NORTH CAROLINA
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
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Information Circular 14

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AN INTRODUCTION TO

RADIOACTIVE MINERALS IN NORTH CAROLINA

BY

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RADIOACTIVE MINERALS IN NORTH CAROLINA

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INTRODUCTION

With the advent of the "atomic age" in July 1945, the search for uranium in the United States began. During the intervening ten years interest in prospecting, especially in the western part of the United States, has increased rapidly and today has attained proportions best described as a "uranium rush". However, unlike the gold rush of 1849, the quest for uranium is confined principally to areas at close proximity to the homes of the prospectors, who represent citizens from all walks of life. Perhaps the primary reasons for this massive search can be attributed to the relative ease by which prospecting can be carried out with a Geiger counter or other types of portable electronic equipment and the cash bonus offered by the United States Government for the discovery and subsequent development of commercial uranium-ore deposits.

In North Carolina, long known for its wide variety of minerals and rocks, considerable interest has developed during the past few years in the possibility of finding commercial amounts of uranium especially in the mountainous areas. During the years 1953-1955 large areas in Pisgah National Forest and other parts of Western North Carolina were prospected by individuals, and several areas of slight to moderate radioactive anomaly were discovered. These findings, probably more than any other single factor, have aroused interest in uranium prospecting in the state. At the time of this writing prospecting for radioactive minerals has become not only a full-time quest by some but also a popular weekend activity of many in various sections of North Carolina. Consequently, numerous inquiries relating to radioactive minerals in the state are received weekly by the Division of Mineral Resources of the North Carolina Department of Conservation and Development.

Purpose and Scope

The primary purpose of this circular is to acquaint interested persons with the general physical and chemical properties, mode of occurrence, and general distribution of radioactive minerals, with particular emphasis on known occurrences in North Carolina. It is not intended to be a scientific discussion of the subject but rather an introduction to the field of radioactive materials, their detection, and occurrence in North Carolina. Other subjects, such as mineral rights and permits to prospect on private, state, and federal lands, are discussed briefly. Through the short discussions and summaries of these subjects, this report is designed to answer some of the questions arising in the minds of prospectors and potential prospectors for radioactive minerals in North Carolina.

Acknowledgments

Grateful acknowledgments are due Dr. Jasper L. Stuckey, State Geologist, who supplied much valuable information concerning radioactive minerals in North Carolina and under whose general supervision this circular was prepared. Likewise, considerable information was obtained through personal communication with Mr. Sam D. Broadhurst, Assistant State Geologist. Mr. B.B. Frye of Conover supplied several samples of radioactive minerals and rocks from an area in Burke County and Mr. Douglas B. Sterrett, Consulting Geologist of Taylorsville, introduced the writer to a newly discovered allanite locality in Wilkes County.

RADIOACTIVE MINERALS

Radioactive minerals can be divided generally into two major classes, the uranium-bearing and thorium-bearing compounds, the former being the present source of fissionable material used in atomic devices. Uranium and thorium are the heaviest of the naturally occurring elements, and their distribution in the earth's crust is very widespread; in abundance, however, they are relatively rare. Although more than one hundred minerals are known to contain the radioactive elements, only a small number of these contains sufficient amounts of uranium or thorium to merit their being mined for commercial extraction of the element or its compounds. The uranium minerals are usually classified as primary, or those which are in the same physical state as when originally deposited, and secondary, or those which are formed by the chemical alteration of the primary minerals. Primary uranium minerals are usually of a dark gray to black color and are found principally in metalliferous vein deposits and pegmatites. The more important of these minerals are pitchblende and uraninite. Others include betafite, euxenite, and samarksite. The secondary minerals are normally brightly colored, powdery or flaky materials and may occur in almost any type of rock. Important secondary minerals are carnotite, autunite, and torbernite. The primary uranium minerals and many of the thorium minerals possess a high specific gravity, and both share a common physical property with the secondary minerals, that of emitting invisible particles of matter referred to as alpha, beta, and gamma radiation, or rays. Most of the secondary minerals are lighter in weight than the primary minerals, and some of them possess the property of fluorescence.

DETECTION OF RADIOACTIVITY

The property of radioactive disintegration characteristic of the uranium and thorium minerals accounts for the relative ease by which prospecting can be carried out. The emission of particles, especially the gamma rays, from a radioactive mineral or rock cannot be seen, heard, or felt but may be detected by specially constructed electronic instruments, the more important ones being the Geiger counter and the more sensitive scintillation counter, or scintillometer. Both these instruments are built to detect radioactive emissions from rocks and minerals but will not distinguish between radiation from uranium and thorium. For these determinations, other tests are necessary, including the so-called "bead test" and the far more positive petrographic analysis and chemical assay, the chemical assay being the most effective method. The percentage of uranium or thorium contained can be determined very roughly by following the procedure outlined in the manual of instructions which comes with most counters, but a chemical assay is necessary for absolute certainty of radioactive mineral content.

The Geiger counter (and scintillometer) not only detects the presence of anomalous radioactivity in a given area but also records the aggregate radiation caused by minute amounts of radioactive materials present in most rocks and the cosmic rays from outer space which constantly bombard the earth. The clicks registered on a Geiger counter in the absence of uranium and thorium in appreciable amounts are thus called background count and will always be present. The frequency of counts resulting from the background effect will vary from place to place as well as from day to day. In North Carolina, for example, background count will be greater in areas underlain by granite, gneiss, and associated rocks and less in the limestone and sandy regions of the Coastal Plain. Likewise, this effect will be less in deep, constricted valleys and greater atop a hill or mountain. Before prospecting for radioactive minerals, the background count should be determined beyond the immediate area of proposed prospecting by counting the number of clicks during three separate two-minute periods and averaging the total so as to learn the average number of background counts per minute. This should be done several times during the prospecting period, as background effect is sometimes quite variable in intensity. With the background count known, anomalous radioactivity can be ascertained with little difficulty by subtracting the background effect from the readings obtained during prospecting. Before attempting to prospect properly an area, the manual of instructions which accompanies most counters should be studied thoroughly to become familiar with the counter and its potentialities as well as its limitations. It should always be remembered that the Geiger counter is a well built instrument designed for field use, but it is also a delicate electronic device which should be handled with care at all times.

OCCURRENCES OF RADIOACTIVE MINERALS

Uranium and other radioactive minerals occur in metalliferous vein deposits; in pegmatites, or course-grained granite veins; as deposits in sedimentary rocks such as sandstones and shales; in metamorphic rocks, principally highly fractured gneisses, schists, and slates; in placer deposits, and in small quantities in some granites and related primary rocks. Rocks of all geologic ages and, as apparent from the foregoing sentence, almost all rock types may contain radioactive minerals in sufficient concentrations to be detected by counters.

Of prime importance in the commercial production of uranium are the pitchblende vein deposits of high-grade ore found in Canada, the

Belgian Congo, Czechoslovakia, and the widespread deposits of carnotite, a lower grade ore of uranium found in sandstone and associated rocks of the Colorado Plateau section of the United States. Other areas in the world containing productive or significant deposits of uranium minerals include Australia, France, Portugal, Great Britain, and the Soviet Union (Nininger, 1954). Deposits of pitchblende and carnotite, the principal ores of uranium, are not known in North Carolina, but uraninite, a mineral very similar in physical and chemical properties to pitchblende, is found in small quantities in some pegmatites in Mitchell and Yancey Counties. Various shale deposits, largely of marine origin, contain small amounts of radioactive minerals, but none are known to be worked for uranium or thorium at present. Pegmatites very often contain radioactive minerals, but the extraction of these minerals other than as a byproduct in mica, feldspar, or other industrial mineral processing will probably not prove feasible. In placer deposits, the occurrence of radioactive minerals is usually restricted to various thorium compounds, uranium minerals rarely being found due to their susceptibility to rapid solution or chemical decomposition.

Recently, considerable attention has been given to radioactive mineral occurrences, principally uranium minerals, in such metamorphic rocks as quartzites, slate, gneiss, and schist. Many of the secondary minerals have been found in highly fractured and deformed rocks of these types with the promise that commercial deposits may be discovered in some metamorphic rocks. Gneissic and schistose rocks have widespread occurrence in the western Piedmont and Blue Ridge regions of North Carolina, and it is in these sections that most of the more recent discoveries of secondary uranium minerals have been made.

Occurrences in North Carolina

Radioactive minerals are present in pegmatites, placer deposits and to a limited extent in some granitic rocks in North Carolina. Most have been known for many years, and thorium-bearing placers (monazite) were mined in the state as late as 1953. Secondary uranium minerals have been discovered in recent years in metamorphic rocks in the western part of the state, and because this section is underlain largely by this rock type it presents an interesting area in which to search for uranium-bearing and thorium-bearing rocks.

In order to present the information concerning the radioactive minerals known to occur in North Carolina in the most practical manner, they are listed alphabetically, along with the general composition of each, a short description of the physical properties of the mineral, and the locality where each has been recognized. The names of the more important of these minerals appear in bold type, and those containing uranium are preceded by an asterisk. The classification of primary or secondary is indicated by P or S immediately following the mineral name.

ALLANITE (P): Allanite, a moderately heavy, brownish-black mineral, is a silicate of the rare-earth elements cerium, yttrium, and lanthanum. Its mild radioactive properties are attributed to small amounts of thorium which almost inevitably occur in the mineral. This mineral is present in pegmatites in Swain County north of Bryson City, in Madison County west of Marshall, in Wake County near Wake Forest, and in pegmatites and hornblendic rocks near North Wilkesboro in Wilkes County. The allanite-bearing pegmatites commonly occur in the contact zone between granites and older gneisses and schists. It is a potential source of the rare-earth elements rather than uranium.

Auerlite (P): Auerlite is a dull yellow to orange-red silicate-phosphate of thorium, containing up to 70 percent thorium oxide. It is found in very small amounts near Zirconia in Henderson County, where it is associated with zircon-bearing pegmatites.

*Autunite (S): Autunite is a lemon to sulphur yellow mineral usually associated with uraninite. It is a brittle, micalike phosphate of calcium and uranium. Small quantities of autunite are present in some mica and feldspar mines in Mitchell and Yancey Counties.

*Cyrtolite (S): Cyrtolite is an altered silicate of zirconium, containing uranium, yttrium, and other rare-earth elements. It occurs in small quantities in some pegmatites in the Spruce Pine district of Mitchell and Yancey Counties and in zirconium-bearing pegmatites near Zirconia, Henderson County.

*Euxenite (P): Euxenite is a brownish-black mineral, containing yttrium, erbium, cerium, uranium, columbium, and tantalum. It is found in small amounts in pegmatites near Spruce Pine, Mitchell County.

GADOLINITE (P): Gadolinite is a black to greenish-black, mildly radioactive mineral, quite similar to allanite but also containing beryllium in significant amounts. It is reported found in contact-zone pegmatites in Ashe County in an area northwest of West Jefferson. Like allanite, it is a potential source of the rare-earth elements.

*Gummite (S): This mineral is reddish-yellow, orange, or reddish-brown and is an alteration product formed during the chemical breakdown or uraninite. It is found in pegmatites at the Deake and Flat Rock Mines near Spruce Pine, Mitchell County. Uranium, rare-earth elements, thorium, and rare gases make up the mineral composition.

MONAZITE (P): Monazite is a yellowish-green phosphate of cerium, lanthanum, and other rare-earth elements and contains varying amounts of thorium which accounts for its property of radioactivity. Monazite often contains exceedingly small amounts of uranium, but it is primarily a source of thorium oxide and rare-earth elements. Monazite occurs in many recent stream deposits just east of the Blue Ridge in Burke, Cleveland, McDowell, Polk, and Rutherford Counties; as crystals along contacts between gneisses and granites in Alexander and Madison Counties, and as coarse crystals in pegmatites in Mitchell County at the Deake Mine. It is also found in small amounts in many of the granitic rocks of the North Carolina Piedmont and in small quantities in the sands of the Coastal Plain. Monazite has been produced in commercial quantities from placer deposits in Cleveland, Burke, and Rutherford Counties.

*Polycrase (P): Polycrase is a black-to-brown radioactive mineral, similar in physical and chemical properties to euxenite. It has been observed in small amounts in placer deposits and in association with zirconium-bearing pegmatites near Zirconia, Henderson County.

*Samarskite (P): Samarskite is a heavy, black mineral, containing columbium, tantalum, rare-earth elements, calcium, and uranium. In North Carolina, it has been found in pegmatites of Mitchell County in masses weighing up to 20 pounds.

*Torbernite (S): Torbernite and metatorbernite, both hydrous phosphates of copper and uranium, long known to occur in some pegmatites of the Spruce Pine district, have been identified recently as the coating and disseminated flakes in samples of mica schist and chlorite gneiss from northwestern Burke County and in granite-gneiss from Avery County. This mineral, containing up to 56 percent uranium trioxide, is an emerald green, micalike material which stands out very prominently in the host rock.

*URANINITE (P): Uraninite is an oxide of uranium, lead, zirconium and/or thorium, the rare-earth elements, and various gases which include nitrogen, helium, and argon. It is a very heavy, black to grayish-black to greenish-black mineral, which is frequently altered to other radioactive minerals, including clarkeite and gummite. Uraninite is found in some pegmatites in Mitchell and Yancey Counties. In past years a small amount of uraninite production was made in Mitchell County as a byproduct in the production of mica and feldspar (Murdock, 1950).

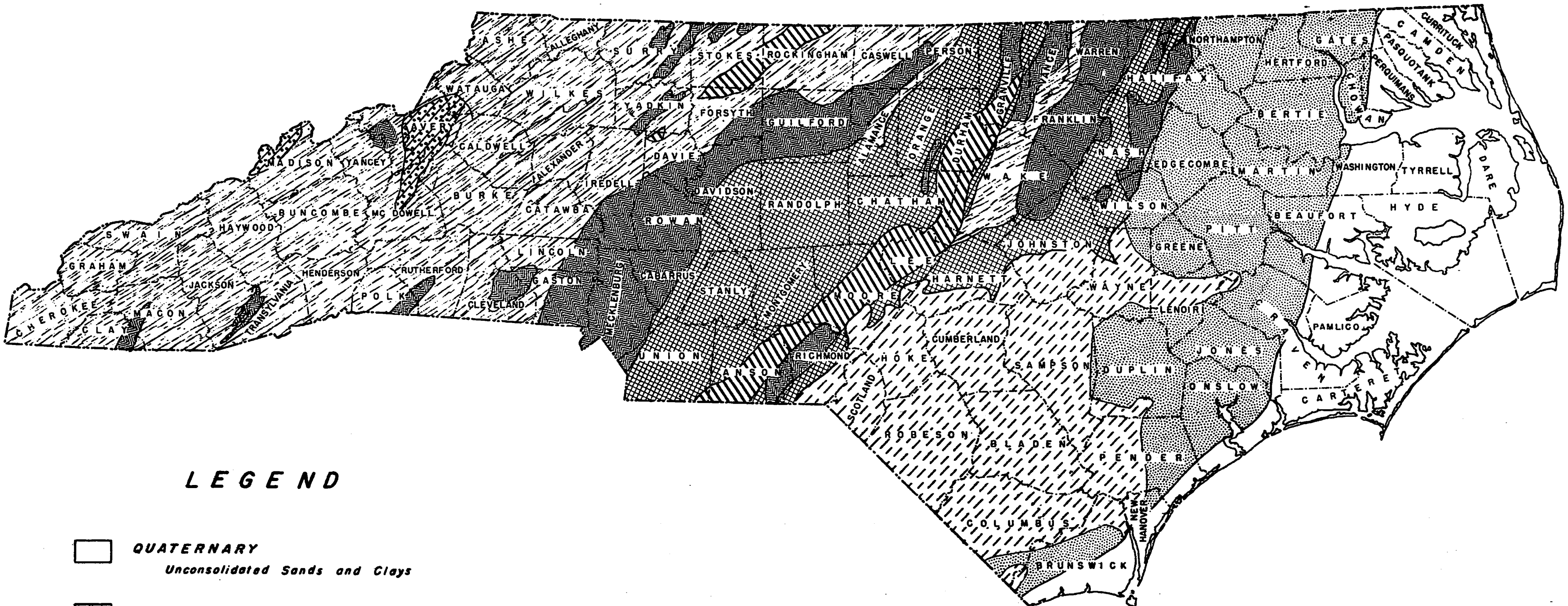
*Uranophane (S): Uranophane, often called uranotil, is a silicate of calcium and uranium which is an alteration product formed by the chemical d composition of uraninite to gummite to uranophane. The lemon-yellow color is a distinctive property of this mineral. It is found in the same areas in Mitchell and Yancey Counties in which uraninite occurs.

Others: Other radioactive minerals in North Carolina include columbite-tantalite and as yet unidentified minerals in slates, quartzites, and shales in Burke County, also unidentified minerals in granite-gneiss in Avery County.

The outline map of North Carolina on page 11 shows the general location of known radioactive mineral occurrences in the state, with only the more important localities being depicted. An area of slight radioactive anomaly in Avery County is not shown on the map and should be placed in the east-central part of the county.

WHERE TO PROSPECT

According to the United States Atomic Energy Commission (1949), prospecting for uranium should provide best results where: (1) uranium has been found previously, (2) the geologic conditions are similar to those



LEGEND

QUATERNARY
Unconsolidated Sands and Clays

TERTIARY
Clays, Sands and Marls

CRETACEOUS
Sands, Clays and Marls

TRIASSIC
Sandstones and Shales

CARBONIFEROUS
Principally Granite and Diorite

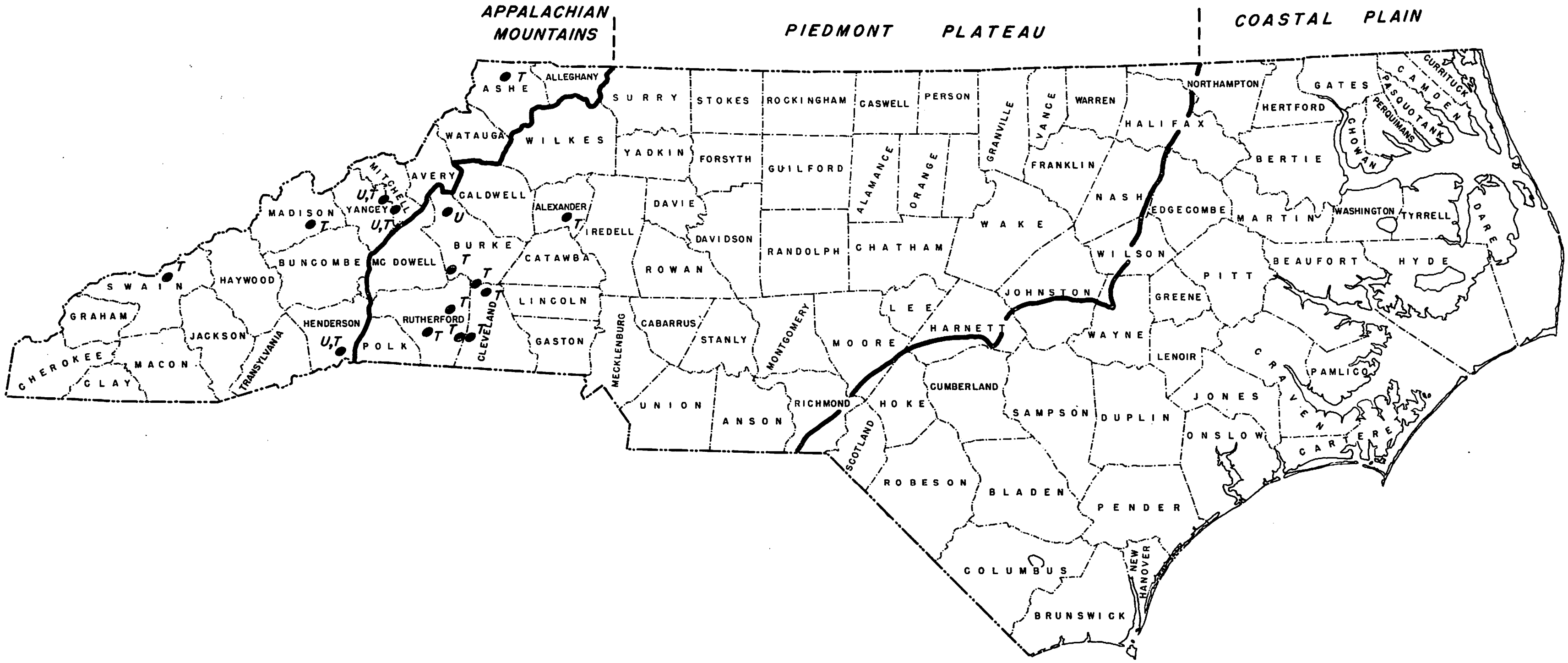
CAMBRIAN
Quartzite, Slate, Shale and Limestone

VOLCANIC SLATE SERIES *(Lower Paleozoic?)*
Interbedded Slates, Flows, Tuffs and Breccias

PRE CAMBRIAN
Gneisses and Schists

GENERALIZED GEOLOGIC MAP OF NORTH CAROLINA

Scale
0 25 50 100
MILES



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prevailing in known uranium areas, or (3) where such metals as cobalt, nickel, bismuth, copper, vanadium, and silver are known to occur. A study of the generalized geologic map of North Carolina on page 12 will show that most of the uranium and thorium occurrences shown on the preceding outline map are in areas underlain by gneissic and schistose rocks. Consequently, it is deemed advisable to search for radioactive minerals in North Carolina where gneisses and schists are the prevailing rock types. This, of course, is a generalization and is not intended to discourage prospecting in any part of the state. In the central part of the Piedmont Plateau, for example, there are many "mineralized areas" in which copper and silver, two of the metallic elements with which uranium is often associated, are of importance. These areas are generally spoken of as the gold-mining sections of the Piedmont and should merit at least reconnaissance radiometric surveys. The Coastal Plain of North Carolina is perhaps the section least likely to contain commercial deposits of uranium minerals, but prospecting is not discouraged since the thorium mineral monazite is known to occur in surficial sands in that part of the state and may be found to occur in commercial amounts.

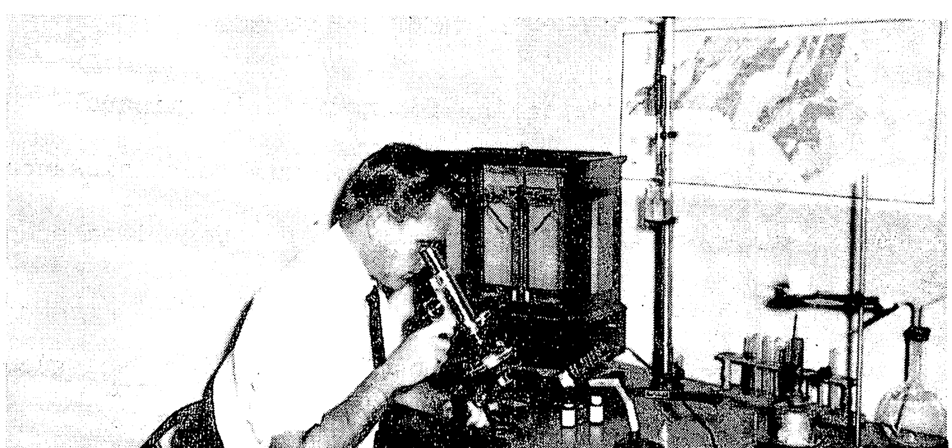
HOW TO PROSPECT

In prospecting for radioactive minerals there are two general methods of approach: (1) general reconnaissance and (2) the grid survey. Both of these methods are described adequately in the booklet "Prospecting for Uranium", prepared jointly by the United States Atomic Energy Commission and the United States Geological Survey. The following is taken from that booklet:

> After having first determined the background count for a general region, the prospector may proceed by merely walking

PROSPECTING FOR
RADIOACTIVE MINERALS

MAKING A GRID SURVEY



LABORATORY IDENTIFICATION OF
RADIOACTIVE MINERALS

with his Geiger counter over the area in which he is interested, meanwhile taking into account the general topography and geology of the land. At any place where the counter registers two or three times the background count, a close examination should be made with the counter probe in order to determine the precise source of the radioactivity. In particular, the prospector should try to determine whether the radioactivity is coming from high-grade veins or from a mineral sparsely distributed through the rocks, since a relatively large area of weakly radioactive rocks will cause a response similar to that of a small crevice filled with high-grade ore.

It is not possible to say that minimum reading a counter should give to indicate acceptable quantities or grades of uranium ore. A specific area that consistently gives readings of more than twice the background may well prove to be significant. The matter of primary importance is to obtain the reading in a specific area in terms of the background and to select representative samples of the ore for assay. If the radioactivity of any particular rock is four times the background count, a sample should be taken.

In prospecting with the Geiger counter, it is important not to cover ground too rapidly. Otherwise, the counter may not have time to register narrow veins that might be passed over. It is good practice to pause and take 1-minute readings at frequent intervals, especially in areas where preliminary testing indicates that radioactive minerals may be present. These readings should be taken by placing the counter probe on the ground.

The question of how close a Geiger counter must be brought to uranium in order to detect it canot be answered in terms of feet or inches. A counter's ability to detect a uranium deposit depends primarily upon four factors: the amount of radioactive ore, the richness of the ore, the amount of overburden, and the distance of the counter from the surface. The depth of overburden that rays from a radioactive mineral can penetrate depends upon the type of overburden. In some cases as little as 6 inches will conceal the presence of uranium. Naturally, high-grade ore will produce stronger rays than low-grade ore, and, therefore, may be detected at a greater depth beneath the earth's surface. Even high-grade ores, however, can rarely be detected under more than 2 feet of overburden.

Once it has been established that a definite area is radioactive, it may be studied in more detail by means of the "grid survey." In this case, the area under investigation is marked off in squares about 20 feet to aside, and a map of the area is outlined with corresponding lines. One-minute readings are taken at the corners of the squares by placing the counter probe on the ground, and the readings are noted on the map in their proper locations. When readings have been taken over the entire area in this manner, lines are drawn on the map connecting the points of greatest radioactivity. Then lines are drawn connecting the points of next greatest radioactivity, and so on until all parts of the area showing above-background radioactivity are outlined. The map will then indicate roughly the extent, shape and variation in grade of the deposit. More than one such survey may have to be made before valid results are obtained. It is also desirable to note any points of particularly high activity that are encountered between the corners of the grid.

In making a grid survey, it is important that the background count be subtracted from the readings in order to give them meaning. In this case, the background is always obtained by taking a number of readings off the area of interest and averaging them together.

MINERAL RIGHTS AND PERMITS TO PROSPECT

Mineral Rights: Mineral rights, unless sold or leased, go with the surface rights in North Carolina; so, permission to prospect for minerals, including radioactive varieties, on private lands should be secured from the owner. In the event mineral rights have been sold or leased, permission of the possessor of the surface rights must still be secured prior to prospecting.

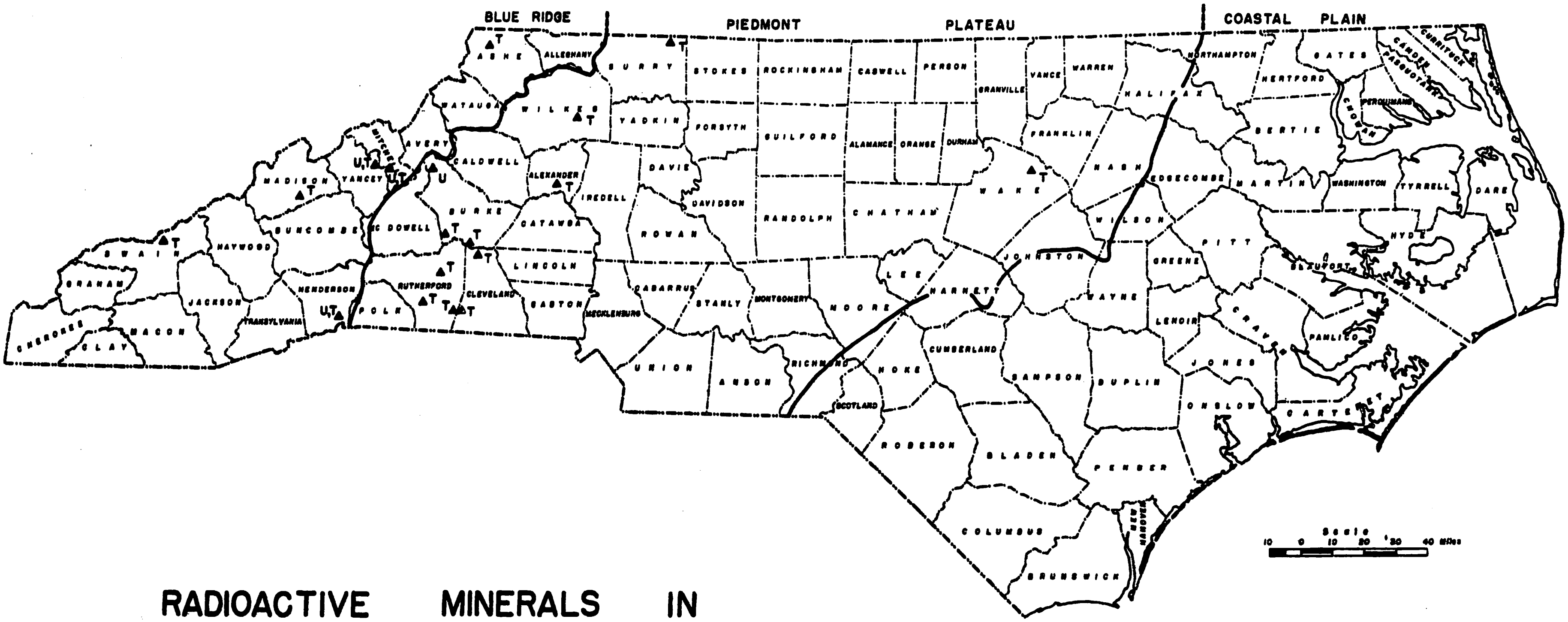
Federal Land: Large areas in Western North Carolina and one area in the eastern part of the state are owned and are under the jurisdicition of the United States Department of the Interior. These lands have been designated as the Pisgah, Nantahala, and Croatan National Forests and the Great Smoky Mountains National Park. The Pisgah National Forest occupies parts of the following counties in North Carolina: Avery, Buncombe, Burke, Caldwell, Haywood, Madison, McDowell, Mitchell and Yancey, while the Nantahala National Forest covers most of the southwestern part of the state. The Croatan National Forest covers parts of Carteret, Craven, Jones and Onslow Counties in Eastern North Carolina. The Great Smokey Mountains National Park occupies parts of Swain and Haywood Counties.

National parks are closed to prospecting at all times. However, national forests may be prospected for valuable minerals by securing a permit to prospect from the Supervisor of National Forests, Box 731, Asheville, North Carolina. Since the national forests are not a part of the public domain, CLAIMS CANNOT BE STAKED IN THESE AREAS OR ON ANY FEDERAL LANDS IN NORTH CAROLINA. Should the prospector discover deposits of valuable minerals, a lease to mine may be negotiated through the same channels from which the permit to prospect was secured.

State Land: It is not known precisely how much land is owned by the State of North Carolina. At the time of the adoption of the State Constitution, all swamp lands in Eastern North Carolina which had not previously been deeded to individuals were granted to the State Board of Education. Among the best known of these swamp lands are Holly Shelter Swamp in Pender County and Angola Swamp in Duplin and Pender Counties. A large part of Whiteoak Swamp in Jones and Onslow Counties belongs to the State through the Department of Forestry of North Carolina State College, Raleigh. These swamp lands have never produced and are not known to contain valuable minerals; but, should an individual desire to prospect in these areas, it is necessary to secure permission through the office of the Superintendent of Public Instruction, Raleigh, North Carolina.

Large bodies of water in Eastern North Carolina, the principal of which are Albemarle and Pamlico Sounds including streams and lesser sounds tributary to them, belong to the state. These areas are administered by the Department of Conservation and Development, and requests for permission to prospect them should be directed to the director of the department in Raleigh.

Other state-owned lands consist of parks, game refuges, and small tracts set aside as locations for fire-watch towers. These lands are closed to prospecting at all times. As in the case of federal land, THERE ARE NO STATE-OWNED LANDS ON WHICH CLAIMS MAY BE STAKED. Mining



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leases may be obtained through negotiation with the controlling authority.

Summary: THERE ARE NO LANDS IN NORTH CAROLINA, EITHER FEDERAL OR STATE ON WHICH MINERAL CLAIMS MAY BE STAKED. Federal-and state-owned lands, EXCLUDING parks, game refuges, and fire-tower areas, may be prospected for minerals by securing permission from the appropriate authority. Permission to prospect on private land must be secured from the owner.

The outline map of North Carolina on page 18 shows the principal areas covered by federal-and state-owned lands. It should be noted that these are approximate and all-inclusive boundaries in which some private lands are present. Military reservations, state parks, land occupied by state institutions, and other small tracts are not shown on the map. These areas are closed to prospecting at all times.

MINING LAWS

There are no mining laws, as such, relating to the mining of mineral deposits in North Carolina. The North Carolin a Department of Labor, however, does administer certain rules and regulations pertaining to mining in the state. The expressed purpose of these rules, as authorized by the Consolidated Statutes of North Carolina, is "to provide safety standards for the protection of the health, safety and general well being of employees engaged in the mining industry."

Regulations regarding the marketing and transfer of mined uranium ores and concentrates, as well as the United States Government's rights and powers relating to the production of such materials, are described in the booklet, "Prospecting for Uranium." It is strongly recommended that potential prospectors for radioactive minerals secure a copy of this booklet.

PUBLICATIONS

A few of the many publications dealing with prospecting for and the detection of radioactive minerals, which will supplement the introductory information in this circular, are listed below:

Prospecting for Uranium: Superintendent of Documents, United States Government Printing Office, Washington 25, D.C. $0.55. (This booklet gives an excellent summary of procedures best used in prospecting for radioactive minerals and also lists companies which sell Geiger Counters).

Prospecting with a Counter: United States Atomic Energy Commission, Washington 25, D.C. $0.30.

You Can Find Uranium: By Joseph L. Weiss and William R. Orlande. J.B. Weiland and Co., Box 2189, San Francisco, Cal. $2.00.

Handbook of Uranium Minerals: A Practical Guide for Uranium Prospecting: By Jack DeMent and H.C. Dake, Mineralogist Publishing Co., 329 Southeast 32d Ave., Portland 15, Oregon. $2.00.

Minerals for Atomic Energy: By Robert D. Nininger. D. Van Nostrand Co., Inc., New York. $7.50.

SAMPLE IDENTIFICATION

Samples of North Carolina rocks and minerals thought to be radioactive will be tested with a Geiger counter by the Division of Mineral Resources, North Carolina Department of Conservation and Development, Raleigh, free of charge. Samples should be packaged securely and sent to the above address by parcel post. If the sender wishes the samples returned, postage for that purpose should be sent with the package or in an accompanying letter. Chemical assays cannot be performed by this Division but must be sent to a federal or commercial assayer. The Division does not have Geiger or scintillation counters available for rent or loan.

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