Region J Geology:

A Guide For North Carolina Mineral Resource Development And Land Use Planning

by
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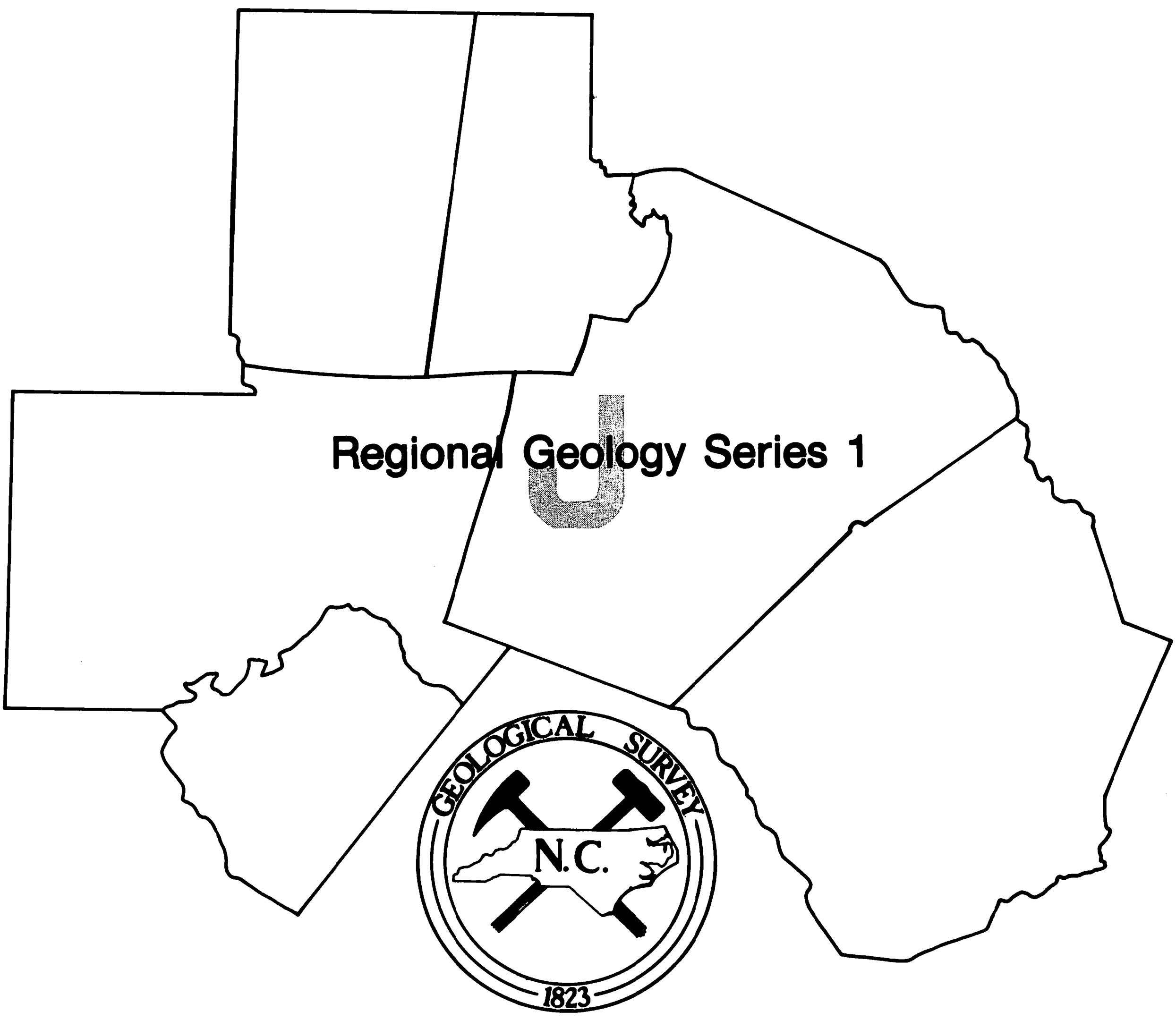

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REGION J GEOLOGY: A GUIDE FOR NORTH CAROLINA MINERAL RESOURCE DEVELOPMENT AND LAND USE PLANNING

BY

William F. Wilson and P. Albert Carpenter, III

ABSTRACT

Region J, located in the eastern Piedmont and extending into the southeastern Coastal Plain, includes Durham, Orange, Wake, Johnston, Chatham, and Lee counties. The region covers an area of 3,314 square miles, is predominantly urban, and has a population in excess of 671,405 people. This area contains a variety of rock types which can collectively be divided into three distinct groups. These are metamorphic and intrusive rocks of the Piedmont, sedimentary and intrusive rocks of the Triassic basin, and marine and nonmarine sediments of the Coastal Plain. Intrusive into the Piedmont rocks are igneous plutons of varying sizes and compositions. Triassic diabase dikes not only intrude Piedmont rocks, they, along with diabase sills, intrude sedimentary rocks of Triassic age.

Basic technical data are presented on Region J's geology, mineral resources, soils, ground water, and topography. This information can be used as a guide in making practical decisions on mineral resource evaluation and as an aid in making practical and workable decisions on land use planning. A geologic map provides much of the basic data upon which land use planning and management decisions should be made.

The assimilation of data in the Regional Geology series is provided for these reasons. This information represents the expertise of many technical people from different but interrelated fields correlated to help insure the wisest use of our land and our resources.

The basic information provided in this text should be used as a supplement to other information acquired on this Region to insure a broad and direct application to human needs. Without wise and careful use of all the knowledge available within an area, we may become victims of critical mineral resource shortages and ill-advised growth.

NORTH CAROLINA MULTI-COUNTY PLANNING REGIONS

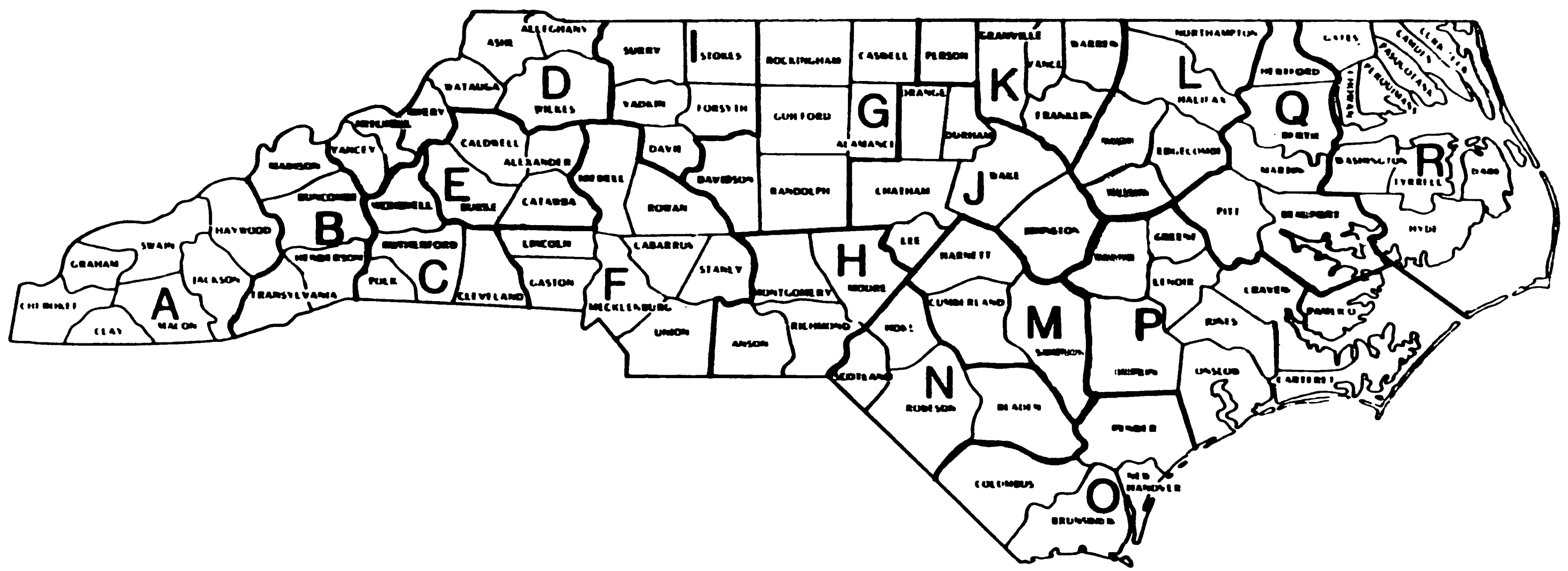

Figure 1: Index map showing location of Region J, North Carolina

INTRODUCTION

On May 7, 1970, Governor Robert W. Scott signed an Executive Order designating a system of seventeen multi-county planning regions for North Carolina. These planning regions were established so that local, State, and Federal planning and development activities could be better coordinated and better provide the needs of the citizens. The boundaries of the multi-county regions were based upon the following factors:

1) The economic and social inter-relationships between urban centers and the surrounding areas,
2) Existing cooperative programs among counties and municipalities,
3) At least three counties should be in each region,
4) A population base of at least 100,000 people in each region, and
5) The existence of mountain ranges or rivers that might separate one region from another.

Six counties in eastern Piedmont North Carolina were grouped together to form Region J. The region occupies 3,314 square miles and includes Chatham, Durham, Johnston, Lee, Orange, and Wake counties. The population of the region in 1980 was 671,405 with approximately 58 percent of this total incorporated and 42 percent unincorporated. Manufacturing and non-manufacturing jobs including government, services, and trades employed 313,810 people, agriculture employed 9,490 and 332 were employed in mining. Major cities and towns include Raleigh, Durham, Chapel Hill, Sanford, Siler City, and Smithfield.

Region J is the home of the State Government complex in Raleigh and is also the home of three major universities and various colleges and other institutions of higher learning. The major universities are the University of North Carolina at Chapel Hill, North Carolina State University at Raleigh, and Duke University located in Durham. These three universities form what is referred to as the Research Triangle.

Located in the center of the Research Triangle is the Research Triangle Park, a 5,400-acre tract established to house industrial and governmental research and development facilities. The Research Triangle and Research Triangle Park provide a unique opportunity for research in a wide range of fields and are two of North Carolina's most valuable assets. Current research programs include research on instrumentation for space probes, analysis of deep earth tremors, studies on atmospheric chemistry, marine geology, textile fibers, and pharmacology. Corporations with research facilities in the Triangle Park include Beaunit, Chemstrand, U.S. Environmental Protection Agency for the southeastern United States, Northern Telecom, Hercules, Burroughs Wellcome Co., and the National Humanities Center.

The presence of the State Government complex, the university system, and the Research Triangle Park gives the people of Region J the potential to provide a variety of services to other scientific, agricultural, business, educational, and governmental communities in the State. The Region J community has the capacity to lead other communities and be the forerunner in many areas, such as local and regional land use planning.

PURPOSE

In January 1973, the Mineral Resources Section of the Department of Natural and Economic Resources began a program aimed at completing a series of geologic maps for each of North Carolina's seventeen Multi-County Planning Regions. These maps are being compiled at a scale of 1 inch equals 4 miles. At this scale, maps can be completed in a short period of time and will provide a suitable base for planning on a regional scale. Region J was chosen as the pilot region for the project because of the availability of detailed geologic mapping in the region and because the field time involved would not be as great as in mapping a region more distant from Raleigh. Also, the local and regional planning agencies were already involved in programs which required geologic information.

This report contains the results of geologic and mineral resource studies in Region J and is written for use as an aid to regional land use planning. It is hoped that the information will acquaint planners, and others, with the value of basic geologic, hydrologic, soils, and engineering information and will help to demonstrate how the data can be used effectively. Although the map scales in this publication are not suitable for obtaining detailed, on-site information, they do provide a general picture of the problems that might be encountered in the region, and they indicate areas where more detailed studies may be needed.

ACKNOWLEDGMENTS

Many individuals and agencies cooperated in furnishing the data used in this publication. The geologic map is a compilation of the most detailed work available in Region J and includes the geologic mapping of ten geologists. Each geologist is acknowledged in the index on the geologic map.

Eldon P. Allen of the Mineral Resources Section compiled information on the clay and shale sample locations, and Pete H. Evans of the Mining Section compiled the information on the mine locations in Region J.

Soil information was furnished by W. W. Stevens of the Division of Resource Planning and Evaluation and by the U. S. Department of Agriculture, Soil Conservation Service. Appreciation is expressed to J. W. Cawthorn, of the Soil Conservation Service, for his cooperation in the project. W. D. Bingham, H. F. Koch, and J. S. Britt of the North Carolina Department of Transportation and Highway Safety, Division of Highway, furnished information concerning the engineering characteristics of rock groups.

GENERAL GEOLOGY

Multi-county Planning Region J is located in a complex geologic setting which is further complicated by the deep weathering of most of the rock types. The rocks are difficult to study because of the lack of outcrops, and in many places where rocks are exposed, fresh samples are difficult to obtain.

The geologic map (Plate 1) indicates the surface distribution of the various rock types in Region J. Each lithologic unit represented on the map indicates the major rock type occurring in that unit. The composition, texture, and structure of the major rock type may vary within the unit and other similar rock types are usually present, but in minor amounts. The geologic map can be used to locate and identify rocks that most likely will be encountered in an area and can be used to determine problems that are most likely to arise during land use planning. The geologic map cannot be substituted for on-site investigations when knowledge is required for a specific use of a small land area.

Geologic units in Region J can be arranged into three main rock types based upon their location within the region. These groups are Piedmont rocks, Triassic rocks, and Coastal Plain rocks. Included in these groups are igneous, metamorphic, and sedimentary rock types of differing compositions, textures, ages, and areal distributions.

Coastal Plain Rocks

Marine sediments of uncertain age and alluvial terraces of Quaternary to Recent age blanket the greater part of Johnston County and extend into the southeastern corners of Wake and Chatham counties in Region J.

The marine sediments are predominantly buff-colored, unconsolidated surfical sands interlayered with clays and, in places, gravel beds which contain a predominance of well-sorted and well-rounded quartz pebbles. Some brown- to red-colored, limonite-cemented quartzitic sediments occur as resistant ridges within the thick marine sediments.

Along the irregular Piedmont-Coastal Plain boundary, the marine sediments form only a thin veneer 2 to 4 feet thick, but then thicken rapidly in a southerly direction. In the extreme southern part of Johnston County they are 60 to 90 feet thick.

Non-marine buff- to gray-colored alluvial sands, clays, and gravels of Recent age form undulating terraces of various sizes near the major drainages systems, especially along the Neuse River. Interlayered sands and clays with some gravel beds are found in the floodplains of the major streams which dissect the area.

Floodplain alluvium: The floodplains include those areas that are subject to frequent flooding. Floodplains in the crystalline rocks are relatively narrow. Floodplains broaden in areas underlain by Triassic sedimentary rocks and become more extensive to the southeast as the drainage dissects the Coastal Plain sediments. This broadening of the floodplains in the Coastal Plain sediments occurs in response to changes in gradient and topography of the area. They also indicate the susceptability to frequent flooding from rapid runoff of waters from the upland Piedmont and the inability of the unconsolidated surficial sands and clays to contain the erosional effects of excessive volumes of water.

Floodplain alluvium consists of unconsolidated sediment of variable thickness. The material is primarily dark-brown to gray silt, sand, and clay with some gravels and coarse boulders occasionally intermixed.

Coastal Plain sediments: The Coastal Plain sediments consist primarily of unconsolidated sands, clays, silts, and interbedded sandy gravels. At the surface, the sediments comprise a generally unconsolidated residual mantle of very light-gray or yellowish-gray sandy loam or sand. Locally, the unit may contain beds cemented by limonite. The clay strata, occurring in various shades of yellow, brown, or orange, are composed of white plastic kaolinite, scattered angular quartz grains, and mica. The sands are fine- to coarse-grained, light-gray or yellowish-gray and consist of angular to subrounded quartz grains with mica, feldspar, and occasional heavy minerals. A kaolinitic clay matrix binds the sand grains together.

Gravels: Gravels are scattered throughout the Coastal Plain sediments but are also concentrated at a few locations along major streams, particularly in the Deep River region of Lee and Chatham Counties. Gravels in the Coastal Plain sediments consist of white, gray, red, brown, or purple quartz and quartzite pebbles and cobbles. The pebbles and cobbles, usually well-rounded, occur in a matrix of coarse, angular to subrounded quartz grains, and brown, orange, or pink limonitic clay.

Limonitic sediments: Locally, beds within the Coastal Plain sediments are firmly cemented by limonite. Generally, these beds are only a few inches thick, but the beds in one deposit, located on the geologic map, are several feet thick in places. The unit consists primarily of limonite containing scattered angular to subangular quartz grains.

Triassic Basin Rocks

Sedimentary rocks of the Durham and Deep River Triassic basins occur in long, narrow, north- to northeast-trending "half-grabens". These sediments commonly dip gently to the east or southeast and are up to 10,000 feet thick. The basins occupy an area 5 to 20 miles wide and are bounded to the east by the Jonesboro fault and to the west by metamorphosed volcanic and sedimentary rocks of the slate belt. Numerous northwest-trending faults crosscut the sediments, particularly in Lee County. These faults developed during late Triassic or early Jurassic time.

The Triassic sediments are divided into three formations; from oldest to youngest, they are: the Sanford Formation, the Cumnock Formation, and the Pekin Formation. These formations consist of claystone, siltstone, shale, sandstone, conglomerate, and fanglomerate. Intrusive into the sediments are diabase dikes, which occur throughout the basin, and diabase sills, which are abundant in the Durham area.

Floodplain alluvium: The floodplains include those areas that are subject to frequent flooding. Floodplains in the crystalline rocks are predominantly narrow. Floodplains broaden in areas underlain by Triassic sedimentary rocks and become more extensive to the southeast as the drainage dissects sediments of the Coastal Plain.

Floodplain alluvium consists of unconsolidated sediment of varying thickness. The material is primarily dark-brown to gray silt, sand, and clay with some gravels and coarse boulders occasionally intermixed.

Gravels: The terrace deposits in the Deep River region include deposits of clay, sand, and gravel. These units consist dominantly of friable silty or sandy clay and subordinate amounts of sand and gravel. Pebbles and cobbles in the gravel consist of white or gray quartz and occasionally of pre-Triassic metamorphic rocks and Triassic rocks. The gravels constitute a small part of the terraces but residual accumulations of sandy gravel are present where the terrace materials have been extensively eroded.

Sanford Formation fanglomerate: The fanglomerate ranges from jumbled accumulations of angular and subangular rock fragments with little sandstone matrix to scattered, isolated blocks embedded in a predominantly sandstone matrix. The fanglomerate usually shows little or no bedding. Fragments of all the pre-Triassic metamorphic and igneous rock types exposed southeast of the Triassic basin occur in the fanglomerate. Adjacent to the Jonesboro fault, fragments up to 8 feet in width occur, but, generally, in a northwest direction they become finer grained and more regularly bedded. The unit contains lenticular beds of relatively fragment-free sandstone and siltstone and local beds of conglomerate.

Sanford Formation: The Sanford Formation is variable in composition. It contains few distinctive beds and no subdivisions that can be traced for any distance. The lower two-thirds of the formation consists of lenticular beds of red or brown claystone, siltstone, and sandstone, with occasional interlayering of beds of arkosic sandstone. The siltstones and claystones are mixtures of quartz, clay minerals, sericite, chlorite, and iron oxides. Sandstones consist primarily of quartz and feldspar and contain a few rock fragments. Coarse-grained sandstones and conglomerates are also present. The upper one-third of the formation is the fanglomerate unit.

Cumnock Formation: The Cumnock Formation consists of claystone, siltstone, shale, and sandstone and contains two coal beds; the Cumnock bed and the Gulf bed. These coal beds, approximately 200 to 260 feet above the base of the formation, are underlain by light-gray, medium-dark-gray, and dark-greenish-gray siltstone and fine-grained sandstone that contain small amounts of claystone and shale. The coal beds are overlain by medium-light-gray to black shale with small amounts of claystone, siltstone, and sandstone. The shale is irregularly calcareous and carbonaceous.

The claystones and siltstones are mixtures of quartz, clay minerals, sericite, chlorite, and iron oxides. The sandstones are primarily quartz and feldspar with rock fragments. They are normally unconsolidated but, locally, cemented by calcite and silica.

Pekin Formation: The Pekin Formation is stratigraphically the lowermost of the three Triassic formations. The unit consists of yellowish-gray or grayish orange, medium- or coarse-grained, crossbedded arkosic sandstone; red, brown, or purple, fine- and medium-grained, crossbedded sandstone; and lenticular beds of red, brown, or purple claystone, siltstone, and fine-grained sandstone. The siltstones and claystones are composed of quartz, clay minerals, sericite, chlorite, and iron oxides. The sandstones are primarily quartz and feldspar, contain rock fragments, and are normally friable but locally are cemented by calcite or silica.

Pekin Formation basal conglomerate: The basal conglomerate consists of a heterogeneous assemblage of cemented and uncemented masses of conglomerate containing local lenses of conglomerate and coarse-grained sandstone. Grain size, composition, color, and thickness of the unit changes abruptly. The conglomerate contains angular to subrounded to rounded pebbles, cobbles and boulders of volcanic and igneous rocks and quartz, usually in a sandstone matrix. One portion of the unit, called "millstone grit," is a firmly cemented quartz conglomerate composed of subangular or subrounded, gray, pink or colorless quartz pebbles and less abundant fragments of tuff embedded in a silica-cemented, dark-yellowish sandstone matrix.

Diabase dikes and sills: Diabase dikes of Triassic age intrude sedimentary rock sequences throughout the Durham basin. The diabase sills are restricted to Triassic sedimentary sequences in Durham County. The dikes exhibit a high degree of spheroidal weathering, and some can be traced overland by the presence of spheroidal boulders. Diabase sills are recognized in somewhat the same manner with the exception that their outcrop patterns are much more extensive. Size, length, and thickness of the dikes and sills is varied, and many are discontinuous along the surface.

The unweathered rocks are black, medium to fine-grained and are composed of labradorite feldspar, augite, olivine, magnetite, and some secondary chlorite, clay, and limonite.

Weathering produces a brown to dark-brown soil with residual boulders which are easily traceable where exposed on the surface.

Piedmont Rocks

The Piedmont rocks of Region J vary widely in their types, compositions, ages, and areal distribution (Plate 1). Low-rank metamorphic rocks of a predominantly volcanic-sedimentary origin, intruded by igneous rocks of various compositions and ages, form a broad northeast-trending interlayered rock sequence. This rock sequence extends from the extreme southwestern corner of Chatham County through Orange County into the northern half of Durham County. This rock sequence is but a small part of a complex belt of rocks that extends for a length of approximately four hundred miles from central Georgia to southeastern Virginia. In North Carolina, this sequence of rocks is known as the Carolina slate belt.

The rocks located just east of the Jonesboro fault in Wake County are a complex interlayered and interfingered sequence of high- and low-grade metamorphic rocks oriented in a northeast-trending belt known locally as the Raleigh belt. These rocks were originally a volcanic-sedimentary sequence that varied greatly in their types, compositions and areal distribution. Included in this sequence are phyllites, metatuffs, flow rocks, and mafic and felsic gneisses and schists. Within this interlayered sequence are a series of altered ultramafic rocks that are located in the northern part of the county.

This rock sequence reflects several episodes of deformation during which igneous intrusions of various compositions, sizes and ages were emplaced. The most extensive intrusion is a granitic pluton, the Rolesville batholith, that crops out in northwestern Johnston County and covers a large area in eastern Wake County. The metamorphic sequence is also dissected by pegmatite dikes and numerous diabase dikes of various lengths and widths.

Younger alluvial and marine sediments, many of which form terraces of different widths and elevations, occupy much of Johnston County and southern and extreme eastern Wake County.

Floodplain alluvium: The floodplains include those areas that are subject to frequent flooding. Floodplains in the crystalline rocks are predominantly narrow, because of steep gradients, resistant rock types and rolling topography. Floodplains broaden in areas underlain by Triassic sedimentary rocks and become more extensive to the southeast as the drainage dissects sediments of the Coastal Plain.

Floodplain alluvium consists of unconsolidated sediment of variable thickness. The material consists primarily of dark-brown to gray silt, sand and clay with some gravels and coarse boulders occasionally intermixed.

Argillites: The light- to medium-gray to brown, fine-grained argillites are epiclastic rocks with well-developed bedding, some of which is closely spaced, imparting a laminated appearance. These argillites are composed predominantly of quartz, chlorite, and sericite. Cleavage is both bedding plane and slaty with the latter being more prevalent. Sections or slabs ¼-inch thick can easily be cleaved from this rock type. The laminated bedding indicates quiet-water deposition below wavebase. The argillites were apparently derived from positive areas of pre-existing volcanic flows and pyroclastic rocks which were then weathered, eroded, transported, and deposited in a quiet-water environment.

In outcrop, the laminated argillites weather to a light-gray to buff-brown color. The cleavage and foliation planes accelerate the weathering processes which causes the argillites to form broad areas of slightly undulating topography.

Arkoses: The arkoses are fine- to medium-grained, light-gray- to buff-colored epiclastic rocks containing feldspar and quartz. The arkoses occur as lens-shaped rock units interbedded with argillites and can be traced for only short distances.

In outcrop, they weather to a light-gray or buff color. Weathering of these epiclastic rocks occurs at a more rapid rate than in other rock types, because of the high percentage of feldspar present. Because of the scarcity of this rock type, it exerts no appreciable affect on the general topography.

Novaculites: The novaculite is dense, cryptocrystalline, highly siliceous, light- to medium-greenish-gray rock exhibiting a well-developed conchoidal fracture. The rock type is essentially a bedded cherty-type silica precipitate that occurs within the volcaniclastic-epiclastic rock sequence.

In outcrop, the novaculite weathers to an orange-brown to tan color. Novaculite, because of its dense siliceous composition, is highly resistant to weathering and forms small discontinuous ridges within the epiclastic rocks.

Graywackes: The graywackes are light- to medium-greenish-gray, medium- to coarse-grained epiclastic rocks. They are strikingly similar to the matrix of the wacke conglomerates, and have a speckled appearance because of the abundance of darker gray lithic particles and white- to buff-crystal particles disseminated throughout the matrix. The rock is composed of subround to rounded quartz and feldspar and rounded lithic fragments of pre-existing volcanic flows and pyroclastic rock types. The matrix is highly chloritized and a well-developed foliation occurs within this rock type.

In outcrop, the graywackes weather from a reddish-brown to a light-grayish-green color. They form discontinuous resistant northeast-trending ridges within the epiclastic sequence.

Wacke conglomerate: Medium- to coarse-grained, medium- to dark-greenish-gray wacke conglomerate exhibits a sequence of well-defined beds of graywackes and conglomerates with a graywacke matrix. These volcaniclastic-epiclastic rocks are composed of detrital fragments of pre-existing volcanic rocks, both flows and pyroclastics, that have been subaqueously deposited through the natural processes of weathering, erosion, transportation, and deposition. This volcaniclastic sequence contains well-rounded fragments of tuff, rhyolite, andesite, etc., that occur in a graywacke matrix. Bedding and cleavage are well developed. In some places the cleavage is bedding plane and in others it is slaty.

In outcrop, the conglomerate is light- to medium-greenish-gray in color and exhibits a knobby surface texture. These conglomerates usually form long linear discontinuous ridges that strike in a northeasterly direction.

Rhyolite flow rocks: Dense, cryptocrystalline, medium- to light-gray porphyritic to spherulitic rhyolite flow rocks exhibit a well-developed flow structure and a prominent conchoidal fracture. The porphyritic rhyolites contain euhedral laths of feldspar and crystals of quartz disseminated in a dark- to medium-gray cryptocrystalline groundmass. The spherulitic flows exhibit a contorted flow structure that can be traced around the spherulitic structures in the cryptocrystalline groundmass.

In outcrop, flow banding is quite apparent on light-gray weathered surfaces. These flow lines form a series of tiny, parallel ridges.

Because of the extremely high silica content, the rhyolitic flows are highly resistant to weathering and usually cap hills and ridges in the surrounding terrain.

Rhyolite tuffs: Dense, cryptocrystalline, light- to medium-gray aphanitic rhyolite tuffs exhibit a well-developed conchoidal fracture. The high-silica content, relic bedding, and cryptocrystalline character suggests that this rock type may have a fumerolic origin and may be classified as a metasiliceous sinter.

The rhyolitic tuffs form small lens-shaped ridges that are discontinuous in their outcrop pattern. The fact that the lens-shaped bodies could only be traced for short distances tends to indicate that the source area was in close proximity to the present rock location.

Felsic tuffs: The fine-grained, dense, medium- to light-gray to greenish-gray felsic tuffs have a subconchoidal to conchoidal fracture. Most outcrops exhibit a well-developed vertical to steeply dipping cleavage which parallels the foliation and accelerates the weathering processes. The felsic tuffs weather to a light-gray to buff color. However, when sheared, the tuffs sometime weather to an almost white color, presumably because of the high percentage of sericite present in the sheared rock.

Most felsic tuffs, by themselves, are not ridge formers but instead form a somewhat low undulating topography. The fold axes in this rock type are aligned parallel to one another and strike in a northeasterly direction.

Felsic crystal tuffs: The felsic crystal tuffs are dense, medium-grained pyroclastic rocks exhibiting subconchoidal to conchoidal fracture. The dark- to medium-gray aphanitic matrix contains subhedral to euhedral feldspar crystals most of which are partially replaced by epidote. Other minerals present include quartz, sericite, and iron minerals.

In outcrop, the tuffs weather to a medium-red to light-greenish-gray color. Many of these tuffs are welded and were once vitric (glassy) in texture. However, most of the vitroclastic texture has been destroyed by subsequent metamorphism. Some relic glass shards can be observed in thin section.

These tuffs, because of their high-silica content and dense matrix, form elongated northeast-trending discontinuous ridges that are elevated above the surrounding countryside.

Felsic crystal-lithic tuffs: The felsic crystal-lithic tuffs are dense, fine-grained pyroclastic rocks exhibiting a subconchoidal to conchoidal fracture. The tuffs are mottled to speckled in appearance because of the presence of light-gray to white euhedral feldspar crystal clasts and multicolored and multishaped lithic clasts disseminated within the uniform, dense, greenish-gray matrix.

In outcrop, these tuffs weather to a light- to medium-greenish-gray color. The clastic texture is obvious in hand specimen but is most pronounced on weathered outcrops which causes a knobby appearance on the weathered surface. Many of these tuffs appear welded which would indicate that deposition occurred at or above the temperature at which welding occurs.

Some outcrops exhibit deformed clasts that have been elongated in the plane of foliation and cleavage. The elongation probably occurred during periods of regional deformation and metamorphism.

The tuffs, because of their dense, siliceous matrix and lithic character form elongated northeast-trending discontinuous ridges that are elevated above the surrounding terrain.

Andesitic crystal tuffs: The dense, fine-grained, medium- to dark-grayish-green andesitic crystal tuffs exhibit a subconchoidal fracture and consist of epidotized plagioclase feldspar crystals, chlorite, actinolite, and magnetite in a dark-grayish-green groundmass.

In outcrop, the tuffs weather to a deep-red color and form linear discontinuous northeast-trending ridges. In most outcrops, cleavage and foliation are well developed and parallel the regional northeast trend.

Andesitic crystal-lithic tuffs: The andesitic crystal-lithic tuffs are dense, fine-grained crystal-lithic pyroclastic rocks exhibiting a subconchoidal to conchoidal fracture. The epidotized plagioclase feldspar crystal clasts and the multicolored lithic clasts give the rock type a speckled appearance. These clasts are disseminated in a dark-grayish-green matrix which is composed predominantly of chlorite, epidote, and actinolite.

In outcrop, these tuffs present a knobby reddish-brown appearance. Because of the absence of graded bedding and the random orientation and sizes of the clasts, they are considered to have been deposited in a subaerial environment.

These tuffs, because of their dense matrix and lithic character, are highly resistant to weathering. They form discontinuous northeast-trending ridges that project themselves above the surrounding terrain and parallel the regional northeast strike.

Andesite flow rocks: Dense to very fine-grained, dark-grayish-green porphyritic andesite flow rocks consist of large euhedral laths of plagioclase feldspar disseminated within a dense dark-grayish-green matrix. Some of the andesite flow rocks exhibit concentrically arranged groupings of plagioclase feldspar crystals forming glomeroporphyries.

In outcrop, these flow rocks weather to a dark-reddish-brown or dark-grayish-green color. Because of the dense texture, the flow rocks form long linear northeast-trending ridges that project above the surrounding terrain.

Mafic tuffs: These tuffs include rocks which are andesitic to basaltic in composition and range in color from medium grayish green to dark green to black. Some are slightly porphyritic to aphanitic and exhibit subconchoidal to conchoidal fracture. Most are dense, fine grained, and have a well-developed cleavage. Faint bedding can be observed in some, whereas others show no apparent bedding. This suggests that some rocks were deposited in subaerial and others in subaqueous environments.

In outcrop, these tuffs weather from a dark-red to a dark-reddish-brown color. In general, the tuffs are not as weather resistant as the mafic flow rocks. Thus, they tend to form broad undulating northeast-trending ridges and valleys.

Basalt flow rocks: The basalt flow rocks are predominantly dense, fine-grained, massive, dark- to medium-grayish-green amygdaloidal to porphyritic flow rock. A few outcrops exhibit irregular subelliptical, loaflike and amoeboid pillow structures. Most basalt outcrops, however, are massive, have a hackly fracture and exhibit no apparent layering or cleavage. Weathering usually produces a medium-grayish-green sharkskin surface which tends to emphasize the flow lines and amygdules.

Cascades and waterfalls commonly occur where streams cross the basalts. In outcrop, the basalts form long linear northeast-trending resistant ridges that project above the surrounding terrain.

Sericite phyllites: The very fine-grained, medium- to light-greenish-gray deeply weathered sericite phyllites exhibit a distinct layering and are thinly laminated. The rocks exhibit a well-developed foliation and cleavage that commonly is parallel to layering but, in places, may cut across the layering or bedding at oblique angles. This rock type consists predominantly of quartz, sericite, and chlorite with minor feldspar, pyrite, and martite.

The sericite phyllite is deeply weathered and forms an undulating northeast-trending topography.

Phyllite, meta-arkose and greenstone: These rocks consist of metamorphosed volcanic rocks including flows and tuffs of intermediate to fairly mafic composition. Metasedimentary types include arkoses, partly conglomeratic, epidote-bearing siltstone, quartzite, ironstone, and sericite-chlorite phyllite. Bedding is commonly well developed; cleavage is poor to fair.

Hornblende gneisses: The hornblende gneiss rock type consists of medium- to coarse-grained, dark, massive hornblende amphibolite and foliated hornblende gneiss. Plagioclase (oligoclase) and quartz are present in various amounts, and biotite and epidote are common. The hornblende gneisses and amphibolites are generally conformable to adjacent rocks, but some small bodies are sharply discordant.

These rocks were derived from mafic tuffs and intrusives and possibly in part from siliceous dolostone.

Mica gneisses and schists: The mica gneisses and schists are medium–to coarse-grained, commonly with distinct layering and bedding foliation. They consist primarily of feldspar, quartz, muscovite, and biotite. Biotite is more common in the gneisses while muscovite is more common in the schists. Plagioclase (usually oligoclase) is the chief feldspar but microcline and orthoclase are also common. Garnet is especially prominent in the schists. Layers and narrow belts of hornblende gneiss are numerous.

The gneisses and schists were originally a thick sequence of sedimentary graywackes and related rock types, probably including tuffs and flow rocks of intermediate and mafic composition.

Felsic gneisses: The felsic gneisses are light-colored, medium-grained rocks characterized by high quartz and microcline content and a predominance of muscovite mica over biotite. Interlayered with the gneiss is garnet-mica schist and two persistent belts of graphitic schist. Three types of felsic gneiss are distinguishable, quartz "disk" gneiss, quartz "prism" gneiss, and lineated quartzitic gneiss. Kyanite occurs in the more easterly distributed schists.

The original source material of the gneisses were well sorted sandstones and shales and may have included carbonaceous silty mud.

Diabase dikes and sills: Diabase dikes of Triassic age intrude volcanic, intrusive, metamorphic, and Triassic rocks within the area. The diabase sills appear restricted to the sedimentary rocks of Triassic age. The dikes exhibit a high degree of spheriodal weathering and can sometimes be traced overland by the presence of multisized spheriodal boulders. Diabase sills are recognized in somewhat the same manner with the exception that their pattern of outcrop is much more extensive. Size, length, and thickness of the dikes and sills is variable. Many are discontinuous and form irregular patterns on the surface.

The unweathered dike and sill rocks are black, medium to fine grained and are composed of labradorite feldspar, augite, olivine, magnetite, and some secondary chlorite, clay, and limonite. Weathering produces a brown to dark-brown soil with residual boulders which are easily traceable where exposed on the surface.

Felsic and mafic igneous intrusive complexes: Intrusive rocks of the area consist of a series of coarse- to fine-grained, massive to well foliated to porphyritic, commonly well jointed igneous rocks. Intrustive bodies range in size from small lens-like bodies to large single plutons and to plutonic complexes of various mineralogical compositions.

Most of the small intrusive bodies are individual masses of one particular rock type and range in composition from granite, adamellite, granodiorite, tonalite, and diorite to gabbro. The larger intrusive bodies usually include combinations of several distinct individual rock types.

The mafic intrusive complexes consist primarily of diorite and gabbro. These rocks are composed of varying proportions of plagioclase feldspar and amphibole or pyroxene. The felsic intrusive complexes include granite, adamellite, granodiorite, quartz diorite, and tonalite. Primary minerals in the felsic rocks are quartz, plagioclase feldspar, potassium feldspar, and muscovite and biotite mica.

The mafic intrusive complexes normally weather to dark red to brown and form clayey soils; whereas the felsic complexes form light-colored, sandy soils.

Ultramafic intrusive rocks: The ultramafic rocks are primarily black to green soapstone, serpentinite, actinolite-chlorite rocks which consist chiefly of various combinations of talc, antigorite, chlorite, actinolite and carbonate, with small amounts of olivine, augite, enstatite, chromite, magnetite, and corundum.

Pegmatites: Pegmatites from a few feet to more than 50 feet thick, occur in the igneous complexes and in the gneiss and schist lithologic unit. Most are tabular and are approximately concordant with the steeply dipping layered gneiss and schist. They strike generally northward to northeastward, although a few strike about east-west. Some discordant, highly irregular pods are also present.

Grain size of the pegmatites varies with thickness, and the larger pegmatites contain some microcline feldspar and muscovite mica crystals over a foot thick. Most of these pegmatites are large. Some can be traced along strike for more than 2000 feet.

The pegmatites consist chiefly of microcline feldspar, perthitic microcline feldspar, quartz, and muscovite and biotite mica.

Injected gneisses and schists: These rocks consist of layered mica gneiss containing numerous sills and dikes of granite, pegmatite and aplite. Also present are light and dark biotite gneiss with interlayered biotite-garnet schist and minor hornblende gneiss. Injected material makes up as much as one-third of their thickness near the Rolesville igneous complex and decreases outward. Granite masses range up to 50 feet in thickness, contain numerous inclusions of gneiss, and have both sharp and gradational contacts. Pegmatites range from a few inches to about 25 feet in thickness, are both conformable and disconformable, and have sharp contacts. Aplites are only a few inches thick. Pegmatites and aplites cut across granite sills as well as gneissic layering.

MINERAL RESOURCES

General Statement

North Carolina is endowed with an abundance of rocks and minerals that are of vital economic importance to our sophisticated, highly industrialized society. Over seventy rock and mineral types are used in industrial and commercial processes, and as a result, mining has been an important factor in the State's industrial economy since Colonial times. Our mineral industry is a stabilizing factor in the ability of the state to compete and to supplement the mineral and raw rock materials needed to insure a healthy growth of our Nation's economy.

In 1980, North Carolina's total mineral production was valued at 361 million dollars and directly employed in excess of 5,000 persons. This places us 16th among the 50 states in nonfuel mineral production. At present, we produce no fossil fuels or geothermal energy.

North Carolina ranks first in the Nation in the production of lithium minerals, feldspar, scrap mica, and pyrophyllite; second in the production of olivine, crushed granite, and common clay; and third in the production of phosphate rock and crushed marble.

A sense of national urgency and public attention should be directed to the mineral situation because much of the U. S. economy is based on metallic and non-metallic minerals as well as energy resources. We should focus our attention to the fact that the Nation does not have an adequate, known domestic supply of all the minerals needed to just maintain our society for the foreseeable future. This fact is more meaningful when one considers that our domestic raw mineral and energy materials form the basis of our gross national product.

Because mineral and energy resources are finite commodities, mining must be done where economic deposits are found. Intense geologic mapping and mineral exploration must be done. The cost factor for this, by necessity, must increase. But any cost will be more than repaid with the discovery of new sources of minerals that will add to our decreasing domestic supplies. The popular misconception that a steady supply of minerals from the crust of the earth is simply a matter of favorable economics and technology has induced widespread public complacency. Neither technologic magic nor astronomical dollar value can make it possible to extract raw mineral and rock products from rocks in which they are not present.

Mineral Resources of Region J

Although Region J contains deposits of both metallic and nonmetallic minerals, only nonmetallic minerals are currently mined. In 1980, there were 23 companies operating 35 mines in the Region. Of these active mines, there were 9 crushed stone quarries, 12 clay and shale pits, 11 sand pits, 2 gravel (sandrock) pits, and 1 pyrophyllite mine. Crushed stone is annually the leading mineral commodity in the State and in Region J.

Crushed stone is mined from quarries in each county in the Region. A variety of rock types are quarried including granite, diorite, gneiss, diabase, felsic tuff and andesitic tuffs. Most of the production comes from granitic rocks within felsic igneous complexes. These complexes provide the greatest potential for future production and for the discovery of new sources of crushed stone.

Clay and shale, used in the manufacture of face bricks and tile products, are mined in Chatham, Durham, Lee, and Wake counties. All the production is from sedimentary rocks of the Durham and Deep River Triassic basins. These large sources of clay and shale help North Carolina remain the leading brick producer in the Nation, a position the State has held since 1962. A recent study of the clay resources indicates that additional clay sources for brick and tile may be available, both from the Triassic sedimentary rocks and from other rock types throughout Region J (Plate 1).

Sand and gravel is produced primarily from Coastal Plain sediments, floodplain alluvium and decomposed granitic rocks. Most of the sand and gravel is used for building purposes and paving and is mined in each county in the Region, with the exception of Durham County. The largest reserves are probably in eastern Wake County, where large areas are underlain by weathered felsic igneous rocks, and in Johnston County, where much of the county is underlain by Coastal Plain sediments. Coastal Plain sediments in eastern Lee County should also provide reserves.

The only known occurrences of pyrophyllite in Region J are near Hillsborough in Orange County. Pyrophyllite has been mined at this location since the mid-1950's and is now being mined by Piedmont Minerals Company. Pyrophyllite is primarily used in the refractory, ceramic and insecticide industries. No additional reserves of pyrophyllite are known to exist in Region J.

Nonmetallic minerals that were once mined in Region J include coal, graphite, mica and soapstone. Even though it is not now economically feasible to mine these deposits, one or more of the deposits may become mineable in the future, either because of improved market conditions, the discovery of larger reserves of the mineral, improved mining and recovery methods, or the discovery of new uses for the mineral.

Small deposits of metallic minerals, including chromite, copper, gold, iron, and manganese, occur in Region J, but little production has been realized from the deposits. Most of the occurrences have only been prospected, with the exception of iron which was mined primarily during the Revolutionary war. Large reserves of metallic minerals have not as yet been discovered in Region J, but by using modern exploration techniques, large deposits may be found in the future.

A recent study of the potential feldspar resources of North Carolina (Neal and others, 1973) located several bodies with concentrations of high potassium feldspar in Region J (Plate 1). These occurrences are primarily in pegmatites and felsic igneous rocks. Tests indicate sufficient percentages of recoverable K_2O, but total volumes of available feldspar will have to be determined. Several of the pegmatites are no longer mineable because of the encroachment of housing developments. A similar study concerning the use of mica schist as a source of scrap mica (Lewis and others, 1971) did not indicate potential source areas in Region J.

SOIL RELATIONSHIPS

General Statement

The composition of a soil is directly related to the rock types from which it was derived. Other factors influencing soil formation are climate, organisms, relief, and time. As rocks weather, some soils begin to form in place while some are transported by erosional agents to form alluvial floodplains, terraces, and alluvial fans that are common geomorphic features found in most drainage basins. Soils are classified on the basis of soil properties, such as texture, consistence, structure, thickness, drainage, and horizons. Relationships among large numbers of soils are shown by grouping soils into soil associations. Each association consists of one or more major soils and at least one minor soil. On this basis, the association is named for the major soils. Some soils may be included in more than one association. Nevertheless, the distribution pattern and use characteristics will vary between associations.

A general soils map used in conjunction with geology, topography, mineral resource data, and ground water information is a useful aid and guide to long range land use planning and land use management for present and future developments.

Soil Associations in Region J

Region J contains eleven soil associations, each with its own distinct content, physical characteristics, and areas of distribution (Plate 2). These factors control the suitability of each soil for use in agriculture, construction, forestry, sanitary facilities, water management, wildlife habitats, etc. Table 1 indicates the degree of limitation prevailing in each association for selected specific types of land use. This table provides general information and guidance for different types of land use on broad areas. For specific small land areas, detailed on-site soil investigations should be made.

The General Soils Map contains an explanatory legend with a brief description of each of the eleven soil associations. Information and guidance for the development of land uses not shown on the map and table can be obtained from the Soil Conservation Service, U. S. Department of Agriculture, Raleigh, North Carolina.

Table 1: SOIL INTERPRETATIONS — GENERAL SOIL MAP FOR REGION J, NORTH CAROLINA

Soil Associations	Potential For: Dwellings with Sewerage Systems	Potential For: Dwellings with Septic Tank Filter Fields	Potential For: Camp Sites
1. APPLING — CECIL	Good	Fair: MP	Good
2. GEORGEVILLE — HERNDON	Good	Fair: MP	Good
3. WHITE STORE — CREEDMOOR — MAYODAN	Poor: LS, SS	Poor: SP	Poor: SP, C
4. NORFOLK — WAGRAM	Good	Good	Good
5. LIGNUM — IREDELL — HERNDON	Poor: LS, SS	Poor: SP	Poor: SP, C
6. CHEWACLA — WEHADKEE — ROANOKE	Poor: F, W	Poor: F, W	Poor: F, W
7. HELENA — APPLING	Fair: LS, SS	Fair: SP	Fair: SP
8. APPLING — LOUISBURG	Good	Fair: MP	Good
9. LYNCHBURG — RAINS — NORFOLK	Poor: LS, W	Poor: W	Fair: W
10. GILEAD	Fair: SS	Poor: SP	Fair: SP
11. GEORGEVILLE-DAVIDSON-MECKLENBURG	Good	Fair: MP	Good

Good is the rating given soil associations that have soil properties for the rated use. The number of unfavorable properties are minor and can be overcome easily. Good performance and low maintenance can be expected.

Fair is the rating given soil associations that have a moderate number of unfavorable soil properties for the rated use. The unfavorable soil properties can be overcome or modified by special planning, design or maintenance. During some part of the year the performance of the structure or other planned use is somewhat less desirable than for soils rated *Good*.

Picnic Areas	Play Grounds	Small Commercial Buildings	Local Roads and Streets	General Agriculture	Woods
Good	Fair: S	Good	Fair: LS	Good	Good
Good	Fair: S	Good	Fair: LS	Good	Good
Good	Poor: S, SP	Poor: SS, LS	Poor: LS, SS	Fair: LP	Good
Good	Fair: S	Good	Good	Good	Good
Good	Poor: SP	Poor: SS, LS	Poor: LS, SS	Poor: LP	Fair: LP
Fair: F, W	Fair: F, W	Poor: F, W	Poor: F, W	Fair: LP	Good
Good	Fair: S, SP	Fair: SS, LS	Fair: LS, SS	Good	Good
Good	Fair: S, RO	Good	Fair: LS, R	Good	Good
Fair: W	Poor: W	Poor: LS, W	Poor: LS, W	Good	Good
Fair: S	Poor: S	Poor: S	Fair: S, SS	Fair: LP	Fair: LP
Good	Fair: S	Good	Fair: LS	Good	Good

Poor is the rating given soil associations with soil properties generally unfavorable for the rated use. The soils in these associations generally require major soil reclamation, special design, or intensive maintenance. Some of these soils, however, can be improved by reducing or removing the soil feature that limits use, but in most situations it is difficult and costly to alter the soil or to design a structure so as to compensate for these adverse soil properties.

Legend:
LS — Low Strength
SP — Slow percolation
SS — Shrink-swell
RO — Rock outcrops
R — Depth to Rock (Soil shallowness)
C — Too clayey

S — Slope
LP — Low productivity
F — Flooding
W — Wet
MP — Moderate percolation

GROUND WATER IN REGION J

General Statement

Water located in the saturated zone of the earth's crust and supplied by precipitation in the form of rain or snow is called ground water. Many differing factors control the amount of ground water available from any one location. The two most important factors are the amount of annual precipitation available for supply and recharge and the ability of the rocks and soils to absorb, store and transmit the precipitation. Other factors which have a direct effect on ground water supply are rainfall intensity, topography, climate and types and densities of vegetation cover within an area.

Porosity, which is the percentage of the bulk volume of a rock or soil that is occupied by intersticies, and permeability, which is the ability of rock and soil types to transmit ground water, varies from place to place (Tables 2-7). Secondary interstices, such as joints, cleavage, schistosity, and solution channels, are the most important features responsible for transporting water in crystalline rocks. Secondary features afford avenues controlling the amount and the movement of ground water within an area.

The soil type or types within the area have a direct relationship to the amount of precipitation absorbed into the ground water zone. Tightly compacted clays act as impermeable barriers accelerating the run-off of precipitation. Loose sandy loams and sandy clay loams can absorb the precipitation and transmit it to the aquifers.

In general, the ground water of the region is steadily moving under the influence of gravity from recharge areas to discharge areas. In this area, the ground-water table usually slopes toward the streams and rarely falls below their level. This affords a continuous discharge which maintains the flow of the streams during dry periods and adds to their flow during wet periods. This is also evident in springs and seeps which could be good sources of water provided no septic systems or farms are in the immediate vicinity.

TABLE 2: WAKE COUNTY WATER QUALITY

Rock Groups	Number Of Wells	Average Yield Gal./Min.	Average Depth (Feet)	Water Quality As $CaCO_3$ ppm (Number of Wells) Soft 0-60 ppm	Moderately Hard 61-120 ppm	Hard 120-180 ppm
Intrusive Rocks	77	20	137	Predominantly Soft		
Mica Gneisses and Schists	80	19	147	Predominantly Soft to Moderately Hard		
Metavolcanic Rocks	23	27	212	Soft to Moderately Hard		
Phyllite	11	14	183	Soft to Moderately Hard		
Triassic rocks (undifferentiated)	57	5	158	Moderately Hard to Hard		

TABLE 3: JOHNSTON COUNTY WATER QUALITY

Rock Groups	Number Of Wells	Average Yield Gal./Min.	Average Depth (Feet)	Water Quality As $CaCO_3$ ppm (Number of Wells) Soft 0-60 ppm	Moderately Hard 61-120 ppm	Hard 120-180 ppm
Intrusive Rocks	13	NA*	NA*	8	5	0
				Predominantly Soft to Moderately Hard		
Mica Gneisses and Schists	7	NA*	NA*	6	1	0
				Soft		
Metavolcanic Rocks (undifferentiated)	19	NA*	NA*	16	3	0
				Predominantly Soft		
Coastal Plain	18	NA*	NA*	13	5	0
				Predominantly Soft		

* Data not available

TABLE 4: DURHAM COUNTY WATER QUALITY

Rock Groups	Number Of Wells	Average Yield Gal./Min.	Average Depth (Feet)	Water Quality As $CaCO_3$ ppm (Number of Wells) Soft 0-60 ppm	Moderately Hard 61-120 ppm	Hard 120-180 ppm
Intrusive Rocks	5	4	90	3	1	1
					Predominantly Soft	
Triassic Rocks — (undifferentiated)	41	8	138	26	10	4
					Predominantly Soft to Moderately Hard	
Metavolcanic Rocks						
1. Felsic Rocks	7	12	NA*	5	2	0
					Predominantly Soft	
2. Mafic Rocks	4	NA*	NA*	3	1	0
					Predominantly Soft	
3. Andesite	1	NA*	NA*	1	0	0
					Soft	

TABLE 5: LEE COUNTY WATER QUALITY

Rock Groups	Number Of Wells	Average Yield Gal./Min.	Average Depth (Feet)	Water Quality As $CaCO_3$ ppm (Number of Wells) Soft 0-60 ppm	Moderately Hard 61-120 ppm	Hard 120-180 ppm
Triassic Rocks (undifferentiated)	31	8	108		NA*	
Metavolcanic Rocks (undifferentiated)	15	11	106		NA*	

* Data not available

TABLE 6: CHATHAM COUNTY WATER QUALITY

Rock Groups	Number Of Wells	Average Yield Gal./Min.	Average Depth (Feet)	Water Quality As $CaCO_3$ ppm (Number of Wells) Soft 0-60 ppm	Moderately Hard 61-120 ppm	Hard 120-180 ppm
Intrusive Rocks	23	8	68	14	6	3
					Predominantly Soft	
Metavolcanic Rocks						
1. Felsic Rocks	25	7	99	15	3	7
					Predominantly Soft	
2. Mafic Rocks	61	7	99	29	22	10
					Predominantly Soft to Moderately Hard	
3. Andesitic Rocks	18	7	100	16	2	0
					Predominantly Soft	
4. Argillite-Graywacke	17	5	123	11	4	2
					Predominantly Soft to Moderately Hard	
Triassic Rocks (Eastern Part of County)	47	7	98	22	20	5
					Predominantly Soft to Moderately Hard	
Triassic Rocks (Southern Part of County)	8	7	100	3	2	2
					Soft to Hard	

TABLE 7: ORANGE COUNTY WATER QUALITY

Rock Groups	Number Of Wells	Average Yield Gal./Min.	Average Depth (Feet)	Water Quality As $CaCO_3$ ppm (Number of Wells) Soft 0-60 ppm	Moderately Hard 61-120 ppm	Hard 120-180 ppm
Intrusive Rocks	21	12	77	12	3	3
					Predominantly Soft	
Metavolcanic Rocks						
1. Felsic Rocks	20	NA*	NA*	10	1	0
					Soft	
2. Mafic Rocks	20	NA*	NA*	17	3	0
					Predominantly Soft	
3. Andesitic Rocks	4	NA*	NA*	3	1	0
					Predominantly Soft	
4. Phyllite	2	NA*	NA*	2	0	0
					Soft	
5. Argillite	4	9	95	4	0	0
					Soft	

* Data not available

GEOLOGY AS A BASIC TOOL FOR LAND USE PLANNING

A geologic map is the foundation upon which all land use planning and land management decisions should be based. Geologic knowledge as a basic tool for land use planning has always been a necessity; many times, an overlooked necessity. The rapid increase in population and the transition of our structure from one of a predominantly agrarian society to one of complex interrelationships of manufacturing and technical services has over-taxed our resource evaluation and planning capacity. We find, therefore, that we have become the victims of virtually unplanned developments. Many times, the wants of a few have taken precedence over the needs of many.

It is now becoming apparent, that in order to supply the ever increasing demand on our non-renewable mineral resources, all future planning must include basic geologic data and must be accomplished so as to insure the protection of our active and potential mineral resource sites for present and future generations.

Because of the accelerated growth, much planning is done after development rather than during the conceptual planning period that preceeds development. Consequently, the hasty development of many urban communities has left us in the unfavorable situation of trying to provide the needed resources these expanding areas demand while unplanned growth patterns have seriously abused our land and have not made the fullest and most productive use of our natural and mineral resources.

In addition to providing the planners with the distribution of the geologic rock types and structure and the locations of inactive, active, and potential mineral resource sites, many solutions to land use planning and engineering problems, which arise with urbanization, can be solved through careful study of the information present on the geologic map. The following lists the types of information that can be obtained from a geologic map: (Plate 1, Tables 9 and 10)

A. Bedrock geology describing rock types and their distribution
B. Active, inactive, and potential mineral resource sites
C. Topography of the area showing unique topographic features
D. Drainage systems and basins
E. Floodplains
F. Flood prone areas
G. Terraces—alluvial and marine
H. Areas susceptible to extreme erosion
I. Landslide prone areas
J. Slope design for highway and industrial sites
K. Cut and fill sites
L. Surface and subsurface data on the design and construction of public and private industrial projects
M. Dam site locations
N. Fault and shear zones which may be of significance in the location of dams, industrial sites, etc.
O. Location of solid and liquid waste disposal sites
P. Water well location sites to supply ground water to areas without municipal facilities
Q. Green belt locations
R. Recreational sites (parks, etc.)
S. Future location sites for bicycle and other trails

This information will save valuable time and money as new areas are planned for and incorporated into the evergrowing urban framework.

The urban area that does not project its long-range planning program for its existing and its potential mineral resource sites will have to bear the consequences of either added financial burden of higher transportation costs from distant source areas or of higher cost substitutes which may be in limited supply. So, it is imperative that city and county land use planners should, for present and future use, acquire all available geological and mineral resource information on their area. This information is essential in order to make the most advantageous use possible of the strategically located supplies and deposits of raw rock and mineral resources within an area.

TABLE 8: DERIVATIVE GEOLOGIC MAP POSSIBILITIES

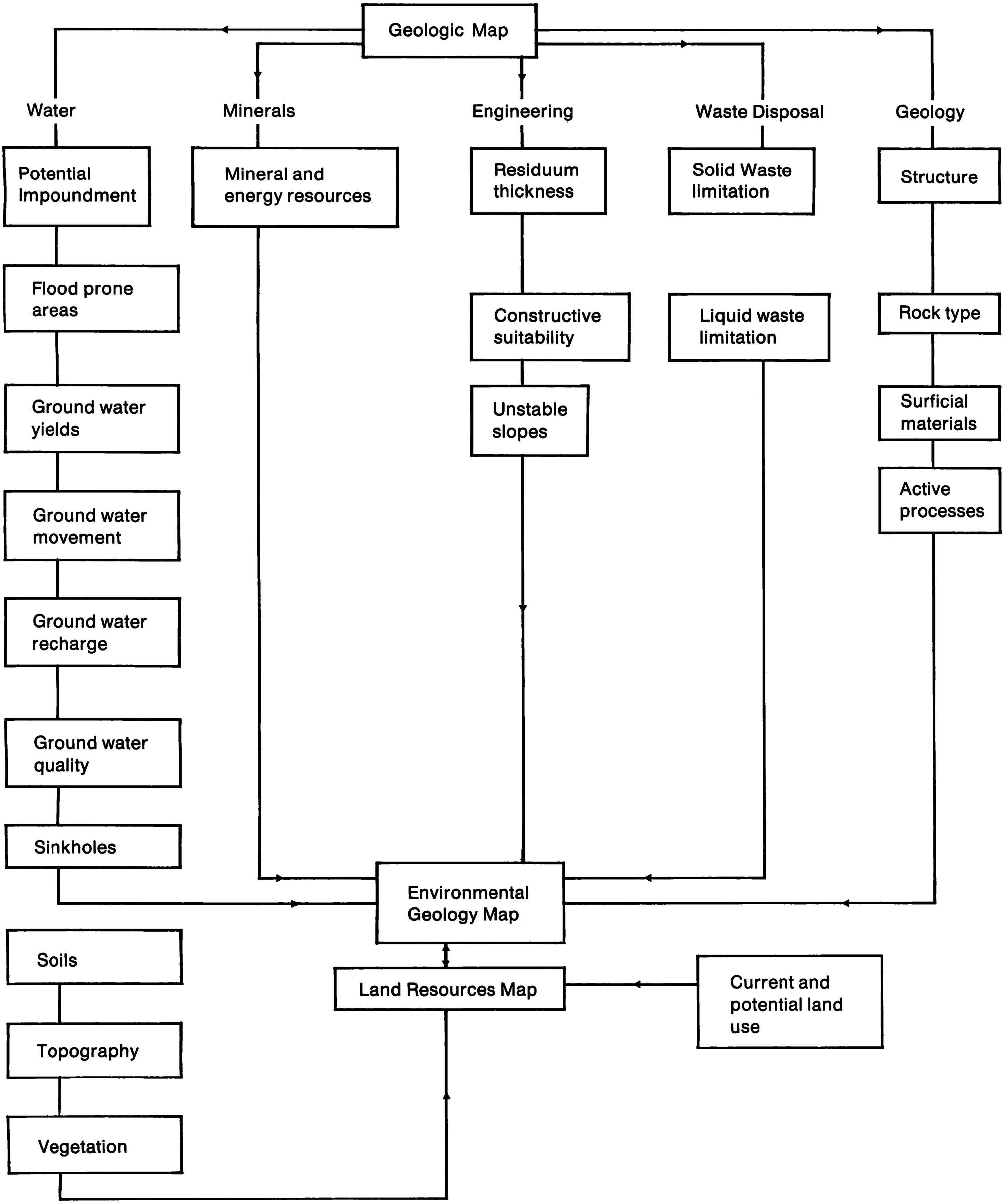

TABLE 9: GEOLOGIC MAP UNITS, CORRELATED WITH THEIR GENERAL ROCK TYPES, TOPOGRAPHY, AND USES IN REGION J

GEOLOGIC UNIT	ROCK UNIT	TOPOGRAPHY	USES
Floodplain Alluvium	Unconsolidated sands and clays	Narrow to broad lowlands	Construction sand; brick clay (selected locations) ceramic clay (selected loc.)
River terrace and Coastal Plain deposits	Unconsolidated clays, silt, sands and some gravels, often interlayered	Flat to moderately sloping divides; gentle to moderate slopes	Construction sand; decorative gravel (landscaping, etc.)
Coastal Plain sediments	Loose sand; some gravel terraces	Flat top divides and gentle to moderate slopes	Construction sand, decorative gravel (landscaping, etc.); ceramic clays (selected locations)
Triassic sediments	Red shales with interbedded sandstones, siltstones, and claystones	Low rolling hills, undulating	Brick and tile clay; ceramic clays (selected locations) lightweight aggregate (selected locations)
	Red to white consolidated gravels (conglomerate)	Gentle to steeply sloping hills and ridges	
Triassic dikes, sills and mafic igneous complexes	Dark colored massive crystalline rocks	Rounded hills; slightly to steeply sloping to broad lowlands	Construction — crushed stone (highway base aggregate)
Felsic igneous complexes	Light colored massive and granitic texture	Rolling dissected hills; slight to moderate slopes	Construction — crushed stone (highway base aggregate); concrete products
Flows, graywackes, lithic and crystal tuffs and conglomerates	Hard metamorphic rocks	Steep hills and rough stoney ground	Construction — crushed stone (highway base aggregate)
Argillite, tuffs, phyllites	Soft metamorphic rocks — exhibits laminations and banding	Rolling hills and lowlands	Construction — light-weight aggregate
Schists and schistose gneiss	Mica bearing metamorphic rocks — exhibits laminations and banding	Rolling dissected hills	Construction — crushed stone (highway base aggregate)

TABLE 10: PHYSICAL CHARACTERISTICS OF ROCK GROUPS

ROCK GROUPS	SOIL ASSOCIATIONS	NATURAL DRAINAGE	SUSCEPTABILITY ** TO EROSION	PERMEABILITY **	SHRINK — SWELL ** CHARACTERISTICS
Felsic and Mafic Gneisses and Schists. Granite Gneiss.	Appling — Cecil	Well	Moderate	Moderate	Slight
Felsic and Mafic Gneisses, Granite Porphyries and Pegmatites.	Appling — Louisburg	Well to Excessive	Moderate	Moderate to Rapid	Slight
Talc-Chlorite Schists, Soapstone, Serpentinite.	Helena — Appling	Well to Moderately Well	Moderate to Severe	Moderate to Slow	Slight
Felsic Flow Rocks, Pyroclastics and Epiclastics.	Georgeville — Herndon	Well	Moderate	Moderate to Slow	Slight
Mafic Volcanics, Andesitic to Basaltic Flow Rocks and Pyroclastics.	Tirzah (Davidson) Efland (Mecklenburg-Enon) Georgeville	Moderately Well to Well	Moderate to Severe	Slow to Moderate	Slight to Moderate
Intrusive rock, Diorites and Gabbros.	Lignum — Iredell Herndon	Well to Moderately Well	Moderate to Severe	Slow to Very Slow	Moderate to Severe
Triassic Rocks (undifferentiated)	White Store — Creedmoor Mayodan	Moderately Well	Severe to Very Severe	Slow to Very Slow	Moderate to Severe
Coastal Plain, Poorly Drained.	Lynchburg — Rains Norfolk	Well to Poor	Slight to Moderate	Moderate	Slight
Coastal Plain, High Marine Terraces.	Norfolk — Wagram	Well to Excessive	Slight to Moderate	Rapid to Very Rapid	Slight
Coastal Plain, Side Slopes and Lower Elevations of High Marine Terraces.	Gilead	Moderately Well to Somewhat Poor	Moderate	Moderately Slow	Moderate
Flood Plain Alluvium, Low Lying Terraces.	Chewacla — Wehadkee Roanoke	Somewhat Poor to Poor	Slight to Moderate	Moderate to Slow	Slight to Moderate

** These values are determined mainly by the soil's texture, structure and clay types.

PHYSICAL CHARACTERISTICS OF ROCK GROUPS—CONTINUED

SLOPE STABILITY * 0' to 15' (VERTICAL) MAXIMUM PERMANENT SLOPES NOT REQUIRING PERMANENT RETAINING STRUCTURES	DEPTH OF SOIL SOLUM (Inches)	AVERAGE THICKNESS OF SAPROLITIC BEDROCK (Feet)	DEPTH TO BEDROCK (Feet)	FOUNDATION REQUIREMENTS FOR HEAVY LOAD — BEARING STRUCTURES
1.5 to 1; over 15 ft. 2.5 to 1	18 in. to 40 in.	Variable	Surface to 100 ft. plus	1. Pilings 2. Deep Footings 15 ft. 3. Shallow Footings
1.5 to 1; over 15 ft. 2.5 to 1	12 in. to 40 in.	Variable	Surface to 100 ft. plus	1. Pilings 2. Deep Footings 15 ft. 3. Shallow Footings
1.5 to 1; over 15 ft. 2.5 to 1	14 in. to 36 in.	Variable	Surface to 100 ft. plus	1. Pilings 2. Deep Footings 15 ft. 3. Shallow Footings
1 to 1	18 in. to 40 in.	Variable	Surface to 100 ft. plus	1. Pilings 2. Deep Footings 15 ft. 3. Shallow Footings
1 to 1	18 in. to 40 in.	Variable	Surface to 100 ft. plus	1. Pilings 2. Deep Footings 15 ft. 3. Shallow Footings
1 to 1; over 15 ft. 2 to 1	14 in. to 40 in.	Variable	Surface to 50 ft.	1. Pilings 2. Deep Footings 15 ft. 3. Shallow Footings
3 to 1; Special Investigations over 15 ft. Individual design req.	18 in. to 36 in.	Variable	Variable	1. Shallow Footings 2. Deep Footings 15 ft. 3. Pilings
2 to 1; over 15 ft 3 to 1	30 in. to 42 in.	Variable	5 ft. to 100 ft.	1. Pilings 2. Shallow Footings
2 to 1; over 15 ft. 3 to 1	30 in. to 42 in.	Variable	Variable	1. Pilings 2. Shallow Footings
2 to 1; over 15 ft. 3 to 1	20 in. to 36 in.	Variable	Variable	1. Pilings 2. Shallow Footings
2 to 1; over 15 ft. 3 to 1	30 in. to 42 in.	Variable	Variable	1. Pilings 2. Shallow Footings

* 75 to 80% of information obtained from highway slope design. If excessive amounts of ground water occur, individual slope designs are required.

CONCLUSION

For intelligent resource management and land use planning, as much useful information as possible should be obtained before any decisions are made and any plans or programs initiated. The assimilation of data in the Regional Geology Series is provided to meet these needs. These data represent the expertise of many technical people, from different but related fields, correlated for the most basic reason of all—understanding. Without the basic knowledge and understanding of an area, sound resource management and land use planning cannot and should not be implemented.

In order to plan properly, the basic information provided in this Series should be used as a supplement to other information acquired for these purposes. Without wise and careful use of all the knowledge available, we become the victims of unplanned growth and of shortages of critical mineral resources, rather than the residents of well-planned communities.

Planned growth patterns primarily depend on the availability of suitable useable land and the mineral and natural resources for its development and continued support. Present and future land use planning and mineral resource evaluation and development depends upon our ability to work in close cooperation with one another and to use our combined knowledge to its wisest advantage. These facts are becoming more critical to us daily as we realize that we have the knowledge to plan land use but are beginning to lack many of the critical nonrenewable mineral resources needed to sustain our progress. This places the burden of responsibility upon us to help insure the wise conservation and expanded exploration of mineral and energy resources.

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APPENDIXES

MINE LOCATIONS
IN
REGION J

MINES LOCATED IN REGION J

ACTIVE MINES: NONMETALLICS

CHATHAM COUNTY

1. Boren Clay Products Company — Gulf Mine (Sh)
2. Martin Marietta Aggregates — Siler City Quarry (CS)
3. Pomona Pipe Products Co. — Gulf Mine (Sh)
4. Cherokee Brick Company — Brickhaven (Sh)
5. Sanford Brick Corporation — Chatham Brick & Tile Mine (Sh)

DURHAM COUNTY

1. Nello L. Teer Company — Durham Quarry (CS)
2. Triangle Brick Company — Durham Mine (Sh)
3. Borden Brick & Tile Co. — Stone Road Mine (Sh)
4. Borden Brick & Tile Co. — Cook Mine (Sh)

JOHNSTON COUNTY

1. Rea Construction Company — Bobbitt Sand Pit (S)
2. Nello L. Teer Company — Princeton II Quarry (CS)
3. Barrus Construction Company — Allen Pit (S)
4. S. T. Wooten Construction Co. — Allen Pit #2 (S)
5. S. T. Wooten Construction Co. — Stewart Pit (S)

LEE COUNTY

1. Martin Marietta Aggregates — Lemon Springs Quarry (CS)
2. Lee Paving Company — Wilkins Pit (S)
3. Hanford Brick Company — Colon Mine (Sh)
4. Lee Brick & Tile Company — Sanford Mine (Sh)
5. Sanford Brick Corporation — Sanford Brick Mine (Sh)
6. Borden Brick & Tile Company — Sanford Mine (Sh)
7. N. C. Beal and Sons — Beal Sand Pit #1 (S)
8. N. C. Beal and Sons — Beal Sand Pit #2 (S)
9. Wake Stone Corporation — Moncure Quarry (CS)
10. Hancock Sand Company — Hancock Sand Pit #3 (S)
11. Kelly Sand Company — Kelly Mine (S)
12. R G K, Incorporated — R G K Pit (S)

ORANGE COUNTY

1. Piedmont Minerals Company — Hillsborough Mine (Py)
2. American Stone Company — Chapel Hill Quarry (CS)
3. Mellott Trucking & Supply Co. — Mellott Gravel Pit (G)
4. Billy C. Merritt — Merritt Gravel Pit (G)

WAKE COUNTY

1. Martin Marietta Aggregates — Garner Quarry (CS)
2. Nello L. Teer Company — Raleigh Quarry (CS)
3. Nello L. Teer Company — Crabtree Quarry (CS)
4. Triangle Brick Company — Carpenter Mine (Sh)
5. Wake Stone Corporation — Knightdale Quarry (CS)

C — Coal
CS — Crushed stone
DS — Dimension stone
G — Gravel
K — Kyanite
Mu — Muscovite
Py — Pyrophyllite
S — Sand
SG — Sand and Gravel
Sh — Clay and Shale
So — Soapstone

INACTIVE MINES: NONMETALLICS

CHATHAM COUNTY

1. Material Sales Company — Moncure Quarry (CS)
2. Nello L. Teer Company — Goldston Quarry (CS)
3. State Highway Commission — Marie Culberson Pit (S)
4. Ceramic Minerals, Incorporated — Mashburn Mine (Sh)
5. Elmer O. Pendergraft — Gravel Pit (G)
6. Brooks Harris
Norfolk Southern Railroad Co. — Cumnock Mine (C)
Erskine Ramsey Coal Co.
7. Raleigh Mining Company — Carolina Mine (C)
Carolina Mining Company
8. American Stone Company — Pittsboro Quarry (CS)
9. D. R. Allen & Son, Inc. — New Hope Quarry (CS)
10. Dept. of Transportation — Lystra Pit (G)

DURHAM COUNTY

1. Borden Brick & Tile Company — Durham City Mine (Sh)
2. Nello L. Teer Company — Braggtown Quarry (CS)

JOHNSTON COUNTY

1. Crumpler Brick & Tile Company — Smithfield Mine (Sh)
2. Barrus Construction Company — L. Sugg Mine (S)
3. C. C. Mangum, Incorporated — Mangum Sand Pit (S)
4. Barrus Construction Company — Holt Pit (S)
5. State Highway Commission — Willie Batten Pit (S)
6. State Highway Commission — Worrels Pit (S)
7. U. S. Geological Survey — Corbett Prospect (K)
8. C. C. Mangum, Incorporated — Johnston County Pits 1 & 2 (S)
9. Nello L. Teer Company — Princeton Quarry (CS)
10. Rea Construction Company — Mary Taylor Sand Pit (S)
11. Dept. of Transportation — Cox's Mill Pit (S)
12. Dept. of Transportation — Piney Grove Pit (S)

LEE COUNTY

1. No specific locations designated — Clay pits
2. State Highway Commission — N. J. Womack Sand & Gravel Pit (S)
3. Department of Transporation — Pine Knoll Soil Pit (S)

ORANGE COUNTY

1. Superior Stone Company — Mebane Quarry (CS)
2. State Highway Commission — Bacon Quarry (CS)
3. Material Sales Company — Eno Quarry (CS)
4. Duke University — Duke Quarry (DS)

WAKE COUNTY

1. Triangle Brick Company — Holy Springs Mine (Sh)
2. Superior Stone Company — Knightdale Quarry (CS)
3. Superior Stone Company — Rolesville Quarry (CS)
4. Superior Stone Company — Wendell Quarry (CS)
5. Nello L. Teer Company — Gresham Lake Quarry (CS)
6. Vulcan Materials Company — Buckhorn Quarry (CS)
7. Annie L. Wilkerson — Wilkerson Quarry (DS)

WAKE COUNTY—continued

8.	State Highway Commission	— W. L. Choplin Pit (S)
9.	Matthews Granite Quarries Co.	— Knightdale Whitley Quarry (CS & DS)
10.	NA*	— Umstead Park, Sycamore Creek Quarry (CS)
11.	William M. Silver	— Kerney Mine (Mu)
12.	Robert L. Hammond & others	— Thompson Mine (Mu)
13.	NA*	— Lead Mine Creek Area (Gp)
14.	Capital Sand and Gravel Company	Capital Mine (G)

* Information not available

INACTIVE MINES & PROSPECTS: METALLICS

ORANGE COUNTY

1. Hill (Cu)
2. Bradsher (Au)
3. Womble (Au)
4. Stebbins (Cu)
5. Duke Forest (Au)
6. Weaver-Carr (Au)
7. Chapel Hill Iron (Fe)
8. Haw (Au)
9. North State (Au)
10. E. M. Stroud (Cu)

DURHAM COUNTY

WAKE COUNTY

1. Adam Mountain (Cr)
2. Privett prospect (Mn)

Au — Gold
Cr — Chromite
Cu — Copper
Fe — Iron
Gp — Graphite
Mn — Manganese

CHATHAM COUNTY

1. Graham (Cu)
2. Gilmore Hart (Cu)
3. Ore Hill (Fe)
4. Sloan (Cu)
5. Phillips (Cu)
6. Bear Creek (Cu)
7. Barringer Phillips (Cu)
8. W. H. Purvis (Cu)
9. Cassana Kid (Cu)

LEE COUNTY

1. Clegg Mine (Cu)

JOHNSTON COUNTY

1. Wilson Iron Mine (Fe)

SUMMARY:

ACTIVE MINES (NONMETALLICS)	— 23 Companies operating 35 Mines
INACTIVE MINES (NONMETALLICS)	— 44 Mines
ACTIVE MINES (METALLIC)	— 0
INACTIVE MINES (METALLIC)	— 23 Mines & Prospects

OF THE ACTIVE MINES THERE ARE:

9 Crushed stone quarries	11 Sand pits
1 Pyrophyllite mine	2 Gravel (Sandrock) pits
12 Clay & shale pits	1 Building stone quarry

Together these operations have a total "affected acreage" of *1,303 acres.*

"Affected acreage" as defined by the "Mining Act of 1971" is "the surface area of land that is mined, the surface area of land on which overburden and waste is deposited, and the surface area of land used for processing or treatment plant, stockpiles, and settling ponds."

CLAY AND SHALE SAMPLE LOCATIONS IN REGION J

CHATHAM COUNTY

A total of twenty shale and residual clay samples were collected from different selected locations in Chatham County. Laboratory tests provide comparative information and potential uses for five samples presently used and indicate potential uses for fifteen additional samples as follows:

Sample No.	Location	Use
1	Cherokee Brick Company Brickhaven mine	Present: Brick Potential: Tile and drain tile.
2	Chatham Brick & Tile Company Div. of Sanford Brick Corporation Gulf Mine	Present: Brick and tile Potential: Pottery.
3	Pomona Pipe Products Company Gulf Mine	Present: Pipe. Potential: Outside pottery; shrinkage should be lowered for brick and tile.
4	Boren Clay Products Company Gulf Mine	Present: Brick Potential: Tile, drain tile, and pottery.
5	Boren Clay Products Company Pleasant Garden plant	Present: Brick Potential: Tile, sewer tile, and pottery.
6	Merritt Chapel site	Potential: Brick, tile, and pottery.
7	Shaddox Creek site	Potential: None.
8	Merry Oaks site	Potential: If shrinkage reduced, may be used for brick and tile.
9	Corinth site	Potential: Brick, tile, and pottery.
10	Secondary Road 1912 site	Potential: Brick.
11	Ralph Seagroves site	Potential: Brick.
12	Gulf site	Potential: Brick.
13	U. S. Highway 64 site	Potential: Brick and tile; sewer tile and pottery, if alkali added.
14	Siler City east site	Potential: Good color range for face brick; possibly porous clay products or as a component in sewer pipe and other structural clay products.
15	Siler City northwest site	Potential: Sole component in porous clay products; further temperatures indicate brick, tile and other structural clay products except sewer pipe.
16	Pittsboro site	Potential: Sole component in tile, face brick and decorative brick.
17	Carbonton West site	Potential: Sole component in most structural clay products, sewer pipe, and face and decorative brick; possible use in domestic earthenware industry.
18	R. M. Reams site 1	Potential: Face brick.
19	R. M. Reams site 2	Potential: Face brick.
20	Bynum site	Potential: Not suitable for use in vitreous clay products.

DURHAM COUNTY

A total of sixteen shale and residual clay samples were collected from different selected locations in Durham County. Laboratory tests provide comparative information and potential uses for two samples presently used and indicate the potential uses of fourteen additional samples as follows:

Sample No.	Location	Use
1	Borden Brick & Tile Company Durham Mine	Present: Brick and tile.
2	Triangle Brick Company new pit	Present: Brick. Potential: Pottery if alkali added; sintering aggregate possibility.
3	S. L. Gattis site	Potential: Brick and sewer tile; sintering aggregate a possibility.
4	U. S. Highway 15 site	Potential: Brick.
5	H. F. Dehart site	Potential: Brick; pottery if alkali added; sintering lightweight aggregate possibility.
6	L. W. Carden site	Potential: Brick.
7	Jimmy Keith site	Potential: Soft brick.
8	Willie Hicks site	Potential: None.
9	Nelson site	Potential: Brick at 2100°F.
10	H. L. Page site	Potential: Brick at 2100°F.
11	Secondary Road 1001 site	Potential: None, unless shrinkage lessened.
12	Overnite site	Potential: Brick.
13	Camp Butner site	Potential: Brick.
14	Orange Factory site	Potential: Component in sewer pipe and other structural clay products.
15	Rougemont site	Potential: Brick, tile and porous clay products such as drain tile.
16	Bahama site	Potential: Bond clay in structural clay products.

JOHNSTON COUNTY

Eight residual clay samples were collected from different selected sites in Johnston County. Laboratory tests indicate potential uses of these samples as follows:

Sample No.	Location	Potential Use
1	Mitchner property	Additive to lighten the color of red-burning clay.
2	Crumpler Brick & Tile Company Smithfield Clay Pit	Coated face brick, structural tile, drain tile, quarry tile.
3	Crumpler Brick & Tile Company Smithfield Clay Pit	Coated face brick, structural tile, drain tile, quarry tile.
4	Hares Crossroads site	Brick and tile.
5	Bethel Church site	Kaolin fraction in stoneware bodies.
6	Austins Pond site	Nonplastic component to control shrinkage in structural clay
7	Swift Creek site	Not suitable for use in vitreous clay products.
8	Buffalo Creek site	Nonplastic component to control shrinkage in structural clay products.

LEE COUNTY

Nine shale samples and one residual clay sample were collected from different selected locations in Lee County. Laboratory tests provide comparative information and potential uses for three samples presently used and indicate potential uses of the seven additional samples as follows:

Sample No.	Location	Use
1	Lee Brick & Tile Company Sanford mine	Present: Brick and tile. Potential: Pottery, if alkali added.
2	Borden Brick & Tile Company Sanford plant	Present: Brick and tile. Potential: Pottery, if alkali added.
3	Sanford Brick & Tile Company Colon mine	Present: Brick and tile. Potential: Drain tile and pottery, if alkali added.
4	Rosser site	Potential: Brick.
5	Osgood site	Potential: Brick, tile and pottery, if alkali added.
6	Cumnock site	Potential: Brick, pottery, if alkali added.
7	James Wicker site	Potential: Brick and tile if shrinkage lowered.
8	West Sanford site	Potential: Soft brick.
9	Center Church site	Potential: Soft brick.
10	Blacknel site	Potential: Brick and tile; possible use in stoneware industry.

ORANGE COUNTY

A total of six samples of shale and residual clay were collected from different selected sites in Orange County. Laboratory tests indicate potential uses for the raw materials represented by these samples as follows:

Sample No.	Location	Potential Use
1	Sunoco site	If shrinkage lowered, brick and tile.
2	Andrew L. Mooney, Jr., site	Soft brick; hard brick, if mixed with less shrinking clay.
3	Hillsborough site	Excellent color and good general properties for brick and other structural clay products except sewer pipe; possible use in porous clay products such as drain tile.
4	Oaks site	Brick, tile, drain tile, and structural clay products.
5	Cedar Grove site	Good color range for brick, tile and most structural clay products, except sewer pipe; a nonplastic grog would cut shrinkage in considering this clay for artware or pottery.
6	Carr site	Nonplastic component to control shrinkage in structural clay products.

WAKE COUNTY

A total of seventeen shale and residual clay samples were collected from different selected locations in Wake County. Laboratory tests provide comparative information on one raw material presently used and indicate potential uses for materials represented by sixteen additional samples as follows:

Sample No.	Location	Use
1	Triangle Brick Company Durham mine	Present: Brick. Potential: Tile and sewer tile.
2	J. C. King site	Potential: Brick.
3	Mrs. I. D. Marcom site	Potential: Brick, tile and sewer tile.
4	Otto Lyons site	Potential: Brick; lightweight aggregate by sintering method.
5	Carpenter site	Potential: Brick and tile below 2050°F.; lightweight aggregate by sintering method.
6	U. S. Highway 70 site	Potential: None.
7	Bonsal site	Potential: Brick, tile, sewer tile and outdoor pottery.
8	New Hill site	Potential: Brick.
9	Holly Springs site	Potential: Brick.
10	Beaverdam Creek site	Potential: None.
11	N. C. Highway 55 site	Potential: Soft brick.
12	Morrisville site	Potential: Brick; outside pottery, if alkali added.
13	Willow Springs site	Potential: Additive to lighten color and stiffen plastic red-burning clay.
14	Zebulon site	Potential: Brick and tile.
15	Rolesville site	Potential: Nonplastic component to control shrinkage in structural clay products.
16	Neuse site	Potential: Nonplastic component to control shrinkage in structural clay products.
17	McCullers site	Potential: Nonplastic component to control shrinkage in structural clay products.

GLOSSARY

GLOSSARY*

Alluvium—The general name for all sediment deposited in land environments by streams.

Amygdaloidal—An adjective describing a rock containing openings filled by one or more minerals.

Aphanitic—A texture of igneous rocks in which individual particles are not visible to the unaided eye.

Aquifer—A body of permeable rock through which ground water moves.

Batholith—A large intrusive igneous rock body that generally cuts across the country rock and has an exposed area of more than 40 square miles.

Bed—A definite layer of rock, 1 cm or more thick, that has been deposited and spread out upon the Earth's surface.

Calcareous—Containing calcium carbonate.

Carbonaceous—Containing carbon or organic matter.

Chloritized—The introduction or formation of chlorite.

Clastic—Pertaining to or being a rock or sediment composed principally of broken fragments that are derived from the physical transport and deposition of broken particles of older rocks, of older sediments and of organic skeletal remains usually derived from a source within the depositional basin.

Cleavage—The capacity of a mineral to break in preferred directions along surfaces parallel to internal planes in a mineral.

Conchoidal fracture—Breakage resulting in smooth curved surfaces.

Cross-bed—A single, thin-bedded, often lenticular layer of homogeneous or gradational lithology deposited at an angle to the original surface of deposition. Produced by swift, local changing currents of air or water (dunes, stream channels, or delta).

Cryptocrystalline—A texture of rocks in which the crystalline particles are so small that they cannot be resolved with an ordinary microscope.

Crystalline rock—An inexact but convenient term designating an igneous or a metamorphic rock, as opposed to a sedimentary rock.

Dense—Said of a fine-grained, aphanitic igneous rock whose texture is so fine that the individual particles cannot be recognized with the unaided eye.

Detrital—A term used to indicate a source for rocks, minerals or sediments from outside the depositional basin.

Dike—A tabular body of intrusive igneous rock having discordant surfaces of contact with the country rock.

Dip—The angle in degrees between a horizontal plane and an inclined plane, measured down from horizontal in a vertical plane perpendicular to the strike.

Epiclastic rock—A rock formed at the Earth's surface by consolidation of fragments of preexisting rocks; a sedimentary rock whose fragments are derived by weathering or erosion.

Euhedral—Said of an individual mineral crystal, in a rock, that is completely surrounded by its own regularly developed crystal faces and whose growth was not restrained or interferred with by adjacent crystals.

Fault—A fracture along which the oppositie sides have been relatively displaced.

Felsic—An adjective used to describe an igneous rock in which light-colored minerals predominate.

Floodplain—That part of any stream valley which is inundated during floods.

Fluvial—Of or pertaining to a river or rivers.

Foliation—A general term for a parallel or nearly parallel planer arrangement of textured or structural features usually in metamorphic rocks along which the rock tends to split.

Fracture—A general term for any break in a rock, whether or not it causes displacement, due to mechanical failure by stress.

Fumerolic—A type of volcanic activity characterized by the emission of gases and vapors from a volcanic vent or fumarole.

Geology—The study of the planet Earth.

Groundmass—A term for the smaller particles surrounding conspicuously larger particles in a rock. (syn. matrix)

Half-graben—An elongate, relatively depressed crustal unit or block that is bounded by faults on one of its long sides.

Heavy mineral—A mineral generally having a specific gravity greater than 2.8; usually dark-colored, iron and magnesium rich minerals.

* Taken from GLOSSARY of GEOLOGY and RELATED SCIENCES, A.G.I., J.V. Howell, Chairman, Washington, D.C., 1957.

High-grade metamorphism—Metamorphism that is accomplished under conditions of high temperature and pressure.

Hydrology—The science that deals with continental water, its properties, circulation and distribution, on and under the Earth's surface and in the atmosphere.

Igneous—Pertaining to a rock or mineral that solidified from molten material (magma). One of the three main classes of rocks.

Igneous complex—An assemblage of intimately associated igneous rocks differing in form or in rock type. A plutonic body consisting of a diverse association of igneous rocks.

Intrusive rock—Rock that originated from solidification of magma emplaced in older bedrock (sometimes called country rock).

Joint—A fracture on which no appreciable movement parallel with the fracture has occurred.

Laminated—Said of a rock that consists of thin layers.

Lath—A crystal shape that is long, thin and of moderate to narrow width.

Lenticular—Resembling a lens in shape.

Lithic—Said of a medium-grained sedimentary, and of a pyroclastic rock, containing abundant fragments of previously formed rocks, also said of such fragments.

Lithologic unit—A unit consisting of a certain rock type or types possessing certain objective physical features observable in the field or subsurface.

Low-grade metamorphism—Metamorphism that is accomplished under conditions of low to moderate temperature and pressure.

Mafic—Referring to dark-colored, iron- and magnesium-rich minerals, or to rocks composed of such minerals.

Marine—Formed or deposited in the sea.

Matrix—The small particles of a sediment or sedimentary rock, which occupy the spaces between the larger particles that form the framework. (syn. groundmass)

Metamorphic—Pertaining to the process of metamorphism or to its results.

Metamorphism—The changes, in mineral composition, arrangement of minerals, or both, that take place in the solid state within the Earth's crust at high temperatures or high pressures, or both.

Mineral—A naturally occurring, usually inorganic, crystalline substance with characteristic physical and chemical properties that are due to its atomic arrangement.

Orthogneiss—A gneiss derived from an igneous rock.

Outcrop—That part of a geologic formation or structure that appears at the surface of the Earth.

Paragneiss—A gneiss that was derived from a sediment.

Permeability—The capacity of a material for transmitting fluids.

Pluton—Any body of intrusive rock.

Porosity—The portion, in percent, of the total volume of a given body of material that consists of pore spaces.

Porphyritic—An adjective describing an igneous rock in which conspicuously larger crystals (phenocrysts) are set in a finer groundmass which may be crystalline or glassy or both.

Pyroclastic—Pertaining to clastic rock material formed by volcanic explosion or aerial expulsion from a volcanic vent.

Residual—Said of minerals or soil formed by mechanical or chemical concentration in place (as opposed to transported materials).

Rock—Any naturally formed material (but not soil) composed of a mineral or minerals and having some degree of chemical and mineralogic constancy.

Sediment—Mineral or organic matter deposited by water, air or ice.

Sedimentary—Pertaining to or containing sediment. Formed by the deposition of a sediment.

Soil—The natural medium for growth of land plants.

Spherulitic—Said of the texture of a rock containing numerous spherulites, spherical bodies with a radial internal structure arranged around one or more centers.

Strata—Tabular or sheet-like masses, or single and distinct layers, of homogeneous or gradational sedimentary material of any thickness, visually separable from other layers above and below.

Strike—The line formed by the intersection of a horizontal plane and an inclined plane.

Subaerial—Occurring beneath the atmosphere or in the open air (as opposed to subaqueous).

Subaqueous—Said of conditions and processes that exist or operate, or of features and deposits that are formed or situated, in or under water.

Terrace—A relatively flat, elongate surface, bounded by a steeper ascending slope on one side and a steep descending slope on the other. Also, a bench along the side of a valley, the upper surface of which was formerly the alluvial floor of the valley.

Vitroclastic—Pertaining to a pyroclastic rock structure characterized by crescentically or triangularly fragmented bits of glass.

Volcanic—Pertaining to the activities, structures or rock types of a volcano. A synonym of extrusive.

Volcaniclastic—Pertaining to a clastic rock containing volcanic material, without regard to its origin or environment.

Weathering—The chemical alteration and mechanical breakdown of rock materials during exposure to air, moisture and organic matter.

PHYSICAL FACTORS AFFECTING GROUND WATER RECOVERY

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By: V. J. May and J. D. Thomas

In the area, ground water from all rock types is generally of acceptable quality for domestic use provided it is free of surface pollution. Some of the physical factors which affect the quantity of available water in the area are described below.

Rock Texture

Rock texture refers to the size, shape, and arrangement of the component particles of a rock. Coarse-textured rocks generally are more permeable than fine-textured rocks and consequently, may be better aquifers.

Fracture Planes in Rock

The interstices in many of the rocks in the area are secondary fractures. Wells drilled at places where fractures or fracture systems such as joints or zones of shearing are better developed will yield more water than wells drilled into more massive rocks.

Cleavage and Schistosity

Cleavage planes and planes of schistosity are important avenues of ground water movement and storage in the area. They usually dip at some angle to the horizontal which allows water to percolate by gravity down dip along these schistose and cleavage planes. Yields are greater where schistose and cleavage planes are plentiful, especially where differential rock movement along these planes has caused some degree of separation.

Quartz Veins and Diabase Dikes

Quartz is a hard, brittle mineral that fractures easily from stress caused by slight crustal movements. Quartz veins in the area are generally more fractured than the enclosing rock, and hence, are better aquifers. Generally the veins are vertical or dip at nearly vertical angles. A well that is to penetrate an inclined vein should be located away from the outcrop area in the direction in which the vein dips. The presence of a quartz vein can be detected even in deeply weathered areas by the train of loose quartz fragments on the soil.

Dikes are tabular rock bodies of intrusive igneous rock. They are not usually good aquifers, but often the host rock adjacent to them may have been made more permeable by fractures resulting from the force of intrusion and heat. Many wells near Triassic diabase dikes in the Triassic sedimentary rocks are above average producers. These dikes sometimes form underground dams which obstruct the natural movement of ground water, causing the water table to be closer to the surface on one side of the dike.

Topography

Topography is one of the most useful criteria in determining the relative water-bearing characteristics of the underlying rocks.

In general, wells drilled on hills or other upland areas are less apt to yield the desired quantity of water than wells drilled in draws or other depressions.

(1) Hills and upland areas readily shed much water from precipitation as surface runoff. As a result, there is less seepage into the ground to become ground water. On the other hand, the lowlands obtain influent seepage directly from precipitation and also from upland surface runoff.

(2) The direction of movement of the ground water is toward the valleys where part of it discharges into streams. In addition, influent seepage may occur from upland rock slopes beneath the residual material. The more impervious the bedrock, the more readily is water deflected down the slope along this contact.

(3) Wells located in lowlands may salvage some of the water that would be lost naturally by discharge from the underground reservoir. There the depressed water level resulting from pumping, if near a discharge area, prevents further discharge out of the area.

(4) Wells on hills penetrate the water table at a greater depth than those in lowlands. When a well on a hill is pumped, the water table is lowered as a cone of depression, the center of the cone being at the well. As pumping continues the cone may grow larger and deeper but its span is limited because of the topography and because of the relatively low permeability of rocks at progressively greater depth below the surface. The yield of wells under these conditions is not great. On the other hand, wells in lowlands, even though penetrating the same rocks as those on uplands, intersect the water table near the ground surface. Thus, the water table can be lowered a greater distance by pumping than in a well of the same depth on a hill. The fact that the static and pumping water levels lie nearer the ground surface than in wells on hills results in the pumping level lying in a more permeable zone; hence the intake area is broader and the yield of the well is larger.

(5) In many places hills exist because the rocks there have a greater resistance to erosion than in the valleys, this resistance being due in many places to poor jointing. Joints and fractures facilitate entrance of ground water, which promotes chemical decay and permits mechanical erosion. Thus depressions such as draws or

valleys suggest that the rock underlying the depressions has more openings through which ground water can move than the rock underlying the hills.

Thickness of Weathered Material

Chemical weathering of rock is facilitated by the infiltration and movement of water. Therefore, a thick mantle of saprolite may be an indication that the underlying rock has joints, fractures, or pores which contain ground water. Saprolite is usually porous, although not necessarily very permeable, so that a thick mantle of saprolite has a large storage and recharge potential.