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Technical Papers

Natural Black Uranium Powder

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A soft, black, uranium-bearing powder has been found in several localities during the exploration of uranium deposits in the western United States. The nature of this powder, its significance from the standpoint of origin, and its distribution constitute matters of scientific interest, as well as of practical importance. Among the localities in which the powder has been particularly noted, specimens were collected for study from Marysvale and White Canyon, Utah, and the Caribou and Bellvue-Rochester mines in Colorado. Material of similar appearance has also been noted in a collection of specimens from the Belgian Congo.

The soft pulverulent character of the material and the color suggest that it might be a form of the organic uranian mineral thucholite, recognized by Ellsworth (*1*) as a black uranian hydrocarbon in rocks of the Canadian shield. However, analyses for carbon (Table 1) made by the New Brunswick laboratory of the AEC yield amounts so low that thucholite could hardly be present in any significant amount.

The material in question is not thucholite, and laboratory studies indicate that it is largely uraninite. The various pulverulent materials collected yield substantial amounts of uranium on the basis of x-ray fluorescence analysis, with the use of a technique similar to that described by Birks and Brooks (*2*). Moreover, diffraction patterns yield interplanar spacings that establish the prevailing crystalline uranian constituent of the powder as uraninite. The material is commonly mixed with fine pyrite, and at some localities other metallic sulfides are associated.

TABLE 1

Carbon Content of Sooty Uraninite Samples

	A (%)	B (%)
Bellvue-Rochester mine, Colo.	0.12	
White Canyon, Utah	0.15	0.09
Marysvale, Utah	0.18	0.13

It has been observed that certain samples of uraninite from the Shinkolobwe mine in the Belgian Congo are also sooty, and one specimen with slickensides even appears graphitic. On analysis these samples are likewise shown to be noncarbon-bearing. Such specimens yield x-ray diffraction patterns corresponding to uraninite but with low lattice constants, in contrast to the lattice constants of hard cubic crystals of uraninite from the same locality (Table 2).

A number of observations indicate that the sooty uraninite may be a later form high in UO_3 that has originated at the expense of earlier hard uraninite, high in UO_2. Ellsworth (*3*) studied the successive zones in a large, progressively altered uraninite crystal from Villeneuve, Quebec, and pointed out that UO_2 and total U decreased from the center outward but that, at the same time, UO_3 notably increased until accountable for the entire uranium content at the most highly altered surface. Kidd and Haycock (*4*), in their study of the ores of Great Bear Lake, noted a later type of uraninite, less lustrous and softer than original hard uraninite, and formed at the expense of the earlier mineral. In the earlier uraninite the ratio $UO_2 : UO_3$ was 10 : 2.2, but in the later uraninite the ratio was 1 : 10. Analyses of both sooty and graphitic

TABLE 2

Lattice Constants, Shinkolobwe Uraninite

Well-formed cubic crystal	5.453 A.U.
Graphitic type	5.438
Sooty type	5.411

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[1] In the conduct of these studies the writer has had the benefit of cooperation by C. J. Rodden, chief, Microchemical Branch, New Brunswick Laboratory, AEC, and Harold Wright, who is studying the mineral relationships at the Caribou mine.

types of pulverulent uraninite from Shinkolobwe suggest a high UO$_3$ content for this material. At Marysvale and Caribou hard, brittle uraninite has been found in association with the sooty material, the latter coating and penetrating the solid brittle ore.

Although the sooty mineral is later, it is found at such depths that it apparently does not represent a typical surface-weathering product. At White Canyon it is found 50–100 ft underground from the tunnel portal but not directly at the surface. At Marysvale, it is found a corresponding depth below the surface and, in addition, in lower mine workings in the Prospector mine. At Caribou the sooty mineral occurs at the 1,040-ft level and below. At Bellvue-Rochester it lies far below the surface.

The environment in which the sooty mineral is found is more or less porous and permeable to solutions. At the two Colorado localities and at Marysvale, it occurs in an envelope of fractured clay, having a thickness of several feet on either side of the uranium-bearing core where the enclosing wall rock has been altered to clay and associated porous minerals. At White Canyon the wall rock is a more or less horizontal stratum of porous sandstone about 10 ft thick, with shale above and below. The porous character of the environment in which the black powder is found, even including the associated host rock on the Shinkolobwe specimens, indicates an enclosing zone permeable to solutions. Observations at the surface itself and a few feet below the outcrop are inconsistent with the assumption that the sooty mineral is the result of simple weathering, since the pulverulent material, if formed in such a way, should persist to the surface. In the outcrop zone at Marysvale and White Canyon, yellow or green oxidized uranium minerals, typical of surface weathering, occur in place of the sooty material.

Associated metallic sulfides of copper at White Canyon, and zinc and lead as well at Caribou, point to the likelihood that the originating temperatures were higher than would prevail for normal ground water. Indicators belonging to the temperature scale of the geologic thermometer have been observed in the form of vein fluorite, chalcopyrite, and sphalerite, but the temperatures of formation are indefinite.

While studies are still in progress and further publication is in preparation, it seems reasonable to conclude that solutions and complete submersion, rather than simple weathering and surface oxidation, must be assumed responsible for the sooty uraninite. Since the mineral is prevailingly uraninite and occurs in a hydrothermal environment, it also seems reasonable to suggest that the solutions from which precipitation occurred were heated.

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Plant Growth-regulating Activity in Certain Aryloxyalkylcarboxylic Acids

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In our first report on substitution into the side chain of certain aryloxyacetic acids (*1*), it was suggested that the presence of a hydrogen atom on the carbon adjacent to the carboxyl group may be necessary for certain types of plant growth-regulating activity. Further compounds have now been synthesized, the assessment of biological activity has been extended by the inclusion of other tests, and additional evidence obtained to support our original suggestion. The following classes have been investigated, in which the aryl groups are phenyl, 2-chlorophenyl, 4-chlorophenyl, 2 : 4-dichlorophenyl, 2-methyl-4-chlorophenyl, 2 : 4 : 5-trichlorophenyl, 1-naphthyl, and 2-naphthyl:

ArOCH$_2$COOH (I) aryloxyacetic acid	ArOCH(CH$_3$)COOH (II) α-(aryloxy)-propionic acid
ArOCH(C$_2$H$_5$)COOH (III) α-(aryloxy)-*n*-butyric acid	ArOC(CH$_3$)$_2$COOH (IV) α-(aryloxy)-*iso*butyric acid

It was previously shown (*1*) that four aryloxy*iso*butyric acids failed to induce responses in the tomato leaf epinasty test (*2*). These findings have been confirmed, all the eight *iso*butyric acids listed above being inactive in this test, whereas with the exception of phenoxyacetic acid, all the acetic, propionic, and *n*-butyric acids (I, II, and III) were active.

Other methods we have employed for assessing growth-regulating activity have included the *Avena* curvature (*3*), *Avena* cylinder (*4*), tomato parthenocarpy (*5*), tomato leaf rooting (*6*), and Went pea curvature (*7*) tests. In addition, the capacity to induce morphological changes in the growth of tomato plants has been studied (*8*).

In general, it was found that compounds that possess at least one hydrogen attached to the α-carbon of the side chain (I, II, and III) give a positive response in the tomato leaf epinasty, *Avena* curvature, and *Avena* cylinder tests, all of which depend upon cell elongation. Compounds in which such hydrogen atoms had been substituted by methyl groups (IV) were found to be uniformly inactive in these tests at the concentrations employed; indeed, certain of the compounds appeared to inhibit the normal growth of cells.

In tests involving cell division—e.g., tomato parthenocarpy, leaf rooting, and production of morphological effects—most of the *iso*butyric acids (IV) were inactive. However, 2 : 4-dichloro-, 2-methyl-4-chloro-, and 2 : 4 : 5-trichlorophenoxy*iso*butyric acids showed