SPHALERITE FROM A PEGMATITE NEAR SPRUCE PINE, NORTH CAROLINA*

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A peculiar black sphalerite from the McKinney mine, near Spruce Pine, North Carolina, was brought to my attention in the summer of 1933 by Mr. B. C. Burgess, of Spruce Pine. The genetic relations of this sphalerite to the typical pegmatite minerals with which it is associated, are shown so clearly that the occurrence evoked unusual interest; and the locality was visited in 1934 and again in 1936. By 1934 the original sphalerite-bearing lens and a smaller one encountered later had been completely removed, but some tons were still on the waste dumps, and abundant material was secured for study. The McKinney mine is operated by open pit, and is one of the largest feldspar producers in the Spruce Pine district. It lies about 5 miles southwest of Spruce Pine, 3 miles northwest of Little Switzerland, and in the northeast quarter of the Mt. Mitchell geologic folio.

The dominant minerals of the pegmatite are microcline, plagioclase that varies from albite to oligoclase, quartz, muscovite, and a little garnet. Thus, except for the locally abundant sulphides, the minerals are those characteristic of pegmatites of the region. Sphalerite is by far the most abundant sulphide mineral, but chalcopyrite, pyrite, pyrrhotite, galena, covellite, scheelite, and a few alteration products are also present. The pegmatite also contains euxenite?, samarskite, and columbite as rare but conspicuous masses. Water-bearing joint planes have yielded very beautiful specimens of fluorescent hyalite which have found their way into many museums.

The sphalerite-bearing lens was several feet thick and is said to have extended almost across the pegmatite body, for a distance of perhaps a hundred feet or more. This great mass composed as it was of intergrown black sphalerite and white albite, must have been a spectacular mineralogical exhibit, since even individual specimens show striking contrasts.

The relations of the feldspars are well shown in a quarry opening to the south of the large quarry, where large rounded masses of microcline are enclosed in the replacing plagioclase. A contact between albite and microcline is shown in fig. 3, where it is marked by the narrow, irregular white area lying between sphalerite above and microcline (gray) below. Microscopic examination shows albite with small, complex interfingering masses penetrating the microcline. Where replacement has been complete the individual grains of albite (*Ab* 95 where associated with the sphalerite) vary from a small fraction up to several millimeters in great-

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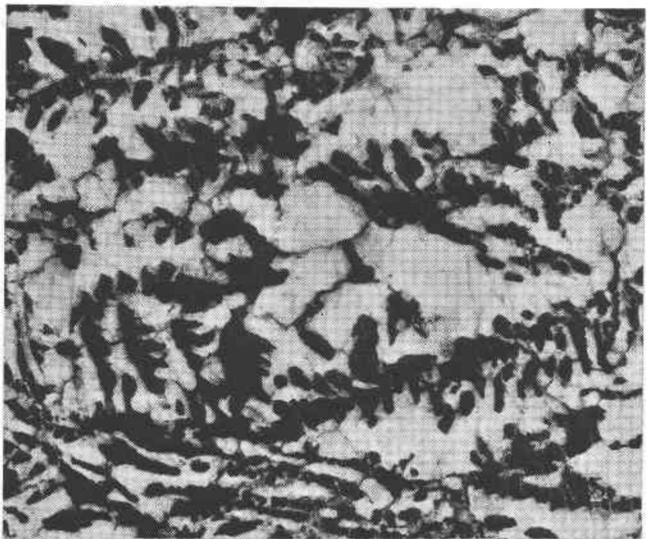

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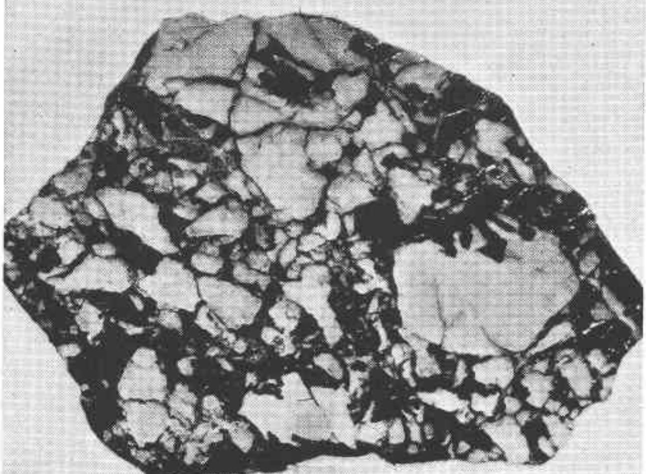

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Fig. 1. Polished specimen illustrating the typical relations between albite and replacing sphalerite. Note the coarsely dendritic habit of the sphalerite. Natural size.

Fig. 2. Polished specimen illustrating fracturing of albite, and veinlets of sphalerite in albite (upper part of figure). Near the right side are spearhead-like areas of sphalerite which have replaced albite. Natural size.

est dimensions, and these interfinger in a very complex manner. Many of the larger albite areas are made up of small segments which give undulatory extinction as in badly strained quartz, and others are so warped that the cleavage planes are strongly curved. Associated with the secondary albite, or on the contact between albite and microcline are sporadic masses of muscovite which reach 20 to 30 centimeters in diameter. A microscopic study reveals numerous vein-like areas of muscovite, and other widely separated but uniformly oriented areas which interfinger with the albite. Some of these have warped or twisted forms that indicate distortion at the time the feldspars were locally fractured. Quartz forms irregular grains associated with albite, and veins up to several centimeters in diameter cut both microcline and albite.

The sphalerite-bearing lens was made up of about equal proportions of albite and sphalerite by volume, with only a small proportion of other minerals. In most of the material from this lens, sphalerite and albite are almost completely unaltered. The complexly intergrown habit of albite and sphalerite, which gives a coarsely dendritic structure, is shown in figs. 1 and 3. Many of the edges of the sphalerite are straight, others are irregular, and cusp-shaped or spearhead-like areas are characteristic. Rounded masses are conspicuously absent. Such structures have at times been assumed to indicate simultaneous crystallization, but it is known that replacement produces the same type of structures. The abundant veinlets of sphalerite that cut fractured albite, illustrated in fig. 2 and more rarely in fig. 1, show clearly that the sphalerite formed after the albite. Moreover, close inspection shows that sphalerite is invariably the invading mineral. The sphalerite in veinlets is identical in character with that in dendritic masses, and single crystal areas are commonly continuous from veins out into dendritic areas. The invasion of microcline by sphalerite along a quartz vein is shown in fig. 3, and veinlets of chalcopyrite in cleavages of microcline are shown in fig. 5. Figure 6 shows irregular areas of chalcopyrite which have partly replaced microcline. The partial replacement of quartz by sphalerite is shown in fig. 3, and microscopic study reveals numerous microscopic veinlets which are in part quartz and the rest sphalerite. In these the quartz occupies clean-cut fractures, but the sphalerite sends out numerous lateral invading areas into the microcline. The invasion of muscovite by sphalerite is illustrated in fig. 4, where sphalerite has developed in the cleavage planes of the mica. Garnet associated with sphalerite is commonly crushed, with sphalerite veinlets in the fractures.

Local areas that evidently came from the border of the sulphide lens, present very interesting mineral relations, although in quantity they are quite unimportant. In the hand specimens such areas show a larger

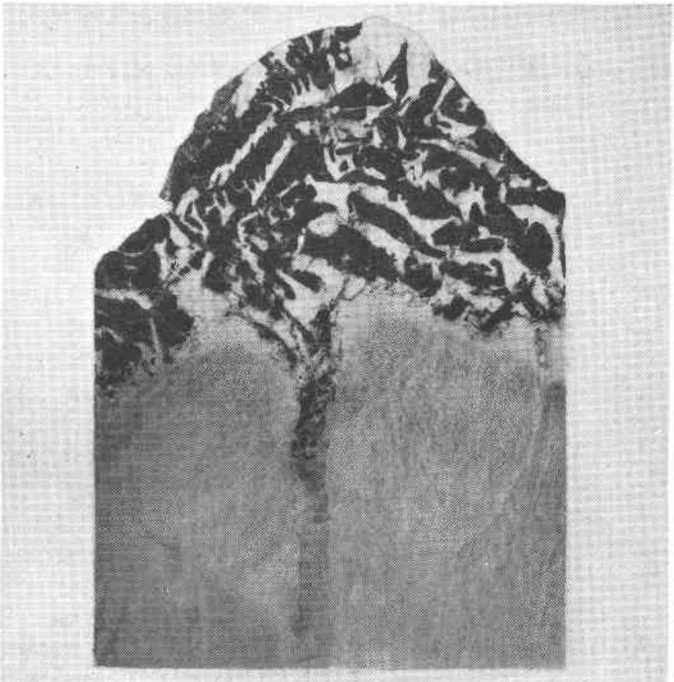

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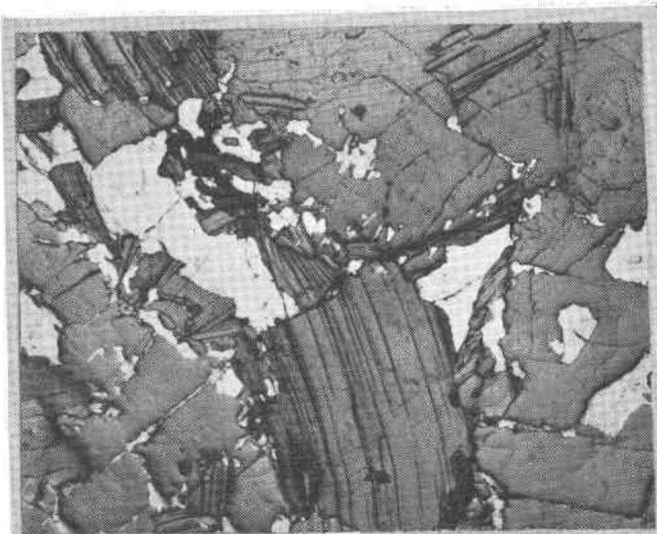
FIG. 3. Polished specimen illustrating the relations of albite-sphalerite to microcline. The lower half of the figure represents microcline cut by a vein of quartz. The narrow light-colored zone between microcline and sphalerite represents granular albite that has partly replaced microcline. Near the center sphalerite has replaced part of the quartz vein. 1/4 natural size.

FIG. 4. Polished specimen illustrating the formation of sphalerite (white vertical veins) in the cleavage planes of muscovite. Near the top is an area of albite (white), and on the left margin is intergrown sphalerite and albite. Reflected light. ×8.



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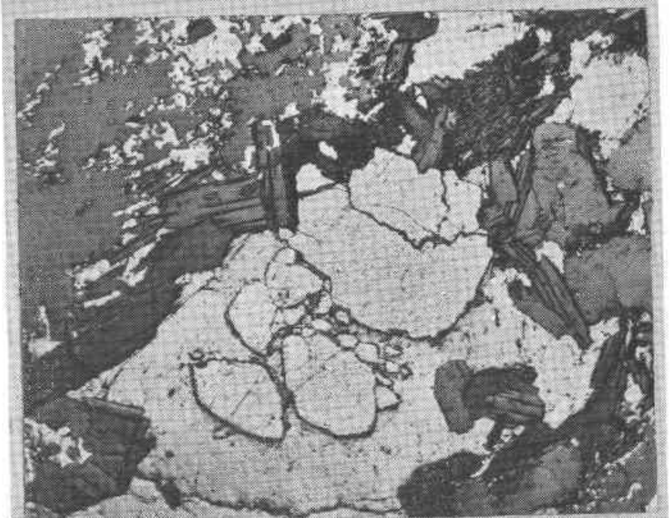

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FIG. 5. Polished specimen illustrating the relations of chalcopyrite. Gray areas with conspicuous cleavage are muscovite, and other gray areas are microcline. White is chalcopyrite. Lower left part of the figure shows chalcopyrite in a cleavage plane in microcline. Reflected light. ×8.

FIG. 6. Polished specimen illustrating the relations of pyrite and chalcopyrite. Near the center of the figure angular grains of pyrite are enclosed in later chalcopyrite. In the upper left portion of the figure patchy areas of chalcopyrite are replacing an area of microcline. Polished specimen. ×8.

proportion of pyrite and chalcopyrite than the main mass, and just outside of the sulphide mass, a zone 1 to 2 centimeters wide in the feldspars has commonly been stained by limonite. In many specimens there has been partial solution of sulphides and masses 1 to 2 centimeters wide have become pitted with cavities 1 to 2 millimeters across. Microscopic study shows that in this border material the sphalerite is somewhat paler in color than the main mass. Some areas contain subhedral crystals of sphalerite which have been slightly rounded, and are surrounded by very narrow reaction rims which appear to have a metacolloidal structure. Others contain abundant pyrite in tiny disseminated blebs, and hematite has formed along cleavages in sphalerite. Scheelite, in euhedral crystals that reach a length of a millimeter, have been observed near the contact between sphalerite and albite in several thin sections. Another specimen from the same zone contains chlorite which seems to have directly replaced albite and muscovite without biotite as and intermediate stage.

The mineralization in these border areas might be interpreted as a slightly later episode than that which produced the main mass of sphalerite, but it seems more probable that it represents the outer zone of mineralization where the solutions had become attenuated, and somewhat cooler. Depletion in the less soluble elements left the solutions relatively richer in others, and so a slightly different mineral suite was deposited. Here scheelite, more abundant pyrite, chalcopyrite, and galena were deposited, and chlorite replaced earlier minerals. A later group of changes are probably to be attributed to supergene processes. During this stage sphalerite was pitted by partial solution, and the remainder seems to have been originally identical with the type characteristic of the lens, but was subsequently leached by the removal of a part of its iron. This released iron now occurs as hematite in the cleavage planes of sphalerite and as limonite in contiguous feldspar. The development of covellite and the formation of hyalite were the result of supergene changes.

A strongly radioactive mineral that has not been analysed, but which has the optical properties of euxenite, was collected at the McKinney mine in 1934. Associated with this were small amounts of chalcopyrite, pyrite, and galena, which seem to have formed about the same time as the enclosing euxenite. With this are minute stains of orange-yellow gummite. The genetic relations of columbite and samarskite were not observed.

The mineral relations described in the foregoing sections show that the hypogene paragenesis falls into three fairly distinct stages. Pegmatite mineralization was initiated by the introduction of primary microcline. The second stage consisted in the partial replacement of microcline by albite, muscovite, quartz, and garnet. During the third stage all the earlier minerals were invaded and partly replaced by pyrite, sphalerite, pyrrhotite, chalcopyrite, galena, scheelite, and chlorite. Euxenite was probably introduced during the same period. There was no doubt a tendency for a mineral sequence within these groups, but they seem to have formed nearly together or overlapped so that the order within a group cannot be fully determined. It is probable that garnet followed the other minerals of its group.

Dr. M. N. Short has kindly studied the sulphides and the relations and has supplied the following descriptions of them:

"The hypogene minerals are pyrite, chalcopyrite, sphalerite, galena, and pyrrhotite. Pyrite is in part older (fig. 6), but all the others are essentially contemporaneous. Sphalerite is immensely more abundant than any other sulphide. It is followed in abundance by chalcopyrite, which is dominant in a few local samples. The others occur only in minute amounts. In specimens where chalcopyrite predominates, sphalerite occurs in chalcopyrite as small rounded, or irregular-shaped inclusions, not over a millimeter in diameter. These sphalerite grains in turn contain chalcopyrite in tiny rounded blebs irregularly dispersed through the host. Galena occurs as tiny rounded blebs in both chalcopyrite and sphalerite. Pyrrhotite occurs as tiny elongated or rounded blebs in sphalerite where it is associated with chalopyrite inclusions. Small amounts of covellite occur as a supergene alteration of chalcopyrite, where it forms aggregates of tiny plates at the boundaries between chalcopyrite and gangue minerals, and in cracks in chalcopyrite."

In the border material, sulphide deposition appears to have been a somewhat more protracted process than in the main mass. Here some of the pyrite is clearly older than sphalerite and part of the chalcopyrite is later. Scheelite and galena are not clearly dated. In some of the pale colored sphalerite, minute uniformly oriented and evenly distributed bleb-like areas of pyrite may be the result of exsolution. Hematite, limonite, covellite, gumite, and hyalite were the result of later supergene processes.

Composition of sphalerite. The following chemical analysis of the typical black sphalerite has been made by Mr. J. G. Fairchild.

Chemical Analysis of Sphalerite

Zn	59.34
Fe	6.16
Cd	0.23
Mn	0.05
Cu	None
Pb	None
S	34.11
Insol.	0.27
Total	100.16
Gravity	4.070

The sphalerite is high in iron as it contains 6.16 of Fe or 9.68 per cent of FeS, and this is no doubt the cause of the very dark color of the sphalerite from the McKinney mine. It is perfectly black in grains only a few tenths of a millimeter in diameter, but gives a chocolate-colored streak.

Under the microscope the color of the sphalerite is ochraceous orange (Ridgway) when examined in white light and in grains about 0.05 millimeters thick. These are dark but entirely limpid, and without dust-like inclusions.

Sphalerite has previously been recognized in pegmatites, but never in such large masses, or where the relations were so well shown. Dr. W. T. Schaller of the U. S. Geological Survey reports[1] small masses (2 or 3 centimeters in diameter) of similar black sphalerite in a pegmatite in the Hottinger mine near Bedford, Virginia. Mr. Hugh Spence, of the Canadian Bureau of Mines, has sent me specimens of a dark colored sphalerite from a pegmatite in Dill Township, Sudbury District, Ontario. He states[2] that it occurs in a small chimney-like zone near the wall of the pegmatite, but observes that it may be connected with one of the later zinc veins that occur in the district. Edwin J. Over, Jr., reports[3] small amounts of a black sphalerite which occurs together with galena in association with fluoride minerals in a pegmatite that lies near the junction of the highway and South Cheyenne Creek on Mt. Rosa, Pikes Peak district, El Paso County, Colorado.

[1,2,3] Personal communication.