Distribution of Silica Resources in Eastern United States

GEOLOGICAL SURVEY BULLETIN 1072-L

Distribution of Silica Resources in Eastern United States

By T. D. MURPHY

CONTRIBUTIONS TO ECONOMIC GEOLOGY

GEOLOGICAL SURVEY BULLETIN 1072-L

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1960

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

CONTENTS

ILLUSTRATIONS

[Plates in pocket]

CONTRIBUTIONS TO ECONOMIC GEOLOGY

DISTRIBUTION OF SILICA RESOURCES IN EASTERN UNITED STATES

By T. D. MURPHY

ABSTRACT

The general distribution of silica resources (minimum SiO_2 content 95 percent) east of the Mississippi River is shown on eight maps. Location of silica operations active in 1955 is indicated on a separate map. The text, which is an expanded explanation and introduction to these maps, includes definitions and uses of various types of silica raw materials, and specifications of significance to the silica industry.

INTRODUCTION

This report presents a summary of the general results of a study of silica resources of the States east of the Mississippi River, made by the writer during the period February 1953–April 1955. The term "silica," as used in this report, refers to any natural material which is composed essentially of silicon dioxide, SiO_2. It may be crystalline, microcrystalline, or amorphous. The term "resources" includes mineral raw materials exploitable at the present time at a profit (reserves) plus mineral raw materials which, to be exploited profitably, require either more favorable economic conditions than those of the present day or new technology (potential resources). For convenience in presenting data on plates 30–36, the States in Eastern United States have been grouped as the Northeastern, Southeastern, and Eastern North Central States.

The Northeastern States are those States north of the Potomac River and east of the Great Lakes: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

The Southeastern States are south of the Potomac and Ohio Rivers: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia.

The Eastern North Central States are those States north of the Ohio River which border on the Great Lakes: Illinois, Indiana, Michigan, Ohio, and Wisconsin.

The siliceous materials included in this study were selected on the basis of quality or purity. A raw material with a minimum uncombined silica content of 95 percent was considered a resource, as well as some materials of lower grade that were either known to compete successfully with commodities of greater purity or which might be upgraded profitably. The types of silica-bearing materials investigated are massive quartz, quartz sand, sandtone, gravel, conglomerate, quartzite, quartz-mica schist, chert, and tripoli. They vary from place to place in composition, lithologic character, thickness, and structure.

SOURCES AND LIMITATIONS OF DATA

Much of the information used in preparation of this report was taken from published sources, but field examinations were made of formations and deposits which are currently exploited or have been worked for silica raw materials, and of formations or deposits described as being of sufficient purity to be of commercial interest. Where possible the raw materials were studied at locations of active operations and at abandoned workings.

The maps (pls. 30–38) show the general distribution of the principal deposits and formations containing silica raw materials east of the Mississippi River. Data for compilation of these maps have been taken largely from published reports, chiefly State geologic maps; no original mapping was done. Because of the small scale of the maps, as well as the reconnaissance nature of much of the study, the delineation of areas in which silica resources occur is approximate.

In all types of silica deposits, variations are to be expected along the strike and down the dip with respect to thickness, lithologic character, degree of consolidation, and purity. Because of such variations the same formation may be a source of more than one silica raw material. This is the reason, for example, why the Cochran formation, the Antietam sandstone and Erwin quartzite, and the Tuscarora quartzite are shown as both quartzite silica resources (pl. 32) and sandstone and conglomerate silica resources (pl. 33).

ACKNOWLEDGMENTS

The writer acknowledges with gratitude the helpful cooperation of the State Geological Survey staffs, the management and technical personnel of various industrial organizations, and of coworkers in the U.S. Geological Survey.

DEFINITIONS

Silica raw material and product terms are sufficiently descriptive, for the most part, to be easily understood. However some of the terminology, as used in this report, requires explanation.

Soft and hard are widely used to denote degree of cohesion or induration of silica raw materials in large masses. This usage is distinct from that expressed by Mohs' scale, which is a measure of resistance to abrasion.

Chert.—Chert is a very dense or compact rock, composed mineralogically of microcrystalline quartz and chalcedony. The rock is tough and breaks with a splintery to conchoidal fracture. Most chert contains 85 to 95 percent silica and ranges from light buff and gray to black in color, depending upon the kind and amount of impurities.

Conglomerate.—Just as sandstone is consolidated sand, conglomerate is a consolidated mass of pebbles, cobbles, and boulders. Strongly indurated sandstone is called quartzite, but conglomerite, the analogous term suggested for highly indurated conglomerate, is not commonly used.

Firestone.—The term "firestone" is applied to silica raw materials used in block form as refractory lining. These materials are fine-grained thin-bedded somewhat clayey types of sandstone and soft quartz-mica schist. The blocks are hand-hewn to specification size and generally used on edge, in tiers, to form a refractory liner for acid converters in copper refining, in acid bessemer-steel work, or for ingot-soaking pits and hot-metal cars. The ratio of iron and alumina is such that fusion takes place and a durable glaze is formed on the stone when heated. The chemical industry uses firestone for lining vats and sulfuric acid towers.

Furnace-bottom sand.—Furnace-bottom sand, formerly called fire sand, is a crude quartz sand containing natural clay bond. Size distribution ranges from 4 mesh down to clay size. Many of the coarse particles are aggregates of finer grains that contain surface moisture. These compound grains decrepitate violently upon heating and the component particles scatter uniformly, thus insuring a smooth and level furnace bottom. It is used for lining and patching cupolas or open hearths utilizing an acid process.

Ganister.—In the United States, the term "ganister" was first used to describe quartzite talus or floe rock incorporated into acid refractories by the early Pennsylvania brickmakers. As now used, the term applies to all quartzite crushed and aggregated for making acid refractory lining. Ganister may be either entirely finely crushed quartzite or such quartzite bonded with plastic clay. In California, a naturally occurring mixture of quartzose sand and clay is known as Livermore ganister (Wright, 1948, p. 48). In southern Illinois, the term "ganister" is applied to a "high-silica material, usually white, cream, light yellow, or red which is loosely consolidated and readily disintegrated into particles an inch or less in size" (Lamar, 1953, p. 27).

Massive quartz.—Silica deposits listed under massive quartz (pl. 37) include pegmatitic quartz, vein quartz, replacement quartz bodies, and silicified zones. Most of this rock is coarsely crystalline quartz.

Quartzite.—As used in this report, quartzite is a rock derived from sandstone, composed dominantly of quartz, and characterized by thorough induration, either through cementation with silica or through recrystallization.

Tripoli.—Soft silica in very finely divided or pulverulent form is called tripoli. Two types of tripoli are recognized in the United States. The Missouri-Oklahoma type is highly porous and weakly coherent, and its color ranges from cream to pink and red. The Illinois-Tennessee type, which is predominant in the region investigated, ranges from dense and compact to porous and noncoherent and, as compared with the other type, is lighter in color and has smaller median-size particles.

USES AND SPECIFICATIONS

Silca raw materials, after appropriate treatment, may be used in industry as finished products or as semifinished products. Examples of finished products used directly, owing to inherent physical properties of the original raw material, are natural abrasives, steel foundry sands and flours, filter media, inert fillers, and extenders. Semifinished products, because of inherent chemical properties of the original raw material, are utilized for such purposes as making glass, silicon alloys, silicon metal, manufactured abrasives and refractories, and in certain heavy chemical products.

For most silica raw materials there are few standard specifications. On a nationwide basis, tolerances for certain types may vary greatly because of such economic factors as proximity of sources to low-cost transportation and markets. Thus, it may be more economical to upgrade material of poor quality from deposits near local markets or large centers of consumption than to pay excessive transportation costs to obtain high-grade raw material from distant deposits. A discussion follows of specifications for each type of silca raw material included in this study.

Sand.—Quartz sand must be of uniform composition and high purity to qualify as a silica raw material for glass melting and chemical use. It is difficult to generalize on tolerances, but in sand suitable for flint-glass melting and for chemical uses the total iron content may range from 0.015 to 0.030 percent; alumina should not exceed 0.20 percent or fluctuate; calcium and magnesium oxides combined should be constant and not exceed 0.05 percent for glass and 0.15 percent for chemical use. Alkalies and titania are tolerated in trace quantities (0.01 percent or less) but must not vary; cobalt and chromium, none. Sand of such composition, or flour produced from it, would qualify for all but the most specialized uses. Sand with a total iron content ranging from 0.05 to 0.15 percent is used for production of amber glass.

Quartz sands may differ greatly with respect to texture, shape and size of particles, and amount and kind of accessory minerals. Soundness of grain, shape or degree of sphericity, roundness, and size distribution are factors in packing and resultant porosity and permeability which are important properties of sand for steel foundry and filter use and hydraulic fracturing of oil, gas, and water wells.

Clay, or some other bond, is a requisite for some types of foundry sand, and careful sizing is required for filter sand. There are no standard requirements regarding shape of grain for most abrasive sand. However, angularity of grain is important for surface-coated abrasives (sandpaper). Consequently, for such use, sand from crushed quartz or quartzite is preferable to naturally occurring sand. For glass melting use, all grains should pass through a 30-mesh sieve and very little be retained on the 40-mesh sieve. Excessive fine material is objectionable, and all grains should be retained on a 200-mesh sieve with a minimum passing the 140-mesh sieve. Grain shape is not significant in glass sand.

Quartz sand is used in the hydraulic fracturing of oil, gas, and water wells to increase their flow. The essentials of sand used to prop the fractures open are: It shall be of uniform texture, the grain size shall be within certain limits, and the grains shall be strong and spherical or nearly so. About 90 percent of the sand used for this purpose is the so-called 20–40 grade, with tolerances of 5 percent +20 and −40 mesh, and 60 percent +30 mesh.

To generalize, a quartz sand with 90 percent of its grains between 20 mesh (0.833 mm) and 100 mesh (0.147 mm), and with a fairly uniform size frequency distribution is a desirable multipurpose industrial sand from a textural standpoint. Any departure from these limits usually poses separation and waste disposal problems which add markedly to the expense of preparation for marketing.

Sandstone.—Few major industrial applications require high-purity quartzose sandstone. Of these, glass sand is probably the most important.

Chemically, problems relating to utilization of sandstone are similar to those pertaining to sand. If the cementing material of quartzose sandstone is silica, the rock is considered a high-grade silica raw material. However, if the grains are bonded by other mineral cements or interstitial detritus, the sandstone cannot be used in its natural state as a source of high-grade silica.

Chert.—No specific standards for the utilization of chert have been established. Purity and, to a lesser extent, size distribution are important if chert is utilized because of its chemical composition, as for a metallurgical flux. Hardness, purity, and density are most important if chert is used for its physical properties, as for linings and grinding media in certain types of pulverizing mills.

Conglomerate.—Weakly cemented conglomerate is subject to the same specifications and use limitations as gravel. High purity, the degree of induration, particle size, and sorting are important. The use of highly indurated conglomerate depends more on the physical properties than chemical composition as, for example, for millstones.

Gravel.—Quartzose gravel, to qualify chemically as a silica raw material, must meet practically the same rigid specifications as sand. In fact, the specifications are somewhat more strict because there are fewer chemical uses than for sand.

Present practice in the manufacture of acid refractories demands careful control of alumina; the maximum allowed in the raw material is 0.6 percent. The total iron content should be low; 0.2–0.4 percent is the desirable range. The calcium carbonate content should be less than 1.0 percent, total alkalies should not exceed 0.5 percent, and the titania content should be low. Opaline silica is highly undesirable because it tends to spall or disintegrate in the kiln, with destructive results. Any gravel in which chert or flint pebbles occur is suspect, and any conglomerate having a matrix of amorphous silica may yield undesirable gravel. A high ignition loss in the chemical analysis is indicative of opaline silica and should not exceed 0.5 percent.

With respect to chemical composition, specifications for gravel used for electrometallurgical purposes are similar to those for chemical uses. Alumina is most undesirable because it is not reduced in the furnace and forms a sticky slag; it should be less than 0.3 percent, but up to 1.5 percent is generally tolerated. Total iron can be as high as 2.0 percent; combined base oxides should not exceed 0.3 percent; titania, phosphorus, and arsenic are undesirable and should not be present; sulfur is not a factor as it volatilizes in the electric furnace. Opaline silica is detrimental because it breaks down in the furnace and seals the charge against free circulation of the desired reducing atmosphere.

Size is the only important physical specification of gravel used for electrometallurgical purposes. The minimum size used is three-eighths of an inch, and half an inch or larger is generally specified. The upper size tolerance is from 6 to 8 inches. Breakdown into fine material upon handling is not tolerated.

Massive quartz.—Since massive quartz must be of extreme purity to qualify as a silica raw material for industrial use, only a few of these deposits can be exploited profitably. Common impurities are the oxides and hydrate of iron, together with clay and sericitic minerals. Only traces of these contaminants are permissible.

Massive quartz is used for special purposes in the glass and ceramics trades and as additives, in the pulverized state, for soaps and cleansers.

Quartzite.—Friable types of very pure quartzite are often used interchangeably with high-grade sandstone for glass melting and chemical uses. Well-indurated types of less pure quartzite are used interchangeably with quartzose gravel in the production of silicon alloys and acid refractories.

Chemically, good commercial quartzite must have essentially the same composition as good marketable quartzose gravel. Thus, in general, specifications discussed previously for gravel commonly are the same for quartzite. However, quartzite used for the manufacture of silicon alloys should be exceptionally high grade. The silica content should be 99.0 percent or more, and alumina should be less than 0.5 percent. Other constituents such as iron oxide, titania, and sulfur should be correspondingly low.

For electrometallurgical use, quartzite should not be brittle or friable. These physical properties cause breakdown in handling and, consequently, increased quantities of undesirable fine material. Quartzite for refractory use should have a dense texture of strongly interlocked grains to insure good strength in silica brick and other shapes produced from it.

Quartz-mica schist.—Quartz-mica schist competes with higher purity types of silica raw materials used in the refractory, abrasive, and chemical industries.

For refractory use, quartz-mica schist should contain 6 to 8 percent alumina. The rock is easily split to specification size for firestone used in lining bessemer vessels, cupolas, and copper-refining furnaces. Crushed material, known as ganister grit, is bonded with plastic clay and rammed into place to make refractory liners for slag pots and hot-metal ladles.

Quartz-mica schist is used for natural sharpening or honing stones. The honing stones are easily made into specified sizes and shapes owing to the micaceous minerals which make the schist easy to cleave.

Inert liners of quartz-mica schist are used in the chemical industry in the production of sulfuric acid by the lead-chamber process.

Tripoli.—The trade has been reluctant to set standard specifications for tripoli because slight variances in chemical composition or physical properties do not disqualify it for some uses. Tripoli of acceptable commercial quality contains 95 to 99 percent silica. The iron content ranges from 0.2 to 2.0 percent. Alumina and combined water, indications of the amount of clay present, normally should not exceed 2.0 percent. Base oxides and alkalies usually are permissible in trace quantities.

The physical properties that control the uses to which tripoli may best be put are size distribution of particles, abrasiveness, and color. Oil absorption and specific surface vary with particle size and shape. Color is dependent on the type and amount of iron present. Abrasiveness is closely related to particle shape and, possibly, to size.

Finely ground tripoli is used as a polishing agent. The coarser grades are used in scouring compounds and soaps and in foundries as facing material. Some tripoli is used as inert fillers and extenders, particularly in paint. Tripoli used in the ceramic industry is called potter's flint.

SELECTED REFERENCES

Alabama Geological Survey, 1926, Geological map of Alabama: Scale 1: 500,000.

American Society for Testing Materials, 1950, Supplement to book of ASTM standards including tentatives, pt. 3: Philadelphia, Pa., ASTM designation C 119-50, p. 96.

Ashley, G. H., 1903, The geology of the Lower Carboniferous area of southern Indiana: Indiana Dept. Geol. Nat. Resources 27th Ann. Rept., p. 68.

Bean, E. F., 1949, Geologic map of Wisconsin [revised]: Wisconsin Geol. and Nat. History Survey, Scale 1: 1,000,000.

Belt, W. E., and others, 1945, Geologic map of Mississippi: Jackson, Miss., Mississippi Geol. Soc., Scale 1: 500,000.

Billings, M. P., 1955, Geologic map of New Hampshire: U.S. Geol. Survey and New Hampshire Plan. Devel. Comm., Scale 1: 250,000.

Bownocker, J. A., 1947, Geologic map of Ohio [revised]: Ohio Geol. Survey, Scale 1: 500,000.

Cooke, C. W., 1936, Geology of the Coastal Plain of South Carolina: U.S. Geol. Survey Bull. 867.

Cooke, C. W., and Mossom, Stuart, 1929, Geologic map of Florida: Florida Geol. Survey, Scale 1: 1,000,000.

Emerson, B. K., 1917, Geology of Massachusetts and Rhode Island: U.S. Geol. Survey Bull. 597.

Flint, R. F., 1930, The glacial geology of Connecticut: Connecticut Geol. and Nat. History Survey Bull. 47.

Galpin, S. L., 1915, A preliminary report on the feldspar and mica deposits of Georgia: Georgia Geol. Survey Bull. 30.

Georgia Geological Survey, 1939, Geologic map of Georgia: Scale 1: 500,000.

Gregory, H. E., and Robinson, H. H., 1907, Preliminary geological map of Connecticut: Connecticut Geol. Nat. History Survey Bull. 7.

Hitchcock, Edward, and others, 1861, Report on the geology of Vermont: Vermont Geol. Survey, v. 2.

Indiana Department of Conservation, Division of Geology, 1932, Geological map of Indiana: Pub. 112, Scale 1: 253,440.

Jillson, W. R., 1929, Geologic map of Kentucky: Kentucky Geol. Survey, Scale 1: 500,000.

Keith, Arthur, 1933, Preliminary geologic map of Maine: Maine Geol. Survey, Scale 1: 1,000,000.

Lamar, J. E., 1953, Siliceous materials of extreme southern Illinois: Illinois Geol. Survey Rept. Inv. 166, p. 27.

Lewis, J. V., and Kümmel, H. B., 1910–1912, Geologic map of New Jersey [revised]: New Jersey Geol. Survey, Scale 1: 250,000.

Martin, H. M., compiler, 1936, The centennial geological map of the northern peninsula of Michigan [and] The centennial geological map of the southern peninsula of Michigan: Michigan Dept. Conserv., Geol. Survey Div. Pub. 39, Geol. Ser. 33, Scale 1: 500,0000.

Maryland Geological Survey, 1933, Map of Maryland, [Delaware included] showing geological formations: Scale 1: 380,160.

Merrill, F. J. H., 1901, Geologic map of New York: New York State Mus., Scale 1: 316,800 [in 12 sheets].

Nelson, W. A., 1923, Geologic map of Tennessee [revised]: Tennessee Geol. Survey, 3d ed., Scale 1: 500,000.

North Carolina Department of Conservation and Development, Mineral Resources and Engineering Division, 1937, Geologic map of North Carolina: Scale 1: 1,000,000.

Reger, D. B., and Price, P. H., 1926, Mercer, Monroe, and Summers Counties: West Virginia Geol. Survey, p. 300, 415.

Siple, G. E., 1946, Progress report on ground-water investigations in South Carolina: South Carolina Research, Plan. Devel. Board Bull. 15, Columbia, S.C.

Stose, G. W., and Ljungstedt, O. A., 1931, Geologic map of Pennsylvania: Pennsylvania Topographic and Geol. Survey, Scale 1: 380,160.

——— 1932, Geologic map of West Virginia: West Virginia Geol. Survey, Scale 1: 500,000.

Virginia Geological Survey, 1928, Geologic map of Virginia: Scale 1: 500,000.

Weller, J. M., and others, 1945, Geologic map of Illinois: Illinois Geol. Survey, Scale 1: 500,000.

Wright, L. A., 1948, California foundry sands: California Jour. Mines and Geology, v. 44, no. 1, p. 48.

○