

## REFERENCES

- BAYLY, M. B. (1960) Modal analysis by point-counter—the choice of the sample area. *Jour. geol. Soc. Australia*, **6**, 119–130.
- (1960b) Errors in point count analysis. *Am. Mineral.* **45**, 447–449.
- CHAYES, F. (1951) In, Fairbairn *et al.* A cooperative investigation of precision and accuracy in chemical, spectrochemical and modal analysis of silicate rocks. *U. S. Geol. Surv. Bull.* **980**.
- (1956) *Petrographic Modal Analysis*. John Wiley & Sons, Inc., New York.
- EMERSON, D. O. (1958) Stage for macro point counting. *Am. Mineral.* **43**, 1000–1003.
- FITCH, F. J. (1959) Macro point counting. *Am. Mineral.* **44**, 667–669.
- JACKSON, E. D. AND D. C. ROSS (1956) A technique for modal analyses of medium- and coarse-grained (3–10 mm) rocks. *Am. Mineral.* **41**, 648–651.
- NESBITT, R. W. (1961) The petrology and structure of the country around Julianehaab, S. W. Greenland. Ph.D. thesis, Univ. of Durham.
- SMITHSON, SCOTT B. (1963) A point counter for modal analysis of stained rock slabs. *Am. Mineral.* **48**, 1164–1166.
- SOLOMON, M. (1963) Counting and sampling errors in modal analysis by point counter. *Jour. Petrology*, **4**, 367–382.
- WHITTEN, E. H. T. (1961) Quantitative areal modal analysis of granitic complexes. *Geol. Soc. Am. Bull.* **72**, 1331–1360.

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PSEUDOMORPHS OF ANATASE AFTER SPHENE FROM  
ROANOKE COUNTY, VIRGINIA

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Well-formed pseudomorphs of anatase after sphene occur in an allanite-bearing pegmatite near the crest of the Blue Ridge in Roanoke County, Virginia. The pseudomorphs are nearly identical to xanthitane (xanthotitane, xanthotitanite) from Henderson County, North Carolina, originally described as a new mineral by Shepard (1856) and Eakins (1888), and later shown by Frondel (1941) to be anatase after sphene. Pough (1934) summarized the earlier literature relating to anatase as an alteration product of sphene, and Deer *et al.* (1962) have reviewed the more recent literature on the subject.

The pseudomorphs vary in size up to 4 cm in their longest dimension, and have the typical wedge-shape of sphene. The interfacial angles on the largest and most perfectly developed of these were measured on a one-circle reflecting goniometer. Although many of the faces reflect light, it was necessary to put water on some of them to increase their reflectivity. The forms present, listed here according to decreasing size, are  $n$  {111},  $a$  {100},  $c$  {001},  $v$  { $\bar{1}01$ },  $m$  {110},  $t$  { $\bar{1}11$ }, and  $Y$  {101}

(orientation of Dana, 1895). The material is light yellow, opaque, and on freshly broken surfaces has a dull porcelainlike luster. Unlike some porous and box-work pseudomorphs described by Pough (1934), these are compact and nearly homogeneous. Also they are completely altered. Dark brown and white stains are common in joints as well as on crystal surfaces of the pseudomorphs. When examined under a microscope the individual anatase grains were seen to be anhedral and about 0.002 mm across. No optical data were obtained. The material is radioactive, a property easily detected for it using ordinary means.

Initially the anatase was identified by the *x*-ray powder method. The comparison of these data with those of pure anatase reported by Swanson and Tatge (1953) is close. However, the average data obtained from five films of five samples made in cameras of 11.46 cm diameter ( $\text{CuK}_\alpha$  radiation), show that the interplanar spacings for the pseudomorphic anatase are consistently larger than those for chemically pure anatase. The calculated unit cell parameters are  $a=3.82 \text{ \AA}$ ,  $c=9.56 \text{ \AA}$  ( $a:c=1:2.503$ ). Chemically pure anatase has  $a=3.782 \text{ \AA}$  and  $c=9.51 \text{ \AA}$  ( $a:c=1:2.514$ ) (Swanson and Tatge, 1953). For an additional comparison, data obtained for anatase from Tavetsch, Tyrol (Lewis Brooks Museum #343), can be seen to be very close to values for chemically pure anatase. This seemed to indicate that the pseudomorphic anatase unit cell is abnormally large, and served as a check on the equipment and method used. The abnormal unit cell size may be due to the presence of other cations like tin and iron substituting for titanium in the structure (Deer *et al.*, 1962). Each of these elements (reported as oxides) is present in amounts greater than 1% according to semiquantitative spectrographic analyses. Semenov (1957) has reported a niobium-bearing anatase with  $a=3.83 \text{ \AA}$  and  $c=9.60 \text{ \AA}$ , values significantly larger than those for pure anatase. Most of the *x*-ray films of the pseudomorphs show small amounts of impurity minerals mixed with the anatase. Data show the presence of quartz, and strongly suggest that kaolinite and perhaps other clay minerals are present.

Three semiquantitative spectrographic analyses showed that  $\text{TiO}_2$  is the major component of the pseudomorphic material. In addition there are considerable amounts (reported as oxides) of Si (7 to 12%), Al (3.5 to 6%), Fe (2 to 6%), and Sn (1 to 3%). The Si and Al are probably from the quartz and clay which were shown to be present by *x*-ray analyses. The role of the Fe and Sn is not clear. Some of the Fe undoubtedly is present as oxide minerals, for example as stains, but there is also a strong possibility that some of it, as well as the Sn, are in the anatase structure substituting for Ti. Chemical analyses presented by

Deer *et al.* (1962) and Palache *et al.* (1944) suggest that such substitutions occur. Also the abnormally large unit cell parameters indicate that a larger ion (Sn for example) substitutes for Ti. Traces of the following, listed in decreasing order (as oxides), were found in all three semiquantitative analyses: Mg (0.5%), Pb (0.2%), Ba (0.07%), and Zr (0.04%). Other elements, found as traces in one or two analyses, listed here in decreasing amounts (as oxides), are As (1%), U (0.5 to 1%), Ca (0.3%), Mn (0.04%), Sr, Mo, Cu, V, Yb, Co, Bi, Y, Sc (0.007%), and Ce (?). The uranium explains the radioactivity of the material. No thorium was detected in the analyses. Goñi (1957) has also reported radioactive pseudomorphs of anatase after sphene, and suggested they contain adsorbed uranium.

The pseudomorphs occur in a deeply weathered pegmatite at the crest of the Blue Ridge on the old Shepherd farm, about 9 miles south of Roanoke. It is not far from the present G. S. Hofawger home, which is located east of U. S. Highway 220 at the end of State Road 921. The deposit is in Roanoke County, but only a few paces from the Franklin County line.

The pegmatite and its hypersthene syenite country rock were briefly described by Watson (1917) in a study of allanite from the same locality. Unfortunately, because the pegmatite has not been appreciably mined and the partially exposed section is so weathered, a detailed description of it is not possible. The dike seems to exhibit simple zoning and is composed mainly of feldspar (kaolinized) and quartz, including much coarse graphic granite. Within the pegmatite, apparently irregularly distributed, are darker units containing much weathered dark-colored mica, both as rather large books and schistose masses. Large amounts of weathered allanite (some pieces 15 cm across), massive gray quartz, and rarer minerals are closely associated with these units. The altered sphene crystals occur as inclusions in allanite, in gray quartz, in fine-grained yellow-green epidote, and in the weathered mica. Also associated with this assemblage are single-crystal magnetite masses (up to 10 cm across) which are very striated and exhibit excellent octahedral parting. Black euhedral zircon crystals (up to 2.5 cm long) and thorogummite occur as inclusions in some of the gray quartz. The thorogummite is yellow-white, earthy, and apparently pseudomorphic after tetragonal crystals (up to 1 cm across) which were presumably originally thorite. The thorogummite identification was based on its radioactivity, its earthy condition, *x*-ray powder patterns, and the fact that considerable water is liberated when the mineral is heated in a closed tube. Distinct radial cracks extend into the quartz around each thorogummite mass.

## REFERENCES

- DANA, E. S. (1895) *The System of Mineralogy of J. D. Dana (6th ed.)*. John Wiley & Sons, New York.
- DEER, W. A., R. A. HOWIE AND J. ZUSSMAN (1962) *Rock Forming Minerals. Vol. 5: Non-Silicates*. Longmans, London.
- EAKINS, L. G. (1888) Note on xanthitane. *Am. Jour. Sci.* **35**, 418-419.
- FRONDEL, C. (1941) priv. comm. cited by Palache *et al.* (1944), p. 588.
- GOÑI, J. (1957) Sur un phénomène d'altération du sphène et les produits qui en résultent. *Bull. soc. franç. Minéral. Crist.* **80**, 199-208.
- PALACHE, C., H. BERMAN AND C. FRONDEL (1944) *The System of Mineralogy of J. D. Dana and E. S. Dana (7th ed.)*, Vol. 1. John Wiley & Sons, New York.
- POUGH, F. H. (1934) Octahedrite as an alteration product of titanite. *Am. Mineral.* **19**, 599-602.
- SEMENOV, E. I. (1957) Oxides and hydroxides of titanium and niobium in the Lovozersky alkaline massif (in Russian). *Trans. Inst. Min. Geochem. Crystalchem. Rare Elements*, **1**, 41-59 (*Min. Abs.* **14**, 278).
- SHEPARD, C. U. (1856) Five new mineral species: I. Xanthitane. *Am. Jour. Sci.* **22**, 96-99.
- SWANSON, H. E. AND E. TATGE (1953) Titanium dioxide (anatase), TiO<sub>2</sub> (tetragonal). *Standard X-ray Diffraction Powder Patterns, Natl. Bur. Standards (U. S.)*, *Circ.* **539**, 1, 46-47.
- WATSON, T. L. (1917) Weathering of allanite. *Geol. Soc. Am. Bull.* **28**, 463-500.

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A NOTE ON THE LATTICE PARAMETERS OF NEPHELINE HYDRATE I

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During an experimental investigation of the system NaAlSiO<sub>4</sub>-H<sub>2</sub>O at 1,000 kg/cm<sup>2</sup> water vapour pressure, a low temperature modification of NaAlSiO<sub>4</sub>, similar to that described by Barrer and White (1952) and termed nepheline hydrate I by these authors, was synthesized at temperatures below 415° C. in runs of 4 days duration. The starting material in these experiments was a coprecipitated gel prepared by a modification of the method described by Roy (1956) and the synthesis was carried out in the conventional cold seal pressure vessel (Tuttle, 1949).

Saha (1961) has determined that nepheline hydrate I is stable at temperatures up to approximately 425° C. at this water vapour pressure. This phase can only be preserved at room temperature by rapid quenching in water. Under conditions of air cooling, both nepheline hydrates I and II are formed. Paragonite, reported by Saha (1961), could not be detected either optically or by x-ray powder diffraction methods in runs at temperatures as low as 300° C. A trace of nepheline