RARE METALS.

THE ARSENIC DEPOSITS AT BRINTON, VIRGINIA.

By Frank L. Hess.

GEOGRAPHY.

The Brinton arsenic mine is located on the south slope of Lick Ridge, one of the minor elevations of the Appalachian Mountains, at Brinton, Floyd County, Va., about 14 miles southeast of Christiansburg. (See fig. 33.) So far as is known this is the only mine in the eastern United States which has mined arsenic ore and produced white arsenic from it, although arsenopyrite has been mined in at least two places in New York for shipment to arsenic plants located at other points.

The mine is reached from Christiansburg by a very good mountain road, on which the only steep grades are within a mile of the mine. According to the Survey's topographic map of this region (the Christiansburg sheet) the mine is about 2,400 feet above sea level. Scenically the country is beautiful, and owing to its altitude it is cooler in the summer than lower lying lands, and several summer resorts are located within a few miles of the mine.

The country is well wooded and fields left uncultivated are soon overgrown with trees. Wood for fuel and mine timber is therefore plentiful and comparatively cheap.

Owing to the roughness of the country the tillable fields are small and difficult to cultivate. The soil is poor and good crops can be raised only with the help of fertilizers. As a result of these handicaps and the comparative isolation of the country many of the people are poor and labor is abundant and low priced.

DISCOVERY AND DEVELOPMENT.

The arsenic deposits were found by C. R. Brinton in 1901. Work on the mine and on the erection of a plant for making white arsenic (arsenious oxide, As_2O_3) was begun in March, 1902. The brick necessary for the building of the plant, about 1,250,000, were made and burned and the lumber required was cut and sawed on the place. The mine is equipped with a steam hoist, steam pump, electric lights, and air drills.

The making of white arsenic began in January, 1903, and was continued intermittently for a number of years.

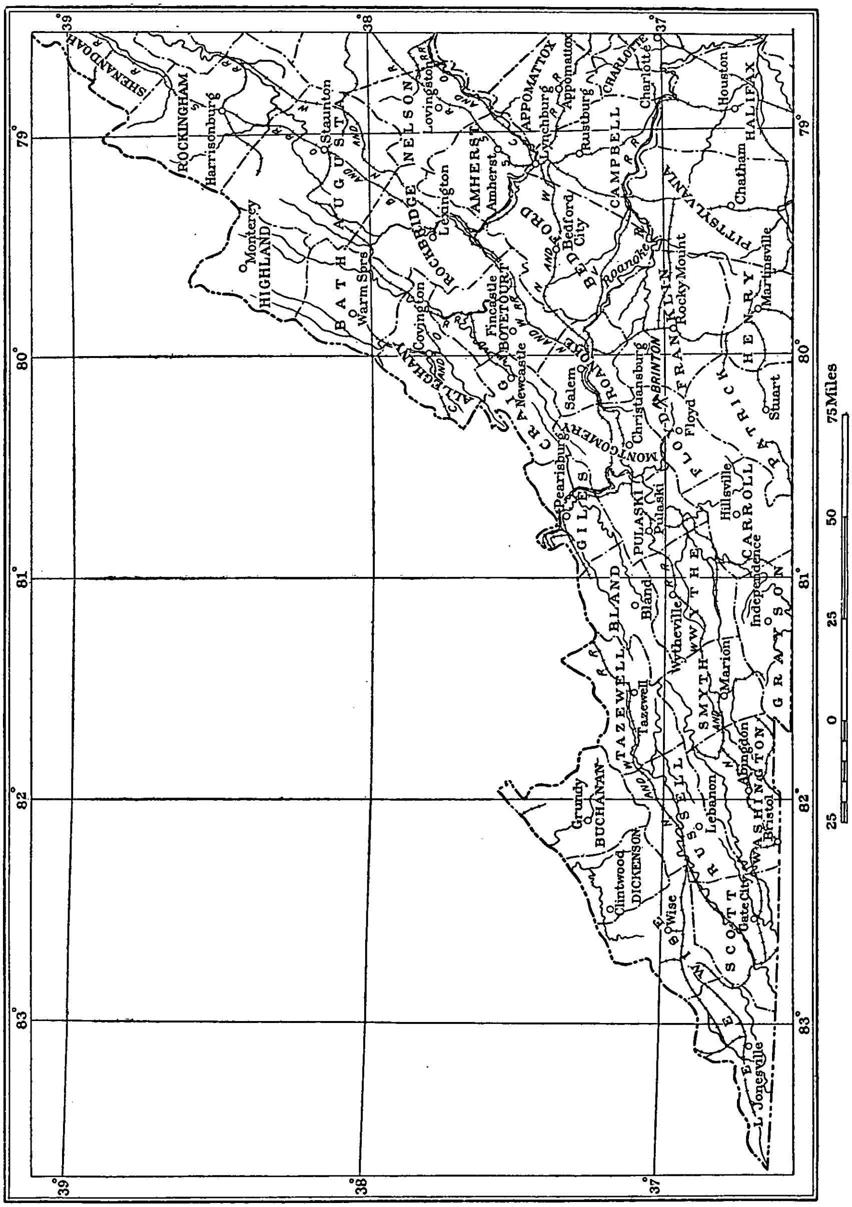

FIGURE 33.—Map of southwestern Virginia, showing location of arsenic deposits at Brinton.

In 1910 a company was organized to manufacture Paris green and other insecticides for which the arsenic produced at the Brinton mine was to be used, and a plant was established at Norfolk, Va., but is not yet (March, 1911) in operation.

GEOLOGY.

The country rock of the region has been called by Arthur Keith[1] the Carolina gneiss and is of pre-Cambrian age. In places the gneiss is coarse, biotitic, and very quartzose. It contains both blue and white quartz. Intercalated with the coarser phases is a dark-gray mica-quartz schist having many beds of lighter color. Near the mine only the schist was seen.

An altered microcline granite cuts the gneiss at numerous places and has generally been squeezed until it also has a coarsely gneissoid structure. In the hasty examination made in the field the granite was thought to be generally of one type, but close examination of the specimens collected makes it seem probable that there is considerable variation. In one variety garnet is prominent. The garnet is crushed and forms possibly 20 per cent of the rock. Under a hand lens it has a dirty brownish-green color. It carries no manganese and, to judge from its color, probably does not contain much iron. Besides garnet the granite carries quartz, andesine, microcline, muscovite, and a little epidote. The quartz contains innumerable minute needles of rutile. What appeared in the field to be a closely related rock shows under the microscope a considerably crushed, finely granular mass of quartz and microperthite. The feldspar has an exceedingly minute perthitic structure and contains a great number of inclusions which are so small that determination is difficult, but which appear to be largely apatite. The rock contains a little biotite which is invisible to the unaided eye.

The gneisses are also cut by many dikes, from a few inches to 2 feet thick, of what is supposed to have been pegmatite. These dikes in general follow the gneissoid structure and have been squeezed until they partake of the same general structural appearance but are more or less lenticular. Other dikes which are unmistakably pegmatitic cut across the strike of the gneiss. Some of these contain both blue and white quartz; others, such as one on Giffeys Creek, 1½ miles northeast of the arsenic mine, contain only blue quartz and buff feldspar, are uncrushed, and probably later than the crushed dikes. White quartz veins reaching 300 to 400 feet in length are interbedded with and cut across the gneiss. They contain some muscovite and may be, in part at least, of pegmatitic origin. As some of them cut across the structural lines, it does not seem probable that they are segregational masses such as are often found intercalated in gneiss and schist.

In the immediate vicinity of the mine the rock is a fine-grained gray mica-quartz schist which consists of muscovite and quartz with a very little epidote. On the crest of Lick Ridge, which is here only

[1] Personal communication. The Carolina gneiss is described by Keith in the Cranberry folio (No. 90), Geol. Atlas U. S., U. S. Geol. Survey, 1903, p. 10.

a few hundred feet across, is a vein of milky quartz several feet thick. The ridge follows the east-west strike of the schist, which dips 40° to 45° S. No gneiss was noticed within a quarter of a mile of the mine.

THE DEPOSITS.

The arsenic deposits consist of gray mica-quartz schist impregnated with arsenopyrite adjacent to faults along which aplite or pegmatite has been intruded and later crushed to schist. At many places south, southwest, and east of the mine there are pieces of spongy float rock from which arsenopyrite has evidently been weathered. In the hasty examination made by the writer the deposits now being worked could not be definitely followed on the surface, and they are not believed to be continuous for a great distance, but it is probable that similar deposits occur at a number of places in the vicinity.

The mine is entered by an adit opening on the south side of the ridge, perhaps 100 feet below the summit and about the same distance above the foot of the hill. At 50 feet in the adit cuts an impregnation vein of arsenopyrite, 2 to 8 inches thick, which dips with the schist. The impregnation is most dense in the middle of the vein, and in some places the ore forms an almost solid mass up to 4 inches thick, with leaner rock for 2 or 3 inches on each side.

A similar vein, which is thinner but richer where cut, is crossed 25 feet farther in, and on this vein a drift has been run to the west. Beyond the drift the adit continues into the hill for 100 feet. A dam 4 feet high has been built across it, and this portion of the adit is used as a cistern from which water for the reduction plant is obtained.

Forty feet west of the adit the vein followed by the drift is a few inches thicker, and some ore has been taken out. From this place an inclined winze has been sunk 300 feet following the schist at a dip of 42° S.

Drifts have been run both east and west on levels 100 feet apart, but only a small quantity of ore has been found on the west side.

On the first or 100-foot level most of the ore taken out was from a stope in a lens beginning about 15 feet east of the winze. The lens was 30 feet long east and west, of possibly the same extent along the dip, and 8 or 9 feet thick at most. Beyond the stope the drift extends for 50 or 60 feet, following the vein of arsenopyrite, which reaches several inches in thickness and on either side of which there is more or less impregnation of the country rock. The vein follows a fault which is not very clearly defined. In places a quartz vein 2 or 3 inches thick occurs with the arsenopyrite, but generally a white mica-quartz schist reaching 5 feet in thickness accompanies the ore. From its composition and varying thickness, this schist is believed to be a squeezed pegmatite or aplite in which the feldspars have been largely altered to muscovite. The grain is fine, but this may be due to the crushing. The arsenopyrite on the adit level and on the first and second levels is etched and the centers of the larger aggregates have been removed by leaching. The mineral has largely lost its bright metallic appearance and is nearly black. With the arsenopyrite is more or less pyrite, part of which is bronzy and evidently carries some copper. The mine is wet, and in places along the first level where water drips a thin green scum of malachite has formed. At one point there appeared to be a small amount of metallic copper.

On the second level the vein probably cuts across the schists at a small angle, and is under the winze, which follows the dip of the schist. Lenses of ore similar to that on the first level described above have been taken out on the east side. On the third level, also, the winze is above the vein, and a drift has been run to the east about 75 feet, whence a crosscut to the north was made to cut the vein. Here a lens of ore, said to reach 7½ feet in thickness and between 30 and 40 feet in length, has been stoped. The arsenopyrite is not so much etched as in the upper levels, and in part is fresh and bright. The slipping plane of a fault and the crushed pegmatite are again noticeable on this level. The lenses of ore do not seem to follow one plane and are apparently along a series of more or less parallel slipping planes which lie close together and which may, instead of being parallel, cut into each other.

An assay of a piece of ore rich in arsenopyrite, picked from the ore pile, showed only traces of gold and silver.[1] Mr. Brinton states that he has had assays of $2 and more in gold and 2 to 4 ounces of silver to the ton of 2,000 pounds.

THE ORE.

In thin section under the microscope the ore shows, in nonmetallic minerals, only quartz and muscovite, with minute inclusions of apatite and here and there a crystal of zircon. The arsenopyrite shows none of the perfect bipyramidal forms in which it generally occurs in igneous rocks, but has irregular outlines, though in some places there is a tendency toward skeletal double pyramids. Many of the masses appear to be aggregates of tiny double pyramids which have grown together or masses which have formed from many centers. The arsenopyrite and pyrite have grown together with very irregular boundaries, and particles of the pyrite are buried in the arsenopyrite.

The arsenopyrite forms small rods which lie both along and across the cleavage planes of the muscovite, hence the arsenic mineral is evidently later than the mica. Arsenopyrite generally exhibits a strong tendency to take definite crystal forms when original in a rock,

[1] Assay by E. E. Burlingame & Co., Denver, Colo.

and the lack of definite crystal planes on the arsenopyrite in this deposit also shows that it was introduced after the schist was formed.

In most of the observed granitic masses, and accompanying a number of the pegmatitic dikes, arsenopyrite occurs in noticeable quantities. As already remarked, the quartz veins of the region are possibly pegmatitic, but no arsenopyrite was noticed near them. A white schistose muscovite-quartz rock of varying thickness, which is probably a mashed and altered acidic pegmatite or aplite, accompanies the vein. There is also some vein quartz.

As the arsenopyrite is in immediate association with the crushed pegmatite or aplite at the mine and no granite is known in the vicinity, it is probable that the arsenopyrite was deposited by solutions accompanying the intrusion of the acidic rock.

METALLURGY.

The plant for the production of white arsenic from the ore is located a few feet below the mouth of the adit, and the loaded mine cars are run directly to an ore pile in the buildings. From the ore pile the rock is run through a Blake crusher, from which it goes to a 10 by 20 inch Stuyvesant roll; from the roll it goes to a rotary calciner—a large iron tube, 50 feet long and 6 feet in diameter, lined with fire brick for 30 feet from the furnace, which is fired with wood. The charge is treated 45 minutes at a temperature of about 800° F. (427° C.). From the calciner all the gases are drawn through a chambered flue 7 feet high, 6 feet broad, and 319 feet long, ending in a tall stack. At intervals of 5 feet baffles cross the flue alternately from each wall to points within 2 feet of the other wall. The alternate contraction and expansion and the cooling of the gas current are said to settle the arsenious oxide so completely that none reaches the last five compartments. In this form the arsenious oxide is a dirty gray powder containing sulphur, iron, and probably other impurities. The draft in the flue is governed by an electric fan, controlled by a rheostat sensitive to barometric pressure. After a sufficient amount of crude arsenious oxide has accumulated in the flues, they are opened and the oxide is removed by hand and taken to the refining furnace. This furnace is a brick reverberatory fired with coke, and volatilizes 1,400 pounds of crude arsenious oxide in two and one-half hours. The sulphur remaining with the crude arsenious oxide is converted to SO_2 and most of the other impurities are left behind as a residue. After passing through the calciner the white arsenic is caught in a flue similar to that used for obtaining the crude product. From the refiner flue the white arsenic is taken by hand to a 32-inch Waldron burrstone mill and after being ground it runs to an automatic weighing and barreling machine. The white arsenic is packed in barrels 22 inches tall, with a 19-inch bilge and 17-inch head, holding

500 pounds. The barrel itself weighs 35 pounds. The white arsenic made is said to have carried 99.975 per cent of As_2O_3.

The scheme of refining is epitomized on the following flow sheet:

Ore from mine.

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Ore pile.

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Ore raised to Blake crusher.

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Ore falls to 10 by 20 inch Stuyvesant rolls.

↓

Ore falls to rotary calciner.

↓

Arsenic fumes to crude flue.

↓

Crude arsenious oxide to refining furnace.

↓

Arsenious oxide fumes to refined flue.

↓

Refined white arsenic to Waldron burrstone mill.

↓

Refined white arsenic to automatic weighing and barreling machine.

↓

White arsenic to market.

SURVEY PUBLICATIONS ON ANTIMONY, CHROMIUM, MONAZITE, NICKEL, PLATINUM, QUICKSILVER, TIN, TUNGSTEN, URANIUM, VANADIUM, ETC.

The principal publications by the United States Geological Survey on the rarer metals are those named in the following list.

These publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. No publications on Alaskan occurrences are listed here.

BANCROFT, HOWLAND. Notes on the occurrence of cinnabar in central western Arizona. In Bulletin 430, pp. 151–153. 1910.

——— Platinum in southeastern Nevada. In Bulletin 430, pp. 192–199. 1910.

——— Notes on tungsten deposits near Deer Park, Washington. In Bulletin 430, pp. 214–216. 1910.

——— Reconnaissance of the ore deposits in northern Yuma County, Arizona. Bulletin 451. 130 pp. 1911.

BECKER, G. F. Geology of the quicksilver deposits of the Pacific slope, with atlas. Monograph XIII. 486 pp. 1888. $2.

——— Quicksilver ore deposits. In Mineral Resources U. S. for 1892, pp. 139–168. 1893. 50c.

BLAKE, W. P. Nickel; its ores, distribution, and metallurgy. In Mineral Resources U. S. for 1882, pp. 399–420. 1883. 50c.

——— Tin ores and deposits. In Mineral Resources U. S. for 1883–84, pp. 592–640. 1885. 60c.

BURCHARD, E. F. Chromic iron ore. In Mineral Resources U. S. for 1909, pt. 1, pp. 591–594. 1911.

CHRISTY, S. B. Quicksilver reduction at New Almaden [Cal.]. In Mineral Resources U. S. for 1883–84, pp. 503–536. 1885. 60c.

COLLIER, A. J. Chromite or chromic iron ore. In Mineral Resources U. S. for 1906, pp. 541–542. 1907. $1.

DAY, D. T., and RICHARDS, R. H. Investigations of black sands from placer mines. In Bulletin 285, pp. 150–164. 1906. 60c.

EMMONS, S. F. Platinum in copper ores in Wyoming. In Bulletin 213, pp. 94–97. 1903. 25c.

GALE, H. S. Carnotite in Rio Blanco County, Colorado. In Bulletin 315, pp. 110–117. 1907.

——— Carnotite and associated minerals in western Routt County, Colorado. In Bulletin 340, pp. 257–262.

GLENN, W. Chromic iron. In Seventeenth Ann. Rept., pt. 3, pp. 261–273. 1896.

GRATON, L. C. The Carolina tin belt. In Bulletin 260, pp. 188–195. 1905. 40c.

——— Reconnaissance of some gold and tin deposits in the southern Appalachians. Bulletin 293. 134 pp. 1906.

HARDER, E. C. Some chromite deposits in western and central California. In Bulletin 430, pp. 167–183. 1910.

HESS, F. L. Some molybdenum deposits of Maine, Utah, and California. In Bulletin 340, pp. 231–240. 1908.

——— The Arkansas antimony deposits. In Bulletin 340, pp. 241–256. 1908.

——— Note on a tungsten-bearing vein near Raymond, California. In Bulletin 340, p. 271. 1908.

——— Minerals of the rare-earth metals at Baringer Hill, Llano County, Texas. In Bulletin 340, pp. 286–294. 1908.

——— Tin, tungsten, and tantalum deposits of South Dakota. In Bulletin 380, pp. 131–163. 1909.

——— Note on a wolframite deposit in the Whetstone Mountains, Arizona. In Bulletin 380, pp. 131–163. 1909.

——— Arsenic. In Mineral Resources U. S. for 1908, pt. 2, pp. 599–601. 1909.

——— Antimony. In Mineral Resources U. S. for 1908, pt. 1, pp. 709–711. 1909.

——— Bismuth. In Mineral Resources U. S. for 1908, pt. 1, pp. 713–714. 1909.

——— Selenium. In Mineral Resources U. S. for 1908, pt. 1, pp. 715–717. 1909.

——— Tellurium. In Mineral Resources U. S. for 1908, pt. 1, pp. 719–720. 1909.

——— Tungsten, nickel, cobalt, vanadium, etc. In Mineral Resources U. S. for 1908, pt. 1, pp. 721–749. 1909.

——— Tin. In Mineral Resources U. S. for 1909, pt. 1, pp. 771–779. 1909.

HESS, F. L., and GRATON, L. C. The occurrence and distribution of tin. In Bulletin 260, pp. 161–187. 1905. 40c.

HILL, J. M. Note on the occurrence of tungsten minerals near Calabasas, Arizona. In Bulletin 430, pp. 164–166. 1910.

HILLEBRAND, W. F., and RANSOME, F. L. On carnotite and associated vanadiferous minerals in western Colorado. In Bulletin 262, pp. 9–31. 1905.

HILLEBRAND, W. F., and SCHALLER, W. T. Mercury minerals from Terlingua, Texas. Bulletin 405. 174 pp. 1909.

HOBBS, W. H. The old tungsten mine at Trumbull, Connecticut. In Twenty-second Ann. Rept., pt. 2, pp. 7–22. 1902. $2.25.

——— Tungsten mining at Trumbull, Connecticut. In Bulletin 213, p. 98. 1903. 25c.

KAY, G. F. Nickel deposits of Nickel Mountain, Oregon. In Bulletin 315, pp. 120–127. 1907. 50c.

KEMP, J. F. Geological relations and distribution of platinum and associated metals. Bulletin 193. 95 pp. 1902. 30c.

LINDGREN, WALDEMAR. Platinum and allied metals. In Mineral Resources U. S. for 1909, pt. 1, pp. 595–602. 1911.

McCASKEY, H. D. Quicksilver. In Mineral Resources U. S. for 1909, pt. 1, pp. 549–560. 1911.

PACKARD, R. L. Genesis of nickel ores. In Mineral Resources U. S. for 1892, pp. 170–177. 1893. 50c.

PAIGE, SIDNEY. Mineral resources of the Llano-Burnet region, Texas, with an account of the Pre-Cambrian geology. Bulletin 450. 103 pp. 1911.

RICHARDSON, G. B. Tin in the Franklin Mountains, Texas. In Bulletin 285, pp. 146–149. 1906. 60c.

——— Antimony in southern Utah. In Bulletin 340, pp. 253–256. 1908.

ROLKER, C. M. The production of tin in various parts of the world. In Sixteenth Ann. Rept., pt. 3, pp. 458–538. 1895. $1.20.

SCHRADER, F. C. An occurrence of monazite in northern Idaho. In Bulletin 430, pp. 184–191. 1910.

SCHRADER, F. C., and HILL, J. M. Some occurrences of molybdenite in the Santa Rita and Patagonia mountains, Arizona. In Bulletin 430, pp. 154–163. 1910.

SIEBENTHAL, C. E. Cadmium. In Mineral Resources U. S. for 1909, pt. 1, pp. 603–604. 1911.

STERRETT, D. B. Monazite deposits of the Carolinas. In Bulletin 340, pp. 272–285. 1908.

——— Monazite and zircon. In Mineral Resources U. S. for 1909, pt. 2, pp. 897–906. 1911.

ULKE, T. Occurrence of tin ore in North Carolina and Virginia. In Mineral Resources U. S. for 1893, pp. 178–182. 1894. 50c.

WATSON, T. L., and TABER, STEPHEN. The Virginia rutile deposits. In Bulletin 430, pp. 200–213. 1910.

WEED, W. H. The El Paso tin deposits [Texas]. Bulletin 178. 15 pp. 1901. 5c.

——— Tin deposits at El Paso, Tex. In Bulletin 213, pp. 99–102. 1903. 25c.

WEEKS, F. B. Tungsten deposits in the Snake Range, White Pine County, eastern Nevada. In Bulletin 340, pp. 263–270. 1908.