A PRELIMINARY REPORT OF THE GEOLOGY OF THE PROFFIT AREA OF CAMBRIAN ROCKS.

By Charles Marshall Gravatt.

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University of Virginia, Virginia.

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TABLE OF CONTENTS.

	Page
Introduction.	1
Acknowledgments	2
Location.	2
Historical.	3
Topography and Drainage.	4
Descriptive Geology and Petrography.	5
Rocks of Sedimentary Origin	6
Crystalline Schist	6
Graphitic Schist	8
Rocks of Igneous Origin	10
Age Relations	10
Granite-Gneiss	10
Amphibolite	12
Rhyolite	14
Structure	16
Occurrence and Origin of the Phosphate	17
Apatite in Igneous Rocks	17
Apatite in Sedimentary Rocks excepting Graphitic Schists	18
Apatite in Graphitic Schists	18
Sedimentary Origin of the Apatite	19
Magmatic Origin of the Apatite	20
Organic Origin of the Apatite	21

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INTRODUCTION.

The area described in this report comprises about 50 square miles, lying just north of Charlottesville, in Albemarle County, Virginia. Some beds of graphitic schist occurring in this area have been found to contain much phosphate. The object of this report is to describe the geology of the area and the mode of occurrence of the phosphate in the rocks, its origin and extent. The field studies, which form the basis of this report were made by the writer during October and November, 1913, and April, May, October and November, 1914.

This report is of necessity of a preliminary nature, and it is not intended to represent a final discussion of the rocks of the area or of the origin of the phosphate in the rocks. It is a description of the work so far done in the field and laboratory and includes a discussion of the ways in which the phosphate may have originated.

The scarcity of exposures, due to the depth of the residual rock decay, renders the detailed mapping of the different beds composing the schist impossible, and, with the exception of the graphitic beds, no attempt has been made to do so; the schists being merely mapped as a unit. Even the black graphitic beds in

many cases show no surface indications, except where crossed by roads or streams, and, on the map such boundaries as could not be definitely traced, are marked with dotted lines.

ACKNOWLEDGMENTS. The writer desires to thank Dr. Thomas L. Watson, State Geologist, under whose supervision the work was done, for the privilege of studying the area, and for his valuable advice and kindly assistance in the preparation of this report. He is also greatly indebted to Adjunct Professor Justus H. Cline for much valuable assistance both in the field and in the laboratory.

LOCATION.

The area described in this report is situated in the northwestern part of Albemarle County, Virginia, and roughly includes a belt about five miles wide and fifteen miles long extending in a northeast southwest direction. The Southern Railway, running parallel to the general strike of the rocks, forms the eastern and southern limits of the area studied, while the granite-gneisses form the western boundary, toward the north the area extends to the County line. The exact location and shape of the area may be seen in figure (1).

The area lies within the Piedmont Plateau province, near its western boundary, and is about twelve miles east of the Blue Ridge Mountains. It is parallel to the general strike of the rocks and includes a belt of highly folded sediments in contact

with Catoctin schists on the southeast and granite-gneisses on the northwest.

HISTORICAL.

The graphitic schists of this area have for some years past excited considerable interest and numerous prospect holes have been opened at different points along their outcrops.

The deepest shaft, 85 feet deep, is sunk in the graphitic schist near Gilberts Station on the Southern Railway. One car load of this material was shipped to Pittsburg, Pa., to be used for its graphite content in the manufacture of paint. However, it was found to be too low in carbon for profitable working. No extensive prospecting work has been done in the area since.

In 1913 a sample of the graphitic schist from the Austin farm near Proffit, was analysed by the U. S. Department of Agriculture, and this sample was found to contain about 30% of calcium phosphate. Since this discovery so much interest has been shown in the area that further investigation has been deemed advisable.

Figure 1.

The areal distribution of the larger rock masses has previously been mapped, and the schists are considered to be of early Cambrian age. The correlation with similar beds in the Catoctin belt of northern Virginia was done by the State Geological Survey in 1911. These schists were previously considered to be of pre-Cambrian age.[a]

TOPOGRAPHY AND DRAINAGE.

The land surface of the area is gently rolling, consisting of rounded flat topped hills and narrow valleys. The hill tops, with the exception of Kearney's Mountain, Observatory Mountain and Stillhouse Mountain, have about the same elevation (650 feet above sea level), and are the remains of a former peneplain at present undergoing degradation. The mountains mentioned above, together with many other mountains and ridges throughout the western part of the Piedmont province represent areas which were not base leveled with the rest of this area and their summits also have nearly the same elevation (775 feet above sea level) and these represent a still older peneplain. A peneplain of still greater age is represented by the tops of the Blue Ridge Mountains.

From this it may be noted that the area has undergone at least three periods of peneplaination with subsequent uplifts, and is at present moderately far advanced in its fourth cycle of

(a) Notes on the Geology of the Monticello Area. By W. A. Lambeth.

erosion. The streams of the area with U shaped valleys and moderately swift currents are characteristic of early maturity.

Referring to the accompanying map, Plate I, it is seen that the area is well drained by the Rivanna River, and its net work of tributary streams. The Rivanna River is the largest stream in the area, and its general direction of flow is toward the southeast across the schistosity of the rocks. Its channel has been superimposed on the structure of the rocks over which it flows. The smaller streams, on the other hand, are almost entirely governed by the structure and their channels follow the schistosity.

DESCRIPTIVE GEOLOGY AND PETROGRAPHY.

In the area mapped are found rocks of both sedimentary and igneous origin. These will be described separately, as follows:---

1. Rocks of sedimentary origin.

   (a) Crystalline schist.
   (b) Graphitic schists

2. Rocks of igneous origin.

   (a) Granite-gneiss.
   (b) Amphibolite.
   (c) Rhyolite.

ROCKS OF SEDIMENTARY ORIGIN.

CRYSTALLINE SCHIST.

General Features. Highly folded and metamorphosed crystalline schists, of Cambrian age, constitute the dominant rock type of the area. They are made up chiefly of interstratified beds of light grey arkosic quartzites and quartz-sericite schists varying in color from light yellowish brown through grey to greyish green.

Other beds of lesser extent are, the dark grey to black graphitic schists, some beds nearly pure white in color and made up almost entirely of sericite (muscovite) and a bed of dark red ferruginous sandstone.

Although most of the schists carry, more or less, feldspar the more arkosic beds occur, as a rule, near the contact with the granite-gneisses along the northwest border.

As is clearly shown by field evidence, the schists are of sedimentary origin and were derived chiefly from the older granite-gneisses. First many of the beds are arkosic, that is; they contain feldspar, a mineral that is easily broken down by weathering due to surface agencies. The presence of feldspar in the sedimentary bed, therefore, argues for a nearby source of the material composing the bed, as it cannot be long exposed to surface agencies and transported to any great distances without changing over to other minerals more stable under surface conditions.

Again, many of the quartz and feldspar grains, composing the sediments, are not so highly rounded as would be the case if they

had traveled a great distance before reaching their final resting place.

Lastly, many of the quartz grains of the sediments are of a pale blue color, due to inclusions of many microscopic needles of rutile, and such blue quartz is peculiar to the neighboring granite-gneisses.

Subsequent to their deposition the sediments have been subjected to intense regional metamorphism changing them into schists and compressing them into a series of closed isoclinal folds which strike N. 38 E. and dip toward the southeast at about 80 .

Petrography. The microscopic study of thin sections of the schists show them to be made up dominantly of quartz, muscovite, biotite and feldspar with varying quantities of minor minerals.

Quartz is the most abundant mineral present and is of both primary and secondary origin. The primary quartz occurs as rounded grains containing numerous inclusions of rutile needles, amphibole, zircon and apatite and often shows secondary enlargement. The secondary quartz grains have irregular outline and contain numerous inclusions of muscovite, biotite, titanite and apatite. Much of the quartz shows evidence of having been subjected to pressure by its mortar structure and wavy extinction.

Muscovite is, as a rule, the next most abundant mineral; and it occurs as small flakes and aggregates. Sometimes biotite equals or exceeds the muscovite in abundance, but it is usually of minor importance.

The feldspar is of very variable occurrence sometimes being rather abundant and again entirely absent. Orthoclase and

plagioclase feldspar occur and both contain abundant inclusions of muscovite, biotite, titanite and apatite.

Small grains and crystals of pyrite, ilmenite, apatite, zircon, titanite, epidote, and sericite occur in variable quantities and constitute the principal accessory minerals. Abundant garnet is found in a slightly graphitic sericite schist outcropping on the Austin farm near Proffit.

GRAPHITIC SCHIST.

General Features. Black or grey graphitic schists are common in the Cambrian of Virginia. They occur interbedded with quartz-sericite schist, arkose, and other sediments. The graphitic beds are of variable thickness and extend throughout the length of the area here described, and are also found extending for considerable distances both to the north and to the south. So far as known at present the only locality where these schists contain a high percentage of phosphate is between Rio and Gilberts, stations on the Southern Railway just north of Charlottesville. This distance measured along the strike of the rocks is about six miles.

In general the graphitic schist varies in color from light grey to black according to the amount of graphitic carbon it contains. The structure is highly schistose, and in places the rock is considerably crinkled.

The rock is made up dominantly of quartz, and muscovite with varying amounts of graphitic carbon. In some places much pyrite in well defined crystals is present. As stated above some beds occurring between Rio and Gilberts contain considerable

phosphorous in the form of apatite; a calcium phosphate with either chlorine or fluorine.

Petrography. As seen under the microscope much of the quartz is original and contains inclusions of rutile needles and gas bubbles. Secondary quartz is common. Much of the quartz shows effects of pressure in that it is granulated and shows wavy extinction. The muscovite is probably all secondary and is present in small distorted leaves and parallel, oriented scales. Ilmenite, biotite, zircon, zoisite, epidote, and titanite occur in small but variable amounts.

The apatite is undoubtedly of secondary origin, and is in the form of small well defined crystals filling microscopic veinlets parallel to the schistosity. Often the veinlets are completely filled with apatite, sometimes showing comb structure, or small crystals of apatite occur along the walls of the vein and the remaining space is filled with secondary quartz. Again, apatite occurs as elongated radiating crystals in the graphite itself.

Figure 2.

The graphite is of the amorphous variety and in some places small grains have been compacted which consist entirely of graphite, but in general it is irrelegularly distributed throughout the rocks in minute particles.

ROCKS OF IGNEOUS ORIGIN.

AGE RELATIONS.

The field relations show that undoubtedly the gneisses are the oldest rocks in the area and that they underlie the Cambrian sediments which for the most part were derived from them. The amphibolite dikes are found cutting the Cambrian schists and at Rio Mills a dike is seen cutting both the pre-Cambrian gneisses and the Cambrian schists and hence must be younger than Cambrian in age,. These dikes are older than Triassic for they do not cut the Triassic sediments which lie a little north of the area mapped.

In a cut along the Southern Railway just north of Rio, rhyolite dikes are seen cutting amphibolite so they must be younger in age. The rhyolites are entirely massive and the minerals, as seen under the microscope, are fresh except where altered by surface agencies so these dikes may be as late as Triassic in age.

GRANITE-GENIESSES.

General Features. This rock is the one on which the western margin of the Cambrian sediments rest and from which much of the Cambrian material was derived. Its areal distribution in the area mapped may be seen on the accompanying map. Plate I.

This rock has been highly metamorphosed by pressure effects resulting in a pronounced foliated structure and the original phenocrysts of feldspar have been drawn out and enclosed between the biotite layers forming distinct "augen" of light colored minerals enclosed in a dark groundmass. The original rock from which these gneisses were derived was dominantly porphyritic but in some localities it was not and the resulting gneiss is finer grained and in general lighter colored than the porphyritic variety.

The porphyritic phase is well exposed in one of the cuts on the Southern Railway in the southwestern part of the area and grades into the finer grained rock toward the northeast. At Rio Mills an even grained rock is exposed which is probably a phase of the original rock that was not squeezed or possibly it is an aplite dike cutting the gneiss and adjoining schist, the exposures being too poor to determine with certainty the exact relations of the rocks.

The strike of the schistosity of the gneiss is uniformly parallel to the strike of the Cambrian schists which is about northeast.

The principal minerals, recognizable by the naked eye, are feldspar, quartz, and biotite and the rock is identical with the quartz monzonite gneiss found a few miles further south in Nelson and Amherst Counties and described in detail by Watson and Taber [a] and called by them a quartz-biotite monzonite-gneiss. A characteristic feature of these rocks is that they all carry more apatite than is usually present in igneous rocks of this type.

(a)------Bul. 3 A. Va. Geol. Survey.

AMPHIBOLITE.

General Features. Many dikes of amphibolite varying from a few feet to half a mile in thickness, cut the Cambrian schists and their trend is usually very nearly parallel to the strike of the schists but in some places the dikes cut the schistosity at varying angles. The areal distribution of the dikes may be seen in the accompanying map . Plate I.

The amphibolite is a holocrystalline even grained rock and varies from medium to coarse granular in texture. A dark green amphibole is the dominant mineral in the rocks and the color of the rock varies from greenish grey to dark green according to the proportion of amphibole it contains. Quartz is the only other mineral recognizable by the naked eye.

Petrography. The microscope shows that the dark green amphibole, of which the bulk of the rock is made up. is actinolite, one of the most common forms of amphibole occurring in metamorphic rocks. It occurs as anhedral grains, less often as needles, and is highly pleochroic in shades of yellow, green and greenish blue, and has an extinction angle of 16 degrees in 010 sections. The actinolite is usually fresh, but in some cases shows by loss of color that alteration by weathering has set in. Many small inclusions of secondary minerals (quartz, epidote, and calcite) are seen in the actinolite and this shows conclusively that the actinolite itself must have been formed contemporaneously with or

subsequently to them, and, therefore, is of secondary origin.

Next to the actinolite, colorless quartz is the most abundant mineral present and occure as grains of various sizes, as veinlets and as filling interstitual cavities. It is undoubtedly of secondary origin and some was formed contemporaneously with the actinolite as is shown by the fact that some of the quartz grains, included in actinolite, have, themselves inclusions of actinolite. Gas bubbles, needles of rutile, zoisite, epidote, and actinolite also occur as inclusions in the quartz.

Most of the quartz is granulated and has wavy extinction showing that it has been subjected to pressure metamorphism. Practically all of the feldspar in the original rock has been altered to zoisite, epidote, calcite, and kaolin. Only a few of the numerous sections studied show any unaltered feldspar remaining in the rock and it was not possible to determine the exact variety with certainty. The feldspar has an index of refraction barely lower than that of quartz and is in all probability oligoclase.

In many sections zoisite occurring as elongated crystals or as rounded or squared grains, and closely associated with quartz and epidote is very abundant. Epidote in varying amounts is present in nearly all the thin sections studied.

Among the lesser constitutents, many aggregates of secondary calcite associated with kaolin occur, and several sections show abundant grains of ilmenite, which usually are altering to leucoxene. Small grains of apatite occur in all the amphibolites. Sometimes the apatite is fresh, but often it is wholly or in part altered to osteolite. Small grains of titanite are abundant in

some sections. Biotite is scarce and where found is altering to chlorite.

The study of thin sections of the amphibolite show clearly that the rock has been intensely metamorphosed under deep seated conditions with the result that practically the entire mineralogical character of the rock has been changed. Most of the original minerals have been changed to new compounds and only a very small amount of the more resistant original minerals now remain. When the rock first cooled from the magma it probably was composed chiefly of pyroxenes or amphiboles, or both, together with plagioclase. If this is true, the rock as it originally cooled from the magma, was a diorite. Subsequent changes induced by heat, pressure, solution, and deposition have completely altered the original pyroxenes or amphiboles or both to actinolite and the feldspars have almost entirely gone over to epidote, zoisite, calcite, and kaolin. The quartz now present in the rock is entirely secondary and was probably derived from the decomposition of silicate minerals.

RHYOLITE.

General Features. Throughout the area mapped are found numerous dikes of very fine grained, light colored rhyolite. The dikes as a rule are narrow, and though some follow the bedding most of them cut across the schistosity as various angles. As a rule, the mineral grains are too small to be distinguished by the naked eye, and the rock appears to be a compact homogeneous mass varying from cream to pinkish in color. A porphyritic phase also

occurs in which distinct phenocrysts of pink feldspar are found, and small grains of blue quartz are also recognizable by the naked eye.

Petrography. The microscope shows orthoclase and microcline feldspar to be the dominant minerals, and in some cases these make up practically the entire rock. In some sections the feldspars are in nearly rounded interlocking grains while in other sections they occur in lathe shaped crystals, these latter are often radiating from a common center and show a tendency towards spherulitic structure. A phase of the rhyolite in which the spherulitic structure is well developed is found about half a mile west of Proffit. The spherules are made up of radiating, elongated feldspar crystals, and they sometimes have a separate crystal of feldspar in the center, and from this the other crystals radiate. The space between the spherules is occupied entirely by granulated quartz.

Most sections showed more or less quartz with the feldspars and one section contains abundant very minute flakes of muscovite. Small grains of magnetite or ilmenite, pyrite, and titanite are the only original accessory minerals noted. All sections showed the effects of weathering by the presence of minute grains and aggregates; probably of kaolin and calcite stained yellow by iron oxide. One section showed considerable epidote developing along minute fractures and a few small grains of chlorite were also noted.

STRUCTURE.

In general the area is one of coystalline schists occurring in closed isoclinal folds striking northeast and with a steep did toward the southeast. These folds rest upon, and, toward the northwest, are in contact with granite-gneisses the whole being cut by numerous dikes of amphibolite and rhyolite. No evidence of faulting was found.

Figure (3) is an ideal northwest-southeast section across the strike of the rocks, and it shows the general relations of the larger rock types. A more detailed discussion of the structure of the different rock types has been given under separate descriptions.

Figure 3.

The rocks of the area have been subjected to intense regional metamorphism at depth, and as a consequence they are highly schistose. The schistosity is best developed in the finer grained highly micaceous schists, and is less pronounced in the arkoses. In the granite-gneisses the schistose structure is as a rule distinct, but both the amphibolite and rhyolite rocks are massive. The only exception is a dike of amphibolite crossing

the Harris farm a short distance east of Frys Spring; here the rock is distinctly schistose.

OCCURRENCE AND ORIGIN OF THE PHOSPHATE.

Qualitative chemical tests (a) show that nearly all of the rocks occurring in the area contain more or less phosphate but only in some of the black graphitic schists is the phosphate content high enough to be of commercial value.

The microscopic study of thin sections of the various rocks has shown that in every case the phosphate occurs in the form of apatite. The only observed exceptions are where the apatite has broken down due to weathering into the earthy form osteolite. This alteration of apative was only noted in some of the amphibolites although it has probably taken place to a more or less extent in the other rocks also.

The presence of apatite in the different kinds of rocks being due to greatly different causes, its origin in each rock type will be discussed separately as follows:----

1. Apatite in igneous rocks.
2. Apatite in sedimentary rocks, excepting graphitic schists.
3. Apatite in graphitic schists.

1. Apatite in igneous rocks. The apatite grains in the amphibolite and granite gneisses are seen under the microscope to be, as a rule, well formed grains interlocking with the

(a) The test used consists of placing a small amount of powdered ammonium molybdate upon the rock specimen and adding a few drops of dilute nitric acid. If phosphorous is present it will, in a few minutes, give decided yellow color to the molybdate.

other mineral grains which go to make up the rocks, also it occurs as inclusions in the other minerals.

These facts show conclusively that the apatite is a primary constitutent of the rocks and that, as is usually the case, it was one of the first minerals to crystallize out from the molten magma on cooling.

In the fine grained rhyolites the apatite cannot be distinguished but undoubtedly it is of magmatic origin as above.

2. Apatite in sedimentary rocks, cementing graphitic schists. Bearing in mind the fact that the granite-gneisses contain an unusually large amount of apatite, it is to be expected that the sediments derived from them should also contain apatite widely distributed through them. Such has been found to be true and nearly every specimen tested gave a more or less decided reaction for phosphate. The microscope shows the apatite to occur as small more or less rounded grains irregularly disseminated through the rock mass and it was undoubtedly introduced at the time of deposition being transported from the area of granite-gneisses, with the other minerals which make up the sediments., During the period of transportation, the grains became rounded and waterworn as they now appear.

3. Apatite in Graphitic Schists. As has been shown elsewhere, the apatite in the graphitic schsits is found with well defined crystalline structure filling microscopic veins and as aggfegates in the graphite.

From the close association of the apatite and graphite in the rocks, it seems probable that they had the same origin or that the graphitic carbon palyed an important part in the precipatation of the apatite from solution. Agian, in a general way, the apatite content of the schists varies directly with the amount of carbon present. Those schists which contain only a small amount of carbon show only a trace of phosphate, if, indeed, any at all.

No definite statement can be made concerning the origin of the apatite in the graphitic schists, and the best that can be done at present is to enumerate the several different ways in which it may be accounted for and give a discussion of each.

1. Sedimentary origin of the apatite.
2. Magmatic origin of the apatite.
3. Organic origin of the apatite.

1. <u>Sedimentary Origin of the Apatite.</u> Although the microscopic study of the graphitic schists did not disclose any rounded or waterworn grains of apatite, it is possible, and even probable, that a very small amount of apatite was laid down with the beds during their formation. The apatite seen under the microscope is not of sedimentary origin for it is in well formed crystals filling small veins. This fact alone renders the sedimentary hypothesis for the origin of the apatite untenable.

3. Magmatic Origin of the Apatite. If the apatite is of magmatic origin it must have been given off from the cooling masses of intruded igneous rocks in some form of solution----- possibly the solution of calcium phosphate in magmatic waters together with the solutions of such mineralizers as chlorine or fluorine, or both. These solutions were able to pass through the adjoining porous sediments without depositing their phosphate but when coming into contact with the more compact graphitic schists precipitation took place due to stagnation of the solutions, with the result that apatite was deposited in the graphitic schists closely associated with the graphite.

The field relations of the igneous intrusive rocks and the graphitic schists render this hypotheses improbable. In fact there seems to be absolutely no relationship between the igneous rocks and the phosphate. If the above hypothesis is the correct explanation of the origin of apatite, one would expect to find the apatite most abundant nearest the igneous masses. The field evidence shows that exactly the reverse is true. For instance in a cut along the Southern Railway just south of Charlottesville amphibolite and graphitic schist are adjacent, and though the amphibolite contains some apatite, the graphitic schist gives no reaction to the test for phosphate.

Near Proffit and Gilberts, where apatite is most abundant in the graphitic schists, they are much further removed from the nearest igneous mass. At Gilberts the nearest large dike is more than half a mile away.

Again, if the presence of the apatite is due to igneous emanations other minerals such as garnet, tourmalin, etc., which are characteristic of such impregnation deposits should occur with the apatite. With one exception, in no case are such minerals found either in the graphitic schists or in any of the other rocks of the area.

The exception noted is a bed of slightly graphitic garnetiferous schist exposed on the Austin farm about a mile south of Proffit. These garnets may be due to igneous emanations, but, restricted as they seem to be to only one locality, it seems most probable that they were formed, due to local favorable lithological or chemical character of the bed in which they occur, during a period of regional metamorphism.

These facts, though not by any means conclusive, render the magmatic origin of the apatite extremely doubtful.

3. Organic Origin of the Apatite. Apatite in large amounts occurs only in these schists in which the graphite content is high. This, together with the fact, that in the rock apatite crystals only occur next to and included in the graphite aggregates, points to a close relationship between the two. The theory that will best explain the origin of the apatite must also show adequate cause for its relationship to the graphite, and also show why apatite does not occur in large amounts in those beds which contain no graphite.

These facts are more easily explained under the hypothesis that the apatite is of organic origin than by any other theory so far advanced.

Sedimentary beds rich in amorphous calcium phosphate are widespread as are also sediments containing carbonacous material, which is usually of vegetable origin. Should a bed containing both abundant carbonacous material and phosphates undergo regional metamorphism, as have all of the rocks of the Piedmont province, there will result a schist containing a high percentage of both graphite and phosphate. This phosphate will, in all probability, crystallize out as apatite, and the resulting schist will be similar in all respects to the black schist here described. That phosphates of organic origin will crystallize in the form of apatite is held by W. H. McNairn.

Granting that the schists, as they are now found, are the result of metamorphism of sediments containing abundant carbonacous and phosphatic material, it still remains to be shown what conditions would give rise to such a sedimentary bed.

This is discussed under two separate headings, as follows;—

1. Animal accumulations under salt water conditions.
2. Vegetable accumulation under fresh water conditions.

1. <u>Animal Accumulations under Salt Water Conditions.</u> Sea water contains small traces of phosphates, which are absorbed into the shells, bones, and tissues of marine animals, and are so concentrated to some extent. When the remains of such animal life collect on the sea bottom slightly phosphatic beds result. The calcium phosphate tends to become more concentrated by the subsequent leaching out of the soluble calcium carbonate, thus finally resulting in a deposit rich in amorphous, calcium

phosphate or phosporite. Most of the known phosphate deposits are of marine origin and they are often of great commercial value.

There are several facts which render this theory of marine accumulation rather doubtful in this case. First, if the phosphate was originally contained in the hard parts of marine animals, one might expect to find some trace of fossils, even though the rocks have been metamorphosed. No trace of fossils has been found in the graphitic schists. Secondly, to supply the graphite content of the schists requires the presence of much organic matter in the original sediment. It is extremely doubtful if the organic portion of animals could accumulate in sufficient quantity in a single bed to allow for as much as 31% graphite as is found in some of the samples of schist analysed. Lastly, according to this theory continuous deposition under the sea must have taken place so it is rather doubtful why one bed only should contain animal remains and then in such large quantities.

2. <u>Vegetable Accumulation under Fresh Water Conditions.</u>

If instead of continuous sedimentation under the sea, the ocean bottom was at one time raised a little above the sea level, then there would have developed a broad flat coastal plain marsh. This would furnish ideal conditions for luxuriant plant growth and for the accumulation of plant remains. Into this marsh the streams flowing over the area of granite-gneiss must have discharged. Remembering that these gneisses contain unusually large amounts of apatite, which is soluable in carbonate waters, these streams would contain a comparatively large amount of phospahtes in solution

besides transporting small grains of apatite and would discharge both into the waters of the swamp.

As shown by C. L. Reese [a] in a series of experiments upon calcium phosphate, it is found to be quite soluable in swamp waters rich in organic matter.

Therefore, the phosphates already in solution in the stream water would be held in solution by the marsh water, and further, the apatite grains discharged by the streams would be further dissolved, both together rendering the marsh water unusually rich in phosphates. It is a well known fact that all plants take up phosphates, fresh water plants take up more than marine plants, and the phosphates thus absorbed continue in the plant remains. If the marsh waters were unusually rich in phosphates in all probability the plant remains would also be exceptionally rich in phosphorous.

Here then, it is seen are conditions ideal for the formation of a sediment rich in both carbonaceous and phosphatic materials, which by metamorphism, is altered to a schist similar to the one herein described. That is, by high heat and immense pressures, due to regional metamorphism at depth, the carbonaceous material is converted into graphite with the crystallization of the phosphates into apatite.

(a) American Journal of Science. 3rd. Series Vol. 43, 1892, p.402.

LEGEND

POST-CAMBRIAN

Iron ore
(Gossan derived from sulphide ore body.)

Quartz felsite porphyry
(Porphyritic texture often not apparent. Trachytoidal groundmass composed of orthoclase and quartz, and phenocrysts of orthoclase, when porphyritic in texture.)

Amphibolite
(Chiefly a massive, dark green rock, composed of hornblende specked with tiny white areas of secondary quartz.)

CAMBRIAN

Graphite schist
(Chiefly a dark blue-gray, thinly foliated rock, phosphatic in places.)

Quartz-mica schist
(Includes interbedded arkosic sandstones and quartzites, intruded by fine, even-granular biotite granite.)

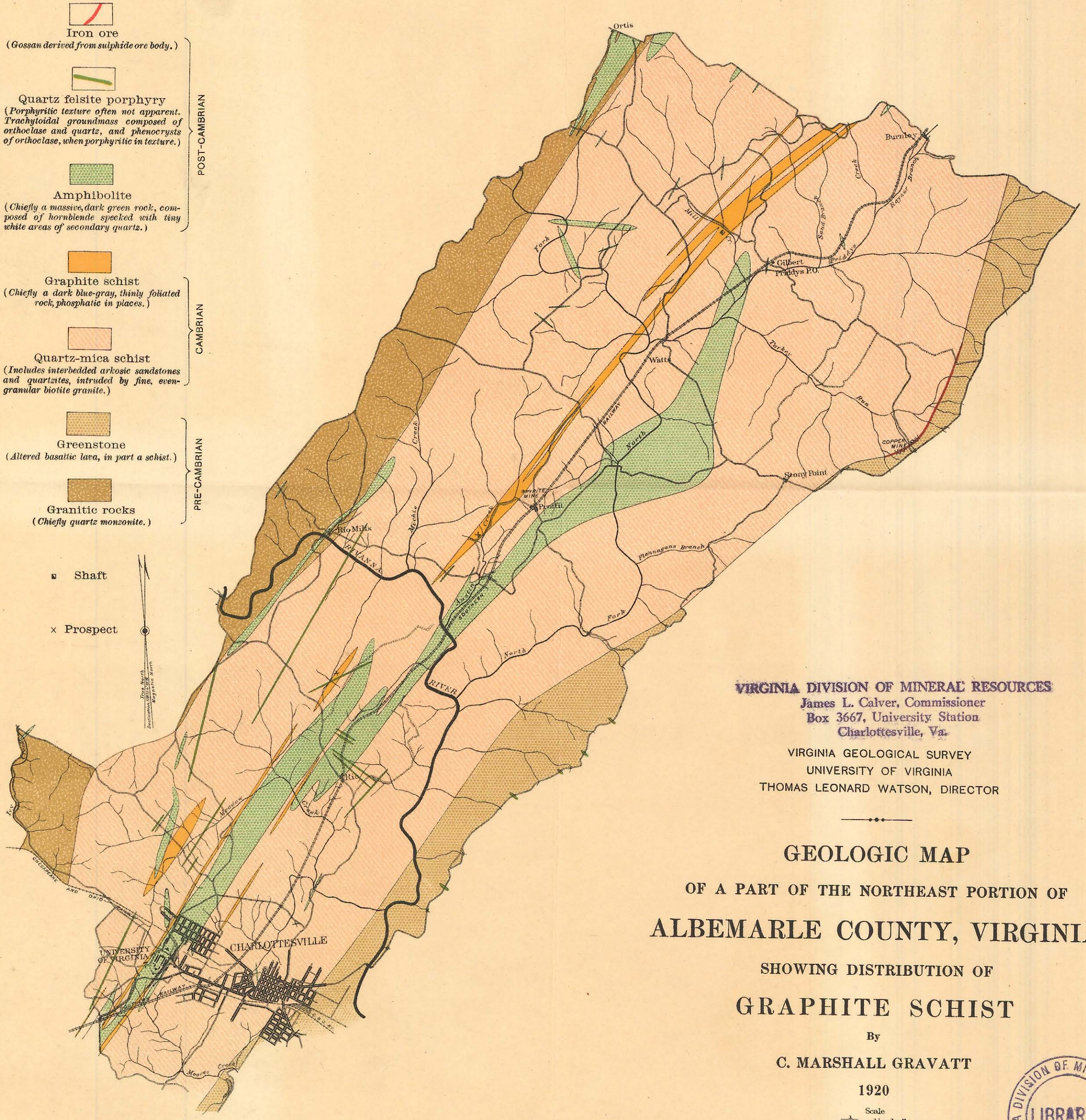
PRE-CAMBRIAN

Greenstone
(Altered basaltic lava, in part a schist.)

Granitic rocks
(Chiefly quartz monzonite.)

Shaft

× Prospect



VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver, Commissioner
Box 3667, University Station
Charlottesville, Va.

VIRGINIA GEOLOGICAL SURVEY
UNIVERSITY OF VIRGINIA
THOMAS LEONARD WATSON, DIRECTOR

GEOLOGIC MAP

OF A PART OF THE NORTHEAST PORTION OF

ALBEMARLE COUNTY, VIRGINIA

SHOWING DISTRIBUTION OF

GRAPHITE SCHIST

By

C. MARSHALL GRAVATT

1920

Scale
$\frac{1}{63360}$ or 1 in.=1 mile
1 ½ 0 1 mile

VIRGINIA DIVISION OF MINERAL RESOURCES
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