NOTES AND NEWS

CARBONADO FROM VENEZUELA

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A dark gray specimen of a compact, tenacious material of superior hardness was recently submitted to the Mineralogical Laboratory of Columbia University. The sample was found by Mr. Robert W. Michael while studying the diamond deposits of the Gran Sabana district of Venezuela. It weighed 20.45 carats and measured approximately 15×10×6 mm. The occurrence of the material suggested that it might be carbonado, which had not previously been reported from the area. Mr. Michael stated that the specimen was from the Surukun valley and was by no means unique, for "almost every digger in the region carries one as a lucky piece."

VENEZUELAN DIAMOND LOCALITIES AND PRODUCTION

The first diamond was found in Venezuela at the turn of the century and to date the total production has been some 234,000 carats, worth about $3,420,000. Further, some stones presumably have been smuggled across the Brazilian border, and are not included in this estimate. Three districts in the State of Bolivar produce diamonds; Gran Sabana, El Pao, and the upper Caroni River areas. Venezuela produces from 13,000 to 34,000 carats per year, 75 per cent of this amount, it is reported, being gem material. From 75 to 85 per cent of the production comes from the Gran Sabana district. Most Venezuelan stones are small, but some large ones have been found in Gran Sabana—notably one fine gem stone, the Libertador, of 155 carats, found in 1942.

Like the diamond deposits of Bahia in Brazil, the Venezuelan occurrences are in an area of pre-Cambrian granite gneiss and phyllite, intruded by younger igneous rocks of many different types. Concentrations of diamonds occur in the sand, gravel, and clay fillings of old stream channels (Ahlfeld, 1923). The detrital material in these channels has been derived from erosion of the basal members of the overlying Roraima sandstone, whose age has not been determined, because of the lack of fossils (Connolly, 1927). This sandstone is also the source of many of the diamonds found in the important British Guiana fields to the east. Little is known of the distribution of the intrusives from which the diamonds contained in the Roraima must have been derived. It is of interest that the large production of diamonds in Bahia is also believed to be a second-

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ary concentration from "hard, yellow sandstones and interbedded conglomerates" (Stutzer and Eppler, 1935, p. 159).

RECORDED OCCURRENCES OF CARBONADO

Carbonado was discovered in the diamond placers of San José, district of Sincora, Brazil, in 1843, but prior to 1846, even when recovered in mining gemstones, it was thrown away. Thereafter, it was exported to Holland in common nail kegs for a time. Its value as an abrasive was increasingly recognized, until fine grades sold for as much as $185 a carat in the late eighties of the last century. The production has never been large and today approximates 30,000 carats a year. However, between 1926 and 1930 (Stutzer and Eppler, 1935, p. 162) the value of carbonado produced in Brazil was, at its lowest figure, twice that for diamonds of all types produced in the same year. The Brazilian carbonados were said by Bauer (1909) to vary in size from "That of a pea to a mass of 700 or 800 carats . . . the average weight being 30 to 40 carats"; however, most of the stones now appearing on the market are only about 6 carats. The largest carbonado ever found, discovered at Lencoes, Bahia, in 1905, weighed 3167 carats, or slightly more than the Cullinan diamond.

The major Brazilian production is from alluvial concentrations near the town of Lencoes, in Bahia province (Stutzer and Eppler, 1935). Carbonado has also been reported from Parana province (Bétim, 1929), and a few stones have been received in shipments from Minas Geraes. Old descriptions (Couttolenc, 1892; Moissan, 1893) of the DeBeers Mine in South Africa mention small amounts of the mineral occurring there, and Ksanda and Henderson (1939) identified black grains from the Canyon Diablo meteorite as carbonado. The ultimate source of the carbonado reported by competent authorities in diamond shipments from French Equatorial Africa and Arkansas is in doubt, while all stones from Borneo which have been examined by Mr. Ball have been well-crystallized black gem stones, rather than aggregates.

A complete listing of reported occurrences of carbonado is difficult because of the rather confused nomenclature which exists for description of the subspecies of diamond. The terms used are often those applied by miners in one region to diamond aggregates which seem unusual to them; consequently, the terms are poorly defined and overlap at times. There exists a need for a critical analysis and revision of this nomenclature. "Bort" is dark-colored diamond occurring in rounded, poorly-crystallized grains which are translucent to opaque (Shipley, 1945); in the gem trade this definition is extended to all impure diamonds and even to fragments and powder of gem diamonds, provided that on account of their small size they are valueless as gem stones. Williams (1932, vol. II, p. 470) uses bort as a general name for "granular crystalline" diamond, ranging from "phanero-crystalline to crypto-crystalline structure." Williams' work deals with South African occurrences, and is therefore an excellent reference for the terminology of that area: "Framesite" is an extremely fine-grained type of bort, in which the particles are so arranged that it is almost impossible to saw the material with the ordinary diamond saw. "Stewartite" is bort which Dr. J. C. Sutton (1928, p. 38) found to be slightly magnetic and polar because of the presence of intimately admixed magnetite. Stewartite is cindery-looking and minutely porous, with the low specific gravity of 3.45; it occurs in dull-gray to grayish black lumps in the Wesselton and Jagersfontein mines (Wagner, 1914, p. 142). Both framesite and stewartite thus have features in common with "carbonado," which is a Brazilian term for a more or less porous, fine-grained to dense aggregate of minute diamond particles, which are usually light brown individually. The dark gray to black color seen in aggregate is largely caused, therefore, by the small opaque particles of amorphous carbon, graphite, and various metallic oxides and more complex minerals which occur within and between the diamond individuals. Larger crystals of diamond sometimes are found in this fine-grained, black matrix. By applying a blowpipe flame briefly to a polished surface of carbonado, Fettke and Sturgis (1933) were able to distinguish grain boundaries more clearly, and to demonstrate that the toughness of the mineral was due not only to the fineness of the grain size, but also to a definite interlocking of those grains.

LABORATORY EXAMINATION OF SURUKUN SPECIMEN

A spectrographic analysis was kindly made by Dr. M. L. Fuller of the Research Division of the New Jersey Zinc Company at Palmerton, Pennsylvania. He reported Si present in moderate amount, faint lines of Al and Ti, very faint Fe and Ni lines, and extremely faint lines of Cu, Mg, and Be.

An x-ray pattern taken with a Debye powder camera, using iron radiation contained the 111-α, 111-β, 220-α, 220-β, 311-α, 311-β and 400-β lines of diamond. These 7 lines constitute the entire group of reflections for diamond using iron radiation. In addition, there were several extra lines corresponding to strong reflections in a reference pattern of quartz. Since the sample was prepared in an iron mortar rather than the agate mortar used for routine work, this impurity must have come from the carbonado itself. The presence of a quartz-family mineral is further verified by the amount of Si in Dr. Fuller's analysis, and by optical examination of fragments of a white crust which can be seen to fill minute cracks in the specimen. The aggregate extinction, pinkish color in parallel light, and index $N=1.530$ for these fragments, indicate that the crust is probably chalcedony. Unfortunately, this component was not present in sufficient quantity to furnish enough for an *x*-ray sample.

The material responsible for the black color of the specimen cannot be resolved into discrete particles under high magnification, does not appear as a prominent impurity spectrographically, and gives no lines in the *x*-ray pattern. It may be amorphous carbon. The compounds contributing Al to Ti to the spectrographic analysis are present in such minute amounts that they do not produce lines on the *x*-ray pattern. An intense darkening of the background of an *x*-ray pattern of carbonado, in comparison with that of a single crystal of diamond, was noted by Gerloch (1924). No such contrast was observed in the present study.

The specific gravity of the specimen is 3.412, considerably below the value 3.511 quoted for single blue-white diamond crystals (*Dana*, 1944, p. 147). The specimen has a visibly low porosity which may account for the slightly high value for carbonado. Due to the filling of existing openings with chalcedony, a properly corrected value might be slightly higher.

The aggregate nature of carbonado, recognized by its toughness and lack of well-defined cleavage directions, is further substantiated by *x*-ray powder patterns taken in this study. All samples were broken by impact on a steel plate, and the steel fragments were subsequently removed with a magnet. In reflected light the surface of the carbonado was seen to be composed of unit reflecting areas, which are not necessarily unit crystals, of an average diameter of slightly less than 0.02 mm. The natural diameter is so small that the grains lie within the particle size limit for *x*-ray powder photographs. Hence, the natural fineness of a grain of carbonado is assumed to be responsible for the smooth lines in the pattern. One reference pattern obtained by grinding a small diamond crystal had extremely spotty lines. Another, obtained by cleaning and screening abrasive residues from a grinding laboratory, was satisfactory.

The lattice constant for the material, calculated from a Debye powder pattern, is 3.558 Å. A published lattice constant for diamond (Ehrenberg, 1926) is 3.5595 ± 0.0010 Å. It should not be inferred, from the slight discrepancy between these values, that carbonado has a slightly smaller lattice constant than diamond. Greater precision in measurement would be necessary to yield definite information on this point. Within the experimental limits of the technique employed the two are the same.

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DOMESTIC SOURCES OF PIEZOELECTRIC CRYSTALLINE QUARTZ

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An adequate supply of crystalline quartz of piezoelectric grade and size continues to be of fundamental importance to the U. S. Army Signal Corps. Current electronic development programs of the Armed Forces depend upon the use of quartz crystals in all applications where accurate frequency control is necessary. In peacetime this may not seem too significant, but in planning for possible national defense emergencies, an adequate supply of piezoelectric grade raw quartz is just as important as an adequate supply of some of the more publicized strategic minerals.

Prior to World War II, the Signal Corps accepted the use of quartz crystals for frequency control purposes in essentially all electronic communication, navigation and radar equipment operating in the audio and radio frequency spectra up to and including the ultra high frequency channels. Some equipments required a complement of 100 or more crystal units plus spares and replacements for satisfactory operation. As a result, over 70,000,000 crystal units were manufactured for the Army, Navy and Air Forces, requiring over 4,000,000 pounds of radio grade

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