

U-GALENA AND URANINITE IN BEDFORD, NEW YORK, CYRTOLITE

PAUL F. KERR, *Columbia University, New York City.*

INTRODUCTION

A short time ago a polished surface of cyrtolite was prepared from a slab cut from the side of one of the specimens of cyrtolite used by Luquer (1) in his original description of cyrtolite from Bedford, New York. Observation of the polished surface with a hand lens revealed the presence of numerous metallic specks. Examination with the reflecting microscope indicated that the metallic specks were galena. Ordinarily the discovery of small amounts of galena even in material from a pegmatite in the vicinity of Bedford would call for no more than passing comment. Bedford cyrtolite, however, has been investigated so intensively in recent years in connection with age determinations based upon the lead-uranium ratio and the atomic weight of lead, that it is felt the occurrence of galena in cyrtolite from this locality should receive special attention. A number of specimens have been studied therefore and a short account has been prepared for the purpose of placing on record a description of what appears to be an unusual occurrence of galena. It is possible from chemical data already published to infer the presence of the uranium isotopes of lead as part of the galena. Such an occurrence of what might be called U-galena should be of interest. The microscopic studies connected with the determination of the galena have disclosed certain data concerning the occurrence of the uranium in the cyrtolite also worthy of comment. Further studies of the Bedford cyrtolite and cyrtolite from other localities are in progress and will be published later. Little attention will be paid therefore in the present discussion to the nature of cyrtolite.

DETERMINATION AND DISTRIBUTION OF THE GALENA

A photomicrograph of galena as it occurs in the Bedford cyrtolite is shown in figure 1. In the area photographed the galena fills a small cavity bordered by cyrtolite, unreplaced zircon and muscovite. The galena is restricted in its occurrence to cavities or fractures in the cyrtolite, and is evidently one of the later minerals to form in the history of the specimen. The only later mineral in the

specimen examined is autunite which is apparently entirely secondary and restricted to one or two later fractures. Uraconite was present in some of the material described by Luquer but was not observed in thin sections or fragments of specimens used for the present study.

The galena shows the criteria by which the mineral is ordinarily recognized on polished surfaces. It exhibits triangular cleavage pits, scratches due to abrasive powder cutting a soft mineral in polishing, low relief, and a characteristic blue gray color in reflected

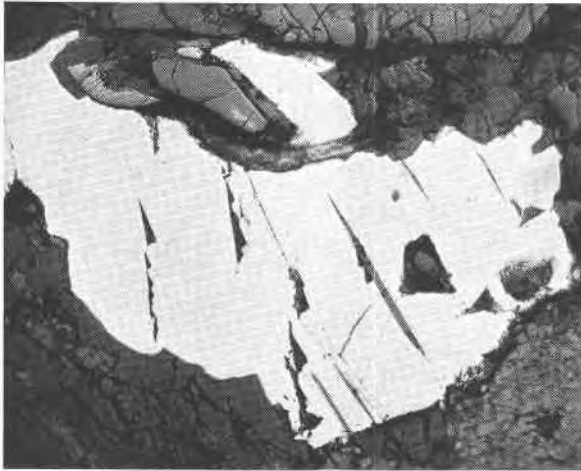


FIG. 1. U-galena in Bedford cyrtolite. The mineral exhibits the characteristic triangular pits of common galena on a polished surface. (Photomicrograph $\times 150$.)

light. It contains occasional needle-like crystals of an unidentified mineral visible only under the microscope.

Analysis of Bedford cyrtolite by Mr. Earl Emendorfer of the Department of Geology and Mineralogy, Columbia University, shows the presence of lead and sulphur as follows:

$$\text{Pb} = 0.33\%$$

$$\text{S} = 0.05\%$$

Although the amounts determined are small the original sample was sufficiently large to justify confidence in the accuracy of the determinations as given.

It is interesting to observe that the Pb:S ratio based upon the above analysis is approximately 1:1. It is probable, therefore, that

all of the lead in the Bedford cyrtolite is combined with the sulphur in the form of galena.

Examination of the published accounts of previous investigations of the cyrtolite fails to reveal any mention of sulphur determinations. This is not unusual, however, since the principal analytical ends desired in age determinations of the cyrtolite appear to be: (1) the amount of uranium present, (2) the amount of lead present, (3) the atomic weight of the lead, and (4) the assurance of the absence of thorium. The sulphur is evidently present in the form of a sulphide since only the faintest trace of sulphate may be detected chemically.

The amount of lead in the Bedford mineral was determined by Muench (2) who gave as the average of seven determinations 0.374%. Differences between two different samples and the conditions of analysis by different analysts could easily account for the difference between Pb=0.33% determined by Emendorfer and Pb=0.374% determined by Muench. In view of the generally mixed nature of the cyrtolite from Bedford as revealed under the microscope it is doubtful whether two different samples could be found which would yield exactly the same amount of lead.

RADIOACTIVE CONSTITUENTS OF CYRTOLITE

Cyrtolite has been a material frequently used by mineral collectors for taking radiograms (3). Generally a rough specimen is placed near a photographic plate and allowed to remain for several weeks until the plate is properly exposed. It is possible, however, by using a polished surface to bring out greater detail in a radiogram and also to lessen the time of exposure. Such radiograms usually show sufficient detail to warrant enlargement. The radiogram shown in figure 2 was taken in this way and enlarged three times.

Radiograms of Bedford cyrtolite exhibit a surprising lack of uniformity in the distribution of the strongly radioactive areas as indicated by the white spots and lines on the radiogram in figure 2. The bright white areas and lines in the radiogram are due both to uraninite streaks or grains and veinlets containing autunite. Two long narrow streaks extending along fractures (NW-SE as the picture stands) are due to autunite. A small area in the lower left-hand corner is also due to this mineral. The strong radioactivity of the remainder of the specimen as indicated by numerous

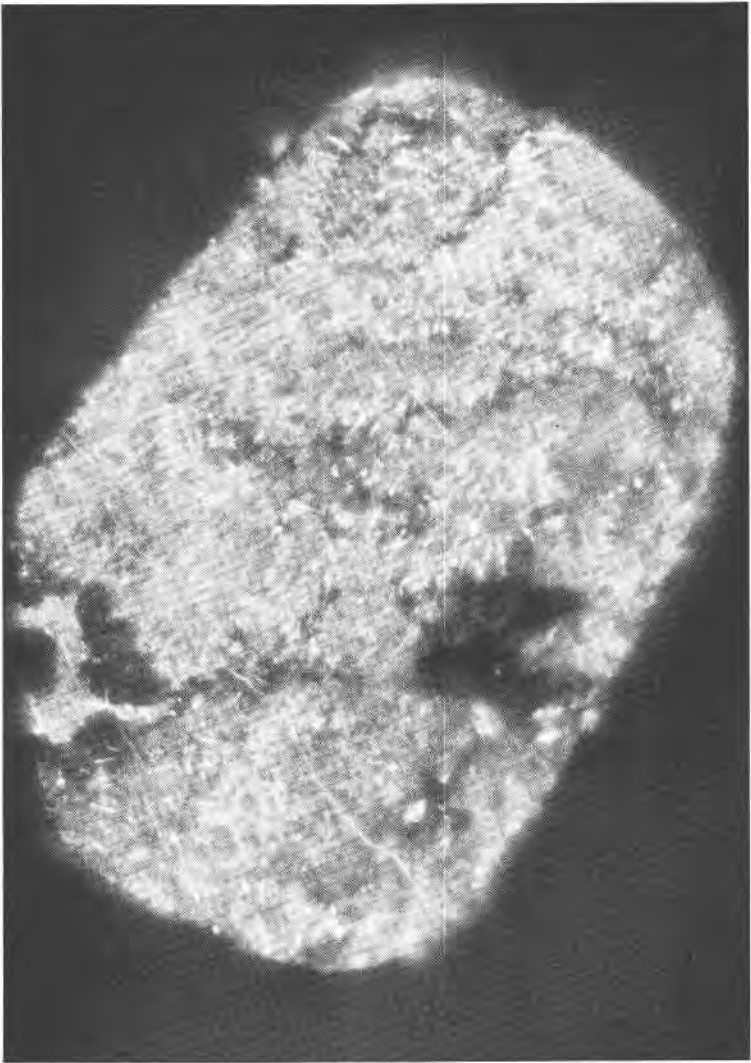


FIG. 2. A radiogram of Bedford cyrtolite. The white areas represent the centers of greatest radioactivity. In order to prepare this exposure a polished surface of cyrtolite was placed directly over a photographic plate and allowed to remain four days in a light tight box. The white spots and short streaks are due to the radioactivity of uraninite. (Enlarged three times.)

short streaks and many bright spots is due to uraninite. The dark and shaded areas in the radiogram intermediate between the bright areas of uraninite represent exposures due either to cyrtolite or to cyrtolite containing finely disseminated grains of uraninite. The effect of cyrtolite on a photographic negative is slight when compared with that of uraninite.



FIG. 3. A veinlet and scattered grains of uraninite. The photomicrograph represents the appearance of a veinlet responsible for one of the streaks in the radiogram. Most of the spots and streaks in the radiogram are due to uraninite of this type. It is not unusual for a veinlet to produce a streak on the radiogram twenty times as broad as the original veinlet. It should be pointed out therefore that the radiogram Fig. 2 gives an exaggerated idea of the actual radioactive area. (Photomicrograph $\times 150$.)

A photomicrograph of uraninite as it occurs in veinlets and disseminated grains scattered through the Bedford cyrtolite appears in figure 3. The veinlets are uniformly small measuring about 0.01 mm. in thickness and are for the most part not more than a centimeter in length. Under the microscope sections of crystals showing cubic outline may be observed in places. *X*-ray diffraction patterns of the cyrtolite have been taken which show extraneous lines agreeing with lines in standard patterns of uraninite. The relief and color of the mineral on polished surfaces as examined under the microscope also agree with uraninite. The veinlets illustrating the appearance of uraninite under the microscope are the same veinlets

responsible for the intense radioactivity in the radiogram although exposure due to radioactivity is somewhat diffused. It should be pointed out that Muench in ascertaining the lead-uranium ratio for the Bedford cyrtolite determined the uranium content to be $U = 7.29\%$. At the same time he found the mineral to be free from thorium. It seems clear, therefore, that uranium is one of the constituents of the cyrtolite mixture. Whether uranium is present in the cyrtolite itself or occurs as an impurity is not evident from chemical data. Microscopic and x -ray data, however, point to at least a large portion of the uranium being present as finely divided uraninite scattered through the cyrtolite.

On account of the uneven distribution of the uraninite it is doubtful whether two different specimens of cyrtolite would yield the same uranium content. This might affect age determinations as they apply to this mineral but the extent of such influence if effective at all is a problem beyond the scope of this paper.*

U-GALENA

In 1931 when Muench published his interesting account of the Bedford cyrtolite he furnished several determinations of the lead and uranium content of the mineral. On the basis of these determinations and following the usual methods (4) used for the purpose of ascertaining the age from the lead-uranium ratio he computed the age of the cyrtolite, giving an age of 373 million years. More recently Baxter and Alter (5) determined the atomic weight of the lead in Bedford cyrtolite finding the figure 205.924. It was Baxter and Alter's conclusion that the lead was essentially uranium lead, that is lead derived substantially from the disintegration of uranium. The atomic weight is slightly lower than it should be but in any event it is considerably below the atomic weight 207.21 determined by Baxter and Alter (6) for the common lead from Coeur d'Alene, Idaho.

In view of the above chemical data it seems reasonable to conclude that the atomic weight of the lead in the cyrtolite is not that of common lead. Since the cyrtolite has been considered by both Muench and Baxter and Alter to be thorium free it would not be likely to be of thorium origin. On the other hand the low atomic

* See Report of the committee on the Measurement of Geologic Time, *Nat. Res. Council*, 1934, pp. 26 and 46, for comment on the difficulty experienced by Hecht in checking previous cyrtolite age determinations by Muench.

weight and the presence of uranium indicate a preponderance at least of uranium lead.

It was indicated above that all of the lead in the cyrtolite was probably combined with sulphur in the form of galena. Since the lead has been shown chemically to be uranium lead it must naturally follow that the galena is made up of isotopic lead in combination with sulphur. The galena in the cyrtolite from Bedford, therefore, is not ordinary galena. It seems appropriate therefore to distinguish it as U-galena since judging from published analyses it must be made up essentially of isotopes of lead derived from uranium.

Uranium lead from uraninite, Wilberforce, Ontario, having the atomic weight (7) 206.195 has been investigated by Aston (8) with the mass-spectrograph. This lead yielded a mean mass number of 206.199 and was made up of isotopes $Pb^{206} = 85.9\%$; $Pb^{207} = 8.3\%$; $Pb^{208} = 5.8\%$. Other samples of uranium lead from Katanga, Africa, Great Bear Lake, Canada, and Morogoro, Africa, also investigated by Aston yielded similarly preponderant amounts of Pb^{206} . Thorium lead on the other hand from Norwegian thorite with an atomic weight of 207.90 determined by Fajans (9) yielded a mean mass number 207.895 and contained the isotopes $Pb^{206} = 4.6\%$; $Pb^{207} = 1.3\%$; and $Pb^{208} = 94.1\%$.

In view of Aston's work it would be expected that the lead in the Bedford galena in common with other uranium lead should contain a preponderant amount of Pb^{206} . Investigation with the mass-spectrograph, however, would be needed to determine the relative abundance of the different isotopes and also to explain the slightly lower atomic weight (205.924) reported by Baxter than reported for other uranium lead samples. On the other hand the fact that the atomic weight is low rather than high strengthens the evidence in favor of the uranium origin.

Unfortunately only small amounts of the U-galena are available for study and it is apparently indistinguishable on a polished surface from ordinary galena. It is likely that this galena may be discovered elsewhere in quantities which will allow study of its physical properties. Galena mentioned by Ellsworth as occurring at at Hybla, Ont., Canada was suggested as possibly being galena of this type (10). According to Alter (11) however, ordinary lead is indicated by a study of Hybla cyrtolite.

It is generally recognized that galena is a common associate of

uraninite and occasionally other radioactive minerals. In the usual case, however, the galena has been introduced from an outside source, and the connection with atomic disintegration is difficult to establish.

Evidence concerning the origin of the sulphur was not observed, but the presence of pyrite and pyrrhotite in the adjacent pegmatite at Bedford suggests that solutions carrying sulphur must have been prevalent. Precipitation of galena by reaction of such solutions with radiogenic lead would appear to be a normal result. It is inferred that lead was not introduced in the same way, from the absence of galena elsewhere in the pegmatite and the chemical data on record regarding lead in cyrtolite.

REFERENCES

- (1) Luquer, L. M., Bedford cyrtolite: *Amer. Geol.*, vol. **33**, pp. 17-19, 1904.
- (2) Muench, O. B., The analysis of cyrtolite for lead and uranium: *Amer. Jour. Sci.*, 5th Ser., **21**, pp. 350-357, 1931. Also, *Jour. Am. Chem. Soc.*, vol. **56**, p. 1536, 1934.
- (3) Manchester, J. G., The minerals of New York City and its environs: *Bull. of N. Y. Mineralogical Club*, vol. **3**, No. 1., 1931.
- (4) Knopf, Schuchert, Kovarik, Holmes and Brown, The age of the earth: *Natl. Research Council, Bull.* **80**, 1931.
- (5) Baxter, G. P., and Alter, C. M., *Science*, vol. **76**, pp. 524-525, 1931. Also, The atomic weight of lead from Bedford cyrtolite: *Jour. Am. Chem. Soc.*, vol. **55**, pp. 1445-48, 1933.
- (6) Baxter, G. P., and Alter, C. M., *Science*, vol. **79**, pp. 431-432, 1933.
- (7) Baxter, G. P., and Bliss, A. D., *Jour. Am. Chem. Soc.*, vol. **52**, p. 4851, 1930.
- (8) Aston, V. W., Mass-spectra and Isotopes: Longmans, Green and Company, New York, 1933.
- (9) Honigschmid, O., *Zeit. Electrochem.*, vol. **25**, pp. 91-96, 1919.
- (10) Ellsworth, H. V., Rare-element Minerals of Canada: *Canada Dept. of Mines, Geol. Surv., Econ. Geol. Ser.*, No. **11**, p. 204, 1932.
- (11) Report of Committee on Measurement of Geologic Time, *Natl. Res. Council*, p. 20, 1934.
- (12) Baxter, G. P., and Alter, C. M., atomic weights of several radiogenic leads, *Jour. Am. Chem. Soc.*, Vol. **55**, pp. 467-469, 1935. (Published while the present paper was in press.)