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INFORMATION CIRCULAR

A GENERAL SURVEY OF SOME HIGH SILICA MATERIALS IN NORTH CAROLINA

By
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INTRODUCTION

North Carolina has long been known to possess deposits of relatively high silica rocks in the Mountain, Piedmont, and Coastal Plain sections. However, little has been recorded concerning their quality and quantity. As a result of increasing interest in the utilization of high silica materials in the refractory and other specialized industries, an economic survey of the major silica resources of the State was made during the summer of 1948.

This project was carried out cooperatively by the Division of Mineral Resources of the North Carolina Department of Conservation and Development, and the Regional Minerals Resource Division of the Tennessee Valley Authority. Chemical analyses were made by the North Carolina State College Minerals Research Laboratory in Asheville.

The Purpose of the investigation was an economic appraisal of some of the major silica resources of North Carolina to establish their potential as raw materials in the refractory and other specialized industries. Results of the survey are summarized in this report.

Time did not permit an exhaustive study, therefore the information is of a reconnaisance nature intended as a guide for future studies. Attempts were made to obtain samples of representative materials which appeared most likely to approach or meet the rigid industrial specifications. Where large volumes of high silica rock were available, those localities representing possible quarry sites were sampled. Tonnage estimates, made in some cases, are preliminary and are presented merely to serve as a general indication of size of typical deposits.

ACKNOWLEDGMENTS

This work is a compilation of information contained in several unpublished field reports. The section covering western North Carolina was written by E.C. Van Horn, Geologist with the Tennessee Valley Authority, who was in charge of field work in that area of the State. General direction of the investigation was supervised by Dr. Jasper L. Stuckey, State Geologist of North Carolina, and Mr. H.S. Rankin, Head, Regional Minerals Section of the Division of Chemical Engineering, Tennessee Valley Authority.

ABSTRACT

The high silica rocks in North Carolina include quartzites, quartz veins, sands, and gravels. Although some occur in relatively large quantities, those deposits meeting or approaching the specifications required by users of high silica materials are limited in volume.

In general, the quartzites in North Carolina are impure, containing excessive amounts of alumina. The higher grade quartzites occur in the Mountain area where large tonnages averaging 90 per cent or more silica and over 4 per cent alumina are available. In the Piedmont, the quartzitic rocks are highly contaminated, averaging nearly 10 per cent alumina.

There are a few sizeable quartz veins in the State which are quite pure, some containing 98 per cent silica. The nature of these deposits usually limits their volume to below required reserves; however, some appear to offer economic possibilities. High grade quartz also occurs as cores in the pegmatites of western North Carolina and may be recovered during mica and feldspar mining. A good grade quartz is now being obtained as a by-product of feldspar flotation.

The sands and gravels of the Coastal Plain appear to be the most important silica resources of the State. Although some treatment is necessary to bring them up to specification, there are sizeable deposits which approach general chemical requirements of the glass and refractory industries. Future development of the silica resources will largely rely on sands and gravels as raw materials.

GENERAL INFORMATION

A high silica rock is one composed essentially of nearly pure silicon dioxide (SiO_2), usually in the form of quartz. Although there is no exact limiting factor by which a material is classed as "high silica", most industrial specifications require a minimum silica content of over 95%, 99% usually being desired. Iron and alumina are the chief harmful impurities, and a combined content of 1% or less is desirable. Alumina is especially undesirable in materials for the silica refractory industries, 0.5% being the maximum. In North Carolina, rocks which meet or approach the general classification of high silica materials occur as vein quartz, quartzites, and as sands and gravels. Low grade sandstones are also present in the State, but are too contaminated or in too small amounts to be considered of value for their silica content.

Vein quartz.- This type of quartz occurs as narrow tabular bodies filling cracks and fractures in the metamorphic rocks of the Mountain and Piedmont areas. Although often somewhat contaminated by varying degrees of mineralization, many veins are composed of nearly pure quartz. Such quartz is usually milky white in color and varies from a friable , granular type to a hard compact dense variety. Fracturing is common. Veins of quartz range in size from mere stringers up to bodies more than a hundred feet wide and several hundred feet long, the latter being rare. It is estimated that the average size is less than one foot wide and ten feet long.

Lenses of high grade quartz also occur as massive "cores" in the "vein-like" pegmatite deposits of mica and feldspar. Such cores, usually found near the center or along the border of a deposit, range in size as radically as do the quartz veins, but seldom exceed a thickness of more than fifty feet. In most cases, they could only be worked as a by-product of mica or feldspar mining.

Although quartz veins and "pegmatite cores" are widespread in occurrence, they seldom contain sufficient reserves to be economically workable for their silica content. However, there are a few deposits in North Carolina which appear large enough for possible commercial exploitation.

Quartzite.- A quartzite is a rock formed by the alteration of sandstone, and results from a recementation of the original sand grains by silica, thus forming a hard crystalline rock. Since the process involved and the original materials are far from being uniform, the resulting quartzites vary widely in composition and character. A true quartzite is generally considered to be cemented to such a degree that it will break across the individual grains. Many rocks classed as quartzite will not meet this requirement, and are often referred to as being quartzitic.

In North Carolina quartzites or quartzitic rocks occur as large massive formations often capping mountains, as large and small lenticular masses enclosed in schists and gneisses, and as thin to medium beds interlayered with schistose rocks into which they sometimes grade. For the most part they are fine to medium grained, light gray to white on fresh exposure, and are usually quite tough. Impurities include feldspar, sericite, pyrite, kyanite, and other minerals in lesser amounts.

Although the total reserves of quartzite are large, their chemical and physical characteristics vary widely between and within individual beds, thus making it difficult to block out sizeable tonnages of a uniformly high grade material at any given location. In spite of such irregularities, however, certain zones within the quartzites are of sufficient purity to be considered as potential raw materials which may find some use in the refractory field.

<u>Sands and gravels.</u> - High grade quartz sands and gravels are confined chiefly to the Coastal Plain. The sands are usually of a light tan color, fine to medium grained, and somewhat sub-angular. Impurities of feldspar, mica, clay, and other minerals are common, but usually not excessive. The larger deposits occur along the western edge of the Coastal Plain and in the lower Coastal areas. Small deposits of a very white sand occur as low rims along some of the Carolina Bays in the southern part of the Coastal Plain. These deposits appear as leached material derived from the underlying brown sands. Reserves of sands in the State are quite large, and some may offer possibilities in the manufacture of glass.

High grade gravels occur as old terrace deposits along the western rim of the Coastal Plain. Such gravels consist of slightly stained quartz pebbles mixed with fine sand and clay lenses. The deposits range from very thin to a thickness of 30 or more feet. After washing, these gravels are very high in silica and contain minor amounts of iron and alumina.

The sands and gravels represent the largest reserves of high silica materials in the State. Although they often require washing to bring them up to specifications, these materials approach many industrial requirements.

SILICA ROCKS IN THE MOUNTAIN AREA

In western North Carolina, high silica rocks may be differentiated according to four general groups, their differences being reflected prominently in associations with other rock types. Those quartzose rocks having the greatest extent comprise the "graywackes" and quartzitic phases of mica schists and gneisses in the extreme western part of the State. Included are strongly metamorphosed formations such as the Great Smoky formation, the Brasstown formation, the Nantahala slate, the Carolina gneiss, and others. These quartzose rocks are relatively impure because of their content of ferro-magnesium minerals and secondary mica and pyrite.

A second group of quartzose rocks occurs as beds of true quartzite, both as to formations and as lentils which are included in schists and phyllites. This group is represented by the Nebo quartzite, and by quartzite lentils within the Nichols slate, both well exposed near Hot Springs in Madison County. The rocks are consolidated sandstone beds to which secondary silica has been added.

Included in a third group of silicious rocks are the Tusquitee and Nottely quartzites, principally in Cherokee, Graham, and Swain counties, the Hesse (Erwin) quartzite of Madison County, and the Erwin quartzite of McDowell and Burke Counties. These are probably the purest quartzite formations in all of North Carolina and offer the best possibilities as sources of high silica quartzite.

In addition to the meta-sedimentary quartzites, vein-type quartz must be considered among sources of high silica material. Although quartz veins are widespread in occurrence, they are measured more often in inches than in feet, and seldom are considered in the light of quarryable masses. In western North Carolina, however, quartz occurs in places in large isolated veins and as large cores of pegmatites which might be quarried or mined specifically for their quartz content.

ROCK DESCRIPTIONS AND ANALYSES

Tusquitee quartzite.- The Tusquitee-type quartzite, found in Cherokee, Graham and Swain Counties, is dense white, tan, and grayish-tan in color, usually fine-grained, and occurs as stringers and beds varying in thickness from 10 feet to 500 feet. Outcrops range in length from a few hundred feet to several miles. Mineralogically, the quartzite is predominantly quartz in the form of both altered sand grains and later secondary silica. Principal accessory minerals include feldspar, muscovite, and pyrite. In places the quartzite beds and stringers grade into adjacent schistose rocks and they contain schistose zones of high mica content in the thicker beds. Only in the eastern portion of the Tusquitee occurrence area is the quartzite reasonably free from contained accessory minerals, and from iron oxide infiltrations along joints. That area within a five-mile radius of Wesser, Swain County, has best possibilities as a source of high silica material. Three localities offer the most suitable quarry sites, and these were sampled as follows:

Lab. No. 388: Tusquitee quartzite, Swain County, TVA quadrangle 158SE, on Wesser Creek at Bee Branch, 2 miles south of Wesser Station. Here the Tusquitee crops out on a dip slope where a quarry or series of quarries might

SiO_2 - 91.2%

Al_2O_3 - 6.0

Fe_2O_3 - 0.24

supply 80,000 tons or more of quartzite. A graveled road runs along the edge of the quartzite, slope.

<u>Lab</u>. <u>No</u>. <u>389:</u>

SiO_2 - 93.5%

Al_2O_3 - 5.6

Fe_2O_3 - 0.088

Tusquitee quartzite, Swain County, TVA quadrangle 158SE, on Watia Branch 1,000 feet SE of Watia School and 2-1/4 miles by road north of Almond Station. The quartzite dips steeply but elevation differentials are small. An estimated. 100,000 tons would be available, largely from open-cut work.

<u>Lab</u>. <u>No</u>. <u>391:</u>

SiO_2 - 90.7%

Al_2O_3 - 6.2

Fe_2O_3 - 0.119

Tusquitee quartzite, Swain County, TVA quadrangle 158SE, in an abandoned road stone quarry at Gorge Dell on the right bank of Nantahala River, 2,000 feet west of Wesser Station. The nearly vertical quartzite has been cut across by the Nantahala gorge, leaving a high rough face. The sample represents about 75 feet of section on the first (lower) bench.

<u>Lab</u>. <u>No</u>. <u>392:</u>

Like No. 391 above but represents 50 feet of section on the second level bench of the quarry.

SiO_2 - 91.0%

Al_2O_3 - 6.1

Fe_2O_3 - 0.195

<u>Lab</u>. <u>No</u>. <u>393:</u>

Like No. 395 above but represents an additional section of the second level bench.

SiO_2 - 91.0%

Al_2O_3 - 7.5

Fe_2O_3 - 0.24

Lab. No. 394: Same location and type as Nos. 391-394, but handpicked and best possible material so far as visual inspection could distinguish.

SiO_2 - 91.1%

Al_2O_3 - 6.5

Fe_2O_3 - 0.151

Sample Nos. 391-394 represent separate sections of the main quarry, capable of being worked individually to supply a possible 20,000 tons of quartzite each. A single large quarry, however, might supply several million tons of quartzite averaging 90% SiO_2.

Nottely quartzite. - The Nottely quartzite, in North Carolina, extends from the Georgia state line through Cherokee County to near Wesser, Swain County. In contrast to the Tusquitee-type quartzite, which outcrops as a number of bands across the strike, the Nottely occurs as a single strip up to 150 feet thick. Although mineralogically similar to the Tusquitee, it tends to be somewhat darker and to contain more feldspar and more schist inclusions. Only one section of the Nottely was sampled for analyses. Other sections usually are more arkosic and micaceous, but small quarries might be possible in individual layers of the formation.

Lab. No. 390: Nottely quartzite, Cherokee County, TVA quadrangle 141SE, 3 miles NE of Murphy on U.S. No. 19 at intersection of road leading to Regal. Possibley 75,000 tons of quartzite

SiO_2 -96.1%

Al_2O_3 - 2.9	could be quarried but hand cobbing would be required to eliminate schist and pyrite con-
Fe_2O_3 - 0.28	centrations.

Nichols slate (quartzite facies). - In Madison County the Nichols slate formation consists of fine grained slates and phyllites. These micaceous, often sandy, rocks contain lentils of medium grained to fine grained quartzite to which secondary silica has been added. Keith (1904) reported thicknesses of these quartzite lentils up to 750 feet, but schist inclusions and gradational characteristics reduce the effective thickness of good quartzite to about 50 feet. The parts of the quartzite lentils most suitable for refractory purposes are those which have been strongly silicified by later solutions. Other portions have considerable feldspar and mica, and are quite dark because of their iron oxide and ferro-magnesium content. A single sample was taken for analysis:

Lab. No. 483:	Quartzite facies of the Nichols slate, Madison County, TVA quadrangle 182SW, on East Fork Shut-In Creek, 3/4 mile WSW of Hot Springs and
SIO_2 - 96.7%	500 feet south of the confluence with Shut-In Creek. This is a bed of resilicified quartzite,
Al_2O_3- 3.0	about 20 feet thick, which is exposed for a length of more than 400 feet. Probably 10,000 tons of quartzite would be available from ini-
Fe_2O_3- 0.12	tial operations.

Nebo quartzite. - This formation is most extensive in Tennessee, but several fingers are present north and west of Hot Springs in Madison County (Keith, 1904). The Nebo quartzite, in North Carolina, includes medium grained and fine grained quartzite interbedded with light-colored slates, phyllites, and schists. The quartzite is light-gray, tan, and off-white.

Constituent sand grains have been re-cemented extensively with secondary silica, and feldspar grains show various degrees of re-crystallization. Ferric oxide has been introduced by infiltration along joints and random fractures. Two localities of the Nebo quartzite were selected for analysis as follows:

<u>Lab</u>. <u>No</u>. <u>484</u>: Nebo quartzite, Madison County, TVA quadangle 182NE, on Blood River 3,000 feet south of its intersection with U.S. No. 25-70, 1.9 miles west of Hot Springs. Approximately 60 feet of a strongly silicified phase of the Nebo quartzite outcrops prominently as it crosses Blood River. Possibly 5,000-10,000 tons would be available.

SiO_2 - 95.6%
Al_2O_3 - 4.0
Fe_2O_3 - 0.18

<u>Lab</u>. <u>No</u>. <u>486:</u> Nebo quartzite, Madison County, TVA quadrangle 182 NW. On Shut-In Creek, 1.2 miles south of U.S. No. 25-70, 1.5 miles SE of Antioch. With some hand cobbing, possible 10,000 tons of quartzite would be available.

SiO_2 - 86.2%
Al_2O_3 - 8.6
Fe_2O_3 - 1.3

<u>Hesse</u> (<u>Erwin</u>) <u>quartzite.</u> - This formation occurs below the Shady dolomite in Madison County and is the probable equivalent of the Erwin quartzite of adjacent areas. The Hesse was named and mapped by Keith (1904). It is mostly an off-white, fine-grained quartzite which contains layers of grit conglomerate and sandy shale. Impurities include feldspar grains, muscovite, pyrite, and carbonates. The intensely fractured rocks contain infiltered iron-stained clays. Principally, because of abundant feldspar grains and clay-filled joints, sampling of the Hesse quartizte was limited to a single locality:

Lab. No. 485:	Hesse (Erwin) quartzite, Madison County, TVA quardrangle 182NE. On the Spring Creek Road 1,000 feet south of Hot Springs School. A possible 100,000 tons of available quartzite is estimated in a nearly vertical bed about 25 feet thick.
SiO_2 - 94.3%	
Al_2O_3 - 4.3	
Fe_2O_3 - 0.48	

Erwin quartzite. - The most extensive of the purer quartzites in North Carolina is the Erwin, of Cambrian age, as it froms the greater part of Linville Mountain in Burke and McDowell Counties. The extensive and irregular outcrop pattern of the Erwin results from generally low dips and great differences of elevation. West of the crest of Linville Mountain, the Erwin is a massive white quartzite, usually fine grained to glassy. Its feldspathic content is variable, often great, but little mica or other impurities are present. East of the crest of Linville Mountain the quartzite contains interbedded shale layers which, in places, may exceed 50 per cent of the formation. The Erwin quartzite is severely jointed but remarkably free from iron stain.

Locations of purer phases of the Erwin are restricted to the west slope of Linville Mountain between Linville Caverns and Linville Falls Post Office, from 3 to 6 miles north of the Clinchfield railroad at Ashford, North Carolina. Nearly all of the quartzite outcrop was examined and several dozen sites were selected for sampling among the more accessible locations. All but six samples were discarded in the field, principally because of high content of visible feldspar. The precipitous nature of the area may restrict quarrying as regards access and necessarily high faces.

Analyses were made of the following representative samples of Erwin quartzite from McDowell County:

Lab. No. 428: On U.S. No. 221 at the E.E. English place, 2.4 miles north of Ashford and one-half mile south of the Linville Caverns entrance. Probably 20,000 tons available.

SiO_2 - 95.6%

Al_2O_3 - 2.7

Fe_2O_3 - 0.19

Lab. No. 447: On the east side of U.S. No. 221, 0.2 mile north of the Linville Caverns entrance. Probably 20,000 tons of quartzite available.

SiO_2 - 91.0%

Al_2O_3 - 7.2

Fe_2O_3 - 0.17

Lab. No. 448: From a small road stone quarry on east side of U.S. No. 221, 1 mile north of the Linville Caverns entrance. Probably 20,000 tons minimum.

SiO_2 - 95.0%

Al_2O_3 - 3.7

Fe_2O_3 - 0.27

Lab. No. 449: In rocky draw, 400 feet east of U.S. No. 221, 100 yards north of Linville Caverns entrance. Probably 10,000 tons minimum.

SiO_2 - 95.4%

Al_2O_3 - 3.6

Fe_2O_3 - 0.12

Lab. No. 450: Same location as No. 449 above, except 800 feet east of U.S. No. 221. Probably 20,000 tons minimum.

SiO_2 - 94.9%

Al_2O_3 - 4.1

Fe_2O_3 - 0.16

Lab. No. 474: From cliffs on east side of U.S. No. 221, 1.6 miles north of the Linville Caverns entrance. Sample represents approximately 250 feet of vertical section of the flat-lying quartzite.

SiO_2 - 96.7%

Al_2O_3 - 3.0

Fe_2O_3 - 0.12

Vein-type quartz.- The following are representative samples of vein-type quartz from a number of localities in Western North Carolina. This materials is massive-crystalline, rather than granular, and seldom includes large quantities of impurities. Vein quartz may occur in many types of country rock, so that its probable location cannot be predicted as well as can the quartzites. It is probable, therefore, that many large quartz veins are yet to be reported in the area.

Lab. No. 396: Vein quartz, Buncombe County, TVA quadrangle 184 NE. On White Rock Mountain, 1.5 miles west of U.S. No. 276 at South Hominy, and 4.5 miles SW of Candler, North Carolina. Quartz vein is more than 200 feet long and 40 feet thick at the surface, and contains probably 30,000 tons of available quartz.

SiO_2 - 96.6%

Al_2O_3 - 2.7

Fe_2O_3 - 0.077

Alk. - 0.05

Ign. L.- 0.10

Lab. No. 397: Same location as No. 396 above, but the material has a light salmon color as the result of distributed iron stain.

SiO_2	-	96.9%
Al_2O_3	-	2.6
Fe_2O_3	-	0.09
Alk.	-	0.10
Ign. L.	-	0.04

<u>Lab.</u> <u>No.</u> <u>398:</u> Buncombe County, TVA quadrangle 202 NW. Quartz core of mica pegmatite at the J.M. Burton mica mine, now abandoned, 400 feet north of Fairview Gap, and 3 miles SW of Fairview, North Carolina. Probably 5,000 tons to 10,000 tons available in open cut operations.

SiO_2	-	97.2%
Al_2O_3	-	2.0
Fe_2O_3	-	0.83
Alk.	-	0.10
Ign. L.	-	0.05

<u>Lab.</u> <u>No.</u> <u>402:</u> Vein quartz from Carter Ridge halloysite mine, Mitchell County, North Carolina, 1-1/2 miles S350° E of Spruce Pine, North Carolina. Possible 25,000 tons of quartz available from what may be a quartz core of an altered pegmatite. The quartz mass strikes N25° W, and is about 225 feet long and 25 feet wide. Country rock consists of mica gneiss and mica schist.

SiO_2	-	97.9%
Al_2O_3	-	1.7
Fe_2O_3	-	0.14

<u>Lab.</u> <u>No.</u> <u>432:</u> Vein quartz from the Grassy Ridge scrap mica mine, Jackson County TVA quadrangle 175 NE, 2-1/2 miles ESE of Palsam, North Carolina. Quartz occurs as pegmatite core, as vein material, and as disseminated quartz within pegmatite material. Possible 15,000 tons of quartz core would be available.

SiO_2	-	98.0%
Al_2O_3	-	1.4
Fe_2O_3	-	0.13

Lab. No. 433:		
SiO_2	-	97.3%
Al_2O_3	-	2.1
Fe_2O_3	-	0.077

Vein quartz from Jackson County, TVA quadrangle 175 SE, located 3.6 miles SW of Sylva, North Carolina, and 2,000 feet upstream from the mouth of Cane Creek. Possibly 5,000 tons of quartz are available from a vein which occurs on a steep hillside 800 feet from the right bank of Cane Creek.

SILICA ROCKS IN THE PIEDMONT PLATEAU

Quartzites. - Large deposits of low grade quartzitic rocks occur in two general areas of the Piedmont. One is in the vicinity of Gastonia, where a group of prominent hills, topped by quartzitic rocks, form a belt about 10 miles wide and 40 miles long. The other is in Stokes and Surry Counties where massive quartzites cap the mountains from Pilot Mountain northeastward to Danbury, a distance of about 18 miles. Smaller deposits occur as widely scattered lenses throughout many sections of the Piedmont. Although large tonnages of quartzites are available, most of them are quite impure.

Gastonia Area

Quartizitic rocks crop out at or near the crests of a series of prominent hills and ridges which extend from central Gaston County southwestward through the southeastern corner of Cleveland County to the South Caroline state line. The better exposures are on Kings, Crowders, and Spencer Mountains, and on Jackson Knob. Keith (U.S.G.S. Folio 222) groups these rocks into a composite formation which he terms the Kings Mountain quartzite and assigns to the Lower Cambrian.

In most cases the quartzites are somewhat thin-bedded. Individual beds seldom exceed 5 feet in thickness and are usually separated by, and often grade into, highly schistose rocks. Near the South Carolina state line the formation is conglomeratic; but toward the northeast it grades into a medium to coarse grained kyanitic quartzite, well exposed on Kings Mountain, the Pinnacle, and Crowders Mountain; and further northeastward into a fine to medium grained sericitic quartzite, exposed on Spencer Mountain. Small amounts of nearly pure quartzite occur, but are in too small a volume to be of economic importance.

Most of the quartzites are white to light gray on fresh exposures, fine to medium grained, and quite tough. Staining is prevalent in many areas where weathering has been excessive. Impurities of sericite, kyanite, pyrite, magnetite, hematite, and some sillimanite are common and result in relatively high concentrations of iron and alumina. A composite analysis of 5 samples taken throughout the area shows a silica content of 83.4% and an alumina content of 15.4% (reported as R_2O_3). A selected sample of the highest grade material analyzed 93.6% silica and 3.2% alumina.

In many places weathering has proceeded to considerable depths, and has resulted in many of the quartzites being highly stained. Such staining, resulting from the oxidization of the several iron bearing minerals, is quite prominent near the surface and along cracks and fractures where the quartzites assume various shades of brown and red. Where exposed to weathering for a prolonged period, an outcrop becomes highly leached at the surface and appears very white. However, below this zone of leaching, which may range from a fraction of an inch to several inches thick, the quartzites are often badly stained.

Since much of the rock was of a low grade, samples of only the better grade of material were obtained. Analyses are as follows:

Lab. No. 412: Selected sample of kyanitic quartzite from northeastern end of Crowders Mountain. Material is highly leached, accounting for low iron. Tonnage limited.

SiO_2 - 69.8%

Al_2O_3 - 28.0

Fe_2O_3 - 0.23

Lab. No. 413: Jackson Knob, 4 miles southeast of Gastonia. Selected sample of unstained material; 5,000 tons probably available.

SiO_2 - 96.3%

Al_2O_3 - 3.2

Fe_2O_3 - 0.12

Lab. No. 414: Chip sample from old workings along the lower slopes of Spencer Mountain, southern end, 4 miles northeast of Gastonia.

SiO_2 - 83.7%

Al_2O_3 - 15.7

Fe_2O_3 - 0.34

Lab. No. 415-16: Composite sample from old quarry near top and along southeastern side of Spencer Mountain, 4 miles northeast of Gastonia.

SiO_2 - 83.7%

Al_2O_3 - 15.2

Fe_2O_3 - 0.16

There are many small lenses of quartzitic rocks scattered throughout the southern Piedmont. A series of thin bedded quartzites are well exposed in the road cut where N.C. Route 16 crosses Anderson Mountain in southeastern Catawba County. Along the northwestern slope of Passour Mountain, Gaston County, a narrow lens is well exposed 1/4 mile south of N.C. Highway 277. Among other localities where quartzitic rocks are known to occur are on Berry Mountain in Gaston County; along the crests of three small hills two miles east of Alexis, Gaston County; on Reece Mountain in southeastern Lincoln County; and at the Big Ore Bank in Lincoln County. Other small lenses occur rather widely scattered, some being found in Cabarrus and Mecklenburg Counties. A sample from latter county, 3-1/2 miles SE of Newell, analyzed: SiO_2 81.1%, Al_2O_3 12.9%, Fe_2O_3 0.25%.

Pilot Mountain Area

In the northwestern portion of the Piedmont, low-lying massive quartzites cap a series of large northeasterly trending mountains which extend from the southeastern part of Surry County northeastward to the central part of Stokes County. The best exposures are on Pilot, Sauertown, Moores Knob, and Hanging Rock mountains, where the quartzites form steep bluffs near the crests.

Most of the quartzites are relatively thin-bedded, fine to medium grained, and quite impure. Numerous chloritic and sericitic zones are present, and in most cases zones of highly folded schistose material separates individual beds. Such zones range in thickness from a fraction of an inch to as much as 8 inches. The quartzite as a whole is feldspathic, and contains many small stringers of quartz. Banding is prominent. On Sauertown Mountain many small grains of blue quartz occur scattered throughout much of the formation. Biotite and magnetite are present in small amounts. A sample of the best grade of quartzite observed analyzed 93.9% SiO_2, 4.7% Al_2O_3, and 0.27% Fe_2O_3. This sample was collected on Pilot Mountain along the toll road and represents a thickness of approximately 25 feet.

A schistose variety of quartzite is frequently found along the lower slope of several small hills, and is especially prominent immediately north of Moores Knob and south of Moores Springs. Near Gap, Stokes County, a small area is underlain by a micaceous flexible quartzite, itacolumite.

Although there are very large reserves of quartzites in the Pilot Mountain area, none appear to be of sufficient purity to be considered as raw materials for refractory purposes.

Quartz veins. - Quartz veins occur throughout most of the Piedmont, but appear more abundant in parts of Union, Stanley, Montgomery, Davidson, and Randolph Counties, where they are associated with rocks of the Carolina Slate Belt. These veins, often quite highly mineralized, occur as fillings in cracks, joints, and shear planes in the surrounding rocks. Although many of the veins carry varying amounts of gold, silver, pyrite, chalcopyrite, and other minerals, some are relatively uncontaminated and, when large enough, offer possibilities as sources of high silica materials.

A few sizeable veins occur in the Slate Belt. The most outstanding observed during this investigation is in the northwestern corner of Montgomery County, approximately 1/2 mile north of the small village of Eldorado on N.C Route 190. Here a vein crops out at the crest of a steep hill 1/4 mile east of the road from Eldorado to Coggins Mine. As exposed, the vein has an outcrop width of nearly a hundred feet and is about 500 feet long. Good exposures occur in the semi-bluffs along the western side. The quartz is milky white, somewhat badly fractured, and quite pure. Some surface staining occurs, but it is not excessive. A chip sample from surface exposures analyzed 99.3% SiO_2, 0.50% Al_2O_3, and 0.083% Fe_2O_3. It is estimated that at least 200,000 tons of high grade quartz is available in this deposit above creek level.

Samples of two sizeable veins in Union County were analyzed. The results are listed as follows:

Lab. No. 493: 1 mile south of Wingate, Union County. Possible reserves 20,000 tons.

SiO_2	-	98.4%
Al_2O_3	-	0.7
Fe_2O_3	-	0.57

Lab. No. 494: 1/2 mile south of Wingate, Union County. Possible reserves 20,000 tons.

SiO_2	-	98.3%
Al_2O_3	-	1.2
Fe_2O_3	-	0.13

Many quartz veins occur throughout the Piedmont, and undoubtedly some contain sizeable tonnages of high grade quartz. The economic importance of vein quartz will largely depend upon the available reserves.

SILICA MATERIALS OF THE COASTAL PLAIN

High grade sands and gravels occur throughout many sections of the Coastal Plain and along the eastern edge of the Piedmont. The more prominent deposits occur in Anson, Richmond, Moore, Harnett, Bladen, Northampton, and New Hanover Counties. Smaller deposits are scattered over a wide area of the Coastal Plain. In the upper Piedmont and Mountain Provinces, many local floodplains and old terrace levels are composed of sands and gravels. However, they are too impure to be classed as high silica materials

Sands.- Coastal Plain sands are composed essentially of quartz grains with minor amounts of feldspar, mica, clay, organic materials, and other impurities. In many deposits the impurities are negligible while in others they are excessive. Most of the sands are light tan in color, although colors range from red through dark brown to white, depending upon iron and organic content. Because of the widespread occurrence, only a few of the more outstanding localities were visited. These included the "sand hills" of Moore County, "bay sands" of Bladen and Columbus Counties, and the "Coastal sands" of New Hanover County.

Large deposits of high grade quartz sand occur in the sand hill region of southern Moore County and are well exposed along N.C. Route 211 between Aberdeen and Candor. The sand is generally light tan, somewhat fine grained and angular. It is relatively free from stain, and has little or no organic impurities. The deposits occur as long low ridges, and are from a few to as much as forty feet deep. A composite of two analyses of washed samples from old sand pits near Eagle Springs and Aberdeen is as follows: SiO_2 98.5%, Al_2O_3 1.25, Fe_2O_3 0.125.

In several localities in the southern Coastal Plain, small deposits of very white sand (St. Lucie) occur, usually forming low rims around parts of the Carolina Bays, and along some rivers. The sand is fine to medium grained, of exceptionally white color, and relatively uncontaminated above the water table. This material appears to represent a highly leached zone since it grades downward into light to dark brown (Norfolk) sand. There is little or no overburden. The volume of St. Lucie sand is limited; however, most deposits seldom exceed a thickness of 10 feet, often being 3 feet or less . Two areas appear favorable for small scale development. These are:

In Bladen County near Singletary Lake, and along the Lumber River between Boardman and Fair Bluff, Columbus County. Analyses of samples of sands in Bladen and Columbus Counties are as follows:

<u>Lab.</u> <u>No.</u> <u>426-1</u>: 4 miles SW of Bladenboro, Bladen County. Norfolk brown sand 10 feet thick.

SiO_2	-	97.99%
Al_2O_3	-	1.09
Fe_2O_3	-	0.011

<u>Lab.</u> <u>No.</u> <u>515-5</u>: Singletary Lake, Bladen County. Composite of 4 analyses St. Lucie sand. (Samples unwashed) 150,000 tons minimum

SiO_2	-	95.6%
Al_2O_3	-	1.2
Fe_2O_3	-	2.2
Ign. L.	-	2.6

Along the eastern side of the Lumber River, between Fair Bluff and Boardman, Columbus County, a series of low ridges contain deposits of highly leached white St. Lucie sand, underlain by a light to dark brown Norfolk sand. The deposits consist of low ridges and swales and cover areas as much as 500 feet wide and 1/2 mile long. A series of auger holes showed the sand to range from about 1 to 10 feet in thickness, the average being from 3 to 5 feet. The deposits occur intermittently over a distance of about 3 miles. An average analysis of 5 samples taken throughout the area is listed below. The The sand was washed prior to analysis:

Lab. No. 587: Average of 5 analyses. 4-1/2 miles S. of Boardman along Lumber River. Between 300,000 and 500,000 tons.

SiO_2 - 98.94%

Al_2O_3 - 0.58

Fe_2O_3 - 0.15

Ign. L- 0.19

Lab. No. 587-E: Same as above but represents highest grade white sand available.

SiO_2 - 99.1%

Al_2O_3 - 0.45

Fe_2O_3 - 0.14

Ign.L.- 0.11

Lab. No. 587-C: Same as No.587, but represents organically stained material.

SiO_2 - 98.8%

Al_2O_3 - 0.50

Fe_2O_3 - 0.17

Ign. L- 0.48

A large area of sand occurs in New Brunswick County between Carolina Beach and Wilmington, and along the Atlantic Coast Line Railroad north of Wilmington to the Pender county line. This sand is medium grained, light to medium tan although leached to a very white color near the surface. Three samples were analyzed from this area. The samples were washed prior to analysis.

Lab. No. 526-5: 5 miles N. of Carolina Beach. Represents unleached material. Large tonnage available.

SiO_2 - 97.25%

Al_2O_3 - 1.31

Fe_2O_3 - 0.28

Ign. L- 0.26

Lab. No. 526-6: Same as above but represents upper leached material near surface.

SiO_2 - 98.83%

Al_2O_3 - 0.58

Fe_2O_3 - 0.10

Ign. L- 0.02

Lab. No. 526-7: From pits at Sand Hills, 3 miles northeast of Wilmington. Large tonnage available.

SiO_2 - 97.94%

Al_2O_3 - 1.30

Fe_2O_3 - 0.18

Ign. L- 0.18

Gravels.- Relatively large deposits of high silica gravels occur in Anson, Moore, Harnett, Halifax, and Northampton Counties while smaller ones are found throughout many areas in the Coastal Plain. The gravels, usually intermixed with sand and clay, consist essentially of high grade quartz pebbles which range in size from about 5 inches in diameter to "pea" gravel. Although some iron staining is present in most deposits, it can often be removed by washing.

There are three general areas in which the more prominent deposits occur. In each area the gravels appear to have been laid down along old stream channels in the crystalline rocks, and at present occur as low ridges or terraces well above the local drainage levels.

The first area is along the Roanoke River in Halifax and Northampton Counties where relatively shallow deposits occur from near Thelma to Garysburg. These deposits, ranging from about 4 to 20 feet thick, form low ridges which parallel the river. Most of the gravels are composed of rounded quartz pebbles, relatively unstained, and ranging in size from about three inches to fractions of an inch in diameter, the average size being from 1-1/2 to 1/4 inch. Many of the more promising areas have been worked, however sizeable deposits still remain.

A second area is at Lillington in Harnett County, where extensive gravel deposits were worked some years ago. These deposits, composed of somewhat stained quartz pebbles, appear as old channel gravels paralleling the Cape Fear River. Although many of the better properties have been worked out, some high grade gravels remain.

In Anson County, near Lilesville, extensive deposits of high grade quartz gravels are being worked. Here the gravels, 10 to 20 feet thick, appear as old terrace levels along either side of the Yadkin River, being more prominent along the western side. The gravels range from about 5 inches down to pea size, and are mixed with sand and some clay lenses. This area represents the largest known reserves of high silica gravels in the State. Samples were taken of washed gravels and a composite of 5 analyses is as follows: 99.4% SiO_2, 0.09% Al_2O_3, 0.27% Fe_2O_3, 0.03% CaO, 0.16 Ign. Loss.

Near Carthage, in Moore County, relatively shallow deposits of high grade quartz gravels are exposed over a restricted area. An analysis of this material after washing is as follows: 98.0% SiO_2, 0.57% Al_2O_3, 1.33% Fe_2O_3, 0.06% CaO, 0.02 ign. Loss.

A thorough investigation in this area might lead to the uncovering of other deposits.

Smaller deposits of high silica gravels occur in many sections of the State, but are of importance mainly for local consumption.

GENERAL APPRAISAL OF HIGH SILICA MATERIALS IN NORTH CAROLINA

There are no set specifications for high silica materials, the industrial requirements usually depending upon the type of material produced. In most cases, a 99% silica and 1% or less of iron and alumina is most desirable, although for some uses such as glassmaking, the specifications are somewhat more lenient toward the alumina content. Therefore, in showing the status of the North Carolina materials, a series of tables have been set up in which North Carolina silica rocks are compared with analyses of other high silica materials generally accepted by industry.

Table 1, compares an analysis of North American Ganister[1], a high silica material acceptable for many uses in the silica refractory industry, with some of the typical silica materials of North Carolina.

TABLE 1

	N.A. Ganister	Erwin Qtzite.	Nottley Qtzite.	Vein Quartz	Washed Gravels	Washed Sand Hill Sands	Washed St. Lucie Sand	Washed Coastal Sands
SiO_2	97.92	95.6	96.1	99.3	98.8	98.7	98.21	97.4
Al_2O_3	0.55	2.7	2.9	0.5	0.92	1.1	0.73	1.30
Fe_2O_3	0.58	0.19	0.28	0.08	0.13	0.11	0.09	0.18
CaO	0.22	*	*	*	*	*	*	*
MgO	0.24	*	*	*	*	*	*	*
K_2O Na_2O	0.30	*	*	*	*	*	*	*
TiO_2	0.09	*	*	*	*	*	*	*
Ign. Loss	0.20	*	*	0.13	*	*	0.10	0.18

1. A.I.M.E. Industrial Minerals and Rocks

It can be readily determined that analyses of certain types of vein quartz, gravels and sands compare favorably in chemical composition with North American Ganister. However, the volume of these materials is limited; while the large reserves of silica rocks, as indicated by the quartzites, fail to meet specifications. This is largely due to the feldspathic nature of the quartzites, which results in excessive amounts of alumina.

Specifications for the chimical composition of high silica materials in the manufacture of glass also vary widely depending upon the product. In this field the presence of small amounts of alumina is not prohibitive as in the refractory industry where it serves as an objectionable flux. Some generalized chemical specifications [1] for certain types of glass are listed below. These are followed by analyses of a few North Carolina silica materials.

TABLE 2

	SiO_2 Min.	Al_2O_3 Max.	Fe_2O_3 Max.	CaO-MgO Max.
First quality optical glass.	99.8	0.1	0.005	0.1
Second quality, fling glass containers and tableware	98.5	0.5	0.035	0.2
Sixth quality, green glass containers and window glass. . . .	98.0	0.5	0.3	0.5
Seventh quality, green glass	95.0	4.0	0.3	0.5
Eighth quality, amber glass containers	98.0	0.5	1.0	0.5
Coastal sands, New Hanover Co.	97.3	1.31	0.28	*
St. Lucie sand, Columbus Co.	98.9	0.58	0.14	*
Norfolk sand, Bladen Co.	97.9	1.0	0.11	*
Sand Hill Area, Moore Co	99.3	0.5	0.08	*
High Silica gravels, Anson Co.	98.8	0.92	0.13	*
Massive vein quartz, Montgomery Co . .	99.3	0.5	0.08	*

* Not determined

1. Am. Inst. Min. Met. Eng.; Industrial Minerals and Rocks, p. 757,1940.

Also important in the appraisal of glass sands are the mechanical analysis. Table 3 gives a few screen analyses of glass sand as recommended by the American Ceramic Society and the National Bureau of Standards. Some North Carolina sands are listed for comparison.

TABLE 3 - SCREEN ANALYSES

	Recommended				North Carolina Sands (Washed)			
Mesh Retained	1	2	3	4	*526-3	6	7	602-2
10					0.2	0.0	0.0	1.6
14	0	0	0	0			0.0	
20	0.4	0.6	1.1	0	6.1	1.2	5.5	16.5
28	1.5	2.9	6.3	0.1	21.8	7.6	21.5	33.4
35	4.2	13.0	23.0	14.5				
48	12.3	36.8	52.9	60.0	77.8	61.3	78.0	74.0
65	36.7	72.9	82.5	85.7				
100	81.4	95.7	98.6	98.0	99.8	99.5	99.8	94.7
150	97.5	99.2	99.6	99.8	100.0	100.0	100.0	

* Laboratory Sample Number

Tables 1, 2 and 3 reflect, in general, the status of high silica materials in North Carolina. The quartzites are too high in alumina for use in the silica refractory industry. If selective quarrying becomes economical, however, a sizeable tonnage of relatively high grade material could be produced. Vein quartz, although somewhat low in available tonnage, is of a high grade. Utilization of this material will largely depend upon the development of sufficient reserves. Certain sands and gravels, when washed, offer possibilities as raw materials for certain grades of glass and other products. These latter materials appear to represent the more important silica resources of the State and to occur in amounts favorable for wider development

APPENDIX

Analyses and Locations of Silica Rock Samples

Table 4 - QUARTZITES

Lab. no.	Formation	SiO_2	Al_2O_3	Fe_2O_3	Location	County
390	Nottley	96.1	2.9	0.28	Quarry on U.S. 19 at Regal Station Road	Cherokee
388	Tusquitee	91.2	6.0	0.24	Wesser Creek at Bee Branch	Swain
389	Tusquitee	93.5	5.6	0.088	On Watia Branch SE of Watia School	Swain
391	Tusquitee	90.7	6.2	0.119	Quarry at Gorge Dell on Nantahala R. 1st Bench	Swain
392	Tusquitee	91.0	6.1	0.195	Quarry at Gorge Dell on Nantahala R. 2nd Bench	Swain
393	Tusquitee	91.0	6.4	0.163	Quarry at Gorge Dell on Nantahala R. 2nd Bench	Swain
394	Tusquitee	88.6	7.5	0.24	Quarry at Gorge Dell on Nantahala R. 3rd Bench	Swain
395	Tusquitee	91.1	6.5	0.151	Quarry at Gorge Dell on Nantahala R. Best Mat.	Swain
428	Erwin	95.6	2.7	0.19	1/2 mi. S. Linville Caverns	McDowell
447	Erwin	91.0	7.2	0.17	0.2 Mi. N. Linville Caverns	McDowell
448	Erwin	95.0	3.7	0.27	1 mi. N. Linville Caverns	McDowell
449	Erwin	95.4	3.6	0.12	100 yds. N.Linville Caverns	McDowell
450	Erwin	94.9	4.1	0.16	100 yds. N.Linville Caverns	McDowell
474	Erwin	96.7	2.7	0.11	0.9 mi. N. Linville Caverns	McDowell
485	Erwin	94.3	4.3	0.48	1,000 ft. S. of Hot Springs Church	Madison
483	Nichols (?)	96.7	3.0	0.12	3.4 mi. WSW from Hot Springs	Madison
484	Nebo	95.6	4.0	0.18	1.9 mi. W. of Hot Springs	Madison
486	Nebo	86.2	8.6	1.3	1.9 mi. W. of Hot Springs	Madison
412	Kings Mtn.	69.8	28.0	0.23	North end of Crowders Mountain	Gaston
413	Kings Mtn.	96.3	3.2	0.12	Jackson Knob	Gaston
414	Kings Mtn.	83.7	15.7	0.34	Old Quarry (Lower) Spencer Mountain	Gaston
415	Kings Mtn.	83.5	14.9	0.15	Old Quarry (Upper) Spencer Mountain	Gaston
416	Kings Mtn.	83.9	15.5	0.18	Old Quarry (Upper) Spencer Mountain	Gaston
411	Kings Mtn.	81.1	12.9	0.23	Small lens E. Mecklenburg Co. 3-1/2 mi.E.Newell	Mecklenburg
443	Pilot Mtn.	93.9	4.9	0.27	Pilot Mountain Toll Road	Surry

TABLE 5 - VEIN QUARTZ

Lab. No.	Source	SiO_2	Al_2O_3	Fe_2O_3	Ign. L.	Location	County
396	Vein	96.6	2.7	0.08	0.10	White Rock Mountain (Fresh)	Buncombe
397	"	96.9	2.6	0.09	0.04	" " " (stained)	"
398	"	97.2	2.0	0.08	0.05	Fairview Gap	"
443	"	97.3	2.1	0.08	....	3.6 mi. SE of Sylva	Jackson
593	"	99.3	0.5	0.08	0.12	1/2 mi. N. Eldorado	Montgomery
493	"	98.4	0.7	0.57	....	1 mi. S. Wingate	Union
494	"	98.3	1.2	0.13	....	1/2 mi. S. Wingate	Union
402	Pegmatite Core	97.9	1.7	0.14	....	Carter Ridge 2 mi. S. Spruce Pine	Mitchell
432	" "	98.0	1.4	0.13	....	Grassy Ridge near Balsam	Jackson

TABLE 6 - WASHED GRAVELS

Lab. No.	Source	SiO_2	Al_2O_3	Fe_2O_3	Location	County
546*	Lilesville	98.8	.82	0.10	Composite of 3 Analyses - 1 mi. E. of Lilesville	Anson
547*	Lilesville	98.8	0.95	0.14	Composite of 4 Analyses - 1 mi. E. of Lilesville	"
548	Carthage	98.7	1.18	0.13	Along U.S. 15, 2 mi. E. of Carthage	Moore

*Washed products from two gravel operations

TABLE 7 - SAND

Lab. No.	Source	SiO_2	Al_2O_3	Fe_2O_3	Ign. L.	Location	County
515	St. Lucie	95.6	1.2	2.2	2.6	Composite 4 analyses SE side Lake Singletary	Bladen
515-5	" "	94.7	1.3	0.20	1.16	Black organic material at base of St. Lucie	"
515-6	Norfolk	95.3	1.4	0.24	0.24	Brown sand underlying St. Lucie	"
526-1	"	97.9	1.0	0.111	0.12	Old Pit 4 mi. SW Bladenboro	"
526-2	St. Lucie	98.7	0.68	0.10	0.10	E. side Lumber River 4-1/2 mi. S. Fair Bluff	Columbus
526-3	St. Lucie	98.2	0.73	0.07	0.10	1 mi. S. of above locality	"
587	" "	98.9	0.58	0.14	0.19	Composite of 5 samples from above locality	"
526-4	Coastal	98.1	0.84	0.18	0.12	1 mi. NE of Seaside	Brunswick
526-5	"	97.3	1.31	0.28	0.26	5 mi. N. of Carolina Beach	New Hanover
526-6	"	98.8	0.58	0.10	0.02	" " " " " "	" "
526-7	"	97.4	1.30	0.18	0.18	3 mi. NE Wilmington at Sand Hill	" "
602-1	Sand Hill	98.7	1.1	0.11		Eagle Springs	Moore
602-2	" "	99.3	1.4	0.14		1 mi. W. of Aberdeen	"

TABLE 8
SCREEN ANALYSES - SANDS

Lab. No.	Source	10m	20m	30m	-30m
		% retained	% retained	% retained	% passing
515-1	St. Lucie	0.0	2.44	17.19	82.75
515-2	St. Lucie	0.0	3.66	16.56	83.30
515-3	St. Lucie	0.0	12.28	38.28	61.85
515-4	St. Lucie	0.0	3.02	18.17	81.90
515-5	St. Lucie	0.0	0.91	12.27	87.80
515-6	Norfolk	0.0	2.42	19.15	80.85

TABLE 9

SCREEN ANALYSES - SANDS

Lab. No.	Source	10m	20m	28m	48m	100
		% retained	% retained	% retained	%retained	% retained
526-1	Norfolk	0.3	10.9	32.2	76.2	94.4
526-2	St. Lucie	0.0	3.4	22.1	86.9	100.00
526-3	St. Lucie	0.2	6.1	21.8	77.8	99.8
526-4	Coastal	0.0	0.0	0.6	11.4	98.8
526-5	"	0.0	1.7	7.3	50.6	99.5
526-6	"	0.0	1.2	7.6	61.3	99.5
526-7	"	0.0	5.5	21.5	78.0	99.8
602-1	Sand Hills	1.0	20.2	43.0	81.0	94.7
602-2	" "	1.6	16.5	33.4	74.0	94.7