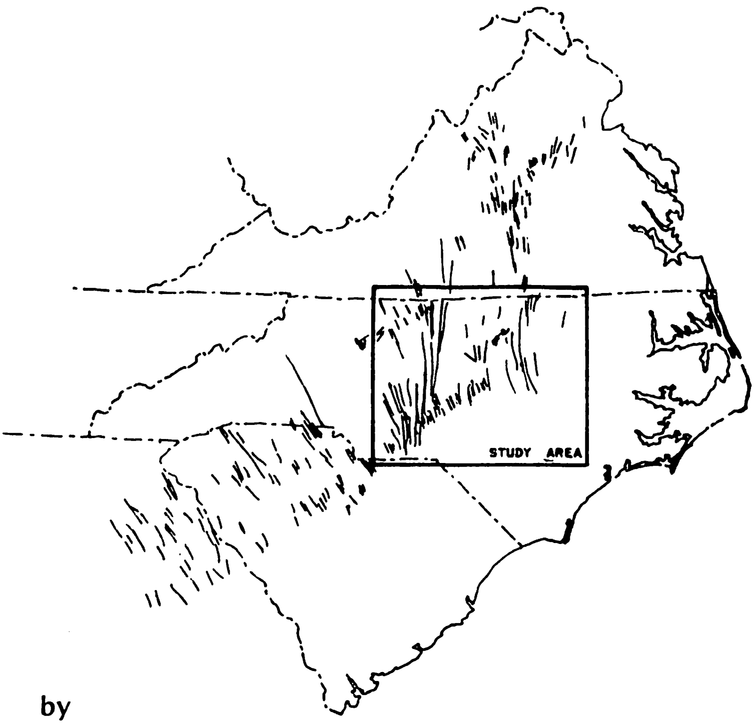
INFORMATION CIRCULAR 23

DIABASE DIKES OF THE EASTERN PIEDMONT OF NORTH CAROLINA



by

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Preface

The map that accompanies this report was prepared as expeditiously as possible in order to make the information available to the geological community and general public in immediate need of basic data with research, economic, and energy applications. The diabase occurrences are accurately located; however, the map should be considered preliminary with respect to cartographic standards.

Errata

Diabase sills on the geologic map are represented by irregular-shaped red areas.

ABSTRACT

Recent reconnaissance geologic mapping and aeromagnetic data show that long, continuous diabase (dolerite) dikes occur throughout the eastern Piedmont of North Carolina. Two major dike trends are evident: one set trending N. 10°–30°W. and another set trending north. A third, less prominent group trends generally east-northeastward. The new knowledge of locations and patterns of diabase dikes presented on the map accompanying this reports supports observations by earlier workers that diabase dikes in the Appalachian region cut across all other structures and thus reflect deep-seated stresses.

In North Carolina, the north-trending set of dikes has been overlooked by earlier workers because of a lack of detailed regional mapping. These north-trending dikes may be of a different age and chemical composition than the northwest-trending dikes and could have intruded along fractures resulting from a separate stress system.

Some diabase dikes exhibit a strong magnetic expression, while others are only faintly expressed, and still others have no magnetic expression. These varied magnetic responses may be attributed to: 1) differences in the chemical composition of the parental diabase magmas, 2) differences in the mineralogical compositions of the country rock lithologies into which the diabases intruded, or 3) a combination of 1 and 2.

INTRODUCTION

In recent years, a number of workers have systematically studied the diabase (dolerite) dikes of eastern North America and speculated in one way or another on their regional significance. King (1961, 1971) pointed out the wide-spread occurrence of Mesozoic dikes in the Appalachian region and drew attention to their systematic pattern. De Boer (1967) carried out a paleo-magnetic-tectonic study of the Mesozoic dike swarms. Weigand and Ragland (1970) examined the geochemistry of the dikes, and May (1971) related the dike patterns to the predrift positions of the continents and to a stress field imposed on the crust at the onset of North Atlantic sea-floor spreading.

Regional reconnaissance geologic mapping has recently been conducted by staff members of the North Carolina Geological Survey Section of the Department of Natural Resources and Community Development. This mapping shows that long, continuous diabase dikes occur throughout the eastern Piedmont section of the state. Occurrences of diabase have been widely recognized and studied in association with sedimentary rocks of the

Durham, Dan River, and Davie County Triassic basins in North Carolina. Diabase dikes also occur in crystalline rocks throughout the Piedmont. However, it was not until the recent reconnaissance mapping that the large number of dikes, their length, and distribution pattern was known.

Most of the dikes on Plate 1 were originally located and traced in the field from exposures in roadcuts, scattered residual boulders, characteristic soil colors, deflections in stream valleys, and by the presence of resistant ridges. Aeromagnetic data became available later during the mapping project. The aeromagnetic maps in numerous instances made it possible to project dikes where field evidence was lacking, to connect scattered exposures along roads into long, continuous dikes, and to confirm the locations of dikes previously mapped.

ACKNOWLEDGEMENTS

Numerous individuals assisted in the preparation of this report. J. M. Parker, III, and S. G. Conrad reviewed the manuscript and made helpful suggestions. The locations of additional dikes in the Durham Triassic basin were obtained from field maps provided by G. L. Bain. L. C. Bain edited the manuscript, and B. J. McKenzie provided the drafting and technical assistance. Appreciation is expressed to these individuals for their efforts.

GENERAL DESCRIPTION

Diabase, a dark-gray to greenish-black, fine- to medium-grained rock, occurs as both dikes and sills in North Carolina. Narrow, steeply dipping dikes occur in pre-Triassic crystalline rocks as well as in sedimentary rocks of the Triassic basins. Sills are restricted to Triassic sediments. The diabase weathers to brown to yellowish-brown, plastic clay soils. Spheroidal boulders, which often have a characteristic rusty to yellow-brown weathering rind, occur commonly in the saprolite and are found scattered on the surface of the ground.

Most of the diabase dikes and sills consist of similar mineral assemblages but in varying proportions. They have been reported by previous researchers as being composed of 40-65 percent plagioclase (An_{50}-An_{70}), 15-45 percent augite, 0-59 percent olivine, 0-25 percent quartz and potassium feldspar (in the form of micropegmatite), and accessory magnetite-ilmenite, apatite, pyrite, titanite, tremolite-actinolite, biotite, and hornblende. Orthopyroxene and pigeonite are present in some diabases. Secondary alteration is evidenced by biotite, sericite, chlorite, serpentine, iddingsite, magnetite, uralite, antigorite, and leucoxene in amounts up to 6 percent.

Textures are commonly ophitic to subophitic. Justus (1966) recognized a progressive variation of texture across dikes of the Deep River basin. Regardless of composition or thickness, textural variation from contact to center was: porphyritic, intergranular and/or intersertal, isogranular, and subophitic. According to Justus, only dikes 8 meters or more wide exhibit ophitic textures.

Various chemical classifications have been proposed for diabase. Most diabase can be grouped according to the classification proposed by Weigand and Ragland (1970) for dikes of eastern North America. They established two main varieties: a quartz-normative variety and an olivine-normative variety. The quartz-normative dikes can be further subdivided on the basis of TiO_2 and Fe_2O_3 content into low-TiO_2, high-TiO_2, and high-TiO_2-high-Fe_2O_3 types. Modal and chemical variations occur across some dikes but are not consistent. Variations are generally more noticable in the wider dikes.

No correlation between chemistry, tectonic setting, country-rock lithology, or gravity or magnetic anomalies has been established (Weigand and Ragland, 1970). In North Carolina and Virginia, Weigand and Ragland found that olivine-normative and high-TiO_2-high-Fe_2O_3 and high TiO_2 quartz-normative dikes occur with olivine-normative dikes being predominant.

Most dikes contain a chilled border and, depending upon the type of rock intruded, may or may not be bordered by a baked zone or contact aureole. In general, argillaceous sedimentary rocks exhibit a higher susceptibility to contact metamorphism adjacent to the dikes than do the predominantly sandy sediments.

DISTRIBUTION OF DIKES

Plate 1 shows the distribution of diabase dikes in the eastern Piedmont of North Carolina. The dikes plotted include those mapped during previous geologic studies in the Piedmont, as well as those mapped during the current regional mapping. Trends of the dikes as indicated by aeromagnetic anomalies are also included.

Two major dike trends are evident: 1) dikes trending N. 10°-30° W. and 2) dikes trending north or a few degrees east or west of north.

A third, less prominent group of dikes trends generally east-northeastward. Northwest-trending dikes most commonly are in sedimentary rocks of the Durham, Deep River, and Wadesboro Triassic basins. They also occur in an area north of the Wadesboro basin in Stanley, Rowan, and Davidson Counties; in the Johnston, Chatham, Wake County area; and in Nash County (see figure 1 for county outline map and generalized plotting of dikes). The major concentration of north-trending dikes is in the western one-third of the study area in a zone extending from the South Carolina state line to the Virginia state line. Dikes in this group are more closely spaced in the south, where they are sharply discordant to the northwest-trending dikes, and fan out as they trend northward deviating both east and west of north. East-northeast-trending dikes are much less common than those of the other sets. Many of the east-northeast-trending dikes are located within the Triassic basins or along their borders, although some are scattered throughout the study area.

The north-trending dikes are, in general, much longer than the northwest-trending or east-northeast-trending dikes. Several north-trending dikes were traced by a combination of field evidence and magnetic anomalies for more than 60 kilometers. The longest of these extends with only one short interruption from east of Hamlet in Richmond County to east of Williamsburg in Rockingham County and on into Virginia. The length of this dike in North Carolina alone is over 160 kilometers. The majority of northwest-trending and east-northeast-trending dikes are between 1 and 25 kilometers long, and none are greater than 50 kilometers long. The longer dikes are irregularly sinuous rather than continuously straight. A few branch along strike and seem to follow separate fault or fracture zones.

Many dikes in the Triassic basins terminate at the basin border or within a short distance after intrusion into the crystalline rocks, but a significant number of dikes extend far across boundaries between major geologic provinces. Dikes that cross major boundaries do so with no apparent change in trend. Several dikes extend across the slate belt-Charlotte belt boundary; however, in Davidson and Guilford Counties, dikes are conspicuously absent in rocks south of this contact. Some dikes in the eastern slate belt extend northwestward into rocks of the Raleigh belt.

Even taking into account the different levels of detail of mapping, diabase dikes are not evenly distributed throughout the study area. Heavy concentrations are present in some areas such as the central portion of the Wadesboro Triassic basin and the Deep River Triassic basin; whereas, other areas such as central Chatham County are nearly devoid of dikes.

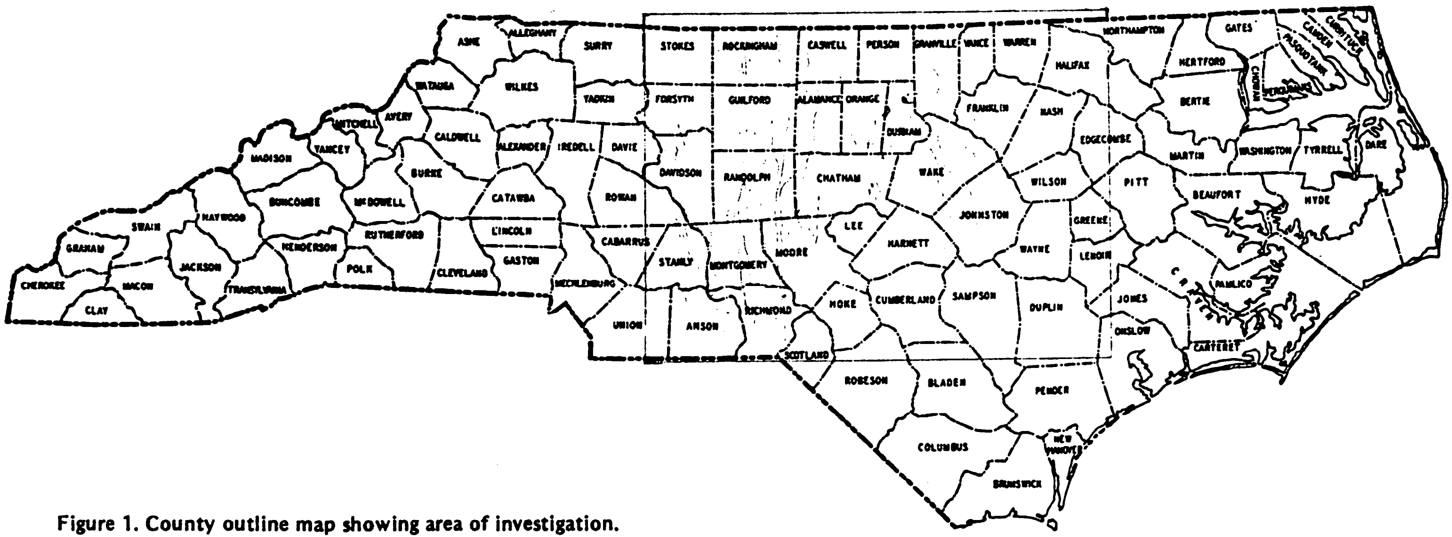

Figure 1. County outline map showing area of investigation.

MAGNETIC SIGNATURES OF DIABASE INTRUSIVE ROCKS

The magnetic signatures or anomalies of many diabase intrusive rocks on aeromagnetic maps are variable and in many instances deceptive. Some diabases exhibit a strong positive magnetic expression, while some are only faintly expressed, and others have no magnetic effect. In general, the north-trending dike set has greater magnetic expression than the other sets. The differences in magnetic effect of the dikes may be the result of differences in the amount of magnetite crystallized from the parental magmas; they may be the result of contact metamorphic effects on country rocks of different compositions adjacent to the diabase intrusives; or they may result from differences in magnetic intensity of the country rock.

Weigand and Ragland (1970) concluded that there can be no simple correlation between chemistry, tectonic setting, country-rock lithology, or gravity or magnetic anomalies among the diabases of North Carolina. Parker (in press) states that sharp linear magnetic ridges, some of which are 600 meters wide and have a relief of 40 to 100 gammas on the aeromagnetic map of the Raleigh, N. C. 1° X 2° quadrangle, result from diabase dikes. He further states that "the dikes are not nearly as wide as the magnetic ridges since half the anomaly is on either side of the dike boundary surface". Parker also points out that many dikes of widths no more than 15 to 25 meters produce prominent magnetic effects, while a 60-meter thick diabase near Garner, N. C., shows only discontinuous magnetic highs. Where diabase dikes extend into the crystalline rocks of the Piedmont, especially those of felsic composition, a relief of 100 to 300 gammas may occur on the aeromagnetic map. However, where the dikes intrude intermediate to mafic intrusive rocks such as diorite and gabbro, their magnetic signature, in most instances, is masked by the strong magnetic expression of the mafic plutons.

Baked or contact metamorphic zones have been described by numerous authors. Allen and Wilson (1968) describe the occurrence of these zones in the Triassic sedimentary rocks adjacent to the diabase dikes in Orange County, N. C. Ragland, et. al (1968) describe the occurrence of dark or purplish hornfels occurring as contact metamorphic aureoles in all argillaceous-type rocks adjacent to the diabase dikes. These hornfels may extend 12 or more meters away from the dikes and the progressive blackening of the clayey rocks toward the dike may be caused by reduction of hematite to magnetite upon heating or by possible metasomatic introduction of magnetite. Contact metamorphic hornfels were not observed where the dikes intruded sandstones. Reinemund (1955) also observed that the diabase intrusives produce contact metamorphic effects in Triassic sedimentary rocks which extend less than 9 meters from the intrusives. Contact metamorphism of the surrounding argillaceous sediments has produced magnetite through the processes of dehydration and reduction. Baked zones adjacent to dikes appear to occur only in Triassic sedimentary rocks and do not extend into the crystalline rocks of the Piedmont.

OBSERVATIONS

The map accompanying this paper significantly expands the knowledge of locations and patterns of diabase dikes that occur in the North Carolina Piedmont. Two major dike trends and one minor trend are evident. One major set of shorter dikes strikes to the northwest, while a second major set of much longer dikes strikes north. The minor trend consists of a few scattered dikes with various strikes grouped around an east-northeast direction.

All the major geologic belts in North Carolina from the eastern slate belt westward to the Blue Ridge belt trend northeast, as do many of the major faults and much of the regional foliation. However, only a few scattered diabase dikes parallel this regional trend—some of which parallel the western border of the Triassic basins or are located within the basins themselves. The northwest-trending dikes strike almost perpendicular to the regional trend of lithologies, while the north-trending dikes are obliquely discordant to both the regional trend of lithologies and the other dike sets. The north-trending dikes crosscut both the crystalline rocks of the Piedmont and the sedimentary rocks of the Triassic basins. These facts add further support to observations by earlier workers (King, 1961, 1971; de Boer, 1967; and May, 1971) that diabase dikes in the Appalachian region cut cleanly across all other structures and thus reflect deep-seated stresses. The irregularly sinuous trace of the dikes suggest that the fractures they intruded are the result of tensile stress, not shear stress.

Weigand and Ragland (1970) found diabase dikes in North Carolina to be predominantly olivine-normative in composition. However, they collected few samples from the north-trending dike set, probably because of the lack of detailed regional maps existing at that time. The lack of comprehensive sampling in previous geochemical studies coupled with the sharply discordant relationship of the two major dike sets in the southern part of the study area and the generally higher magnetic response of the north-trending dike set leaves open the possibility that two major episodes of diabase intrusive activity occurred. The major dike sets may be of slightly different ages and different chemical compositions.

The varied magnetic responses of diabase intrusives may be attributed to the following variables:

1. The chemical composition of the parental diabase magmas
2. The mineralogical compositions of the country rock lithologies into which the diabases intrude, or
3. A combination of 1 and 2.

The dike sets affect local surface drainage patterns and modify groundwater movement in their immediate vicinity. Because some dikes occupy stream valleys, they may nearly everywhere be covered by stream alluvium. For this reason, several extensive dikes mapped on Plate 1 had been overlooked by earlier workers. No doubt we have overlooked some for the same reason.

Throughout this study, we have referred to two major dike sets readily apparent from the map, but we have made no attempt to make a detailed interpretation of the structural significance of this pattern. Are the two major sets of tensile fractures along which the dikes intruded the result of the same stress system? What significance, if any, can be attributed to the fact that the major concentration of the long, north-trending dikes is restricted to a relatively narrow zone in the western one-third of the study area? A systematic study of dike dips might result in additional dike sets being recognized which would influence the structural interpretation of the dike pattern. More detailed studies of dike pattern and chemical composition may help resolve these questions.

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GEOLOGICAL SURVEY SECTION

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