BOOK REVIEWS

FRONDEL (Clifford). *Systematic Mineralogy of Uranium and Thorium.* Washington (U.S. Geol. Surv. Bulletin 1064), 1958. viii+400 pp., 1 pl., 24 text-figs. Price (paper cover) $1.50.

This is a comprehensive monograph on minerals containing uranium or thorium as 'essential constituents', which are described systematically in the following broad chemical categories: oxides, carbonates, sulphates, molybdates, phosphates and arsenates, vanadates, silicates, and niobate-tantalate-titanates. Within each category, minerals of analogous composition and crystal structure are grouped together, such as the torbernite group of phosphates and arsenates. No formal distinction is made in the classification between anhydrous species (primary in origin) and those containing water or hydroxyl (mostly secondary). The author has included some seventy uranium and six thorium minerals, as well as a few minerals whose status as separate species is uncertain and others in which the uranium or thorium content is regarded as non-essential.

Each species is described according to its synonymy, composition, crystallography and crystal habit, physical properties, optical properties, thermal behaviour, synthesis, identification, natural formation, and occurrence. Full X-ray powder data are listed whenever available. The treatment is critical and full; for example, 36 pages are devoted to uraninite alone. The descriptive mineralogy is followed by a series of determinative tables in which the mineral species are arranged according to their X-ray *d*-spacings, chemical composition, optical properties, colour, specific gravity, and fluorescence in ultra-violet light. The work is documented by 826 references to the world literature up to mid-1956. A short introduction gives some interesting historical matter, mentions some of the special difficulties in the identification of uranium and thorium minerals, and discusses briefly the subjects of age determination, autoradiography, and radiation damage, which arise from the radioactivity of these minerals. The book is well produced and the price of half-a-guinea is remarkably low.

There is no doubt that this is a work of the highest merit. The manner in which Dr. Frondel has met his own exacting standards of completeness, accuracy, clarity, and critical assessment compels whole-hearted admiration. Only a few errors have been noted. For example, on p. 155 it is stated that monazite is sometimes elongated along the *a*-axis when

b is meant. On p. 348, trögerite is inadvertently referred to as a phosphate. Cheralite is described with the silicates although it is essentially a phosphate and should follow monazite, not huttonite. The ångström unit is abbreviated A throughout, instead of Å as recommended by the International Union of Crystallography in 1951. In discussing the identification of monazite, mention might be made of the brilliant green colour assumed when viewed in visible light from a mercury-vapour lamp.[1]

The only significant criticism is of the choice of species described in the section on multiple oxides or niobate-tantalate-titanates. This comprises the fairly common or economically interesting minerals betafite, pyrochlore-microlite, brannerite, and davidite, together with two obscure species known only from single occurrences, písekite and delorenzite (the latter since discredited). The widespread species euxenite and samarskite, to take two conspicuous examples, are excluded on the grounds that their content of uranium or thorium is occasional or vicarious. Whatever may be their 'ideal' composition, in nature they invariably contain uranium or thorium, and the percentage is often considerable. With other less common species they are in fact classified as uranium and thorium minerals in U.S. Geological Survey Bulletin 1009-F, to which the reader is referred in the present work. Indeed, as every metamict mineral specimen contains at least some uranium or thorium, it follows that any species that habitually occurs in the metamict state is *ipso facto* a uranium or thorium mineral, and as such warrants a place in a monograph on the mineralogy of uranium and thorium.

A work of this length with tables on nearly every page is bound to take time to print, but two years or more in the press seems rather excessive. Progress in this field has been so rapid that the book is already out of date to a considerable extent. As it is not only an invaluable guide to identification but will also provide the background to detailed work on known and new species, it is important that it should not be allowed to lag too far behind research. Even between mid-1956, when the manuscript appears to have been completed, and April 1959, details of some three dozen allegedly new uranium and thorium minerals have been recorded in this Magazine, in Mineralogical Abstracts, and in the American Mineralogist. About two-thirds of these new mineral names are from Soviet sources. They are the first crop of material released for publication since the 1955 Geneva Conference and are one of

[1] K. J. Murata and H. Bastron, Science, 1956, vol. 123, p. 888.

the products of the intensive work in geology that has been taking place in the USSR since the war. In many cases there is considerable uncertainty as to whether the minerals are in fact new species or merely varieties of known ones. It is often impossible to decide such problems from the published data without direct comparison of actual specimens from the type localities. The free interchange of mineral specimens between East and West would do much to prevent the establishment of two rival nomenclatures.

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HEINRICH (E. W.). *Mineralogy and Geology of Radioactive Raw Materials.* New York, Toronto, and London (McGraw-Hill), 1958. xiv+654 pp., 84 tables, 201 text-figs. Price 112*s.* 6*d.*

'It has been estimated', we are told in the preface, 'that since 1952 more man-hours have been spent in searching for uranium alone than had been spent in seeking all other metals in history.' One result of this unprecedented activity is the spate of publications on all aspects of the geology and mineralogy of uranium, and to a lesser extent of thorium, from which Professor Heinrich has endeavoured to distil the essence for the present survey. An idea of the magnitude of the task may be gained from the 58-page bibliography containing 1342 entries down to the end of 1957. The outstanding feature of the book is the comprehensive treatment of both mineralogy and geology in one volume. It is divided into two parts, of which Part I (149 pages) deals with descriptive mineralogy and Part II (406 pages) with ore deposits, actual or potential.

Part I begins with a rather sketchy chapter on radioactive minerals in general, which bears signs of hasty compilation. For instance, we are told (p. 21) that ^{40}K emits alpha as well as beta particles. U^{4+}, Th^{4+}, and other ions are described as isomorphous (pp. 8, 10) when it is meant that they undergo isomorphous replacement. As many age determinations are quoted later in the book, a section on the lead method could usefully have been included in this introductory chapter with some guidance on the selection of suitable material and the reliability of results. A discussion of the special difficulties encountered in the identification of uranium and thorium minerals would also have been helpful. This might have included such matters as the unreliability of optical data for identifying many uranium secondaries because of the varying content of zeolitic water; the ease with which some secondaries dehydrate to the meta form; the limitations of powder photographs in identifying