HARDNESS OF SYNTHETIC DIAMONDS*

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The hardness tests on synthetic diamond described below were made on a fine diamond grit furnished by the Metallurgical Products Department of the General Electric Company, Detroit, formerly known as the Carboloy Company. Ten carats of grit, minus 325 screen size (<44 microns), were used. By the time rate of settling method a lapping powder, 95% of which was between 15–20 microns, was separated in ethyl alcohol. The coarser particles were crushed and again sized. This was combined with the first fraction and thus the powder tested consisted partly of fine crystals as synthesized and partly of crushed particles. The resulting powder contained a very few of the splinters common to natural powders, which are very difficult to remove by any sizing process.

The hardness of natural diamond increases progressively in the zone from (101) to (111), from its lowest value, which is on (101), to its highest value, that on the octahedron face, provided the lap moves in the direction from (111) to (101) (Denning, 1953). This gives an angle of 35°16′ through which a diamond may be turned with a progessive increase in hardness. Fig. 1*a* shows an octahedron in the position of greatest ease of cutting, Fig. 1*b* in the position in which it is impossible to cut because none of the randomly oriented diamond particles on the lap can be harder than this direction. In commercial practice 3° from the octahedron is considered the closest a facet in this zone can lie to the octahedron and still be cut and effectively polished.

A nearly perfect gem quality natural two and one-half carat diamond with a faint tinge of yellow was abraded on a new lap, freshly charged with the prepared synthetic diamond powder. Diamonds of this type with a faint yellow tinge rarely show internal twinning laminations which would introduce a disturbing factor into the test. No evidence of twinning was observed on the natural octahedron that was used in this test (Slawson, 1950). The synthetic powder readily cut and polished a facet on the natural crystal which lay 3° off the octahedron. After progressively approaching closer to the octahedron a position was arbitrarily chosen as the practical limit of cutting. A good polish was still produced. Subsequent measurement showed that this facet was within 1°23′ of parallelism with the octahedron. This procedure is a very sensitive method of comparing relative hardness.

If a diamond is cut in the softest direction, Fig. 1*a*, the material removed becomes imbedded in the surface of the lap and assists in the

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further cutting on that lap. In this test the natural octahedron was placed on the charged lap for the first time in a position 3° from parallelism with the lap, in other words, close to the position shown in Fig. 1*b*. After an interval of 10 seconds an observable facet was cut. Standard equipment and procedures of gem diamond cutters were followed, except for a special solder dop that allows small angular changes in the position of the diamond on the lap to be made with adjusting screws. The preparation of the synthetic powder and the testing was done by the writer, with financial support from the Office of Naval Research.

One concludes that there is no difference in the actual hardness of natural and synthetic diamond. It is believed that the slightly better

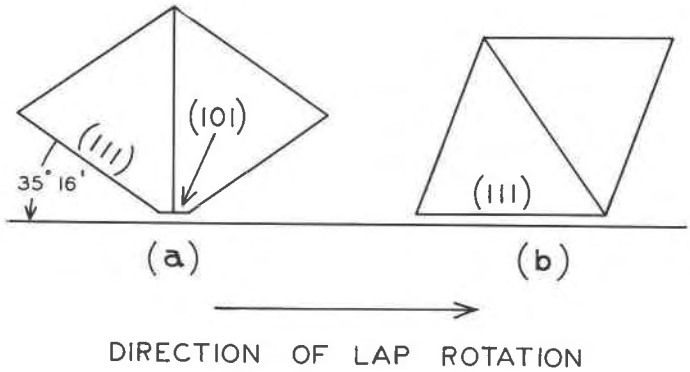

FIG. 1. Grinding hardness in diamond, (a) softest direction, (b) hardest direction.

value and the more rapid rate of abrasion by the synthetic powder can be attributed to the mechanical superiority of the research prepared powder and to its freedom from elongated cleavage splinters. No natural powder was prepared for comparative tests because no appreciable amounts of minute natural crystals were available. Crushing of larger crystals always produces splinter cleavage fragments.

The conclusion that synthetic and natural diamond are of the same hardness was anticipated because *x*-ray diffraction patterns and close microscopic examination revealed no significant differences. A very few faint lines of an unknown impurity were observed on some *x*-ray powder patterns of the synthetic diamond.

REFERENCES

DENNING, R. M. (1953), Directional grinding hardness in diamond: *Am. Mineral.*, **38**, 108–117.

SLAWSON, C. B. (1950), Twinning in the diamond: *Am. Mineral.* **35**, 193–206.

BORAZON

In view of the somewhat inadequate newspaper reports concerning the production by the General Electric Co. of cubic boron nitride, the following information has been obtained from the official report.

It is in the same general range of hardness as diamond; borazon scratches diamond, and diamond scratches borazon. In actual lapping tests, borazon powder polished a diamond at the same rate as diamond powder. But in another important characteristic, borazon appears superior. Diamond, being carbon, burns in air at about 1600° F. Borazon can withstand temperatures of more than 3500° F.

The material produced consists of tiny crystals no larger than grains of sand, and is generally black, brown, or dark red, although milky white, gray and yellow crystals have been made.

Pressures above one million pounds per square inch and temperatures exceeding 3000° F. are used to produce crystals of boron nitride with a structure that is not hexagonal like graphite, but cubic, like diamond. *X*-ray diffraction tests of borazon reveal that the alternate atoms of B and N are packed almost as closely as the C atoms in diamond. The specific gravity is also about the same: 3.45 for borazon; 3.50–3.56 for diamond.

Notice Concerning Decennial Index, 1946–1955

The ten year index for volumes 31 to 40 of *The American Mineralogist* is now in preparation. As in previous issues, this will include a list of Errata. Readers are urged to report any errors which they have detected that have not already been corrected in subsequent numbers. Send to Dr. Earl Ingerson, U. S. Geological Survey, Washington 25, D. C.

Note to Authors

When authors submit papers describing investigations in which *x*-ray powder measurements were made, but omitting the actual *x*-ray data, it is requested that these data be submitted to the Editor of the Joint Committee on Chemical Analysis by Powder Diffraction Methods for possible inclusion in the "*X*-ray Powder Data File," published by the A.S.T.M.

The data should contain accurate listings of "*d*" values and intensities of reflections. Other items of information of value for the data file are: *hkl* indices and lattice parameters if known, radiation used, type of *x*-ray recording employed, method of estimating intensities (visual, photometric, geiger-counter), plus any relevant information concerning the nature and preparation of specimens studied.

G. W. Brindley
Editor, "*X*-ray Powder Data File"
College of Mineral Industries
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University Park, Pennsylvania, U.S.A.

Dr. William T. Pecora has replaced Dr. Earl Ingerson as Chief, Geochemistry and Petrology Branch, U. S. Geological Survey. Dr. Ingerson was at his own request relieved of administrative responsibilities in order to devote full time to research.

It is with deep regret that we report the deaths of several prominent mineralogists.

František Slavík, Correspondent of our Society, and Professor-emeritus of Mineralogy at Charles University, Praha, Czechoslovakia; January 27, 1957, at the age of 80.

George D. Louderback, Fellow, and Professor-emeritus of Geology at the University of California, January 29, 1957, at the age of 82.

Brenno Wasserstein, Fellow, December 12, 1956. Dr. Wasserstein had just come from South Africa to the United States to set up a mineral research laboratory at Oakland, California.

Memorials of these members will appear in a later issue.

Kurt Spangenberg, Professor of Mineralogy and Director of the Mineralogical Museum, University of Tübingen, January 25, 1957.

Apparently damage occurred to a sack of mail going to southern California, which contained copies of the January–February issue of *The American Mineralogist*. Members who failed to receive this issue, or who received a damaged copy, may write to the editor for a replacement.

Sixth Annual Conference on Industrial Applications of *X*-ray Analysis

The technical sessions of this conference, sponsored by the Metallurgy Division, Denver Research Institute, University of Denver, will be held August 7, 8 and 9, 1957, followed by a mountain tour on August 10. Deadline for titles and authors May 1; deadline for abstracts, June 1, 1957. For further information write to

James P. Blackledge, *Head, Metallurgy Division,*
Denver Research Institute, University of Denver

The 27th annual meeting of the Society of Exploration Geophysicists will be held at the Statler-Hilton Hotel in Dallas, Texas, November 11–14, 1957.

The 7th annual convention of the Eastern Federation of Mineralogical and Lapidary Societies will be held August 29–31, 1957, at the Chamberlin Hotel, Old Point Comfort, Virginia, with the Gem and Mineral Society of the Virginia Peninsula acting as host. There are plans to cooperate with the Jamestown Festival.

A collection of Chinese jade, one of the largest and most valuable ever shown in America, will be on display this spring in the Pioneer Museum and Haggin Galleries in Stockton, California. Open to the public without charge.

Professor E. Wm. Heinrich, Department of Mineralogy, University of Michigan, has been appointed editor of *The Geochemical News*, the official news letter of the Geochemical Society.

The 7th Colloquium Spectroscopicum Internationale will take place in Liege, Belgium, in the second week of September, 1958. It will be organized by the Association of Engineers of the Liege University (A.I.Lg.) with Professor L. D'Or as chairman. The address of the secretary is

VII Colloquium Spectroscopicum Internationale Association des Ingénieurs de l'Université de Liège, A.I.Lg., *22, rue Forgeur, Liege, Belgium.*