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GROUND WATER IN THE CRYSTALLINE ROCK AREA IN SOUTH CAROLINA[1/]

By

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Crystalline rocks in South Carolina and much of Appalachia are an important source of water, not because they are capable of producing a large yield from a well, but because they are widespread and capable of providing yields sufficient for individual homes, farms, and small businesses.

Water from crystalline rocks can be obtained almost everywhere in South Carolina, so long as only modest amounts are needed. Even these amounts vary in response to local controlling conditions. An understanding of these conditions should assist both the well driller and the user to locate the water needed.

The most important controlling conditions are topography and rock type, but however important are the differences in rock type the topography controls the yields of wells more than does the rock type. In particular, the position of a well — whether it is in a valley, on a slope, or on the top of a hill — influences well yield. Rock type influences well depth.

Most dug and bored wells obtain water from the zone of sediment overlying the rock. Usually, ample water (yields up to 5 gpm) can be found for domestic needs. Higher yields are uncommon, although a carefully selected site could result in a higher yield. Because of the difficulty in digging below the water table, most dug wells penetrate only a few feet below the water table. Bored wells usually go 10 to 15 feet below the water table encountering no great boring difficulties until crystalline rock is reached. One disadvantage of dug and bored wells is the danger of contamination of the well water, especially in urban areas. Another disadvantage is that during periods of dry weather these wells tend to go dry sooner than wells obtaining water from crystalline rock.

Drilled wells obtain water from crystalline rock only where there are openings or cracks. These openings, formed when the rock was first formed or later by rock movement, stresses, or weathering, occur close to the surface and decrease with depth as to number and size. The openings are usually interconnected; thus water entering the rock openings can travel to different depths and distances. Most openings will discharge ground water to the nearby streams but some can carry water to great depths, bypassing nearby streams and finally discharging the water as a

1/ Publication authorized by Director, U. S. Geological Survey.
2/ United States Geological Survey, Huron, South Dakota.

spring or to a stream in a different drainage basin than that from which the water entered the rock. In general, water does not move more than about 25 miles from recharge to discharge.

The more openings a well encounters in crystalline rock, the greater its yield. Yields as high as 300 gpm (gallons per minute) have been obtained but are rare (Siple, 1946). Yields in general range from 10 to 30 gpm, although yields of 50 gpm can be obtained in many areas. Well yields greater than 5 gpm are rarely obtained below 300 feet because the number and size of rock openings decrease with depth.

Where crystalline rocks are resistant to weathering, they form hills or flat areas, but where the rocks are easily weathered, they form draws, valleys, and slopes. Factors controlling topography include both the rock type and the number of primary fractures of the rock. The size and number of fractures and joints, cleavage, schistosity, veins, and dikes control rock weathering. If the rock has been subjected to great stress, a number of fractures and joints may be large. Most crystalline rocks were subjected to varying degrees of stress, and the rocks in some areas will have more fractures, higher schistosity, and more quartz veins or dikes than those in other areas. As water moves through the rock openings, chemical weathering increases the size of these openings. The larger openings permit more water into the rock openings and the weathering cycle is accelerated.

The main rock types in South Carolina are granite, gneiss, and schist. A single rock type varies so greatly , from one area to another and even in a small area, as to texture, mineral composition, and size and number of fractures and veins that it is difficult to establish an average yield for each rock type. It is even difficult to determine which rock types average higher yields than other rock types. Data obtained from a study by the author in Greenville County, South Carolina, and existing data concerning some areas in Georgia and North Carolina indicate that in general in these areas schist has the highest average yield and gneiss and granite have slightly lower averages.

Although schist has the highest average yield of all rock types, wells that are located in draws, valleys, or on slopes in other types of rock have yields that, in general, are higher than the average yield of wells in schist.

In granite, fractures tend to be nearly vertical and also nearly parallel to the surface topography, and the only concern in selecting a well site is topography.

The yield of wells in schist or gneiss is determined largely by topography but also in part by the direction and angle of the openings along planes of cleavage and schistosity. These may sometimes be determined in nearby rock exposures. Draws, valleys, and slopes again are the best sites, but an individual site should be picked so that the openings encountered in the well, when projected along the cleavage and schistosity planes, meet the saprolite where the greatest recharge can take place (Figure 1). If most of the rock openings encountered in a well come to

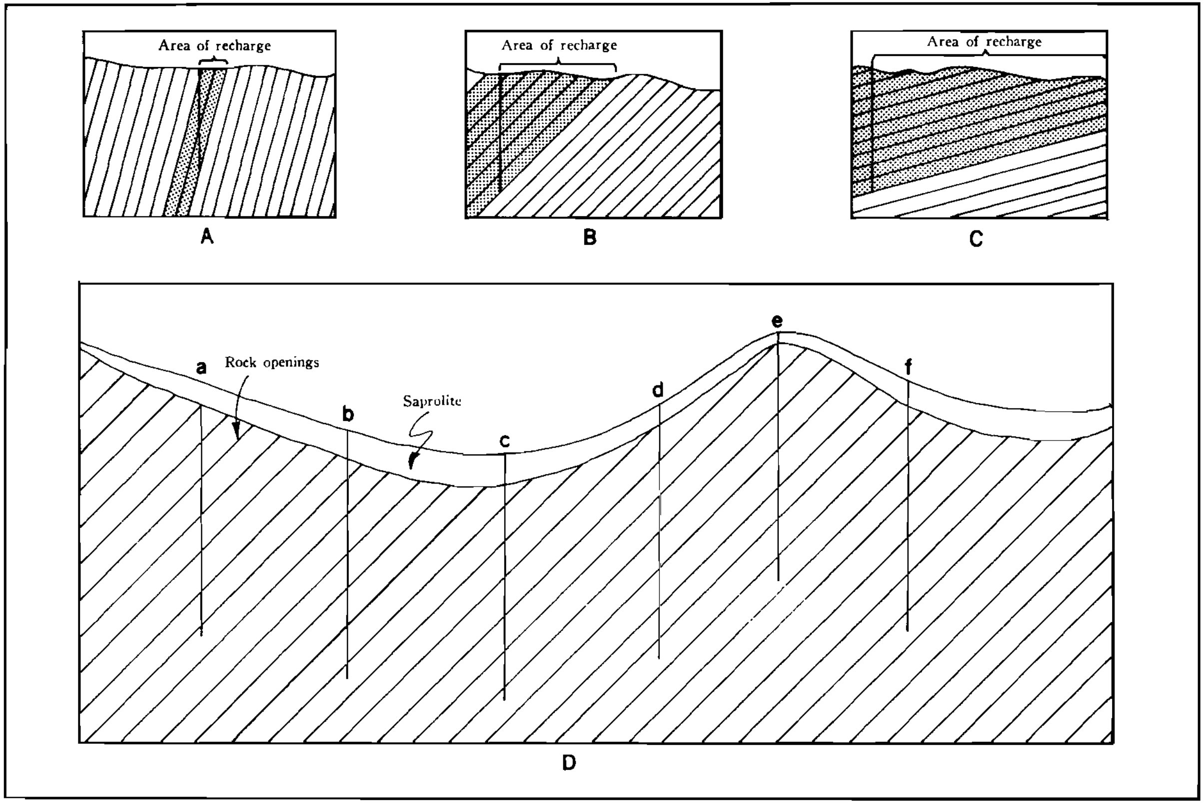

Figure 1. Affect of yield due to angle of rock openings (A, B, C) and relation to topographic situation (D). Wells (a) and (b) are the best sites because the rock openings meet the saprolite where the greatest recharge takes place.

the saprolite or ground surface on the top of a hill, the supply of water will be low. Where the openings dip steeply, a well would have to be drilled deeper to tap the same number of rock openings as a well drilled where the openings are nearly horizontal.

The needed depth of a well to produce a desired yield may be estimated if the rock type is known. In granite, whose fractures tend to decrease with depth, the largest yields can be expected in the first 25 or 50 feet. Therefore, if the desired yield has not been obtained within 100 feet. the prospects of increasing the yield by drilling deeper are poor. In contrast, a gneiss or schist, whose fractures are more persistent, could produce high yields down to about 300 feet.

Another factor influencing well yield is the position of the contact between granite, schist, or gneiss. If granite is penetrated after drilling 100 feet in schist or gneiss, the chances of obtaining much water from the granite are slight. When drilling in schist, a good water supply is usually found at the contact with granite or gneiss.

Higher yields may be obtained if the well is in rock that contains numerous veins or dikes than from wells in rock that has not been disturbed by injections. Also, a well in schist or gneiss, and near granite or some other rock, commonly yields more water than a well away from a contact. A granite usually extends fingers into the surrounding rock and these fingers tend to fracture the country rock and increases its porosity. Where schist and gneiss are in contact, they usually appear to interfinger and be highly fractured. Wells in such locations commonly have high yields.

The complex nature of crystalline rocks makes it difficult to define distinct chemical characteristics for each rock type, but they have been divided into two groups in the Piedmont province (LeGrand, 1958). The granite group consists of rocks similar to granite in composition and includes granite, granite gneiss, mica schist, slate, and rhyolite. These rocks are rich in silica and poor in calcium and magnesium and yield a soft, slightly acidic water which is low in dissolved solids. The second, or diorite, group includes diorite, gabbro, hornblende gneiss, and andesite. These rocks are poor in silica and rich in calcium and magnesium and yield a hard, slightly alkaline water which is high in dissolved solids. A similar division of rock water types was indicated by Siple (1955, Figure 7) for water in the South Carolina Piedmont.

The amount of dissolved solids and other mineral matter that ground water will pick up is dependent, among other things, on the length of time the water is moving through the rock openings. Shallow wells or flowing wells and springs are usually low in dissolved solids because the ground water has not had sufficient time to pick up all the chemical characteristics of the rock. Deep wells usually contain higher quantities of dissolved solids. Where ground water has not had sufficient time to become chemically similar to the rock the water remains close to the chemical content of rain water. Certainly differences in the length of time water has been in contact with rock is one reason for the large variation in pH, dissolved solids, and chemical content in water from wells in the same rock type. Another reason for a variation is travel through different rock types. A well in granite, for example, yielding water that is chemically intermediate between granite and diorite may be yielding water that has passed through gabbro or other rocks of the diorite group. In some places, these rocks are unmapped dikes or veins within the granite and are not apparent from the geologic map. Knowledge of the rock type helps the well driller evaluate the problems to be encountered in drilling, to select the proper well site, to determine how deep to drill, to judge when to stop drilling because of the lack of adequate yield, and to know the approximate chemical quality of the water. But the yields themselves are governed largely by topography. Generally, wells in draw and valleys or on slopes yield the most and wells on or near hill tops the least.

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COARSE-GRAINED SILLIMANITE-QUARTZ ROCK ASSOCIATED WITH THE WINNSBORO GRANITES, FAIRFIELD COUNTY, SOUTH CAROLINA

By

H. D. Wagener[1/]

High grade metamorphic rocks near the northern and northwestern boundaries of the Winnsboro granitic complex include schistose quartzites. Some of these rocks contain varying amounts of muscovite and aluminous minerals, notably sillimanite. The sillimanite quartzites are generally fine grained and contain finely acicular sillimanite in varying proportions. Larger sillimanite crystals occur along some foliation planes. At one or two localities slender bladed crystals more typical of kyanite were noted.

Rocks particularly rich in sillimanite occur about one mile N30°W of the Winnsboro Blue Granite quarry (Figure 1). A large outcrop about 200 feet in maximum dimension juts abruptly out of the soil in a small grove of trees in a clearing near the end of a dirt road leading to the MacFie property from State highway 213.

This deposit is unusual in that it is not noticeably foliated in outcrop or hand specimen, and the grain size of the sillimanite and quartz is large. Sillimanite needles occur in groups up to one inch long randomly oriented in the quartz matrix.

One large thin section (about 800 mm^2) of the rock was studied. The mode is: 52.1% quartz; 46.1% sillimanite; 1.9% zircon. The sillimanite is predominently acicular. Most of the crystals are linearly arranged in groups from which quartz is largely excluded. The crystal groups intersect at angles of approximately 45°. Intersections between some crystal groups resemble jumbled piles of chopsticks, and quartz is intimately interlaced in the sillimanite needles. The ends of most crystal groups contain similarly interlaced quartz.

Grain size of sillimanite and quartz and the availability of residual cobbles and boulders decrease rapidly along strike from the outcrop. Fresh specimens cannot be obtained away from this outcrop. Sillimanite is present in quartzite float along strike for at least 2000 feet, but the percentage is inconsistent. Exposures are too poor to examine the percentage changes in detail.

Thickness of the deposit could not be determined as the dip is uncertain. However, foliation of basic rocks dips very steeply here, and in this area foliation is invariably parallel to layering. The sillimanite unit may be over 100 feet thick, but the thickness could vary markedly

1/ The Citadel, Charleston, South Carolina

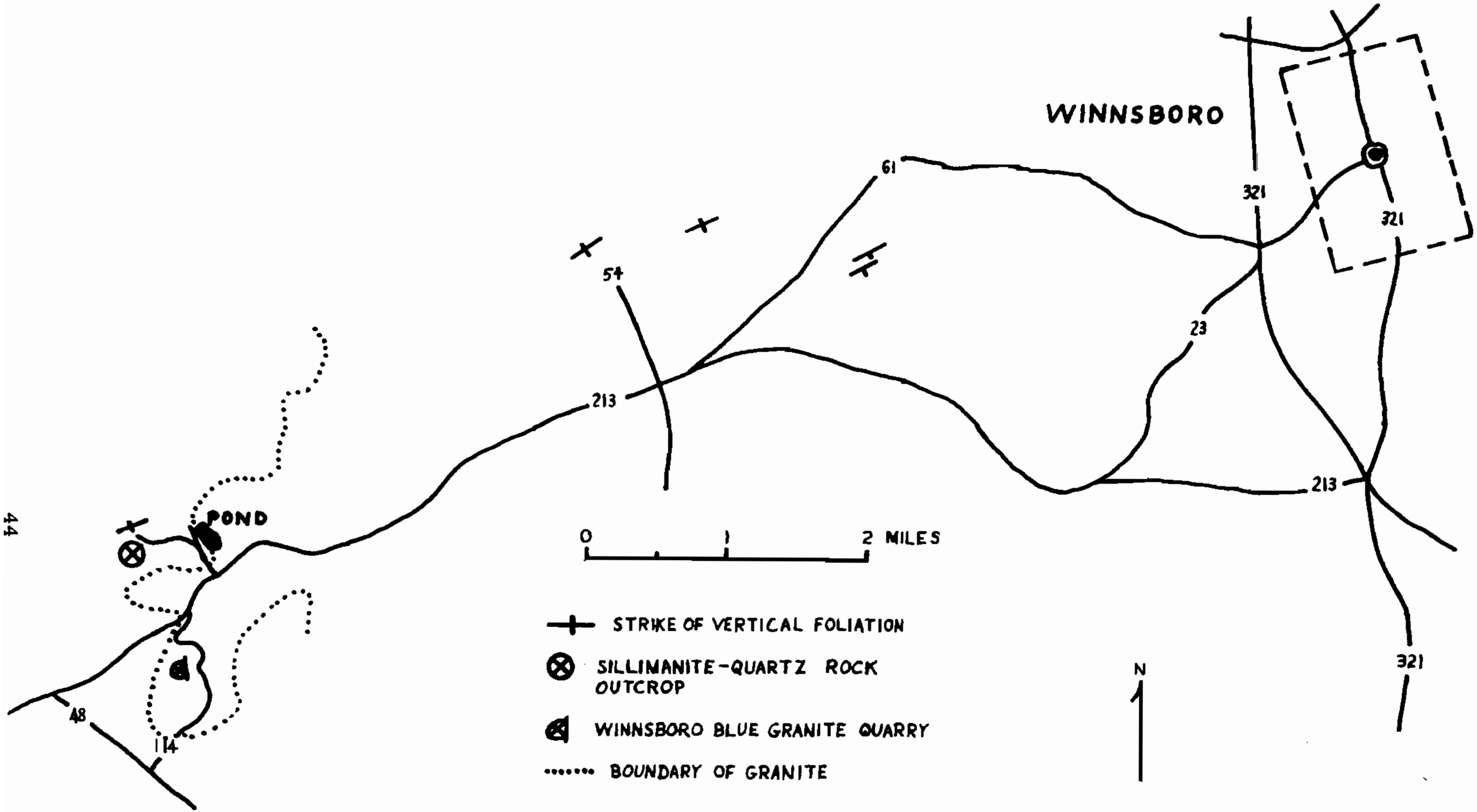

Figure 1. Sketch map showing location of sillimanite-quartz rock near Winnsboro, Fairfield County, South Carolina

within a few hundred feet.

The dip and thickness of the unit at the outcrop could be determined by drilling one or two holes. The soil cover may not average over ten feet thick. Solid rock crops out in streams along either side of the deposit. Two to four additional drill holes along strike from the deposit would probably produce information on variations in thickness of the unit and the percentage of sillimanite present. With this data, a reasonable estimate of tonnages could be made.

There is at least one other sillimanite quartzite unit in the immediate vicinity. Other coarse grained sillimanite deposits might be found by making a thorough field study of all aluminous quartzite units along the northern borders of the granitic complex.

The presence of aluminous minerals in schistose quartzites in this area is probably a reflection of the initial composition of the sediments from which they were derived. Variations in grain size may have been produced by local hydrothermal activity associated with emplacement of the granitic intrusives. Consequently, variations in grain size are not necessarily indicative of variations in the percentage of aluminous minerals.

ORIGIN OF IRON - MANGANESE OXIDE NODULES IN THE WINNSBORO 15' QUADRANGLE, SOUTH CAROLINA

By

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OCCURRENCE

Residual and transported soils associated with fine to medium grained layered amphibolites in certain areas of the Winnsboro 15' Quadrangle (Figure 1) contain brown iron oxide-rich nodules in varying proportions. The nodules rarely make up more than 50% of the soil, though abundant nodules appear in the soils of many shallow road cuts. The nodules, generally round and about 1/8 to 1/4 inch in diameter, litter the surface of some fields and are concentrated in gulleys.

Where the soil is very thin the nodules occur as partial encrustations on cobbles of basic rock, and many of them are reniform. Encrusted cobbles have a thin brown rind of iron oxide-rich material from which round nodules protrude. Some reniform nodules are similarly attached. The encrustations occur on both angular cobbles and those which have been partly rounded by weathering reactions in place. Internally, the cobbles are generally fairly fresh homogeneous fine grained amphibolite. Nothing resembling nodules exists within the body of the rock. An intensive search was made in rocks in place in road cuts, but no positive evidence could be found that any of the basic rocks contain nodules. In every case where nodules seemed to be weathering out of a rock a little hammer work revealed that the nodules are part of a superficial rind.

Thicker, possibly transported soils, especially in what appear to be old flood plains, contain round nodules and "layers" rich in hydrous iron oxides. The "layers" are discontinuous or even only vaguely present and could be described as partly concretionary crusts. They generally occur as a separate horizon several feet below the surface in the B soil horizon.

COMPOSITION

No attempt was made to determine the exact mineralogy or quantitative chemistry of the nodules.

Broken nodules appear finely crystalline and are brownish black to steel blue-gray. The coloration is of the sort that would be expected

1/ The Citadel, Charleston, South Carolina.

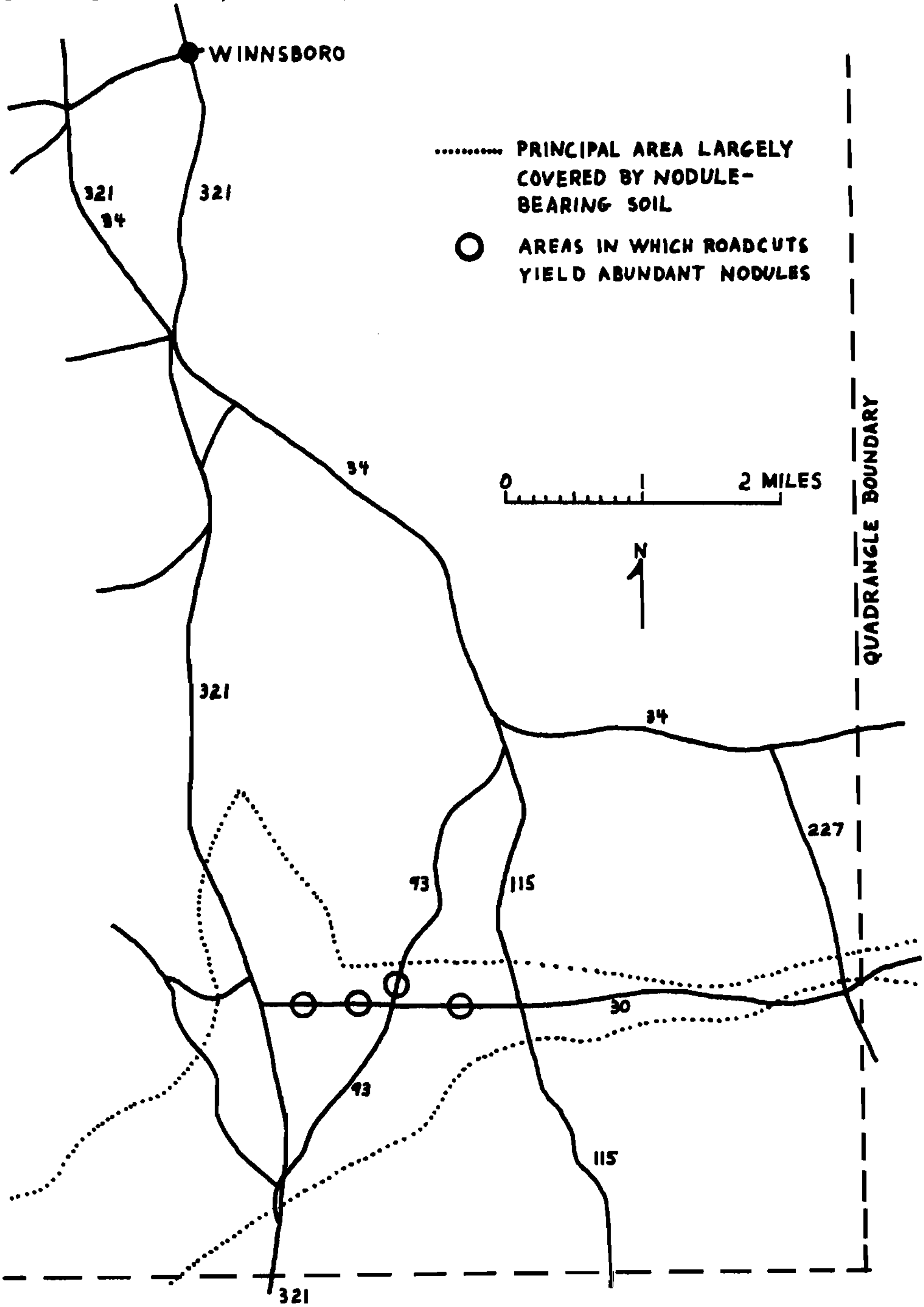

FIGURE 1. AREA OF IRON–MANGANESE NODULES IN SOILS, WINNSBORO 15' QUADRANGLE, SOUTH CAROLINA.

from a mixture of hydrous iron and manganese oxides. The presence of manganese was inferred from the appearance of the nodules and the heavy manganese oxide stains on joint planes in some of the basic rocks. Arcing of powdered nodules in a direct reading spectroscope produced strong manganese lines. Some smaller nodules and a small percentage of nodule powder are attracted to a hand magnet. The actual percentage of manganese is probably not large. Similar nodules from elsewhere in the Piedmont have been analysed chemically and were found to contain largely iron oxides (Henry Bell, personal communication, 1966).

ORIGIN

The nodules are secondary. Their occurrence as partial encrustations on partly rounded cobbles and their association with hydrous iron oxides precipitated in the B soil horizon preclude a hydrothermal origin. The inclusion of quartz sand grains, as in the reniform nodules, would be expected as a result of precipitation of the iron and manganese oxide compounds in sandy soil.

The idea that the nodules may have formed in an earlier, perhaps warmer Pleistocene climatic cycle was expressed by Henry Johnson (personal communication, 1966). It is also possible that these compounds are being precipitated in the rather warm climate of central South Carolina at present. I think it proper to refer to the nodule-bearing soils as lateritic, whether they formed in an earlier more tropical climate or in the recent temperate climate.