

disc out of 1/16 inch metal and cutting notches in the periphery. The notches were spaced five degrees apart by use of a protractor. The disc was fastened to the stage and a small piece of spring brass was fastened to the stationary part of the stage in such a manner that it engaged the notches as the stage was rotated. The stage is rotated until a click is heard which indicates the point to be counted. Before a circular point count is begun, the position of the stage with respect to the vernier should be noted in order that no more than one complete revolution be made in the same spot. It is convenient to paint a reference mark on the disc to indicate the starting point.

The circular point counter was constructed in about two hours, and only common hand tools such as files, drills, and a hack saw were used.

The methods as outlined here should be of value to those petrographers who do not do enough thin-section analyses to warrant the purchase of an integrating stage, a mechanical stage, or a point counter. For circular Rosiwal analyses, no apparatus is required other than a petrographic microscope. For circular point counts, an easily constructed notched disc may be used. The method should also be useful in petrography classes where the ratio of students to integrating stages and/or point counters is high.

ANOMALOUS FLUORESCENCE IN TORBERNITE FROM RUM JUNGLE,
N.T. AUSTRALIA

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Although most, if not all, torbernite is non-fluorescent, reports of torbernite showing anomalous fluorescence appear from time to time. Where such torbernite has been subjected to microscopic examination it has been found to consist of intergrowths of one or more fluorescing minerals, notably autunite, with the torbernite (Meixner, 1939, p. 438), whereas the torbernite in the intergrowths did not fluoresce.

A striking example of torbernite showing such anomalous fluorescence was found recently at Rum Jungle, N.T., in Northern Australia (C.S.I.R.O. *Mineragraphic Report No. 619*). This specimen, which is about 9 in. \times 6 in., is covered with protuberances 1 to 2 mm. high consisting of stacks and clusters of a platy emerald green mineral, apparently torbernite, but the surface fluoresces a vivid greenish-yellow, except in a single band across the center. This band consists of non-fluorescent, slightly darker green crystals.

These darker green non-fluorescent crystals consist of meta-torbernite.

They have $\beta = 1.618$ and are optically negative with a low $2V$. They dissolve readily in acid and the solution yields positive microchemical tests for copper, uranium and phosphorus.

The slightly lighter green fluorescent crystals when examined microscopically under a Mineralight, were found to be composite, consisting of interlayered plates of a mineral with a strong yellow-green fluorescence, and of a non-fluorescent mineral in parallel orientation (Fig. 1). The non-fluorescent green plates, forming about two-thirds of the composite

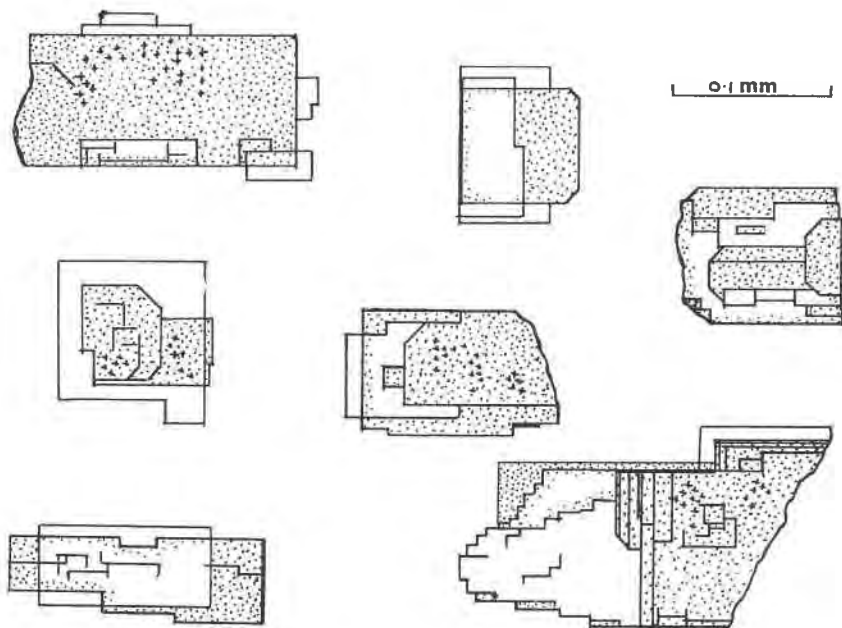


FIG. 1. Cleavage flakes from composite crystals showing torbernite (clear) and autunite (stippled). Weak stippling indicates autunite covered by torbernite. Crosses are fine brown crystallites of an unknown secondary mineral ($\beta = 1.730$). Scale as shown. Individual plates 0.005–0.015 mm. thick.

crystals, are square or rectangular in outline, whereas the yellow fluorescent plates (shown stippled) have, in addition, octagonal facets. The composites range from 0.05 to 0.5 mm. in area, from 0.005 to 0.015 mm. thick, and both minerals have two good cleavages at right angles.

The fluorescent plates vary from pale yellow in color, with a weak birefringence and $\beta = 1.594$, $(-)2V = 30-40^\circ$, to slightly more green with $\beta = 1.598$, $(-)2V = 38^\circ$. They consist of meta-autunite presumably in slightly varied states of hydration. They are readily soluble in acid and the solutions yield positive microchemical tests for uranium and phos-

phorus, and weakly positive tests for copper. The non-fluorescent plates were identified as meta-torbernite, with properties similar to the non-fluorescent plates of the darker green band.

The parallel interlayering of autunite and torbernite plates is well known (Dana, 1951, p. 985), and Pelloux (1934, p. 163) has remarked upon the octagonal habit of autunite interlayered with rectangular plates of torbernite. He also noted that the composite crystals are a brilliant green color.

A strong fluorescence for intergrown autunite and torbernite is recorded by Meixner (1939, p. 439), who reports that the bright fluorescence came from a wafer-thin *coating* of autunite on the surface of the non-fluorescent torbernite. The Rum Jungle material consists of inter-layered plates on the two minerals, often stacked ten to twenty plates high.

When a thin plate of the torbernite is placed so that it completely covers a strongly fluorescing plate of the autunite, the fluorescence is completely extinguished. Such effects may be observed under the microscope, with ultra-violet illumination, using a low power ($\times 10$) objective. However if a corner of the autunite projects from beneath the covering torbernite, then that corner will fluoresce strongly, while the remainder exhibits a weak fluorescence through the torbernite plate. Similar weak fluorescence appears if the overlying torbernite has strongly developed cleavage cracks, these cracks being accentuated by the yellow green fluorescence from the underlying autunite. Again, if a plate showing fluorescent areas is rotated on the point of a needle it can be seen that the fluorescence is confined to exposed plates of autunite, or the edges of interlayered plates.

Autunites are susceptible to base-exchange and Fairchild (1929, p. 265) was able to produce calcium-, sodium, potassium-, barium-, manganese-, magnesium-“autunites” by soaking an artificial soda-autunite in the respective metal-chloride brine for several days. To test this a natural autunite was immersed in copper chloride solution at 80° C. for seven days. The strongly fluorescent sulphur yellow autunite from Mt. Painter in South Australia, with $\beta = 1.575$, $\gamma = 1.577$ ($-$) $2V = 40^\circ$, was converted to a pale green, non-fluorescing meta-torbernite with $\beta = 1.600$ by this method. This agrees well with Fairchild's “copper-autunite” with $\beta = 1.608$ and containing 5.61% Cu, 0.73 Na₂O, 15.62% H₂O by analysis, after similar treatment, using artificial soda-autunite.

In view of the ease with which copper can be substituted for calcium in autunites it is concluded that the interlayering of the copper-rich and copper-free secondary uranium minerals at Rum Jungle and elsewhere must reflect a delicate chemical balance during their deposition. Later

copper bearing solutions percolating through the specimen would have reacted to produce a more homogeneous torbernite.

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NOTE ON TWINNING AND PSEUDO-TWINNING IN DETRITAL
QUARTZ GRAINS

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Detailed studies of etch figures and morphology have shown that with few exceptions single crystals of quartz are made up of more than one individual intimately grown together. The most common intergrowths are described by the Dauphiné, Brazil and combined Dauphiné-Brazil twin laws (Gordon, 1945; Gault, 1949). These types of twinning cannot be detected optically in thin sections of customary thickness. The purpose of the present note is to point out that a second group of intergrowths composed of sub-individuals whose *c* axes do not coincide are not uncommon, though hitherto they have seldom been recognized as such. A twin relationship can be demonstrated between members of some intergrowths of this second group, while in others the relation closely approximates one of the thirteen twin laws designated by Zyndel (1914). Because of the small but consistent departures from the laws of Zyndel, this type of intergrowth has been called pseudo-twinning by Hintze (1915, p. 1270).

Intergrowths of the second group are most conspicuous in individual grains of sandstones. They were repeatedly encountered by the writer in the course of a petrographic examination connected with the artificial deformation of the Asbury Park beach sand (Maxwell and Verrall, 1954; Borg and Maxwell, 1956). Although the crystallographic orientation of a twinned grain can be determined only on deformed material in which recognizable cleavage fractures have formed, twins and pseudo-twins are not themselves products of experimental deformation. They are equally common in the sand prior to deformation. Approximately 1½% of the grains in the Asbury Park sand are intergrowths recognizable in