TUNGSTEN DEPOSIT NEAR TOWNSVILLE, NORTH CAROLINA

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Abstract

The tungsten deposit near Townsville is in an area which heretofore has not been known to be mineralized. The dominant ore mineral is huebnerite which occurs in a quartz vein containing much fluorite and sericite as well as small quantities of rhodochrosite, sulfides and other accessory minerals. Scheelite also forms an important constituent of the ore and is believed to result from the hydrothermal alteration of huebnerite although superficially its appearance suggests supergene origin.

Location

The recent discovery of economically significant tungsten deposits in Vance County, N. C., represents not only the development of a mineral industry new to the southeast, but also the discovery of economic mineralization in a locality where it had never been observed before. The deposit was discovered by Mr. Joseph Hamme of Oxford, North Carolina, and Mr. Richard H. Hamme of Virgilina, Virginia. The principal mineralized area is a little less than a mile long and a few hundred yards wide. It is located near the northwest corner of Vance County a short distance south of the Virginia State boundary and about three miles west of Townsville, North Carolina. It lies between Big Island Creek and Little Island Creek about a mile south of their confluence on properties now controlled by the Haile Mines Company. Less intense mineralization can be traced for several miles to the north and south but apparently the only other important locality is on the Thomas A. Morgan property about two miles south of the Haile Mines location.

Description of Area

The general location is in a part of the lower Piedmont about 50 miles from the inland edge of the Coastal Plain in an area which has been rather well peneplaned. However, the principal tungsten deposit is located on the topographically mature interfluve between Big Island and Little Island Creeks which are dissecting the peneplane, and consequently the area immediately surrounding the deposit has rather sharp relief. The general altitude of the peneplane is about 400 feet whereas the flood planes of graded streams have an altitude of about 260 feet making approximately 150 feet of local relief.

The country is covered by the typical mantle of residual soil which is characteristic of the southeastern Piedmont. Very few outcrops of fresh rock are found save for artificial openings such as an old railroad cut at the north end of the area and certain large gabbro dikes which sometimes stand out as stony ridges or boulder trains. However, the drainage is largely subsequent and affords a fair index to geologic structure. The larger streams such as Big Island Creek, to the northwest of the area, and Little Island Creek to the east have rather well developed flood plains, which are occasionally interrupted by gorge sections where the streams traverse more resistant rocks. Little Island Creek in particular seems to follow the regional strike of the schistosity. The smaller valleys seem to adhere to a rectilinear pattern enforced upon them by the two major directions of structural weakness which are the previously mentioned regional strike (about N. 10° E.) and a series of transverse shears which strike generally about N. 70° W. and frequently show considerable displacement. These two structural directions are also manifest in the orientation of the tungsten bearing veins which, in most instances, have been emplaced parallel to the schistosity but occasionally occupy the transverse shears.

Description of Rocks

Geologically, the area is located on the contact between Carboniferous granite, which appears in rather large mass to the east, and an area of metamorphic rocks to the west. On the regional maps the latter have been shown as part of the volcanics and slates of the "Carolina Slate Belt," but in the immediate area of the veins there is little evidence to suggest that the rocks belong to that less metamorphosed complex. In this paper they have been referred to the Wissahickon correlatives which have long been recognized a little farther east in Warren and southeastern Vance Counties. In the principal mineralized area the wall rocks are dominantly light colored sericite schists intimately associated with bluish gray gneissic rocks that contain much opalescent quartz which appears as clear blue grains in the hand specimen. The origin of this latter, gneissic rock is somewhat obscure. On the maps of the U. S. Geological Survey[1] it has been included with the granite, but to the writer it appears to be an altered phase of the schist, with which it is associated. Its only fresh exposure is found in the old railroad cut toward the north of the area. However, the most characteristic type of float throughout the area underlain by schist is an iron-stained, highly siliceous rock bearing large grains of blue quartz which closely resemble those found in the gneiss. For this reason it is believed that the gneiss is an altered phase of the schist which probably appears rather commonly near the zone of contact with the

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[1] Tungsten Deposits in Vance County, North Carolina and Mecklenburg Co., Virginia Strategic Minerals Investigations Preliminary Map.

granite and in particular near hydrothermal veins. There is little doubt that it was produced by mobile emanations from the granite.

Under the microscope the opalescent quartz resolves to large grains of clear unstrained quartz which are surrounded by finer grained quartz aggregates that apparently are of later origin and have a mosaic-like appearance between crossed nicols. These two generations of quartz are also found in the veins as described below. This rock also contains plagioclase, apparently oligoclase, and an appreciable amount of epidote. Other minerals include magnetite in small euhedral grains, occasional small remnants of hornblende which have been largely resorbed and a little chlorite, calcite, and biotite. Rarely a minute grain of zircon is seen and near the veins pyrite and apatite appear. From microscopic studies of the veins and the wall rocks it is apparent that the mineralizing solutions deposited much quartz during the earlier phases of the period of mineralization and during the later phases deposited much sericite. For this reason in the vicinity of the veins the walls have been highly impregnated with quartz and sericite with the zones of dominant silicification occupying positions farthest from the veins and the zones of dominant sericitization appearing immediately adjacent to the veins.

Along the eastern side of the area, granite forms the country rock. Slightly more generous in fresh outcrop than the above described metamorphic rocks, it is a clearly igneous rock of uniformly coarse texture and shows little evidence of alteration. The probable contributor of most of the metasomatic alteration undergone by the older rocks of the area, the granite in turn has been affected very little by subsequent igneous activity. Rare secondary constituents such as epidote, calcite, and chlorite attest some slight alteration but as a rule comprise an insignificant part of the rock. The large Triassic gabbro dikes described below cut the granite without any megascopically visible effect at the contact.

Under the microscope the granite is seen to contain microcline and plagioclase, apparently albite. There is a fair amount of quartz and the mafic minerals are biotite and hornblende. Hornblende appears only as occasional reticulate remnants of grains which have been largely resorbed by quartz. Accessory minerals include occasional small grains of magnetite and zircon.

The gabbro and basalt dikes of Triassic age which are of common occurrence throughout the North Carolina Piedmont put in a significant appearance in this area. Two large gabbro dikes cut the mineralized zone near its center. One of these attains a width greater than 300 feet. Several smaller dikes, manifest by occasional pieces of float, cannot be traced with any continuity. Probably most of these occur as impersistent lenses when they appear in the schist.

In the hand specimen these rocks are very dark colored; in most instances almost black. However, in thin section they are seen to comprise two dominant constituents; colorless augite and labradorite. Magnetite which sometimes appears in graphic growths is the only primary accessory, although there is a little secondary chlorite and calcite.

In connection with the Triassic dikes it is of interest to note that nearly every natural exposure of granite in the area studied was observed to be closely alongside one of them. Apparently the dike rocks had some inconspicuous contact-metamorphic effect upon the granite host rock rendering it slightly more resistant than the general mass.

In addition to the Triassic gabbro, dikes of an older basic rock appear along the eastern border of the mineralized area. In this rock the effects of alteration have been so differential that no two outcrops are alike although the megascopic appearance is usually that of a dark, greenish holocrystalline rock. Under the microscope most specimens resolve largely to epidote, chlorite, and quartz without clue to primary character, although some of the darker specimens are largely amphibole, apparently produced by uralitization of pyroxene. Occasional ghost structures suggest the former presence of feldspars. Laney[2] writing of the Virgilina District, about 20 miles to the west, describes gabbro dikes which cut the carboniferous granite and are older than the Triassic intrusives. These he says have been much altered and are of variable character in their present form. It is probable that the older basic rock of the Townsville area is the same as this altered gabbro of Laney.

Closely parallel with the older basic dikes just described are a number of small light colored dikes which resemble rhyolite in the hand specimen and occasionally display flow structures. Under the microscope these are seen to be almost wholly composed of secondary minerals such as quartz, chlorite, and zoisite. Rarely a small remnant of hornblende is seen and occasional large ghost structures suggest former feldspar phenocrysts.

STRUCTURE

As noted above, the region seems to have undergone considerable stress in the period following the granite intrusion. A series of small shears and faults were developed which are usually nearly transverse to the regional strike, their mean orientation being about N. 70° W. They are not easily discerned on the ground, but are frequently reflected in topographic development and their influence on cultural boundaries has made them quite manifest in the aerial photograph. Some of the faults

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[2] Laney, F. B., The geology and ore deposits of the Virgilina District of Virginia and North Carolina: *N. C. Geological and Economic Survey, Bull.* **26,** 58 (1917). Also, The Gold Hill Mining District of North Carolina: *N. C. Geologic Survey, Bull.* **21,** 73–74 (1910).

are much more prominently displayed than others, as for instance one which passes along the northern edge of the principal mineralized area causing displacement in the channel of Big Island Creek and localizing the positions of three different ravines. Another notable topographic effect is a series of offsets given to the main ridge line which traverses the center of the mineralized area from the southwest to the northeast. Evidence of motion can also be found in the slickensided surfaces which occasionally appear on the walls of the cross veins in prospect pits. These may also be found on the walls of certain of the veins which follow the schistosity of the country rock suggesting that there has also been some motion in the plane of the strike.

These faults antedate the emplacement of the tungsten-bearing veins and some few of them are occupied by veins. In general, however, the faults do not appear to have had any important effect in delimiting the veins, probably because the mobile solutions could pass with considerable freedom through the schistose wall rock. The faults seem to have been still active to some extent at the time of mineralization.

An interesting feature of the cross faults is the fact that they frequently bring about displacement of the post-fault Triassic dikes. The dikes are offset by the faults, but in a rather unusual manner. From the offset segments there are appendages which persist across the fault plane. From such relationships it is inferred that the dikes are post-fault intrusions which found their most ready avenues of movement in the weaker zones of the schist which were largely oriented parallel with the plane of the schistosity. In such a zone of weakness a dike would keep a fairly straight course until it encountered a fault. There it would find that the particular zone of weakness which it had been following had been truncated. Accordingly it would occupy the fault plane until the same zone of weakness was again encountered or a similar one was found. Frequently, abortive attempts were made to follow inadequate openings which the faults had chanced to throw opposite the major ones which the dikes had been following. Such attempts have produced the occasional appendages to the truncated segments of the dikes. In many instances adequate openings in the schist were apparently so plentiful that the dikes were enabled to cross the faults without appreciable offset.

AGE RELATIONS

The geologic history of the area is not fully revealed by the structural relations observed. The principal barrier to a fuller knowledge lies in the fact that there are very few outcrops and that most of those available are small. In general, however, the sequence of events seems to be as follows. Apparently, in Carboniferous time, the schists which are of pre-

Cambrian origin were intruded by granite. After the granite cooled, the older gabbro and the rhyolite which were probably later differentiates of the same magma were injected into the complex in the form of dikes. Following this the area was subjected to dynamic stress and the series of east-west shears were developed. Apparently there were also some shears developed parallel to the plane of schistosity. It was probably during the later part of this period of strain that the hydrothermal solutions appeared and the veins were emplaced. At the same time much silicification, sericitization, and propylitization took place in the more accessible rocks; the schist especially and to a lesser extent in the older gabbro and the rhyolite. Later, in Triassic time, the region was again intruded by gabbro dikes, which are the youngest rock found.

Description of Veins

The veins seem to be limited largely to those parts of the area underlain by schists. The hydrothermal solutions are believed to have had their origin in the Carboniferous granites, although, here, as generally throughout the region, there is little evidence of hydrothermal bodies in the granite itself. In general the principal area of mineralization is in the schist a short distance to the west of its contact with the granite.

Although the mineralized zones are not quite at this contact, they are near enough to it to suggest strongly that their localization has been influenced by it. With few exceptions the tungsten bearing veins were emplaced in fissures which paralleled the plane of contact, although this may very well have been mere coincidence, because both veins and contact plane follow the direction of schistosity.

Silicification of the country rock adjacent to the veins has caused the mineralized zone to stand out as a prominent topographic ridge which forms the divide between Big Island and Little Island Creeks. Many of the veins are of exceptional thickness, some reaching 30 feet, but they usually do not persist more than a few hundred yards along the strike. The vein matter is dominantly quartz with much fluorite interbanded in long interfingering lenses. The chief ore mineral is huebnerite but considerable scheelite is associated with it. The period of mineralization appears to have begun with the entrance of silica laden water in large volume which passed quite generally through a wide zone of the schist near its contact with the granite. The arterial fissures were filled to form the large lenticular veins, and at the same time the schist itself was densely impregnated with secondary quartz to form the gneissic rock described above. The quartz deposited during the earlier stages of this period of silicification, both in the veins and in the wall rocks, is characterized by a much coarser grain than that which was deposited during the later stages of the period. This difference in grain size makes it rather easy to distinguish the early from the late quartz in thin section. The contact between the two is usually not a sharply demarked line but none the less the later, finer-grained variety usually appears in small tongues, veinlets and lenses which cut the coarser variety and suggest that they were emplaced after a period of renewed clastic movement had brecciated it. An example of this relationship is shown in Fig. 1. Between the end of the period of deposition of the coarse quartz and the beginning of the period of deposition of the fine there may have been a quiescent interval during which no quartz was deposited, but this seems rather doubtful. More probably the deposition of quartz was continuous but of varying intensity.

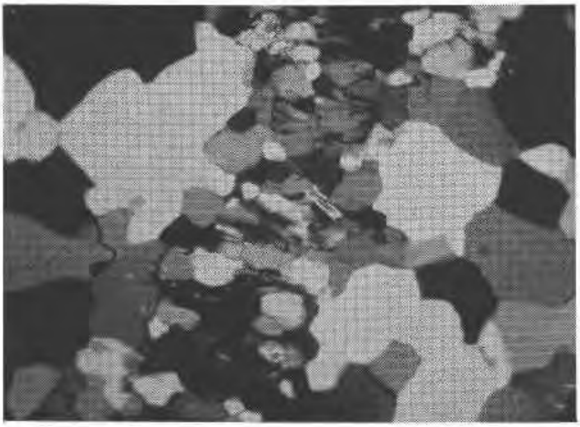

FIG. 1. Small tongue of fine quartz cutting coarse quartz, sericite lath in fine quartz; crossed nicols, ×45.

As suggested in the diagram shown in Fig. 2, huebnerite was the first ore mineral to appear. Apparently it replaced the coarse or early quartz by euhedral crystalline growth. However, almost without exception these original euhedra were fractured and dismembered by clastic movement which seems to have antedated that which created the openings in which the later, finer-grained quartz was deposited. This is demonstrated by the fact that there is no distinction in grain size between the early quartz of the general ground mass and that which filled the openings between the displaced fragments of the broken huebnerite crystals, as can be seen in Figs. 3 and 4.

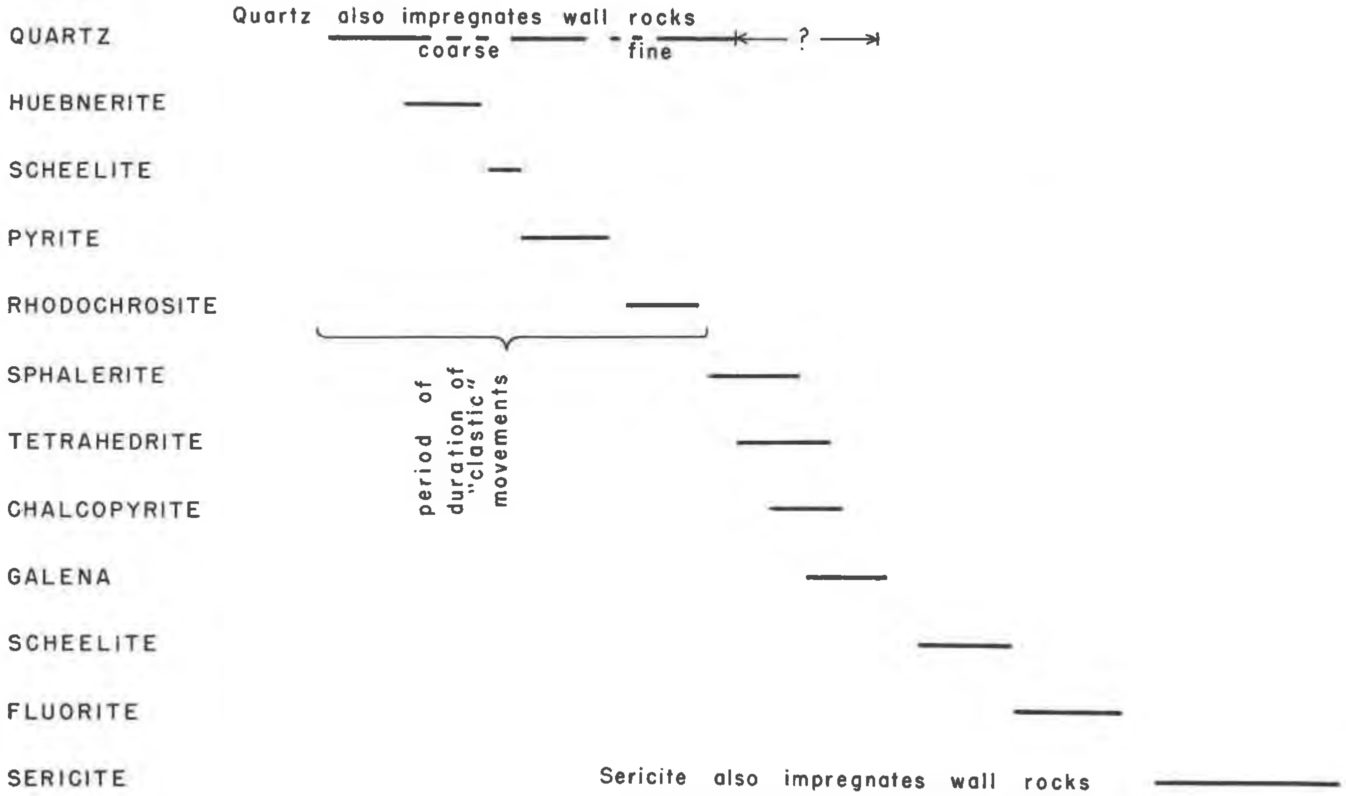

FIG. 2. Diagram showing apparent paragenesis of minerals in veins.

That the dismemberment of the huebnerite crystals is, in most instances, the result of brecciation rather than replacement can be demonstrated from thin sections by the juxtaposition of original structures in the dismembered fragments. Figure 5, for example, shows a zoned huebnerite crystal, in which it can be seen that the boundaries between the color zones in the two displaced segments would match if the segments were brought together again. In Fig. 3 it can be seen that, of the

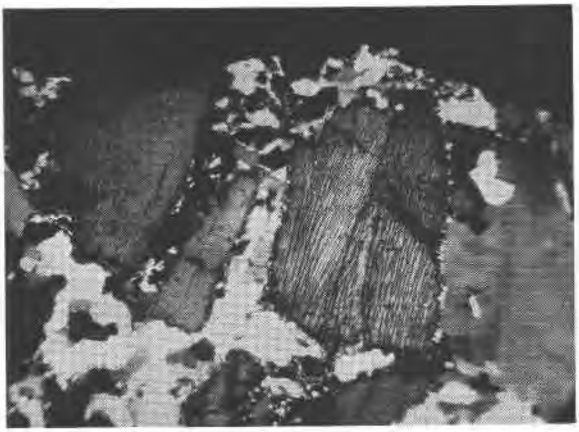

FIG. 3. Fractured huebnerite crystal showing displacement of the several fragments and filling of the fractures by coarse-grained quartz. Laths of sericite replace the quartz filling, and narrow rims of scheelite surround the fragments of huebnerite. Crossed nicols, ×34.

FIG. 4. Fractured huebnerite crystal similar to that shown in Fig. 3. Displacement of fragments is manifest in juxtaposition of severed microstructures; fractures are filled with coarse, early quartz. Crossed nicols, ×34.

three fragments of the large dismembered huebnerite grain shown, the central fragment has been displaced out of line with the ones on either side of it. Again, in Fig. 4, movement of the dismembered fragments of huebnerite can be inferred from the lateral displacement of microstructures on opposite sides of the quartz filled fractures.

FIG. 5. Dismembered huebnerite crystal showing zonal growth. Evidence of displacement can be seen in the matching color zones on opposite sides of the fracture. The fracture is filled with early quartz. A fine reaction rim of scheelite appears at the edge of the huebnerite on both sides of the opening. ×34.

Apparently a small amount of primary scheelite was deposited at the same time as the huebnerite when the hydrothermal solutions were carrying tungsten. This seems evident from the appearance of occasional large crystals of scheelite which have been replaced by pyrite euhedra. However, the bulk of the scheelite is apparently an alteration product of the huebnerite and was formed at a later period when the solutions were carrying calcium but probably no tungsten.

Pyrite appears to have been the next mineral to form after huebnerite. However, it does not seem to have been emplaced until after the huebnerite had been fractured and the openings filled with quartz, for there has been no fracturing or dismembering of the pyrite nor has it been observed as filling between the dismembered fragments of huebnerite. On the other hand, it does sometimes replace huebnerite, usually presenting smooth rounded contacts to both the huebnerite and the enclosing quartz gangue. Sometimes the pyrite itself is in turn replaced by the later fine grained quartz which tends to invade it with irregular reentrants. It thus appears that the pyrite antedated at least part of the fine quartz, but probably was not emplaced until after deposition of coarse quartz had stopped.

Rhodochrosite seems to have entered the veins after the pyrite was deposited. In the sections in which it has been observed, it cuts through an intimate association of quartz, huebnerite and pyrite, but both the rhodochrosite and this assemblage of earlier minerals are replaced by veinlets of fine quartz which carry the later sulfides, chalcopyrite, tetrahedrite, and galena. The rhodochrosite is replaced intimately along the cleavage planes by this late quartz.

The later sulfides, sphalerite, tetrahedrite, chalcopyrite, and galena, were apparently deposited generally in the order named, but with considerable overlap as shown by the paragenetic chart in Fig. 2. Probably the deposition of fine quartz continued to some extent throughout the period of their deposition, for they are all associated with it to a considerable extent. The tetrahedrite appears in intimate association with galena and sphalerite, and the chalcopyrite is usually seen in close association either with pyrite which it replaces or with galena which usually replaces it. From the relationship described in the preceding paragraph it can be shown that sphalerite, tetrahedrite, chalcopyrite and galena are later than rhodochrosite. In other sections sphalerite is seen to replace pyrite and to be replaced in turn by galena and chalcopyrite. As seen to date the sulfides do not form an important component of the ore.

Apparently near the end of the period of deposition of the sulfides the formation of the second generation of scheelite began. Most of it appears in close association with huebnerite although it has been observed in narrow peripheral zones on sphalerite and galena, and traversing the quartz gangue between these minerals. Despite this replacement of other minerals, the predominance of its intimate association with huebnerite has led the writer to conclude that it is largely a hydrothermal alteration product of that mineral. Since fluorite appeared in quantity about the same time as the scheelite it is evident that the solutions must have contained appreciable calcium at that time and there seems little reason to believe that they brought in any additional tungsten. This idea is supported by the fact that by far the commonest mode of occurrence for the scheelite is as narrow but continuous reaction rims on the surfaces of huebnerite crystals. A large percentage of the huebnerite crystals have such coatings of scheelite on their surfaces and traversing internal fractures. Examples may be seen in Figs. 3 and 5 where the scheelite coatings appear as narrow lacy bands with high relief at the very edge of the huebnerite fragments. The same relationship can be seen in Fig. 6 which is discussed below. Not infrequently the alteration process has progressed so far that large percentages of the huebnerite crystals have been changed to scheelite as illustrated in Figs. 7 and 8.

In many instances the manner of occurrence of the scheelite suggests that it might be a supergene alteration product but this possibility seems to be precluded by the fact that it is commonly replaced by sericite, as discussed below.

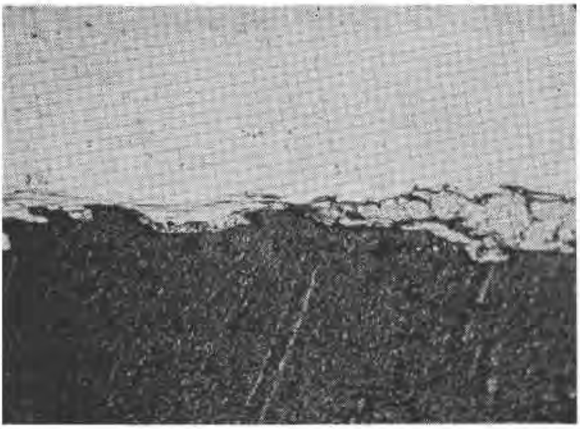

FIG. 6. Huebnerite (dark) and quartz (white) with scheelite and sericite along their contact. Scheelite replaces huebnerite and sericite replaces quartz and scheelite; ×45.

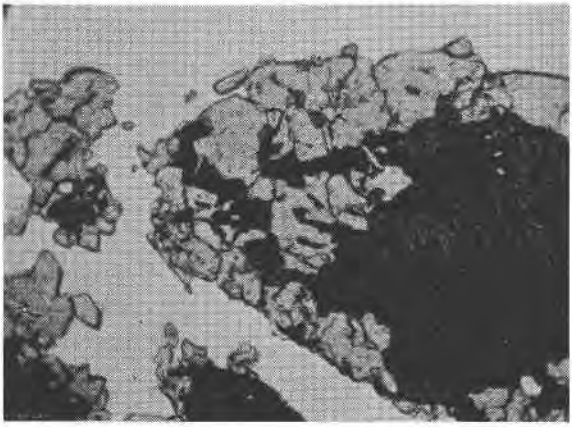

FIG. 7. Huebnerite (dark) replaced by scheelite. White ground mass is quartz; ×45.

The paragenetic position of fluorite is not wholly clear. It can be seen to be younger than sericite which commonly appears throughout it as euhedra, and it is apparently later than most of the quartz which also commonly appears within it, usually as small, isolated, grains and aggregates which have been rounded by resorption. Sulfides occasionally occur enclosed within the fluorite but they also appear to be partiallyresorbed inclusions. All of these relationships are shown by the photomicrograph in Fig. 9 which was taken with nicols at 45° in order that the opaque sulfides and the quartz and sericite might all be distinguished from the fluorite in the same photograph. The relationship between fluorite and scheelite is not known, but since they both appeared after the late sulfides and both contain calcium it is probable that they were deposited at about the same time.

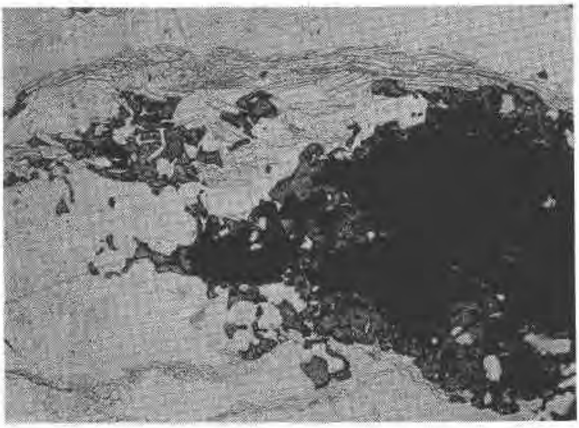

Fig. 8. Huebnerite (dark) replaced by scheelite (high relief). White ground mass is quartz. Laths of sericite (low relief) replace quartz and scheelite; ×45.

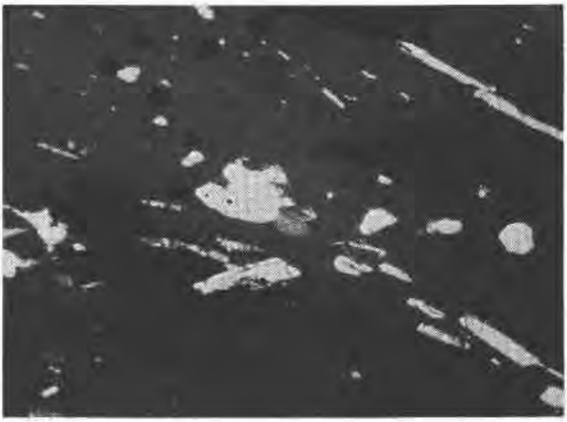

Fig. 9. Fluorite (gray ground mass) replacing sulfides (black) and quartz (white equidimensional areas). Sericite (white laths) cuts fluorite and sulfides; nicols at 45°; ×45.

Sericite was the last mineral deposited. It is abundant in both wall rocks and vein matter and usually appears in wisps of commonly aligned euhedra which traverse the earlier minerals in such clear cut manner as to make their late entry unequivocal. Evidence of this may be seen in the photomicrographs shown in Figs. 3, 6, 8, and 9. In Fig. 3 sericite can be seen replacing quartz between the dismembered fragments of huebnerite. In Fig. 6 it appears, along the contact between the huebnerite and the quartz, invading scheelite which had previously entered the same contact by replacing the huebnerite. It can be seen replacing scheelite and quartz in Fig. 8 and replacing fluorite in Fig. 9.

Apatite also appears in the vein but was not observed in the sections prepared for microscopic study. Therefore, its paragenetic position is not known. Its usual relationships elsewhere would suggest that it was deposited among the early minerals, but the fact that it contains calcium and possibly fluorine lends some credence to the idea that it might have been deposited about the same time as the scheelite and fluorite, toward the end of the period of mineralization. It is of interest to note that it has an orange fluorescence.

Secondary tungsten minerals frequently occur in the zone of leaching. Apparently the commonest of these is tungstite which appears as yellow films and scales.

To the south there is an area where there are many large quartz veins that carry small amounts of black tourmaline but are barren of tungsten minerals.

Two large huebnerite crystals from an outcrop in the northern part of the principal mineralized zone were analyzed for the purpose of mineral identification. It is probable, however, that small amounts of scheelite were included in the analysis. The results were as follows:[3]

WO_3	72.30	68.10
MnO_2	25.68	25.61
Fe_2O_3	2.45	1.40
	100.43	95.11

The writer is indebted to Dr. Paul F. Kerr of Columbia University who checked the identification of huebnerite, pyrite, sphalerite, rhodochrosite, galena and tetrahedrite by means of *x*-ray diffraction patterns.

The deposits have been drilled by the U. S. Bureau of Mines and many of the petrologic observations described here are based upon an examination of their cores.

The work from which this paper is derived was done under the direction of Dr. J. L. Stuckey, State Geologist of North Carolina. Whatever merit it may have is in large measure due to his counsel and assistance.

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[3] Chemical analysis by Dr. W. A. Reid, Chemist, Division of Mineral Resources, Department of Conservation and Development, Raleigh, N. C.