect neutrons back into the core and reduce leakage of neutrons from nuclear reactors. Intensive research and development seeking structural applications particularly in aircraft, missiles and space vehicles is in progress, but more research is needed for fuller utilization of beryllium in these fields. Actual uses of beryllium in these fields include its use in airframe structural parts, inertial guidance gyroscope and gimbal parts. Heat-sink applications such as a shield for project Mercury's man-in-orbit space vehicle

and airplane brake disks are now in use.

Other uses of beryllium include its use in X-Ray tube windows, melting and casting aluminum-magnesium alloys, refractories and household applicances.

BERYLLIUM MINERALS IN NORTH CAROLINA

Varieties

Three of the 80 minerals known to contain the element beryllium occur in North Carolina. These are, euclase, gadolinite and beryl. However, beryl is the only mineral containing sufficient BeO concentration to qualify as an ore mineral. The other two minerals are rare beryllium silicates and are not considered abundant enough to be of economic interest.

Mode of Occurrence

At present, all of the economically important beryl reported in North Carolina is pegmatitic in origin. Pegmatites may be described as igneous rocks of coarse grain found usually as dikes, veins or stringers, associated with a large mass of plutonic rock of finer grain size. The pegmatites located in Avery, Mitchell and Yancey counties, intrude moderately fine-grained, even-textured gneisses, composed of layers of quartz and feldspar, alternating with layers of muscovite and biotite mica. These mica gneisses are usually found interbedded with hornblende gneisses and schists, and coarse textured muscovite schists.

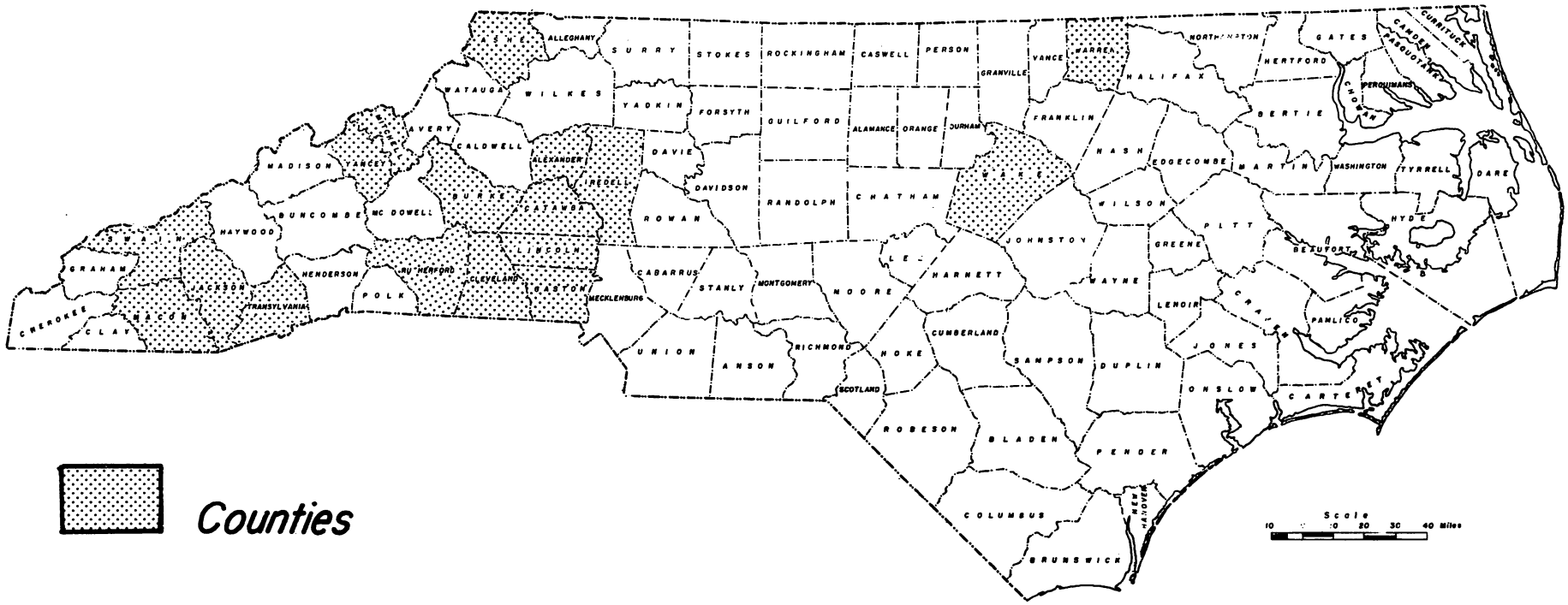
The beryl occurring in these pegmatites is fairly well formed, pale green, hexagonal prismatic crystals, varying in size from a fraction of an inch to about 3 inches in diameter. The beryl is associated with the minerals perthitic microcline, quartz, plagioclase and muscovite. The host pegmatites are of moderate size and the beryl occupies inner positions near

the core. (Parker 1952).

The pegmatites located in Gaston, Lincoln and Cleveland counties, were intruded along zones of weakness within strongly metamorphosed gneisses and schists of the area. The gneisses and schists are a moderate to high-rank group of wide compositional and textural varieties. The pegmatite dikes of the area are of three main types: spodumene-microcline-albite-quartz pegmatite, microcline-albite-quartz pegmatite and perthite-oligioclase-quartz-muscovite pegmatite (Griffitts, 1954). In these pegmatites, the beryl is described as being white to pale green or pale blue, and ranging in grain size from as small as 0.001 inch in diameter, to as much as 2 inches in diameter. The large grains usually have no crystal faces and are stubby crystals about as long as they are wide. The fine-grained white beryl is hard to recognize as its color and luster are not very different from those of the associated quartz and feldspar. Common accessory minerals include apatite, cassiterite, and garnet (Griffitts, 1954, page 3). The pegmatite dikes in these counties range from a few feet to 3,200 feet in length and from 6 inches to 400 feet in width. Drilling has shown that some of the pegmatites extend at least to a 900 foot depth (Anonymous, 1952).

BERYLLIUM RESOURCES IN NORTH CAROLINA

The pegmatite dikes in the tin-spodumene belt of Cleveland, Gaston and Lincoln counties of North Carolina uniformly contain about 0.05 percent BeO (Griffitts, 1954). It has been estimated that minable ore above a depth of 300 feet may contain as much as 823,000 tons of beryl, equivalent to 122,800 tons of BeO. This tonnage estimate would undoubtedly satisfy the future domestic beryllium requirements for many years. However, in order for these reserves to be realized, a satisfactory method must be devised by which the beryl can be profitably extracted from the rock. This extraction will require the rock to be ground and milled with the milling costs to be repaid by the sale of spodumene and feldspar associated with the beryl. The production of beryl will, therefore, depend upon the market potential of spodumene and feldspar. With this in mind, a new metal firm was established in May 1961. Beryllium Metals and Chemicals was formed by Lithium Corporation of America and Alloyd Corporation of Cambridge, Massachusetts, for the purpose of research and development of ultra-pure beryllium metal. This new plant located at Bessemer City, North Carolina, will start production late in 1962.



N.C. COUNTIES REPORTING THE OCCURRENCE OF BERYL SINCE 1900.

OCCURRENCES OF BERYL IN NORTH CAROLINA

Beryl has been mined in North Carolina for use as a gem material since before 1900. Information contained in several North Carolina Economic Papers list numerous accounts of emerald and beryl prospecting as early as 1875. Other accounts describe in detail the prospectors records of discovery, mining methods used and the size and description of all emerald and gem beryl found.

With the discovery of emeralds in North Carolina the search for new sources of beryl was intensified. As North Carolina entered the twentieth century, new discoveries of beryl were reported and since 1900 beryl has been reported to occur in at least 17 of the 100 counties of North Carolina (see Plate 1). Although many of the reported occurrences have been small and insignificant, we have attempted to trace and record as many occurrences as possible. It is hoped that this list will furnish a representative record. However, undoubtedly, there are numerous small beryl occurrences which have not been reported which would be impossible to trace.

Listed below by counties are the reported occurrences.

Alexander County

Emerald and Hiddenite Mine. Located in the city limits of the town of Hiddenite, approximately 3.5 miles southeast of Taylorsville, North Carolina, off Highway N.C. 90.

Russell Gap Road Mine. Located approximately 10 miles from Stony Point.

Little River Church. Located approximately 7 miles west of Taylorsville, North Carolina off Highway N.C. 127.

Ellis Mine. Located 0.5 mile north of the Hiddenite School in a small stream valley.

W.H. Warren Property. Located 1.5 miles southeast of the town of Hiddenite.

Osborne-Lackey Property. Located one-fifth of a mile northwest of the emerald-hiddenite mine.

Miller Estate. Located 1.5 miles east of Hiddenite on the ridge between Davis Creek and Little Yadkin River.

Smith Farm (Old Revis Farm). Located 1.2 miles northeast of Hiddenite at the end of a secondary road across Greasy Creek.

O.F. Poole Property. Located 5 miles northwest of Taylorsville.

Eli Barnes' Property. Located approximately $1\frac{1}{4}$ miles from Rocky-Face Mountain which is located about 6 miles northeast of Taylorsville.

Thomas Barnes Property. Located two miles northwest of Rocky-Face Mountain.

Ashe County

Duncan Mine. Located 1.2 miles southwest of West Jefferson.

Burke County

The Joel Walker Property. Located on a knob 0.5 mile east of Walker Knob of the South Mountains, 8 miles southwest of Morganton.

J.C. Mills Gold Mine. Located in the Brindletown Creek section off highway U.S. 64 approximately 8 miles southwest of Morganton.

Catawba County

Bessie Hudson Mine. Located east of highway N.C. 18, 0.9 of a mile east of the Burke-Catawba County line, in an area between two tributaries of Jacob Creek.

Cleveland County

W.B. Turner Property. Located 4 and three-quarter miles southwest of Shelby, North Carolina on the east bank of the First Broad River.

Plantation Emerald Mine. Located 6 miles south of Shelby on a bend of the Broad River, one mile northeast of the Stice Dam.

Turner Mine. Located 1.5 miles due east of the Stice Dam and 0.2 of a mile east of Highway N.C. 18.

Buffalo Creek Deposit. Located 1.3 miles due east of Earl on a tributary of Buffalo Creek.

Gaston County

Bess Mine. Located 3 miles south of Cherryville, just east of the Cleveland-Gaston County line road.

Iredell County

Campbell Farm. Located in an area north of Snow Creek approximately 11 miles northwest of Statesville off highway U.S. 115.

Jackson County

Thomas Grimshawe Mine. Located near the community of Cashiers approximately 1.5 miles southwest of Highway N.C. 107 on the south side of the Chattooga River.

R.E. Brown Property. Located approximately 2.8 miles southeast of East Laport near the junction of Johns Creek and Caney Fork Creek.

Rice Mine. Located approximately one mile south of Sapphire Lake on the Jackson-Transylvania County line.

Sheep Cliff Mine. Located approximately three miles north of Cashiers, near Cedar Creek.

Toxaway Mountain Prospect. Located off Highway U.S. 64, 0.1 of a mile west of the Jackson-Transylvania County line on the south slope of Toxaway Mountain.

Lincoln County

Brown Mine. Located 0.6 of a mile west of Flay.

Carbine Mine. Located approximately 0.6 of a mile west of Flay.

Macon County

Littlefield Beryl Mine. Located approximately 6.4 miles south of Franklin off Highway U.S. 23-441 on the headwaters of Tessentee Creek, 1 mile south of Whiterock Mountain.

Pegmatite Mine. Located at the northern city limits of Highlands on Highway U.S. 64-A.

Mitchell County

Mica Prospect. Located approximately $2\frac{1}{2}$ miles northeast of Spruce Pine about 1000 ft. south of Highway N.C. 19E, adjacent to old Biotite Mine. A beryl specimen weighing approximately 80 lbs. was collected at this locality and is on display at the North Carolina Museum in Raleigh, North Carolina.

Grindstaff Emerald Mine. Located on Crabtree Mountain, 2.5 miles southwest of Spruce Pine and southeast of the Brush Creek Road.

Grassy Creek Emerald Mine. Located on Brush Creek Mountain near Estatoe, North Carolina.

The Old 20 Mine. Located 5 miles southeast of Spruce Pine on the west side of the road leading to Little Switzerland.

The McKinney Mine. Located approximately 3.1 miles southwest of Estatoe.

Wiseman Mine. Located approximately 2 miles northeast from the center of Spruce Pine.

Flat Rick Mine. Located approximately 3 miles northwest of Spruce Pine.

Beryl occurs in about a dozen mines in the southeastern part of the Spruce Pine district (locations unknown) (Olsen, 1944, p. 31).

Rutherford County

Roy McFarcand Property. Located on the Duncan's Creek road, approximately 2 miles east of the road to Sunshine.

Dycus Mine. Located approximately 1 mile north of Ellenboro.

Fred Toney Property. Located in the general vicinity of the Dycus Mine, north of Ellenboro.

Swain County

Brandon Mine. Located on the property of Mr. James M. Brandon, off a dry-weather road approximately 3,100 feet N. 22° W. of Franklin Grove Church near the base of a spur that extends eastward from the ridge west of the Bryson City lowland. (Beryl occurs in sparsely scattered crystals and columnar groups of parallel crystals the largest groups of which are more than 7 X 5 X 4 inches in size).

Transylvania County

Fallow Face Mine. Located in the Cashiers pegmatite district in Transylvania County.

Wake County

Thompson Farm. Located approximately 1.8 miles south of Parnell, between Horse Creek and a road which intersects Highway N.C. 98.

Warren County

Inez Deposit. Located approximately 0.2 of a mile north of Inez off Highway N.C. 58.

Yancey County

Bay Mine. Located on Hurricane Mountain, 2.5 miles south-southeast of Burnsville.

Spec Mine. Located 2.7 miles southeast of Micaville on the east side of the South Toe River.

SUMMARY

The beryllium outlook for the United States is for expanded utilization to meet the increasing demand for high-quality engineering materials to satisfy the needs of our growing technology. However, in order to satisfy these needs, we must find adequate and dependable long-range domestic sources of beryllium ore that can be mined, milled and processed into beryllium products.

The tin-spodumene belt of North Carolina may offer the possibility of supplying a large percentage of the domestic ore that is needed for industry. Beryl-bearing pegmatites occur in the belt which uniformally contain about 0.05 percent BeO. It has been estimated that the area contains approximately 823,000 tons of beryl. However, a satisfactory method of ore extraction must be devised before the ore can become economically profitable. The United States Bureau of Mines recently set up an experimental flotation plant in North Carolina. Substantial progress was made on an experiment to develop methods to recover beryl from flotation tailings of a commercial spodumene mill in this State. If these experiments continue and succeed, North Carolina long known for its versatile mineral wealth, could become one of the nation's largest producer of beryllium ore.

Bibliography

Bateman, Alan M., 1952, Economic Mineral Deposits: New York, John Wiley and Sons, Inc. 916 p.

Cameron, Eugene N. 1951, Feldspar Deposits of the Bryson City District, North Carolina: North Carolina Dept. Cons. and Development., Bull. 62, 100 p.

Eilersten, Donald E., 1960, Beryllium: Minerals Yearbook, U.S. Bureau of Mines: Volume 1, pp. 253-260.

Griffitts, W.R., 1954, Beryllium Resources of the Tin-Spodumene Belt, North Carolina: Geological Survey Circular 309, 12 p.

Knoerr, Al, Sept. 1960, Beryllium Today and Tommorrow: Eng. Min. Journ., New York, McGraw-Hill, pp. 93-102.

Knoerr, Al., Eigo, Mike, Sept. 1961, Beryllium Update 1961: Eng. Min. Journ. New York, McGraw and Hill, pp. 87-97.

Kunz, George Frederick, 1907, The History of the Gems Found in North Carolina: N.C. Geol. and Econ. Surveh, Bull. 12, Raleigh, 60 p.

Mineral Facts and Problems, 1960, Beryllium: U.S. Bureau of Mines, Bull. 585, pp. 95-102.

Nininger, Robert D., 1954, Minerals for Atomic Energy: New York, D.Van Nostrand Company, Inc., 367 p.

Olson, Jerry C., 1944, Economic Geology of the Spruce Pine District, North Carolina: North Carolina Dept. of Conservation and Development. Bull. 43, 67 p.

Olsen, Jerry C. 1952, Pegmatites of the Cashiers and Zirconia Districts, North Carolina: North Carolina Dept. of Conservation and Development, Bulletin 64, 32 p.

Parker, John M., III, 1952, Geology and Structure of Part of the Spruce Pine District, North Carolina: North Carolina Dept. Conservation and Development, Bulletin 65, 26 p.

Pratt, Joseph Hyde, 1901, The Mining Industry in North Carolina during 1900: N.C. Geol. and Econ. Survey, Econ. Paper 4, 36 p.

_____,1902, The Mining Industry in North Carolina During 1901: N.C. Geological and Econ. Survey, Econ. Paper 6, 102 p.

_____,1903, The Mining Industry in North Carolina During 1902: N.C. Geol. and Econ. Survey, Econ. Paper 7, 27 p.

_____, 1904, The Mining Industry in North Carolina During 1903: N.C. Geol. and Econ. Survey, Econ. Paper 8, 74 p.

_____, 1905, The Mining Industry in North Carolina During 1904: N.C. Geol. and Econ. Survey, Econ. Paper 9, 95 p.

_____, and Berry, H.M., 1911, The Mining Industry in North Carolina During 1908, 1909, 1910: N.C. Geol. and Econ. Survey, Econ. Paper 23, 131 p.