

VIRGINIA METAMICT MINERALS:
PERRIERITE AND CHEVKINITERICHARD S. MITCHELL, *University of Virginia, Charlottesville, Virginia.*

ABSTRACT

Perrierite occurs several places in Virginia, especially in Amherst, Bedford, and Nelson Counties. Chevkinite is found only at a previously unknown locality in Nelson County. All chevkinite reported earlier from Amherst, Bedford, and Nelson Counties is actually perrierite. Indexed x -ray powder data are given, which serve to distinguish between these very similar minerals. Approximate unit cell constants for perrierite are $a=13.61$, $b=5.68$, $c=11.73$ Å, $\beta=113.5^\circ$; for chevkinite, $a=13.60$, $b=5.82$, $c=11.22$ Å, $\beta=100.75^\circ$. Semi-quantitative spectrographic data show no appreciable chemical differences between perrierite and chevkinite. Both minerals contain thorium. Most of the Virginia specimens are only slightly metamict. Heat treatment in air improves x -ray patterns although it produces a slight shrinkage in unit cell dimensions. Chevkinite begins to transform to perrierite above 600° C., and CeO_2 forms from both minerals at higher temperatures. Weathering products associated with perrierite include anatase, churchite, cerianite, bastnaesite, as well as minerals very close to ancylite and florencite.

INTRODUCTION

Recent x -ray studies of metamict minerals which occur in Virginia have shown that some of the materials heretofore reported as allanite or chevkinite are actually perrierite. The purpose of this paper is to give x -ray powder data pertaining to the identification of perrierite and chevkinite, and to report all the known Virginia occurrences of these minerals. The numerous occurrences of allanite in Virginia are to be treated in a separate paper.

Perrierite was first reported from Nettuno, Roma, Italy by Bonatti and Gottardi (1950), who later recognized its chemical and crystallographic similarities to chevkinite (1953, 1954). Fleischer (1951) and Jaffe *et al.* (1956) expressed some doubt regarding the validity of perrierite being a separate species. However, a further consideration of the problem by Bonatti (1959), and the subsequent publication of the structure of the mineral by Gottardi (1960), showed that perrierite is a separate mineral. Lima-de-Faria (1962) demonstrated that chevkinite, when heated in air at very high temperatures, transforms to the perrierite phase and suggested that perrierite may be an oxidized form of chevkinite.

Since its initial discovery several occurrences have been recognized. Bonatti (1959) showed that a material from Kobe-mura, Kyoto Prefecture, Japan, originally named chevkinite by Takubo and Nishimura (1953) is actually perrierite. Lima-de-Faria (1962) has identified perrierite from two localities in India, as well as from Mozambique and Bedford County, Virginia. According to Portnov (1964) a strontian perrierite

occurs with ordinary perrierite in the northern Baikal region of the Soviet Union.

X-RAY DATA FOR PERRIERITE AND CHEVKINITE

Although some similarities exist between *x*-ray data for perrierite and chevkinite, as well as allanite, the data allow one to distinguish between the minerals without difficulty. Differences in the intensities of reflections are of special diagnostic value. That *x*-ray powder data can be used to distinguish between the minerals has also been pointed out by Bonatti

TABLE 1. X-RAY POWDER DATA FOR UNTREATED PERRIERITE FROM AMHERST COUNTY, VIRGINIA

CuK α Radiation. Cameras of 11.46 cm diameter

| hkl | d(calc.) Å | d(meas.) Å | I(obs.) | hkl | d(calc.) Å | d(meas.) Å | I(obs.) |
|----------|---------------|---------------|---------|----------|---------------|---------------|---------|
| 001 | 10.76 | 10.92 | vw | 311 | 2.95 | 2.96 | s |
| 201 | 6.68 | | | 204 | 2.93 | | |
| 200 | 6.24 | | | 020 | 2.84 | 2.84 | m- |
| 002 | 5.38 | 5.41 | w | 021 | 2.75 | | |
| 202 | 5.24 | | | 113 | 2.74 | 2.74 | w |
| 110 | 5.17 | 5.19 | w | 401 | 2.72 | | |
| 111 | 4.99 | 5.01 | vw | 004 | 2.69 | 2.69 | mw |
| 201 | 4.65 | | | 203 | 2.68 | | |
| 111 | 4.39 | 4.40 | vw | 404 | 2.62 | 2.63 | w |
| 112 | 4.08 | 4.10 | mw | 221 | 2.61 | | |
| 203 | 3.84 | 3.85 | vvw | 220 | 2.58 | | |
| 003 | 3.59 | 3.56 | m | 114 | 2.57 | 2.56 | vw |
| 311 | 3.54 | | | 314 | 2.53 | | |
| 112, 202 | 3.45 | 3.47 | w | 022, 312 | 2.51 | 2.51 | w |
| 401, 312 | 3.38 | | | 222 | 2.50 | 2.47 | vvw |
| 310 | 3.36 | | | | | 2.28 | vvw |
| 402 | 3.34 | 3.31 | vw | | | 2.24 | vw |
| 113 | 3.20 | 3.22 | vvw | | | 2.18 | m |
| 400 | 3.12 | 3.14 | vw | | | 2.11 | vvw |
| 403 | 3.03 | 3.05 | vw | | | 2.07 | vw |
| 313 | 2.97 | 2.99 | s | | | 1.95 | m |

and Gottardi (1953, 1954), Neumann *et al.* (1957) and Lima-de-Faria (1962). In the light of recent work the suggestion by Jaffe *et al.* (1956) that the differences between patterns are only due to a great range of chemical substitutions within chevkinite alone, no longer seems tenable.

Even though much of the Virginia perrierite is slightly metamict and must be heated to give the best *x*-ray data, most samples give diagnostic *x*-ray patterns before heat treatment. The measured interplanar spacings for the mineral, given in Table 1, represent the average of values obtained from four sharp *x*-ray powder films (11.46 cm diameter camera, CuK α radiation) made from unheated material from the Burley farm, Amherst County. Using unit cell data and partially indexed powder data reported

by Bonatti (1959) the following approximate unit cell values were determined for the Virginia material: $a=13.61$, $b=5.68$, $c=11.73$ Å, $a:b:c=2.39_6:1:2.06_5$, $\beta=113.5^\circ$. Interplanar spacings calculated from these data reasonably match the observed data, and permit the observed values to be indexed. In Table 1, all calculated spacings allowed by space group $C2/m$ (Gottardi, 1960) are listed for $d_{hkl} \geq 2.50$ Å. All spacings down to 1.95 Å were calculated, but so many different values match each of the measured reflections in this range that inclusion of these data seems pointless. The Virginia data compare well with values published by Bonatti (1959) and Lima-de-Faria (1962) and also match diffraction graphical data presented by Neumann *et al.* (1957).

Films made of heated metamict samples, except for some differences in sharpness of lines, are nearly identical, although careful measurements show a slight shrinkage of the unit cell size with increased temperature. Rarely the CeO_2 lines 3.12 (111), 2.71 (200), and 1.91 Å (220) appear in x -ray patterns of perrierite heated in air. These were noted in two samples from the Burley farm, Amherst County, one heated half an hour at 800° C. and another heated one hour at 1000° C. Other samples from the same locality treated in the same way showed no CeO_2 .

Careful studies of numerous powder films of Virginia perrierite showed occasional weak allanite impurity lines, especially at 9.30 (001), 8.09 (100), 4.65 (111), 3.24 (201) and 2.62 Å (311). There apparently is no relationship between these lines and the heat treatment of the sample since they also appear on unheated samples. The fact that obvious allanite does not occur at the Virginia perrierite localities makes the appearance of these lines problematical.

The measured interplanar spacings for unheated chevkinite, given in Table 2, are the average of values obtained from four x -ray powder films (11.46 cm diameter camera, CuK_α radiation) of material from near Martin's Store, Nelson County. Using x -ray data reported by Jaffe *et al.* (1956) for a comparison, it was determined that the Virginia chevkinite has approximate values of $a=13.60$, $b=5.82$, $c=11.22$ Å, $a:b:c=2.33_7:1:1.92_8$, $\beta=100.75^\circ$. Since the observed data reasonably match interplanar spacings calculated from these values, the data can be indexed. All calculated spacings allowed by the chevkinite space group $C2/m$ are listed in Table 2 for $d_{hkl} \geq 2.43$ Å. Values down to 1.99 Å were calculated, but these data are not included because so many different values match the measured reflections in this range. The observed data reported here compare well with data for untreated chevkinite reported from various localities by Kauffman and Jaffe (1946), Jaffe *et al.* (1956), and Lima-de-Faria (1962). There are, however, minor differences in the indexing of lines compared with results reported earlier by Jaffe *et al.* (1956).

Samples of chevkinite were heated for one hour each in air at 200° C. and 400° C., and at 100° intervals from 600° C. through 1000° C. X-ray patterns of samples heated through 600° C. were essentially the same as those for untreated materials, except for a slight shrinkage of the unit cell, in agreement with results obtained by Jaffe *et al.* (1956). The 700° C. and 800° C. samples showed minor perrierite lines with the chevkinite. At 900° C. perrierite predominated over chevkinite. The 1000° C. sample contained distinct lines for CeO₂ along with perrierite and a few chevkin-

TABLE 2. X-RAY POWDER DATA FOR UNTREATED CHEVKINITE
FROM MARTIN'S STORE, NELSON COUNTY, VIRGINIA
CuK α Radiation. Cameras of 11.46 cm diameter

| hkl | d(calc.) Å | d(meas.) Å | I(obs.) | hkl | d(calc.) Å | d(meas.) Å | I(obs.) |
|-------------|---------------|---------------|---------|------------------|---------------|---------------|---------|
| 001 | 11.02 | | | 203 | 2.99 | | |
| 200 | 6.68 | | | 113 | 2.93 | 2.94 | m |
| $\bar{2}01$ | 6.25 | | | 020 | 2.91 | 2.90 | vw |
| 002 | 5.51 | | | 021 | 2.81 | | |
| 110 | 5.34 | | | 312 | 2.79 | 2.79 | vw |
| 201 | 5.29 | | | $\bar{3}13, 004$ | 2.76 | | |
| $\bar{1}11$ | 4.95 | 4.93 | vw | $\bar{4}03$ | 2.74 | 2.74 | ms |
| $\bar{2}02$ | 4.70 | | | $\bar{2}04$ | 2.73 | | |
| 111 | 4.67 | 4.67 | ms | 220 | 2.67 | | |
| $\bar{1}12$ | 3.98 | | | 402 | 2.65 | | |
| 202 | 3.91 | | | $\bar{2}21$ | 2.64 | 2.64 | w+ |
| 112 | 3.70 | | | 022 | 2.57 | 2.58 | vw |
| 003 | 3.67 | | | 221 | 2.55 | | |
| 310 | 3.54 | 3.55 | mw | 114 | 2.53 | 2.53 | vw |
| $\bar{3}11$ | 3.52 | | | $\bar{2}22$ | 2.47 | | |
| $\bar{2}03$ | 3.51 | | | $\bar{5}11$ | 2.46 | | |
| $\bar{4}01$ | 3.38 | | | 510 | 2.43 | 2.44 | vw |
| 400 | 3.34 | 3.34 | vw | | | 2.35 | vw |
| 311 | 3.23 | 3.22 | m | | | 2.18 | w |
| $\bar{3}12$ | 3.20 | 3.18 | vw | | | 2.08 | vw |
| $\bar{1}13$ | 3.14 | | | | | 1.99 | vw |
| $\bar{4}02$ | 3.13 | 3.11 | w | | | 1.90 | vw |
| 401 | 3.04 | 3.03 | vw | | | 1.65 | w |

ite lines. These results generally are in agreement with Lima-de-Faria (1962) who observed that chevkinite becomes perrierite when heated in air, and that CeO₂ also is often formed.

Occasionally allanite impurity lines were observed in chevkinite diffraction patterns, especially values near 9.30 (001) and 8.09 Å (100). Because of some similarities between strong allanite reflections and certain chevkinite reflections it is difficult to differentiate between some of them when both are present on one x-ray film, *e.g.*, chevkinite 4.67 (111), 3.55 (310), 2.94 (113) and 2.74 Å ($\bar{4}03$), and allanite 4.65 ($\bar{1}11$), 3.52 ($\bar{2}11$), 2.95 (301) and 2.74 Å (021). The presence of the allanite is some-

what problematic since allanite specimens were not found in the deposit studied. Allanite lines were found primarily in unheated samples.

CHEMICAL DATA FOR PERRIERITE AND CHEVKINITE

Specially selected pure samples from most of the perrierite and chevkinite localities discussed in this paper were subjected to semiquantitative spectrographic analyses. Considering the limits of accuracy in the determination of larger percentages with this method one will see a close similarity between these data and quantitative data assembled by Jaffe *et al.* (1956) for these minerals from other localities. A study of Table 3

TABLE 3. SEMIQUANTITATIVE SPECTROGRAPHIC DATA ON PERRIERITE AND CHEVKINITE FROM VIRGINIA

Elements reported as oxides, Analyst: F. W. Barley,
American Spectrographic Laboratories, San Francisco

| Element | Perrierite | | | | | | Chevkinite |
|---------|------------|--------|--------|--------|--------|--------|------------|
| | V2997d | V3049d | V2984d | V3039d | V2996d | V3022d | V2994d |
| Mg | 0.25 | 0.3 | 0.7 | 0.5 | 0.4 | 0.4 | 0.3 |
| Al | 2. | 4.5 | 3.5 | 3.5 | 2.5 | 2.5 | 2. |
| Ca | 4.5 | 4.5 | 5. | 3. | 4. | 3. | 5. |
| Sc | .05 | .08 | .1 | .03 | .07 | .05 | .05 |
| Ti | 10. | 15. | 10. | 12.5 | 12.5 | 12.5 | 17.5 |
| V | .01 | .008 | .003 | .005 | .008 | .02 | .01 |
| Mn | .1 | .08 | .15 | .15 | .12 | .15 | .2 |
| Fe | 8. | 10. | 10. | 10. | 10. | 10. | 12. |
| Ni | .002 | .005 | — | — | .003 | .002 | — |
| Cu | — | .001 | .001 | .003 | — | .002 | .002 |
| Y | .25 | .3 | .5 | .4 | .25 | .3 | .5 |
| Zr | .15 | .2 | .15 | .1 | .25 | .15 | .04 |
| Nb | .2 | .25 | .7 | 1. | .2 | .15 | 1.25 |
| Mo | — | — | — | — | — | — | .03 |
| Sn | .008 | .015 | .06 | .07 | .01 | .02 | .07 |
| Ba | .004 | .003 | .001 | — | .005 | .001 | .007 |
| La | 5. | 7.5 | 10. | 5. | 5. | 5. | 7.5 |
| Ce | 10. | 10. | 10. | 8. | 10. | 10. | 12.5 |
| Pr | .5 | 1.5 | 2.5 | .5 | 1. | .5 | 1.5 |
| Nd | 4. | 6. | 7.5 | 4. | 5. | 4. | 5. |
| Sm | .4 | .5 | 1. | .4 | .5 | .4 | .2 |
| Gd | .3 | .3 | .3 | .4 | .3 | .3 | .2 |
| Dy | .15 | .3 | .3 | .2 | .2 | .12 | .08 |
| Yb | .03 | .04 | .06 | .06 | .03 | .06 | .08 |
| Pb | .007 | .05 | .05 | .04 | .01 | .025 | .07 |

S, Cd, Th Not determinable because of interference.

Si—nondetectables; balance in all seven samples.

V2997d. Amherst County, Burley farm.

V3049d. Amherst County, Wares Gap.

V2984d. Bedford County, north of Chamblissburg.

V3039d. Bedford County (?).

V2996d. Nelson County, east of Roseland.

V3022d. Nelson County, on Hat Creek.

V2994d. Nelson County, southeast of Martin's Store.

shows no outstanding differences among the Virginia perrierites except for the fact that the Bedford County specimen (V2984d) tends to be somewhat richer in some of the rare earths than the other specimens. Differences between perrierite and chevkinite are also nearly negligible, except for slightly larger amounts of Ti, Fe and Nb in the chevkinite. The chemical similarities between the two minerals have already been discussed by Bonatti (1959). Although Th was not detected in the semi-quantitative analyses, because of interference, a detailed study of the radioactivity of the specimens indicated its presence (T. Williamson, pers. comm., 1965). Eakins (1891) also reported thorium in his analyses of specimens (in this study shown to be perrierite) from an unspecified locality in Bedford County.

OCURRENCES OF VIRGINIA PERRIERITE

It is unfortunate that only one of the occurrences of perrierite presented in this discussion, the Burley farm in Amherst County, is an *in situ* deposit. The other materials described either were found as float masses, or are museum specimens whose exact localities are now vague or lost. Only one of the Virginia perrierites has been mentioned in the literature previously. Lima-de-Faria (1962) identified perrierite in a museum specimen from an unspecified locality in Bedford County. Until now three of the localities included here have been considered chevkinite occurrences in the literature. These are the Burley farm, Amherst County (Pegau, 1932), Bedford County (Eakins, 1891), and Hat Creek, Nelson County (Price, 1888).

Amherst County, Burley farm, northwest of Amherst. Numerous specimens of perrierite have been collected from deeply weathered pegmatites on the Burley farm about 5 miles northwest of Amherst. The property is less than a mile south of U. S. Highway 60 on State Road 715. Several shallow pits, which were dug in the weathered deposits years ago, are still visible near the place where the meadow joins the woods on the high hill across the road and southeast of the Burley home. Pegau (1932) briefly described the deposit. He believed the material to be allanite with chevkinite intergrowths. He reported large irregular masses, some weighing 500 pounds, in pockets in a hypersthene granodiorite country rock.

The writer has found several primary minerals associated with perrierite in the weathered deposit. Several reddish-gray subhedral zircon masses, up to $2\frac{1}{2}$ inches across, were found. These exhibit a distinct orange-yellow fluorescence with long-wave ultraviolet radiation. Ilmenite masses, an inch or more across, often showing good parting, are common.

Numerous large pieces of magnetite with excellent parting were found intimately associated with a weathered material resembling mica schist. Fractured gray quartz and pieces of kaolinized feldspar are common in the pits. No specimens of rutile, chevkinite, or allanite, reported by Pegau (1932) were found by the writer. A specimen in the Lewis Brooks Museum collection (V2997d) labelled by Pegau as "allanite with bands of tscheffkinite" was shown in this study to consist only of perrierite. Slight traces of allanite impurity lines were found, however, in x -ray data of some perrierite samples from this deposit.

The perrierite is massive, black, and has a dull to pitchy luster. Commonly narrow pitch-black bands are found in the dull black portions. Most of the perrierite collected by the writer is externally altered to a light brown earthy material. Numerous pseudomorphic masses, with only traces of perrierite at their centers, have been observed. X -ray powder patterns of this earthy material show that anatase is the chief constituent. Preliminary studies of white and pink earthy to porcelainous materials filling fractures in these masses have yielded x -ray data for churchite, cerianite, and a member of the plumbogummite group which is very close to florencite.

Most x -ray powder patterns made of unheated perrierite were very sharp and distinct. Occasionally, however, the effects of metamictization were noted on some samples. Separate samples from one piece (V2987d) were heated in air for one hour each at temperature intervals of 100° C. from 200° C. to 1000° C. The noticeable changes include sharpening of lines, slight decreases in interplanar spacings, and the formation of CeO_2 in the 1000° C. sample. A study of the pitchy and dull bands in the Pegau specimen mentioned above showed no appreciable differences in x -ray data between the materials of different luster, except for the fact that CeO_2 lines appeared when the dull material was heated at 800° C. for half an hour.

Amherst County, at Wares Gap. Mr. B. Smith Campbell of Route 4, Amherst, Virginia, reported (pers. comm., 1963) that he found over 320 pounds of an allanite-like mineral as float pieces at Wares (Weirs) Gap in Amherst County. The locality is about 3.25 miles southwest of the Burley farm occurrence. After a diligent search of the area the writer was unable to find traces of the mineral, but he is fortunate to have a large specimen of the material through the kindness of Mr. Campbell.

The specimen (V3049d) available for study measures 16 by 9 by 8 inches, and is over 80 per cent perrierite. Anhedral to subhedral milky and smoky quartz is embedded in the perrierite, especially on one side of the mass. Small amounts of feldspar are associated with the quartz.

Numerous grayish-red zircon crystals, ranging up to 2.5 inches long and half an inch square, and a fragment of light yellow apatite half an inch long, are associated with the perrierite. The specimen obviously is pegmatitic. The perrierite is black and vitreous with some large dull areas. Although the mass is essentially fresh, in places the perrierite is altered to a light moderate brown earthy substance. X-ray studies of this showed anatase with traces of quartz. Fractures in the fresh perrierite are incrustated with dull pale yellowish orange to grayish orange pink material which is a mixture of bastnaesite and a mineral with x -ray data very close to ancylite. Weak perrierite x -ray patterns were produced from unheated samples. Heating at 800° C. for half an hour in air increased the quality of the patterns.

Bedford County, north of Chamblissburg. Two specimens in a collection of allanite in the Lewis Brooks Museum, assembled by Prof. T. L. Watson in about 1916, were shown by x -ray study to be perrierite. One specimen (V2984d) was labelled "Powell farm, High Knob, Bedford County, Virginia, July 21, 1916." The other (V2981d) had "Stewartsville, Virginia, Mrs. N. A. McMannaway, September, 1915." An allanite specimen (V2985d) also had the Powell farm label. With the McMannaway specimen were also pieces of black vitreous garnet and magnetite. The writer made a serious attempt to find the localities indicated by these labels. He found that both the Powells and McMannaways lived near the present W. E. Dooley farm which is off State Road 616 north of Chamblissburg. The writer did not find perrierite here, but did find two masses of float quartz containing allanite near the edge of a meadow on a ridge located just west of the roadway leading to the Dooley house.

The two specimens of perrierite available for study are each less than an inch square. They are dull to vitreous and black. Unheated samples gave diffuse x -ray patterns of perrierite. Sharper patterns resulted when the materials were heated in air at 800° C. for half an hour.

A third specimen (V3039d) in Watson's allanite collection is labelled "Bedford County(?), Virginia." This specimen, which is a little over an inch square, looks like the Chamblissburg material in every respect. The powder of the mineral is the same light brownish gray which is somewhat different from the Amherst and Nelson County specimens. The x -ray powder patterns of both unheated and heated samples show perrierite with a few very faint allanite lines.

Bedford County. Eakins (1891) reported chevkinite from an unspecified locality in Bedford County. Several more or less rounded masses, coated with a brownish-yellow alteration material, were found. The largest mass

weighed over 7.5 pounds. On fresh surfaces the mineral showed a banded structure of lustrous black and dull black material, the bands varying from mere lines to over one-eighth inch in thickness.

Five pieces of the Eakins (1891) material were obtained for this study from the U. S. National Museum (USNM 83896, one piece; USNM 78512, four pieces). *X*-ray studies of unheated samples of each of these showed definite, but generally weak to very weak, perrierite patterns. The *x*-ray patterns were somewhat improved, but still rather weak, for each of the samples when heated half an hour at 600° C.; heat treatment at 800° C. for half an hour produced much improved perrierite patterns. Very weak allanite lines were observed in one of the unheated perrierites. An *x*-ray study of the alteration crust on two of the samples showed anatase to be the chief component.

Jaffe *et al.* (1956) gave *x*-ray data for heat-treated material from Virginia which they called chevkinite. Although the exact locality was not given, it is implied from the chemical analysis quoted by them, that the material was that of Eakins (1891), shown here to be perrierite. They treated their samples by heating them over a Bunsen burner for an hour. The fact that data for this material match data for definite chevkinite from other localities treated in a similar fashion is expected, now that we know perrierite and chevkinite yield the same products when heated in air at high temperatures. The writer found no evidence to suggest that both perrierite and chevkinite occur among the Eakins (1891) materials, or in other samples from Bedford County.

Another specimen from Bedford County, in the British Museum (BM 86189), was shown by Lima-de-Faria (1962) to be perrierite. A small chip of the same specimen was studied by the writer. The mineral is somewhat metamict, but unheated samples have very definite perrierite *x*-ray patterns. Samples heated in air at 600° C. for half an hour and at 800° C. for an hour gave excellent perrierite data. According to Mr. P. G. Embrey (pers. comm., 1965) of the Museum, this specimen was purchased in 1903 from a James R. Gregory and Company. Although its earlier history is not known, this may be from the Eakins (1891) locality.

The writer was also fortunate to obtain another Bedford County specimen from the British Museum (BM 82694). The mineral was labelled "chevkinite" and was purchased in 1897 from a Mr. J. Graves, although it bears a G. L. English and Company label (P. G. Embrey, pers. comm., 1965). This specimen is very similar to the Eakins (1891) material and may be from the same locality. The sample is one of the most metamict ones observed in this study. An unheated piece showed only the most intense *x*-ray line for perrierite. A sample heated in air at 600° C. for

half an hour gave a faint, but pure perrierite pattern. When heated at 800° C. for an hour the *x*-ray pattern was typical for perrierite.

Nelson County, east of Roseland. Through the kindness of the late Miss J. J. Glass, United States Geological Survey, the writer had available a small specimen (V2996d) labelled "chevkinite" from 4 miles east of Roseland. This isolated mass weighing 1½ pounds when found was collected from near a stream by L. J. Kidd in 1940. It was believed to have come from the nearby Blue Ridge.

The mineral is dull black with some black vitreous bands. Untreated powder yielded the perrierite *x*-ray pattern, but the lines were weak and diffuse. Heat treatment in air at 800° C. for half an hour gave sharp perrierite patterns.

Nelson County, on Hat Creek. Price (1888) reported chevkinite from Hat Creek, 4 miles east of Massie's Mills. The mineral occurred as a loose mass weighing over 20 pounds. It appeared to have been broken from a veinlike deposit about 2 inches thick. The original piece was fresh except for a brown crust attributed by Price (1888) to contamination of adjacent rock.

A small specimen obtained from the U. S. National Museum (USNM 47569; V3022d) is dull black with a few thin black seams of vitreous luster, like that described by Price (1888). Unheated samples gave patterns for perrierite which were usually very sharp and distinct. Samples heated at 800° C. for half an hour gave similar results. *X*-ray films of heated and unheated material frequently also showed the presence of weak allanite lines.

OCCURRENCE OF VIRGINIA CHEVKINITE

Although chevkinite has been considered to occur in Virginia for more than 75 years, since its description by Price (1888), the present work shows these earlier materials are actually perrierite. These invalidated chevkinite localities are the Burley farm, Amherst County (Pegau, 1932), Bedford County (Eakins, 1891), and Hat Creek, Nelson County (Price, 1888). The only chevkinite encountered by the writer is from a previously unreported *in situ* deposit near Martin's Store, Nelson County.

Nelson County, southeast of Martin's Store. A chevkinite-bearing pegmatite occurs in a road cut on the northeastern side of State Highway 6 at a place about one mile southeast of Martin's Store (or four miles northwest of the intersection of U. S. Highway 29 and State Highway 6). The ex-

posure is in a cut on a former curve of the road before the road was straightened out, and is across from where the Rockfish River now flows next to State Highway 6. The dike, which is in a biotite gneiss, is over two feet wide and is exposed vertically in the cut for at least 15 feet. It consists mainly of medium- to coarse-grained blue-gray quartz and white feldspar. The core of the dike consists of fine-grained biotite masses filling spaces between subhedral feldspar crystals. Associated with the fine-grained biotite are tiny pink garnet crystals and a few anhedral to subhedral chevkinite masses not more than three inches across. The deposit shows no evidence of weathering, and it has not been mined.

The masses of chevkinite are intimately associated with biotite and quartz. The mineral (V2994d) is black, locally with a slight brownish tint, and is both dull and vitreous. A bright yellow amorphous substance occurs as irregular inclusions in some of the pieces. The chevkinite shows no evidence of weathering. X-ray studies show it to be scarcely metamict, although it does contain Th. A discussion of how the mineral from this locality behaves when heat-treated was given earlier in this paper.

ACKNOWLEDGMENTS

The writer wishes to express his thanks to individuals who supplied specimens for study, especially to Mr. P. G. Embrey of the British Museum (Natural History), Mr. P. E. Desautels of the U. S. National Museum, and the late Miss J. J. Glass, of the U. S. Geological Survey. Dr. T. G. Williamson, of the University of Virginia Reactor Facility, kindly studied the radioactivity of the specimens. Mr. R. J. Bland, Jr., of Richmond, Virginia, assisted the writer in collecting materials in the field. This research was supported in part by a grant from the Sigma Xi-RESA Research Fund.

REFERENCES

- BONATTI, S. (1959) Chevkinite, perrierite and epidotes. *Am. Mineral.* **44**, 115-137.
- AND G. GOTTARDI (1950) Perrierite, nuovo minerale ritrovato nella sabbia di Nettuno (Roma). *Rend. Acc. Naz. Lincei Ser. 8*, **9**, 361-368.
- AND G. GOTTARDI (1953) Nuovi dati sulla perrierite. Relazioni tra perrierite, chevkinite ed epidoti. *Rend. Soc. Mineral. Ital.* **9**, 242-243.
- AND G. GOTTARDI (1954) Nuovi dati sulla perrierite. Relazioni tra perrierite, chevkinite ed epidoti. *Rend. Soc. Mineral. Ital.* **10**, 208-225.
- EAKINS, L. G. (1891) New analyses of astrophyllite and tscheffkinite. *Am. Jour. Sci.* (3) **42**, 34-38; same paper (1892) *U.S. Geol. Surv. Bull.* **90**, 41-44.
- FLEISCHER, M. (1951) New mineral names—perrierite. *Am. Mineral.* **36**, 926.
- GOTTARDI, G. (1960) The crystal structure of perrierite. *Am. Mineral.* **45**, 1-14.
- JAFFE, H. W., H. T. EVANS, JR. AND R. W. CHAPMAN (1956) Occurrence and age of chevkinite from the Devil's Slide fayalite-quartz syenite near Stark, New Hampshire. *Am. Mineral.* **41**, 474-487.

- KAUFFMAN, A. J., JR. AND H. W. JAFFE (1946) Chevkinite (tscheffkinite) from Arizona. *Am. Mineral.* **31**, 582-588.
- LIMA-DE-FARIA, J. (1962) Heat treatment of chevkinite and perrierite. *Mineral. Mag.* **33**, 42-47.
- NEUMANN, H., T. SVERDRUP AND P. C. SAEBØ (1957) X-ray powder patterns for mineral identification. III. Silicates. *Avhandl. Norske Videnskaps-Akad. Oslo. I. Mat.-Naturv. Kl.* **6**.
- PEGAU, A. A. (1932) Pegmatite deposits of Virginia. *Virginia Geol. Surv. Bull.* **33**.
- PORTNOV, A. M. (1964) Strontian perrierite in the northern Baikal region (in Russian). *Dokl. Akad. Nauk S.S.S.R.* **156**, 579-581.
- PRICE, R. C. (1888) Analysis of tscheffkinite from Nelson County, Virginia. *Am. Chem. Jour.* **10**, 38-39.
- TAKUBO, J. AND S. NISHIMURA (1953) on tscheffkinite from Kobe-mura, Kyoto Prefecture, Japan. *Mem. Coll. Sci., Univ. Kyoto Ser. B*, **20**, 323-328.

Manuscript received January 25, 1966; accepted for publication, February 10, 1966.