Geology of the Piedmont and Coastal Plain Near Pageland, South Carolina and Wadesboro, North Carolina

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INTRODUCTION

Northeastern South Carolina and the adjacent part of North Carolina is a particularly good area for geologic field trips because of the diversity of features easily visited in a short time. Rocks of the Carolina slate belt are here mildly deformed and metamorphosed, and a variety of volcanic and metamorphic features are preserved. The Haile gold mine, historically the most productive gold mine in eastern United States, is now a major source of sericite and is being actively explored for gold again. Several upper Paleozoic batholiths in the region are part of an extensive belt of granites in the Southern Appalachians. The complexly faulted Wadesboro Triassic basin ends near the state line, and the subsidiary Crowburg basin affords the southernmost exposures of Triassic sedimentary rocks in eastern North America. An 1123-foot-thick Mesozoic diabase dike near Kershaw is possibly the thickest in the Appalachians and is part of a system that extends 120 miles across the Piedmont and into the Blue Ridge province. The Coastal Plain sediments lap partly across the region and include the Cretaceous Middendorf Formation as well as overlying enigmatic sands and gravels whose age and history are poorly known. This field trip provides a quick look at all these features. The guidebook gives a status report on our studies, and points the way to a few other localities that we will not have time to visit.

Geologic studies

Overstreet and Bell (1965a, b) and Stuckey and Conrad (1958) discussed the general geology of South Carolina and North Carolina, respectively, and refer to most of the earlier work in this region. Details of the gold mines and mining areas are summarized by Pardee and Park (1948) and more recently by McCauley and Butler (1966). Graduate students from universities in the Carolinas have contributed valuable information; these references are listed at appropriate places in the following text. Butler and Ragland (1969) and Fullagar (1971) studied the petrology and age relationships of some of the intrusive rocks of this area. Randazzo, Swe, and Wheeler (1970) discussed aspects of Triassic sedimentation in the Wadesboro basin. Heron (1958) studied the Cretaceous of the region.

At the present time Henry Bell III and Peter Popenoe of the U.S. Geological Survey are conducting geological and geophysical studies in the Kershaw and Pageland, S. C. region. A detailed airborne magnetic survey (Popenoe, 1970) and a simple Bouguer gravity map have been completed. David E. Howell and J. Robert Butler are mapping Chesterfield County, S. C., at 1:125,000 scale and the Taxahaw quadrangle at 1:24,000. Walter H. Wheeler and several graduate students under his direction have studied over the past several years Triassic and younger sedimentary rocks in the region.

Figure 1 (available as a download) is a geologic map compiled from Overstreet and Bell (1965a) and the geologic map of North Carolina (1958), and modified with information from numerous more recent sources, particularly Waskom and Butler (1971), Nystrom (1972), U.S. Geological Survey (1970), and the authors' present work. Figure 2 (available as a download) shows the field trip route for both days.

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METAMORPHIC ROCKS

Since publication of the geologic map of North Carolina in 1958 and the geologic map of the crystalline rocks of South Carolina (Overstreet and Bell, 1965a), the metamorphic rocks of the Carolina slate belt and adjacent Charlotte belt have been the subject of increasing study and subdivision; formations have been named in three principal areas. In North Carolina, Conley and Bain (1965) mapped and named formations in the slate belt west of the Triassic basins and in the Denton-Mt. Pleasant area; Stromquist and Sundelius (1969) mapped and described a number of formations included in the Carolina slate belt of that area. Southwest of the area of the field trip, Secor and Wagener (1968) and students of the University of South Carolina have also mapped and described rocks in the slate belt without attempting to make detailed correlations with rocks in North Carolina. The field trip, therefore, will traverse a part of the Piedmont centrally located between areas where the Carolina slate belt rocks have been subdivided into formations

Figure 1 shows the Carolina slate belt essentially as shown on the geologic map of the crystalline rocks of South Carolina (Overstreet and Bell, 1965a). In a broad sense the Carolina slate belt in this area consists of a volcanic-sedimentary sequence overlying what is often referred to as the Charlotte belt-various granitoid gneisses, biotite muscovite schists, and biotite muscovite gneisses. At the base of the Carolina slate belt is a unit of mafic volcanic and sedimentary rocks including dark-green, gray, and black, fine- to coarse-grained amphibolite, hornblende schist, hornblende gneiss, actinolite schist, and chlorite schist; some diorite, metagabbro, biotite gneiss, and numerous basic dikes of several ages and relations are also present. These are the mafic rocks which Overstreet and Bell (1965b) found, on the basis of soil characteristics, to be widespread in the Piedmont of South Carolina and which they thought probably represent a stratigraphic unit in the Carolina slate belt. Overlying these mafic rocks are pyroclastic and volcaniclastic rocks (including agglomerate, breccias, tuffs, and flows), predominately felsic but containing some mafic units. These are the oldest rocks cropping out within the area of figure 1. They are intruded by numerous metamorphosed mafic dikes which do not appear to cut the overlying argillite.

It is these pyroclastic and volcaniclastic rocks which are gold bearing at the Haile mine and other nearby mines and in which sulfide mineralization has occurred. Much sericite-chlorite schist, quartz-sericite schist, and silicified rock is associated with these mineralized rocks, particularly at eh Haile and Blackmon mines. Coarsely crystallized muscovite from areas of hydrothermal alteration, dated by K-Ar methods as 415 and 358 m.y. (Bell, Marvin, and Mehnert, 19720, indicates that this alteration preceded by a substantial length of time the emplacement of the nearby granite plutons to which the mineralization had previously been tied (Pardee and Park, 1948). The alteration and mineralization, therefore, is more likely to be related to the volcanism that produced the pyroclastic and volcaniclastic rocks.

The uppermost rocks of the Carolina slate belt in this area are gram and greenish-gray argillite or slates and graywacke. Regionally, these rocks are in the greenschist facies of metamorphism; locally, however, contact metamorphism to the hornblende-hornfels facies has occurred around the granite intrusions. The contact metamorphic aureoles are generally narrow but range from about 0.5-3 miles (about 1-5 km) wide.

The rocks of the Carolina slate belt have been deformed into several broad regional folds and numerous smaller anticlines and synclines, some of which may be isoclines. Two major northeast-trending anticlines occur in the area of the field trip. These are roughly parallel to the trend of the Triassic basins and some of the border faults. The western anticline, plunging to the northeast, has granitic gneiss of the Charlotte belt in the core to the southwest of figure 1 and amphibolite, volcaniclastic rocks, and argillite on the limbs. The eastern anticline, recognized by Waskom and Butler (1971) in North Carolina, plunges to the southwest. These tow anticlines, which may be a single structure, seem to have influenced the location and perhaps the shape of the granite plutons. Faults are numerous and of many ages. Many of the northeast- and northwest-trending faults which cut Triassic rocks can be traced into underlying rocks of the Carolina slate belt. A. major Triassic border fault of this sort may extend southwest from North Carolina across the area shown in figure 1 to the vicinity of Lancaster, South Carolina. Some of the northwest-trending faults apparently related to the Triassic basins have been intruded by diabase dikes. In addition, many of the Triassic dikes, particularly the dike swarm near the Haile mine, also appear to have been intruded into northwest-trending fractures that predated the time of emplacement of the granite plutons.

In the southeast part of the geologic map (fig.1) a major fault is shown cutting rocks of the Carolina slate belt. This fault crops out to the southwest near Camden. It is reflected in the Bouguer gravity anomaly map as a gravity gradient (Popenoe and Bell, 1974) and in both the regional and detailed aerial magnetic data (Taylor, Zeitz, and Dennis, 1968; U.S. Geological Survey, 1970).

GRANITE PLUTONS

In the field trip area, the three granitic plutons which intrude rocks of the Carolina slate belt near the crest of broad regional anticlines are the Liberty Hill pluton to the southwest, the Pageland pluton, and the Lilesville pluton to the northeast. These three plutons appear very similar in hand specimen, outcrop area, petrology, and age. They are generally lacking in cataclastic fracturing, have no gneissic texture or strong foliation, and were emplaced after the last regional metamorphic event.

The three plutons are part of a string of at least eight post-metamorphic granitic plutons that extend about 350 miles, from northeast of Raleigh, N. C. to central Georgia. The plutons were emplaced in the epizone or upper mesozone. Rubidium-strontium whole-rock isochron ages range from 295 to 332 million years, but most are near 300 m.y. (Fullagar, 1971, 1974, pers. Commun.). Other plutons of this group may be hidden beneath the Coastal Plain.

Liberty Hill pluton

The Liberty Hill pluton has a nearly circular outcrop area, a part of which is in the map area (fig. 1). The pluton coincides closely with a large gravity minimum. The Rb-Sr isochron age is 299 +/- 15 m.y. (Fullagar, 1971). The rock is coarse-grained porphyritic or subporphyritic quartz monzonite with some local finer grained or nonporphyritic facies. The pluton is emplaced into rocks of the Carolina slat belt on the south, east, and north. These are pyroclastic and volcaniclastic rocks and argillites that can be correlated with rocks described by Secor and Wagener (1968) in the Irmo and Winnsboro areas to the west. The pyroclastic and volcaniclastic rocks crop out to the northeast of the Liberty Hill pluton along the Wateree River south of the pluton. To the southwest and west the rocks in contact with or close to the Liberty Hill pluton include amphibolite, gabbro, and granitic gneiss.

The Liberty Hill pluton contains large septa and rotated inclusions of adjacent country rock, particularly near the contacts on the south and southeast. This is good evidence for the intrusive nature of the granite pluton.

Contact metamorphic effects produced by the quartz monzonite of the Liberty Hill pluton have not been studied in detail, but thermal effects have been produced on the rocks of the Carolina slate belt and on inclusions in the granite. Aeromagnetic data show, along the contacts, strong anomalies about a mile wide; these are the result of increased magnetite content in hornfels. Cordierite has also been seen about half a mile from the contact.

Pageland pluton

The Pageland pluton is similar in appearance and composition to the Liberty Hill pluton but no fine-grained facies have been identified. It has a Rb-Sr isochron age of 302 +/- 5 m.y. (Fullagar, 1974, pers. Commun.). The outcrop area is largely covered by a thin veneer of Coastal Plain sedimentary rocks. Enough of the rock is exposed, however, in stream valleys to establish that the outcrop area would be oval, the longest axis trending northeast, if the very thin overlying sands were stripped away. The Pageland pluton is intruded into and is in contact with the same formations that are in contact with the east, northeast, and southern contacts of the Liberty Hill pluton. Outcrops of the two plutons are no less than about 6.5 miles (10 km) apart. Nothing indicates that the two bodies are connected at depth. A large gravity minimum occurs in the vicinity of the Pageland pluton. The anomaly is amoeboid in shape, having one lobe in the outcrop area of the pluton and another lobe to the northwest where granitic rock foes not crop out. Contact metamorphic effects have been produced in the country rocks by the intrusion but the pronounced magnetic anomalies produced on similar rocks by the Liberty Hill quartz monzonite do not seem to be present. Bundy (1965) has studied the rocks in contact with the pluton on the north and northwest; he found rocks in the epidote-amphibolite grade of regional metamorphism widespread in the Carolina slate belt.

Lilesville pluton

The granite of the Lilesville pluton has a Rb-Sr isochron age of 332 +/- 12 m.y. (Fullagar, 1974, pers. commum.). The granite as described by Waskom and Butler (1971) has features which set it apart from the other granitic plutons to the southwest, although it is only 10 miles (16 km) from the Pageland pluton. On the southeast the pluton cuts rocks of the Carolina slate belt similar to those cut by the Pageland quartz monzonite. On the northwest, however, it is in contact with rocks of the Wadesboro Triassic basin along a border fault. In addition, a smaller body of Triassic rocks is in contact with the granite to the northeast. A gabbro, clearly intrusive as indicated by the contacts and inclusions of granite within the gabbro (Waskom and Butler, 1971), occurs in the eastern part of the pluton. In the southern part of the granite outcrop, there is an area of mica gneiss that Waskom and Butler interpret to be a window through the granite exposing thermally metamorphosed rocks. The Lilesville granite is a zoned pluton, commonly a coarse-grained porphyritic rock, ranging in composition from adamellite to granodiorite and locally having rapakivi texture. The granite contains numerous xenoliths throughout and more abundantly near the contacts with the country rocks. A thermal aureole occurs in rocks of the Carolina slate belt. It is rocks in the inner portions of the aureole which closely resemble the mica gneiss in the southeast part of the granite.

The Bouguer gravity anomaly that coincides with the Lilesville granite is distinctively different from the anomalies associated with the other two plutons to the southwest. It is a positive Bouguer anomaly trending east-west and slightly offset to the south from the outcrop area. A pronounced high-gravity area of more than 10 milligals occurs over the gabbro intrusion in the eastern part of the pluton. Waskom and Butler assert that “The gabbro intrusion and the mica gneiss unit that underlie the batholith are. . . responsible for such a large gravity maximum over an otherwise felsic igneous intrusion.” As a result of model studies Waskom and Butler (1971) consider that the gabbro consists of a central mass and a tongue intruded northwestward towards the crest of the anticline. They consider the granite to be a thin sheetlike or tonguelike body which is thickest to the northwest.

Gabbro

The gabbro associated with the Lilesville granite is clearly intrusive into the granite as indicated by the contacts and inclusions of granite within the gabbro. The gabbro is a massive coarse-textured rock composed of hornblende, olivine, plagioclase, pyroxene, and accessory minerals. It grades to a diorite composition in the outer part.

TRIASSIC BASINS

The Deep River Triassic Basin may be divided into three parts: the Durham Basin and the Sanford Basin in North Carolina and the Wadesboro Basin in North and South Carolina.

A brief discussion of the Durham and Sanford Basins is presented first, in order that their many differences with the Wadesboro Basin may be noted. The Durham and Sanford Basins are asymmetrical grabens that are tilted to the east toward a major fault, the Jonesboro fault, which was active both during and after Triassic sedimentation. Border fanglomerates along the Jonesboro fault are extensive and extend, at least 2 miles (3.2 km) into the basins at some localities. Fanglomerates are angular, coarse-grained, poorly sorted conglomerated that may be inferred to have been deposited as an alluvial fan. The proximal portions of the fans are very poorly sorted and the pebbles reflect quite closely the lithologies of the adjacent crystalline rocks. The distal portions of the alluvial fans are also predominately pebbles of various crystalline rock types, but they are better sorted and much more rounded. The depositional centers of the Durham and Sanford Basins have sedimentary rocks which indicate some manner of swamp or lacustrine conditions.

The western border of the Durham basin is complexly faulted (Harrington, 1951), and it has conglomerates in some places but not in others. The western border faults, however, need not have been active until after deposition of the sediments. The western border faulting was simpler in the Sanford basin (Reinemund, 1955; Conley, 1962). Very quartzose conglomerated containing rounded quartz pebbles are found on the western border of the Sanford basin northwest of Carthage, N. C. These conglomerates were once quarried as a millstone grit. They were probably deposited near the edge of the basin but before the western border faulting began. The well-known Triassic coal and black shale of the Cumnock Formation is in the depositional center, although not the geographic center, of the Sanford basin (Reinemund, 1955). In the Durham basin one small area of lacustrine limestone and chert has been found (Wheeler and Textoris, 1971).

The Wadesboro basin differs from the Durham and Sanford basins in several important ways. There is no coarsening of the sedimentary rocks toward a post-depositional eastern border fault. The western border is intensely splintered by long narrow horsts and grabens filled from wall to wall with coarse fanglomerate. No coals, limestones, or black shales occur in the depositional center of the Wadesboro basin, but a patch of arkosic conglomerate that is clearly derived from a granite along the eastern border does occur near the western border. Coarse conglomerate containing well rounded clasts of argillite derived from the Carolina slate belt is found in the interior of the basin.

The Triassic sedimentary rocks strike N 33^{o} E and dip about 20^{o} toward the southeastern border fault. They consist dominantly of sandstones and siltstones and lesser volumes of conglomerate and clay. The sandstones are mainly arkosic wackes and feldspathic wackes. The arkosic wackes occur along the eastern margin and in the interior of the basin; the feldspathic wackes occur throughout the basin. An example of conglomerate with argillite clasts and one with feldspar clasts are seen on stops 12 and 11, respectively, of the field trip. Dark red siltstones and claystones are abundant throughout the basin and occur alone or interbedded with sandstone (Randazzo, Swe, and Wheeler, 1970). The fanglomerates of the Wadesboro basin are limited to the structurally splintered western border; they are unexpectedly lacking along the eastern border. Slate pebbles dominate in them, and quartz pebbles are less than 10 percent of the volume. The sand and mud matrix of the fanglomerates ranges from 15 to 35 percent of the volume. Intraformational lenses of sandstone are common.

The eastern border fault of the Wadesboro basin may be an extension of the Governors Creek Fault, which is a large fault in the interior of the Sanford Basin. This fault trends N 33^{o} E except near its southern terminus. Sandstones and siltstones common to these strata dip about 20^{o} into the fault, showing that the fault was post-depositional.

A small outlier of Triassic rocks about 2 miles wide and 6 miles long (about 3 x 10 km) occurs southwest of Ellerbe, Richmond County, North Carolina, and near the northeastern edge of the geologic map (fig. 1). It is about 6 to 8 miles (10 to 13 km) from the eastern border of the Wadesboro basin. The Ellerbe basin contains typical Triassic sedimentary rocks, including some striking fanglomerates. These fanglomerates lead us inevitably to the hypothesis that the Ellerbe basin is remnant of the missing eastern half of a former more extensive Wadesboro basin. The geologic map of North Carolina (1958) shows the Jonesboro fault inferred as passing along the eastern margin of the Ellerbe basin. However, Waskom (1970) mapped the Ellerbe basin and found that the distinguishable fault lay along the western margin, the "wrong side." He found no clear fault along the eastern margin, which, however, is considerably obscured by Cretaceous and Cenozoic Coastal Plain sands.

The western border faults of the Wadesboro basin were noted to some extent by Russell (1892), were well delineated on the North Carolina state geologic map (Stuckey and Conrad, 1958), and reported in great detail at eh the southern end of the basin by Randazzo (1965). The faults bounding the northwest border are recognized by the adjacent fanglomerates and to a lesser extent by long, straight topographic slopes into the little grabens; at some places an actual fault zone a few feet wide was observed (Swe, 1963). The map patterns show areas of generally Triassic rocks where narrow strips and small islands of Carolina slate belt rocks and narrow strips of Triassic sedimentary rock enclosed in areas of Carolina slate belt rock. At one locality northeast of Ansonville, Swe (1963) found in a tiny graben fanglomerates which were crushed to pieces by post-depositional movement.

The Crowburg Triassic basin is southwest of the Wadesboro basin and includes the southernmost outcropping Triassic sedimentary rocks in eastern North America. The basin is wedge-shaped, about 4 miles (6 km) long and as much as 1¼ miles (2 km) wide. The border of the basin is marked nearly everywhere by a prominent scarp that is 50 to 100 feet (15 to 30 m) high. Outcrops in the basin are mainly fanglomerates; much lesser amounts of maroon to yellowish white sandstones and shales crop out.

MESOZOIC DIABASE DIKES

A striking feature of the geology in the field-trip area is the northwest-trending Mesozoic diabase dikes; probably more than 50 dikes are found in the region here. The major concentration of dikes is a swarm between the Liberty Hill and Pageland plutons in which 13 dikes large enough to be detected by magnetic means have been identified in the 6 ½ miles (10 km) between the two granitic plutons. Five have been found in the Haile mine area, where they cut the mineralized rock. The swarm is one of those observed by King (1971) to occur at intervals of about 60 to 80 miles (90 to 105 km) in the southern Appalachians. The largest dike is the Flat Creek dike near Kershaw; it is 1123 feet (340 m) thick where seen at Stop 4 (fig. 1). The dike is thickest where it cuts the Pageland granite and narrows drastically as it passes into the slate belt rocks. Steele (1971) believed that the Flat Rock dike extended for 45 miles (70 km) northwest, but this is hard to demonstrate because of discontinuous exposures. At any rate, the swarm extends for 120 miles (190 km) to the northwest and one member crosses the Brevard zone into the Grandfather Mountain window (Reed, 1964). The dikes range in thickness down to a foot or less, but the median width is probably near 50 feet (15 m). Detailed magnetic surveying has shown the dikes to be more abundant and longer than previously realized from geologic mapping. Some of them cut the granite plutons but most do not. The contact metamorphic effects produced by intrusion of the dikes ranges from pronounced on some rocks to no easily detectable effects on others. Most of the dikes in this swarm are olivine-normative and olivine-modal tholeitic diabases. They are younger and distinctly different from the metamorphosed andesitic and basaltic dikes which cut the volcaniclastic and volcanic rocks of the Carolina slate belt in this area.

COASTAL PLAIN FORMATIONS

Sedimentary units of the Coastal Plain unconformably overlie all of the major rock types discussed previously, including the Mesozoic diabase dikes. In the field-trip area, these rocks are a complex of poorly fossiliferous non-marine strata consisting of sand, silty sand, gravel and some silt and clay. The formations to be seen in the filed-trip area are, in ascending order: Middendorf Formation,[1] Upper Cretaceous; so-called "Citronelle" Formation, upper Miocene or Pliocene; Pinehurst Formation,[2] upper Miocene of Pliocene; and Brandywine Formation, Pliocene (?), but considered Pliocene or Pleistocene by some. Many aspects of these Coastal Plain sedimentary rocks are controversial. Part of the problem is that fluvial sediments of one age may appear similar to fluvial sediments of another age and many outcrops, therefore, are of unknown age. In addition, confusing loose white or light-colored sands mantle much of the Coastal Plain surface in the field trip area. The origin of these sands may be difficult to determine but they are probably of, at least, four types: (1) residual A-horizon of soils developed on the Middendorf Formation; (2) Aeolian sands of the Pinehurst Formation; (3) fluvial sands on stream terraces, some correlated with the Brandywine Formation; and (4) slope wash that moves downhill and clogs the small stream valleys. We do not imply that every outcrop can be confidently referred to one of these types.

Middendorf Formation

The Middendorf Formation as used locally is of early Late Cretaceous age, and it is the oldest Coastal Plain unit in the field-trip area. It is a very typical fluvial unit containing lensing sands and impure clays (field trip stops 1 and 10).

Most sands of the Middendorf Formation are cross-bedded muddy sands which have very small feldspar content and which rarely contain carbonaceous material, although petrified wood is moderately common at some localities. "The Middendorf Formation consists of loose to poorly indurated sands, thin lenses of gritty mudstone to silty clay, and rare laminated layers of sand and mud" (Swift and Heron, 1969, p. 214). The sands contain some gravel lenses. Clay balls are common and quite diagnostic. Very pure kaolin lenses of the

1.This name is herein reinstated for U.S. Geological Survey usage.

2.This name as previously used by Conley (1962) is herein adopted for U.S. Geological Survey usage.

type well known in the Tuscaloosa Formation do not occur in the area. According to Cooley (1970, p. 14), "Clay-ball conglomerates were a significant aid in differentiating the Middendorf and the overlying Citronelle Formation." He also states that gravel occurs throughout the Middendorf in layers 1 to 5 feet (as much as 1.5 m) thick. The gravel contains pebbles commonly as much as an inch in diameter and rarely as much as 3 inches; larger size may occur in a thick basal conglomerate. Cooley (1973) cautions that care must be used to avoid confusing these Middendorf conglomerates with the Citronelle Formation.

The cross-stratification, paleocurrents, and probable environment of deposition were studied intensively in southern North Carolina by Ibrahim (1973). He found large scale grouped planar and trough cross-bedding, distorted stratification of several types, and clay-ball and hematite-cemented concretions. These and other features suggest "channel-point bar environment of deposition. Structures that are indicative of overbank fluvial environment are very scarce in outcropping Middendorf sediments." Paleocurrents show a generally southeast transport but with apparent centripetal flow toward a "Cape Fear embayment" in early Middendorf time. "Fluvial cyclicity was the sedimentary process responsible for the construction of the Middendorf stratigraphic column in south central North Carolina" Ibrahim, 1973).

Citronelle Formation

This name should, perhaps, be written "Citronelle" because the relation of thee rocks to the type Citronelle of southern Alabama is not well known. Other names for these rocks such as "Lafayette" have proven to be inapplicable. The term "high-level gravels" is an accurate description but hardly a good stratigraphic name.

The formation in the field-trip area consists of cross-stratified sands with intercalated stringers of gravel. A basal gravel, usually over 15 feet (5 m) thick, is present. The sands are pebbly with only a small mud content. The pebbles and cobbles of the "Citronelle" are mainly quartzite with less than 20 percent vein quartz. The gravel is extremely high in silica (over 98 percent) and is much in demand by the steel industry (field trip stop 10). The sand beds are not as well exposed as the gravels. The sand grains are angular to subangular and poorly sorted. Feldspar grains are rare (Cooley, 1970). The sands are thick-bedded and the gravels are very thick-bedded (up to 200 cm). The paleocurrent directions show a striking parallelism to the modern stream course of the Pee Dee River, even along southwestern trending segments of the stream. According to Cooley (1970) this contrasts with the generally southeastern direction for the Middendorf paleocurrents in the Pee Dee River area. That the "Citronelle" is fluvial is shown by the well-developed pebble imbrication, medium- to large-scale simple cross-stratification, and moderate to poor sorting of the gravel fraction. The gravels are channel-bar accumulations resulting from intermittent high-energy conditions. The Citronelle Formation has a basal slope of 2m/km (10 ft/mile).

The "Citronelle" Formation of North Carolina was divided into two members by Ibrahim (1973, pp. 13-14): the Lilesville and West End Members. The Lilesville Member of the Citronelle Formation has its type location at eh Hendricks gravel pits near Lilesville in Anson County, North Carolina; his West End Member of the "Citronelle" Formation has its type locality at the D. H. Wilson sand pit east of West End in Moore County, North Carolina. This is a very useful division provided that the lower unit in the West End pit is indeed "Citronelle"; both Bartlett (1967) and Cooley (1970) regard it as an outcrop of the Middendorf Formation.

The problem of the resemblance of different Coastal Plain units to each other will always be with us. A fluvial muddy Cretaceous sandstone is bound to resemble a fluvial muddy Miocene or Pliocene sandstone, especially if the latter is recycled from the Cretaceous deposits into a not dissimilar environment.

Pinehurst Formation

There is a widespread fine-grained unconsolidated post-Middendorf sand unit lying to the west of the Orangeburg scarp in the Carolinas. This unit is the Pinehurst Formation; named by Conley (1962, p. 18) who stated that the type section was in the D. H. Wilson sand pit on the north side of Highway 211, approximately 1.5 miles (about 2 km) southeast of the center of the town of West End, North Carolina. It is unfortunate that he did not include a measured section of the type section, because there are two different formations present at the sand pit as noted by Bartlett (1967, p. 76-77), Cooley (1970, p. 54-55), and Ibrahim (1973, p. 12-13). Bartlett (1967, p. 78-80) does give a measured section from the pit and shows 21.5 feet (7 m) of Pinehurst sands overlying 33 feet (10 m) of micaceous sandstones, quartz gravel, and a little sandy clay of the Middendorf Formation. We are using the term Pinehurst as thus redefined.

The Pinehurst Formation is composed of loose, slightly clayey, medium to very coarse quartz sand. Most outcrops have a good soil profile with an A-horizon that is 1-2 meters thick underlain by 4 meters of white and reddish brown sand. Large-scale high-angle cross-bedding is seen in deep cuts (field trip stop 7). Shallow outcrops seem to be devoid of primary structures, but this is a weathering effect.

The modal class of the sand size ranges from coarse to fine sand, but the mean size is more constant (1.02 to 2.0, first moment calculation). The standard deviation varies from moderately well sorted to moderately sorted. Cooley (1970, p. 60) states that "this range in sorting values does not commonly occur in inland dune sediments, but can be readily explained by a more or less local derivation for poorly sorted sands of the Middendorf." The Pinehurst sands have a standard deviation and skewness which is intermediate between soils on the Middendorf Formation and sand dunes in Georgia. Eolian transport probably removed the fine fraction.

At some outcrops the Pinehurst Formation shows good argillite banding. These are darker colored layers which contain a greater concentration of illuvial clay, but these layers conform to bedding planes. It is a pedogenic process related to downward transport of clay in percolating ground waters, but the original depositional layering exerted some sort of control of this illuvial redeposition (Bartlett, 1967, p. 86).

The origin of the Pinehurst Formation poses a problem. It unquestionably "looks" eolian at first glance. Bartlett so regards it and cites the cross-bedding as evidence (1967, p. 82-89). He cites the general steepness of dip (up to 37 degrees), the unusual length of the cross-bed sets, frosting of the sand grains and general absence of fluvial characteristics as evidence for an eolian origin.

As noted above, Cooley regards the grain size and sorting as simply too coarse to be eolian, and he cites the work of Yeakel (1962) on Silurian sandstones and of Hoyt (1967) on high-angle stratification in littoral and shallow neritic environments of the central Georgia coast.

A further complication in this area is pedogensis. The long, warm summers of Carolina permit vigorous soil formation. The A-horizons of sandy units lose clay downward by illuviation. The upper part of the B-horizons accumulate this clay as well as some iron oxide. The boundary between A- and B-horizons may be quite sharp and have an unfortunate resemblance to a formation contact with a loose white sand with only 2 to 10 percent clay above and a reddish, massive, somewhat resistant clayey sand below. If the Pinehurst Formation may be present in an area, one must be aware that it may bear close resemblance to the A-horizon of the Middendorf Formation. The evidence that a surficial sand may merely be a pedogenic horizon would be (Gamble, Daniels, and McCracken, 1970): uniformity of sand sizes across the A-B contact and a vertically microtounged A-B horizon contact. The A-horizon is very thick in the Sandhills area, because dissection keeps the water table low.

Cooley's map does show a rather unexpected relationship or perhaps lack of relationship between the "Citronelle" and Pinehurst Formations-they are nowhere in contact. The "Citronelle" lies entirely within the area of influence of the Pee Dee River. The Pinehurst Formation lies to the northeast in the Sandhills area. The nearest approach of outcrops is about 4 miles (6 km).

The work of Daniels, Gamble, Wheeler and Nettleton (1966) northeast of the Cape Fear River involved data from many power-auger holes. They found that above the Coats scarp (similar to Orangeburg scarp) there was a post-Middendorf sand and gravel unit which they referred to the Pinehurst Formation. It is rather "Citronelle" in character but is clearly not the Pinehurst Formation as restricted by Bartlett and by Ibrahim.

The "Pinehurst problem" will remain with us for some time.

Brandywine Formation

The Brandywine Formation is lithologically similar in appearance to the "Citronelle" Formation; they differ greatly, however, with respect to physiographic position. The Brandywine Formation lies entirely to the east of the Orangeburg scarp (Johnson and Dubar, 1964), is primarily developed near the larger rivers such as the Pee Dee River, and lies at elevations of about 270 to 230 feet (82 to 70 m). The gravel fraction of the Brandywine Formation differs from that of the "Citronelle" in occurring only as lenses or stringers at the bases of channeled lenses, in being more poorly sorted, and in having only 55 percent of the clasts as metaquartzite (Cooley, 1970), p. 80). The Brandywine Formation is seen at field trip stop 1.

FIELD TRIP LOG FOR FIRST DA

October 5, 1974

ASSEMBLE at Ingram Motel, U. S. Highway 1 and 52, Cheraw, S. C. The trip will start promptly at 8:00 a.m. You should have sufficient fuel for more than 150 miles of driving. In the log, my column M gives cumulative mileage for the day and column D gives distance between notations.

M	D	
0.0	0.0	Parking lot of Ingram Motel, TURN LEFT onto U. S. Highways 1 and 52 north, toward Cheraw business district.
0.7	0.7	TRAFFIC LIGHT in downtown Cheraw, TURN LEFT following U. S. 1 and 52 north.
1.1	0.4	TRAFFIC LIGHT, continue STRAIGHT on U. S. 52 north. U. S 1 turns to right.
2.1	1.0	Roadcuts expose Middendorf Formation and overlying stream gravels; highway to north is on sandflats.
2.9	0.8	Highway crosses Carolina bay that is clearly visible on aerial photographs. Low sand ri can be seen north of the highway
4.9	2.0	Highway leaves sandflats. Roadcuts for next mile are mostly in Middendorf Formation.
6.4	1.5	Good exposures of Middendorf Formation over weathered argillite.
7.0	0.6	Westfield Creek, just south of bridge, has good exposure of argillite which is one of the easternmost in South Carolina. Folds here are overturned toward the southeast, with northwest-

dipping axial surfaces.

7.6 0.6 **STOP 1.** Weathered argillite overlain unconformably by Middendorf Formation overlain unconformably by terrace gravels (Brandywine Formation); basement cored anticline (?) of Middendorf Formation, U. S. 52, 6.5 mi. north of Cheraw, S. C.

The argillite here is deeply weathered, but the attitude of bedding and cleavage can be seen in some places. Diffusion banding (Liesegang banding) that develops during weathering is easily confused with bedding. The Middendorf Formation, unconformably overlying the argillite, is as much as 20 feet thick and consists mainly of cross-bedded sandstone and conglomerate containing clay balls and some clay lenses. There are prominent ledges of iron-oxide-cemented sandstone and conglomerate. The Middendorf is in turn unconformably overlain by terrace gravels as much as 5 feet thick that were correlated with the Brandywine Formation of Cooley (1970). The Brandywine was deposited by an ancestral Pee Dee River as a relatively thin series of channel, bar, and possibly minor overbank deposit.

Near the north end of the outcrop, beds in the Middendorf can be traced across an anticlinal core of argillite, and some beds appear to maintain a constant thickness across the structure. Heron (1959) considered four hypotheses for origin of the structure: (1) tectonic folding, (2) original sedimentation, with beds deposited at the angles now seen, (3) differential compaction in the Middendorf, and (4) differential subsidence in the argillite caused by compaction of by solution of a soluble mineral such as calcite. Heron favored number 4. Everyone knows that the Cretaceous is never folded in this manner, so it can't be number 1. Or can it?

About 200 yards south of the stop is an outcrop of argillite cut by a fault. Offset along the fault is unknown, but could be sizable (tens of feet?).

Continue northwest on U. S. 52.

9.9 2.3 TURN LEFT onto Road 13-61, just south of North Carolina state line.

10.1 0.2 CAUTION, unprotected railroad crossing.

11.1 1.0 Creek, argillite, exposed in valley with Coastal Plain on both sides.

12.7 1.6 STOP SIGN, TURN LEFT onto Road 13-23.

17.7 5.0 STOP SIGN, TURN RIGHT onto S. C. 9.

18.0 0.3 Thompson Creek and Chesterfield city limits.

18.6 0.6 TURN LEFT, following S. C. 9 by-pass through Chesterfield.

19.6 1.0 TRAFFIC LIGHT, intersection with S. C. 145; continue westward on S. C. 9 by-pass.

20.8 1.2 STOP SIGN, TURN LEFT following S. C. 9 west.

23.4 2.6 Intersection with S. C. 265, continue westward on s. C. 9.

25.1 1.7 Ruby city limits.

28.1 3.0 Mt. Croghan city limits.

33.4 5.3 Borrow pit on right exposes residual boulders and saprolite of granite in the Pageland pluton; the contact is a few hundred yards under the Coastal Plain.

33.9 0.5 Pit wall on right exposes sand over Middendorf Formation.

37.2 3.3 Pageland city limit. Pageland, "Watermelon Capital of the World," is built on a thin edge of Coastal Plain sediments overlying granite.

38.2 1.0 TRAFFIC LIGHT, Pageland center. Intersection of S. C. 9 with U. S. 601, continue straight ahead (west).

38.7 0.5 TURN RIGHT on S. C. 207.

39.4 0.7 Low country ahead is the northern end of the Crowburg basin.

39.7 0.3 Light-colored rocks in road cut are felsic metavolcanic rocks that are probably in fault contact with argillite just to the north.

41.0 0.2 **STOP 2.** Triassic fanglomerate in Crowburg basin, S. C. 207, 3.4 mi. northwest of Pageland. The roadcuts here expose westerly-dipping fanglomerates near the east end of the Crowburg Triassic basin. Maroon to red shale, siltstone, and sandstone are interbedded with fanglomerate. The clasts are mostly argillite with some vein quartz, and range up to one ft. across. Fanglomerate is the major rock type observed in the Crowburg basin.

Continue west on S. C. 207.

42.1 0.9 Intersection, CONTINUE westward on S. C. 207. This is the site of the former hamlet of Crowburg.

42.9 0.8 Cross border fault of Crowburg basin and ascend escarpment.

43.6 0.7 TURN LEFT onto Road 13-487.

44.2 0.6 Pass argillite outcrop and descend escarpment of Crowburg basin. Good view across the basin to the escarpment on the opposite side of the basin.

45.1 0.9 TURN RIGHT onto Road 13-105 and re-ascend the escarpment, Argillite north of intersection shows good cleavage-bedding relationships.

45.5 0.4 TURN LEFT onto Road 13-545.

47.1 1.6 South end of outcrop on left (opposite dirt road) is probably the southernmost exposed Triassic sedimentary rock in eastern North America. The border fault is exposed, and has deformed argillite to northwest and strongly weathered Triassic fanglomerate to southeast.

47.3 0.2 TURN LEFT (east) onto S. C. 9. Flood plain of the Lynches River ahead, and large diabase dike on south side of road after turn.

47.5 0.2 Passing good outcrops of felsic metavolcanic rocks.

49.2 1.7 Roadcuts here are dark-red weathering hornfels in the aureole of the Pageland granite, and contact of which we cross about 200 yards to east.

50.0 0.8 Roadcuts on left expose Middendorf Formation lying unconformably over Pageland granite.

50.4 0.4 TURN RIGHT (south) onto Road 13-105.

50.7 0.3 TURN RIGHT (southwest) onto Road 13-67, before reaching the intersection with U. S. 601.

52.7 2.0 In saprolite bank on right, hornfels xenolith is enclosed in granite.

53.6 0.9 Bridge over Lynches River, enter Lancaster County, road becomes 29-37.

53.8 0.2 In roadcuts on left, Mesozoic diabase dike cutting granite, both contacts exposed.

54.3 0.5 **STOP 3.** Contact between granite and hornfels at the southwestern edge of the Pageland pluton, Road 29-37, 0.7 mi. southwest of Lynches River in eastern Lancaster County. The contact is well exposed in cuts in saprolite on both sides of the road and in a barrow pit north of the road. The granite shows some decrease in grain size toward the contact, but there is no fine-grained chilled margin. The contact trends about N25E and dips steeply; however, the dip is varied. Hornfels of the type seen here is common around the 300-m.y.-old granite plutons. The aureoles range from about ½ to 3 mi. wide. Texture of the hornfels is fine-grained and granoblastic or poikiloblastic. The assemblage hornblende-plagioclase-quartz-biotite-epidote indicates the rock is in the hornblende-hornfels facies. Layering in the hornfels near the contact has the attitude N65E, 55NW and appears to be little affected by intrusion of the granite.

Continue south on Road 29-37.

54.4 0.1 Felsic hornfels exposed on left.

56.4 2.0 TURN LEFT on to road 29-123 in downtown Taxahaw.

56.6 0.2 TURN RIGHT onto road 29-27.

57.0 0.4 CONTINUE on Road 29-27. Sand road to right goes to Forty-acre Rock in the Pageland granite, which was Stop 1 of the 1973 CGS Field Trip.

59.0 2.0 TURN RIGHT onto U. S. 601 and cross Flat Creek.

59.5 0.5 **STOP 4.** Flat Creek diabase dike, the “Great Dike of South Carolina,” U. S. 601, 8.5 mi. northeast of Kershaw, and 0.2 mi. southwest of Flat Creek.

This roadcut provides excellent exposures of a northwest-trending Mesozoic diabase dike that is 1123 ft. thick; it may be the thickest diabase dike in eastern North America. To the southeast, the dike is covered by Coastal Plain sediments; to the northwest, Steele (1971) traced the dike for 45 miles. The dike is part of a swarm that extends from the edge of the Coastal Plain across the Piedmont for more than 120 miles. The northwesternmost member cuts the Brevard zone and extends into the Grandfather Mountain window. Mapping by Butler and Howell north of this point shows 14 dikes in a distance of 8 miles across strike.

Most of the dikes in the swarm are olivine-normative and olivine-modal tholeiitic diabases; the Flat Creek dike contains up to 5 percent modal olivine, but is quartz normative with 53 percent SiO_2 (Steele, 1971). Steele’s intensive study (95 samples analyzed from this road cut) showed slight symmetrical changes in chemical composition across the dike. His interpretation is that there were two injections of magma, with some magma mixing and fractional crystallization.

The dike is thickest where it cuts the Pageland granite pluton and narrows drastically where it passes into the slate belt. For example, one-half mile north of the granite contact (about 3 miles northwest of this stop), the dike is only about

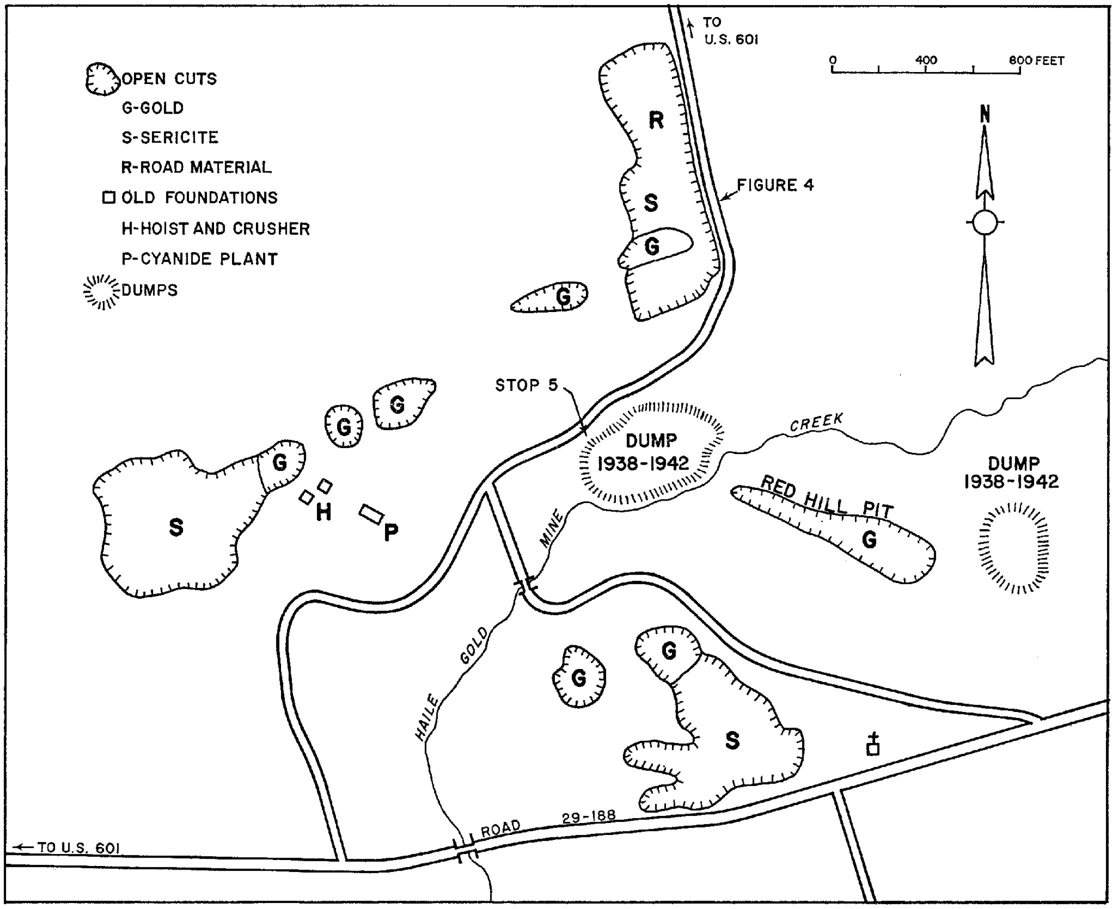

FIGURE 3. MAP OF THE HAILE MINE, LANCASTER COUNTY, S.C.

100 ft. thick.

Granite within about 6 feet of the dike contact is visibly changed by contact metamorphism. The metamorphosed granite is probably in the pyroxene-hornfels facies, as it contains augite, a mineral not observed in "normal" Pageland granite. Farther from the contact, the changes are more subtle and not yet studied in detail.

Continue southwest on U. S. 601.

60.6 1.1 BEAR LEFT, continuing on U. S. 601; S. C. 903 continues straight.

62.3 1.7 CONTINUE on U. S. 601 at intersection with S. C. 265.

63.9 1.6 TURN LEFT onto unnumbered dirt road.

64.6 0.7 Enter borrow pit in Middendorf Formation above sericite pit. Cut on left near south end of pit will be visited as part of Stop 5.

64.9 0.3 **STOP 5** and LUNCH.

The Haile mine and sericite pits, east of U. S. 601 and north of Road 188, 3 mi. northeast of Kershaw, S. C.

The Haile mine is the most productive gold mine in the eastern U. S.; its production is estimated at $6,500,000 (in terms of gold value at the time of production, it would be worth several times that much now). The history of gold mining began about 1829 and ended (perhaps temporally) in 1942, when gold mines were closed by government order to divert effort to base-metal production during the war (Pardee and Park, 1948; McCauley and Butler, 1966). Many of the old workings are filled and covered by more recent sericite mining operations.

The ore bodies are in two northeast-trending zones, about 1500 ft. apart, consisting of silicified and pyritized felsic volcanic rocks (Pardee and Park, 1948, pp. 114-115). Each zone is 100-200 ft. wide and 1800 ft. or more in length.

The dump at this stop is material from the Red Hill pit (fig. 3) mined during the period 1938-1942. Concrete foundations of the crusher, cyanide plant, and support buildings are located

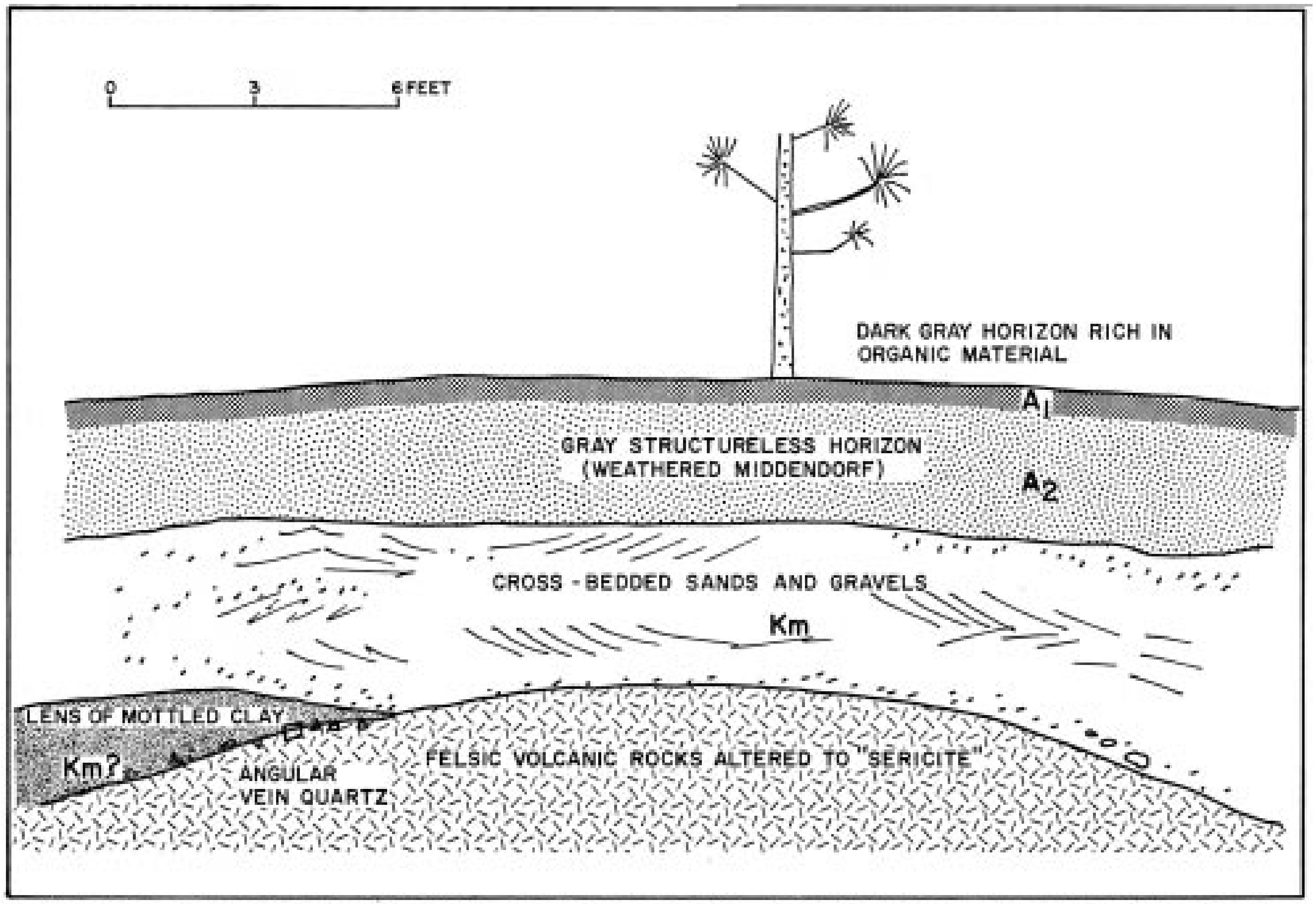

FIGURE 4. SKETCH OF EAST WALL OF BORROW PIT, NORTH PART OF HAILE MINE AREA, LANCASTER COUNTY, S. C.

southeast of this stop.

After looking at the dump, walk back along the dirt road to the pit about 300 yds. North. Figure 4 shows the features seen in the east wall of the pit. Here the loose gray sand layer is the A_2 soil horizon developed on the Middendorf Formation. The Middendorf mantles a knoll of "sericite." Probably derived from hydrothermally altered felsic volcanic rocks. The sericite is a mixture of fine-grained illite, cryptocrystalline quartz, and, locally, kaolin. It has been found in drill holes far beneath the modern zone of weathering. It formed either directly by hydrothermal alteration of by pre-Middendorf weathering of material conditioned by hydrothermal alteration.

Continue west on unnumbered dirt road.

65.0 0.1 TURN LEFT onto dirt road *before* crossing bridge; road ahead leads to other pits.

65.1 0.1 Cross Haile Gold Mine Creek (called Ledbetter Creek on old maps), which drains dumps and old pits.

65.6 0.5 TURN RIGHT sharply onto paved Road 29-188.

65.8 0.2 DRIVE SLOWLY to observe on right the sericite pits of Mineral Mining Corporation. The sericite is taken to a mill at the old Blackmon mine, about 7 mi. northwest, for processing.

66.1 0.3 Residual boulders of Mesozoic diabase dike which is part of the swarm in the vicinity of the Haile mine.

66.7 0.6 TURN RIGHT onto U. S. 601.

67.9 1.2 TURN LEFT onto Road 29-293.

69.1 1.2 BEAR RIGHT onto Road 29-294 and cross creek. Roadcuts on right about 200 yds. West of creek look like Middendorf Formation but are nearly 100 ft. below the general level of Middendorf in this area.

69.8 0.7 TURN LEFT onto County Road 29-88.

70.2 0.4 STOP SIGN, intersection with Road 29-154. CONTINUE straight on dirt road 29-88.

71.5 1.3 STOP SIGN, TURN LEFT onto Road 29-26, then TURN LEFT onto paved road 29-88.

71.9 0.4 **STOP 6.** Coarse volcaniclastic deposits in the Carolina slate belt, Road 29-88, 0.6 miles west of Lynches Creek, Lancaster County.

This road cut in saprolite exhibits coarse volcaniclastic deposits in the volcanic unit of the Carolina slate belt. Outcrops of these rocks occur in the nearby creek beds where the rocks are less weathered. Other occurrences are about two miles to the north and at the Haile mine where mineralized rock of similar character has been found on the dump. Here the foliation trends N65E and dips steeply. In the coarser layers nearby fragments with intermediate diameters of 3 inches or more are common. Although possibly not evident in the road cut, gradations from coarse to finer sizes can be found, suggesting that graded bedding occurs and that top directions will aid in mapping the isoclinal folds that probably occur here. The fragments are predominately much altered felsic volcanic rocks but some fragments of other lithologies can be found.

Near the west end of the outcrop is a deeply weathered metamorphosed dike consisting of very fine biotite and feldspar with probably some hornblende. The saprolite suggests that the dike rock is poorly foliated at an angle to its contacts. In the next rock cut to the east is an unaltered typical diabase dike.

Continue west on Road 29-88.

72.9 1.0 TURN LEFT onto Road 29-95, at Oakhurst Church sign.

74.0 1.1 Exposures on right are felsic meta-pyroclastic rock with abundant disseminated pyrite cubes.

74.9 0.9 STOP SIGN, TURN LEFT onto U. S. 521 toward Kershaw.

78.3 3.4 Intersection with U. S. 521 by-pass, CONTINUE on U. S. 521 business into Kershaw.

79.0 0.7 TRAFFIC LIGHT in Kershaw, TURN LEFT onto U. S. 601 north.

81.0 2.0 Cross Lynches Creek.

84.2 3.2 BEAR RIGHT onto S. C. 265; U. S. 601 continues left.

85.5 1.3 Granite of Pageland pluton exposed near stream, old quarry on right. Coastal Plain sediments cover interfluves.

86.3 0.8 STOP SIGN, intersection with S. C. 903; CONTINUE STRAIGHT on S. C. 265.

91.1 4.8 Cross Lynches River, enter Chesterfield County.

92.9 1.8 Jefferson city limit.

93.6 0.7 STOP SIGN, intersection with S.C. 151 in Jefferson, CONTINUE STRAIGHT on S. C. 265.

96.l 2.7 TURN RIGHT onto Road 13-410, just east of I.G.A. grocery.

96.5 0.2 STOP SIGN, intersection with 13-65, CONTINUE on 29-410.

99.1 2.6 STOP SIGN, intersection with Road 13-571, CONTINUE on Road 13-410. Thick “surficial” sands at intersection.

100.7 1.6 **STOP 7** Giant cross-beds in Pinehurst Formation, Road 13-410 south of Big Black Creek, 7.1 mi. east of Jefferson, S. C.

This clean sand displays prominent bedding and cross bedding. It greatly resembles the type Pinehurst Formation of the Sandhills region of North Carolina, which also lies only to the west of the Orangeburg scarp. This outcrop lies at an elevation of about 430 feet. The apparent fine grain, in contrast with the coarser Middendorf and the much coarser “Citronelle” Formation, the large scale cross-stratification, and the loose white sands of the A-horizon on top of any outcrop, all give an appearance of eolian origin. Yet, the typical sand bed is medium-fine to medium-grained; some beds range up to very coarse sand. The cross-stratification is very striking and overlaps the range of dips of dune bedding. The grain size is, at least, one phi unit too coarse to be typical dune sand.

Some of the finer grained beds could be wind deposited. But, most of the sand was probably deposited by streams in an area of modest gradient nest to an abundant sand source or in a littoral environment.

Continue east on Road 13-410.

101.1 0.4 Weathered argillite in ditch on left; valley is sand clogged.

102.7 1.6 STOP SIGN; TURN RIGHT onto Road 13-138.

104.7 2.0 BEAR LEFT onto Road 13-159.

105.5 0.8 Creek, argillite corps out to left in foundation of mill and dam. BEAR RIGHT just beyond bridge.

106.5 1.0 BEAR LEFT, road becomes 13-138.

107.2 0.7 STOP SIGN, TURN RIGHT onto S. C. 109.

111.5 4.3 STOP SIGN, intersection with S. C. 145, CONTINUE STRAIGHT on Road 13-29.

116.1 4.6 TURN LEFT sharply onto sand road 13-63 (Scotch road).

116.5 0.4 TURN RIGHT onto sand road to Sugar Loaf Mountain.

117.2 0.7 Recreation lake and picnic area.

117.9 0.7 **STOP 8.** Sugar Loaf Mountain Recreation area, Sandhills State Forest, 4.3 miles west of Patrick, S. C.

Sugar Loaf Mountain, 513 ft. above sea level, is a small knob of sands, clays, clayey sands, and cemented sandstones of the Middendorf Formation (Upper Cretaceous). Capped by ferruginous sandstone, Sugar Loaf Mountain lies on the edge of a 100 ft. erosional escarpment which extends southeast from Ruby, S. C. and joins the Citronelle (Orangeburg) scarp near Hartsville, S. C. and may represent a Miocene oceanic inlet or embayment in the Citronelle (Orangeburg) scarp. To the northwest, valleys are as low as 180 ft. above sea level within one mile of Sugar Loaf Mountain. West of Sugar Loaf Mountain, ridges range locally as high as 600 ft. high and valleys are seldom lower than 300 ft. above sea level, except for larger streams such as the Lynches River and Black Creek. West of this escarpment sands probably correlating with the Pinehurst Formation of North Carolina are common with thicknesses up to 50 ft. Between Sugar Loaf Mountain and the Pee Dee River, a distance of almost 20 miles, little Tertiary sand is found and is always quite thin (less than 10 ft. thick).

The stratigraphy of Sugar Loaf Mountain is as follows:

513 feet Ferruginous sandstone, limonite-hematite-cemented, unsorted sands.

503 feet Crossbedded sands, interlayered with thin beds or clay or clay-rich sand.

420 feet Surface of road.

402 feet Clean, tight kaolinitic clay or unknown thickness.

Locally on Sugar Loaf Mountain, crossbedded sands of fluvial origin are common. Some thin, clean clay beds of kaolinite and abundant layers of clayey sand or sand with large (to max. ½ cm) mica (?) flakes are found. Slump or compaction structures (contorted cross beds and layering) are seen in the ferruginous sandstone and sides of Sugar Loaf Mountain.

Horse Shoe Mountain across the road affords another exposure of the ferruginous sandstone.

Turn around and return to Road 13-29.

119.3 1.4 STOP SIGN, TURN LEFT onto Road 13-63. Good exposures of cross-bedded Middendorf Formation 60 yds. West of intersection.

119.8 0.5 STOP SIGN, TURN LEFT onto Road 13-29.

120.7 0.9 Cross Wire Road, which was a major artery from colonial times until U. S. 1 was built in the early 1900’s.

122.0 1.3 Overpass, cuts along RR are the type locality of the Middendorf Formation, but it is no longer a particularly good exposure.

122.7 0.7 STOP SIGN, TURN LEFT (northeast) onto U. S.1.

125.4 2.7 Resistant bed of Kaolin-cemented sandstone in Middendorf Formation.

126.9 1.5 Gravel road across RR tracks to left leads to excellent new Middendorf exposures in RR cut about ¼ mi. to west.

127.4 0.5 Patrick city limits.

129.4 2.0 Good exposure of Middendorf Formation on left across RR.

135.8 6.4 Entrance on right to Cheraw State Park.

137.5 1.7 MERGE with U. S. 52 traffic, continue on U. S. 1 north.

139.8 2.3 YIELD at intersection with S. C. 9, turn right onto U. S. 1-52.

139.9 0.1 Ingram Motel in Cheraw.

FIELD TRIP LOG FOR THE SECOND DAY

October 6, 1974

ASSEMBLE at Ingram Motel, U. S. Highways 1 and 52, Cheraw, S. C. The trip will start promptly at 8:00 a.m. You should have sufficient fuel for 70 miles of the field rip and 20 more miles to get back to a large town. The route follows that of the first day until a point past Stop 1. The field trip disbands about lunch time near White Store, N. C., about 13 mi. southwest of Wadesboro, N. C. and 12 mi. northeast of Pageland, S. C.

M D

0.0 Parking lot of Ingram Motel. TURN LEFT onto U. S. 1-52 north, toward Cheraw business district.

0.7 0.7 TRAFFIC LIGHT in downtown Cheraw, TURN LEFT following U. S. 1-52 north.

1.1 0.4 TRAFFIC LIGHT, continue STRAIGHT on U. S. 52 north, U. S. 1 turns to right.

7.6 6.5 Passing Stop 1 of previous day's field trip.

10.0 2.4 North Carolina state line.

13.8 3.8 Morven city limit.

14.4 0.6 CAUTION LIGHT, intersection with N. C. 145 in center of Morven.

16.2 1.8 **STOP 9.** Lilesville granite, U. S. 52, 1.7 mi. northwest of Morven, N. C. The roadcuts expose typical fresh Lilesville granite in the southwestern part of the pluton. The porphyritic coarse-grained rock has pink microcline phenocrysts and is composed mainly of plagioclase, microcline, quartz, and biotite. Hornblende is present in some samples. The accessories are opaque minerals, apatite, zircon, and sphene. White mica, chlorite, and epidote are minor alteration products. A few dark biotite-rich, round-to-spindle-shaped xenoliths are present in the granite. Geophysical data suggests that the granite intrusion is a tongue-shaped mass emplaced in an anticline of argillite and felsic volcanic rocks (Waskom and Butler, 1971). A large area of biotite gneiss in the south-central part of the pluton is probably part of the floor of the intrusion. A gabbro body cuts the eastern part of the Lilesville granite and is responsible for the large positive gravity anomaly observed in this region.

Continue northwest on U. S. 52.

16.5 0.3 South Fork Jones Creek.

17.5 1.0 TURN RIGHT onto Road 1121.

18.2 0.7 STOP SIGN, intersection with Road 1821, CONTINUE STRAIGHT on dirt road 1121.

19.6 1.4 STOP SIGN, TURN LEFT onto Road 1812. Gravels in roadcut on left, north of intersection.

21.9 2.3 BEAR RIGHT at Y-intersection on Road 1733.

24.3 2.4 STOP SIGN, TURN RIGHT onto U. S. 74 toward Rockingham.

25.0 0.7 Outcrops of Lilesville granite in south edge of Lilesville.

27.1 2.1 Picnic area ("Welcome Center") at intersection with Road 1744. Workings in Lilesville gravels on both sides of road, active pits to south of road.

27.5 0.4 SLOW and PULL RIGHT onto field road parallel to U. S. 74 just east of Ruby Orchard packing shed.

27.8 0.3 **STOP 10.** Granite saprolite nonconformably overlain by Middendorf Formation unconformably overlain by Lilesville gravels ("Citronelle" Formation), U. S. 74, 8.5 mi. east of Wadesboro, N. C.

Saprolite of the Lilesville granite is exposed in ditches south of the highway. The granite is overlain by about 8 ft. of cross-bedded sandstone and conglomerate that is probably Middendorf Formation (Upper Cretaceous). Lilesville gravels up to 25 ft. thick unconformably overlie the Middendorf (?); a very photogenic unconformity occurs north of the highway. Cooley (1970) mapped the Lilesville gravels as part of the "Citronelle" Formation (Pliocene?). Clasts in the gravels are mainly metaquartzite (about 80 percent) and vein quartz, The metaquartzite pebbles normally have a pitted surface. The gravels have been extensively worked in the region near this stop and there are large tracts of unreclaimed workings. The "Citronelle" gravel is more than 98 percent silica and is one of the finest silica deposits in eastern U. S.

Turn around and proceed on U. S. 74.

28.1 0.3 CAUTION; CROSS TO RIGHT LANE of U. S. 74 and continue west.

30.5 2.4 Lilesville city limit.

34.4 3.9 Wadesboro city limit.

35.0 0.6 TRAFFIC LIGHT, Intersection with U. S. 52, CONTINUE west on U. S. 74-52.

36.3 1.3 TRAFFIC LIGHT, major intersection in Wadesboro, CONTINUE west on U. S. 74-52, N. C. 742-109.

37.0 0.7 BEAR RIGHT on U. S. 52 and N. C. 742, U. S. 74 continues to left.

37.6 0.6 BEAR LEFT on N. C. 742, U. S. 52 continues to right. Eastward-dipping Triassic sedimentary rocks are exposed at intervals for the next 2 miles.

42.5 4.9 **STOP 11.** Triassic arkosic conglomerate, N. C. 742, 6.2 mi. northwest of Wadesboro, 0.2 mi. southeast of Brown Creek.

The outcrop consists of eastward-dipping sandstones, conglomerate, and red siltstone as well as a diabase dike. The focus of the stop is a coarse arkosic conglomerate, so rich in feldspar that it could be called a granite wash. The outcrop is about a quarter mile east of a splinter horst of slate belt rocks, yet the source of the feldspar clasts is the outcrop of Lilesville granite porphyry, at least 9 mi. to the southeast. Feldspar clasts as much as an inch in diameter are found.

Continue northwest on N. C. 742.

42.7 0.2 Main bridge over Brown Creek. Argillite occurs just west of bridge.

42.9 0.2 TURN LEFT onto Road 1431.

45.6 2.7 STOP SIGN, TURN LEFT onto Road 1418.

46.9 1.3 Polkton city limit.

47.8 0.9 TURN RIGHT onto N. C. 218 (Polk St.) in center of Polkton.

48.0 0.2 TURN LEFT onto Road 1416 (Moore St.), go through thin graben of Triassic rocks.

51.2 3.2 Peachland city limit.

51.5 0.3 STOP SIGN, TURN LEFT onto Road 1404 (Boston St.). Good exposures of argillite in RR cuts below overpass

51.7 0.2 STOP SIGN, TURN RIGHT onto Road 1403 (Passiac St.).

51.9 0.2 TURN LEFT onto Road 1240 (Clinton Ave.) in Peachland center.

52.1 0.2 BEAR LEFT at south end of bridge over U. S. 74, CONTINUE on Road 1240.

STOP 12. Triassic fanglomerate, about 0.7 mi. south of Peachland, N. C. on Road 1240.

This excellent example of fanglomerate is strikingly similar to the massive fanglomerates of the east side of the Durham and Sanford basins. But, this fanglomerate is on the west side of the Wadesboro basin. This particular deposit lies within a very narrow splinter graben about ¼ mi. wide and 7 mi. long and is completely surrounded by Carolina slate belt rock and is filled wall to wall with fanglomerate (and a few sandstone interbeds). The subangular pebbles and cobbles (and a few boulders) are dominantly the rocks of the adjacent slate belt with less than 10 percent of quarts pebbles. At least a fourth of the clasts are more than 3 inches in diameter. The Carolina slate belt pebbles are generally rectangular with the long direction parallel to their cleavage. Small but conspicuous lenses of coarse red sandstone with scattered pebbles show the generally southeastern dip.

Continue south on Road 1240.

53.2 0.6 Outcrops of argillite in south rim of Triassic sliver.

53.8 0.6 REAR RIGHT onto Road 1252; Triassic rocks occur at intersection and to south.

57.5 3.7 STOP SIGN, intersection with Road 1236, CONTINUE south onto 1236.

59.2 1.7 Brown Creek

59.6 0.7 TURN RIGHT at White Store intersection onto Road 1228.

60.6 1.0 **STOP 13.** Triassic lithic conglomerate, 1.0 mi. southwest of White Store on Road 1228, Anson Co. N. C.

The deposit consists of 2/3 pebbles and cobbles and 1/3 sand, silt and clay matrix. The great rounding of the clasts in such a coarse deposit is unusual in Triassic basin deposits. The clasts are dominantly of the Upper Precambrian-Lower Paleozoic metavolcanic rocks (Carolina slate belt rocks) found in the adjacent Piedmont both west and east of the basin. Of the large clasts about 90 percent are slate belt lithologies and 10 percent are quartz. A few clasts of Triassic sandstone are noted. The deposit is regarded as having been deposited near the tow of a large alluvial fan.

Disband.

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