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BRICK CLAYS OF MEDWAY PLANTATION BERKELEY COUNTY, S. C.

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INTRODUCTION

Brick have been used extensively as a construction material in the Low Country of South Carolina since the beginning of the Colonial Period. Many of the oldest and most famous churches, plantation homes, and town houses were made of brick that were formed by hand prior to the invention of modern brick making machinery. The sources of these handmade brick have become clouded by time so that today it is not well known to what extent these brick were made locally by plantation labor and to what extent they may have been imported from England. Conflicting reports as to their source notwithstanding, these old, handmade brick are today much sought after for construction purposes because of their pleasing color and texture.

Despite great demand for them, the major source of the handmade brick today is reclaimed brick from the destruction of old buildings. An excellent market opportunity appears to exist if facsimiles of the old, handmade brick could be produced economically for sale at the present time. The success of this brick would depend to a great extent on how closely present day production could match the color and texture of the old brick.

The texture of the old brick largely resulted from the manufacturing procedure, i.e., the hand forming process. Machinery is now available that will permit mechanized production of units that would match the texture of the old brick.

The color of the old brick was largely determined by the raw material used, although the firing procedure also played a part. Duplication of the colors of the old brick would depend principally on finding a source of similar raw material.

One of the better known sites of old brick manufacture was at Medway Plantation near Mount Holly in Berkeley County, South Carolina. If it could be established that suitable clay was still available in quantity at this location and that this clay was of the type formerly used in the manufacture of the handmade product, brick could be produced with machinery today that would duplicate the texture and color of the old brick. It was felt also that results of a study of Med-

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WAY CLAYS WOULD BE APPLICABLE TO SIMILAR CLAY DEPO
TO OCCUR AT MANY OTHER LOCALITIES IN THE LOWER COA

FIELD INVESTIGATIONS

Twenty-three power auger holes ranging from 3 to 39 feet in depth were drilled on Medway Plantation (Fig. 1) during January 13, 14, and 15, 1959, by H. S. Johnson, Jr. and L. N. Smith of the Division of Geology, South Carolina State Development Board. The holes were located so as to test the clay deposit from which hand-formed brick had been made prior to the Civil War and also to explore for other types of clays. Lithologic logs were prepared for each hole, and representative samples were taken of each clay unit encountered. The samples were brought to the Ceramic Engineering Department of Clemson College for determination of the ceramic properties and potential usefulness of the clays.

Results of the field investigations indicated that there are on Medway Plantation large reserves of clay thought to be suitable for the manufacture of brick and possibly lightweight aggregate. Geologically the clay deposits can be grouped into two main types, herein termed "Spring Grove" type clays and "Medway" type clays. "Spring Grove" type clays are predominantly sandy, and "Medway" type clays are very plastic and commonly free of sand.

"Spring Grove" type clays on Medway Plantation are principally found on sandy, pine-covered knolls and low ridges with surface elevations above 10'. These clays are characteristically mottled orange-yellow-brown-white sandy clays, but they may be cream colored to brown and relatively free from sand in places. The clay fraction of these deposts is very plastic so that the material holds together well, even when quite sandy. Deposits of "Spring Grove" type clay are up to 12' and possibly more in thickness; but they can be expected to interfinger and grade both vertically and laterally into deposits of fine-grained clayey sand and sand, and consequently may be irregular and unpredictable in outline. These "Spring Grove" type clays are thought to be marine in origin and probably were deposited in shallow nearshore waters during Pleistocene time.

"Medway" type clays on Medway Plantation are principally found at elevations below 10' in flat swampland and low-lying woods adjacent to the larger rivers and creeks. These clays are characteristically dark brown to olive-green and are very plastic. They may be sandy in places, but normally are low in sand content. These clays are commonly from 5 to 20 feet thick and in places seem to grade imperceptibly downward into the Cooper marl of Oligocene (?) age or a similar marly material overlying Cooper marl. The

RESTRICTION OF THESE "MEDWAY" TYPE CLAYS TO THE MARGINS OF RIVERS OR LARGER CREEKS AND THE SIMILARITY TO AND APPARENT GRADATION DOWNWARD INTO MARL SUGGEST THAT THESE CLAYS ARE ESTUARINE DEPOSITS AND THAT THEY MAY HAVE BEEN FORMED LARGELY FROM REWORKED COOPER MARL. AREALLY THESE DEPOSITS MAY BE EXPECTED TO BE RELATIVELY CONTINUOUS AND UNIFORM IN QUALITY ADJACENT TO RIVERS AND LARGE CREEKS.

LABORATORY PROCEDURE

CLAY SAMPLES RECEIVED IN THE LABORATORY WERE DRIED COMPLETELY AT 150° F. AND THEN CRUSHED TO PASS A 14 MESH SCREEN. THIS PROCEDURE ASSURED GOOD MIXING OF POSSIBLY DIFFERENT MATERIALS CONTAINED IN ANY GIVEN SAMPLE.

TEST BARS WERE PREPARED FROM EACH SAMPLE BY MIXING THE CLAY WITH WATER IN A LANCASTER MULLER MIXER. SUFFICIENT WATER WAS ADDED TO DUPLICATE THE CONSISTENCY COMMONLY USED IN EXTRUSION OF CLAY-WATER MIXTURES. AFTER MIXING, THE CLAY WAS PRESSED INTO BARS MEASURING 5" X 1" X 1" USING A FORMING PRESSURE OF 3000 POUNDS PER SQUARE INCH.

AFTER BEING FORMED THE TEST BARS WERE ALLOWED TO DRY FOR AT LEAST 24 HOURS. THEY WERE THEN FURTHER DRIED FOR 12 HOURS AT A TEMPERATURE OF 150° F. AND FOR AN ADDITIONAL 12 HOURS AT 250° F.

AFTER DRYING, THE TEST BARS WERE FIRED TO SELECTED TEMPERATURES IN THE RANGE FROM 2000° TO 2300° F. CONTROLLED ATMOSPHERES WERE USED DURING FIRING TO OBTAIN A VARIETY OF FIRED COLORS. RESULTS OF COLOR CONTROL TESTS ARE DISCUSSED IN THE SECTION ON COLOR OF FIRED BRICK BELOW.

TOTAL LINEAR SHRINKAGE OF THE TEST BARS WAS DETERMINED BY SUBTRACTING THE FIRED LENGTH FROM THE PRESSED LENGTH AND DIVIDING BY THE PRESSED LENGTH. SHRINKAGE WAS DETERMINED ON ALL TEST BARS, AND THEN OTHER QUALITIES OF THE MATERIALS WERE OBSERVED.

RESULTS OF INVESTIGATIONS

TABLE 1 SHOWS TOTAL LINEAR SHRINKAGE OF THE SAMPLES TESTED AT 2100° AND 2200° F. TABLE II SHOWS A CLASSIFICATION OF THE CLAYS ACCORDING TO THEIR COMPOSITION AND CONSEQUENT CERAMIC QUALITIES. TABLE III INDICATES POSSIBLE COMBINATIONS OF CLAYS ON MEDWAY PLANTATION THAT WOULD BE SUITABLE FOR STRUCTURAL BRICK, FACE BRICK, AND LIGHTWEIGHT AGGREGATE. THE SAMPLE NUMBERING SYSTEM USED IN THIS REPORT IS BASED ON THE DRILL HOLE AND DEPTH RANGE FROM WHICH THE SAMPLE CAME. FOR INSTANCE, SAMPLE 17-7-10 IS THE SAMPLE OBTAINED FROM A DEPTH OF 7 TO 10' IN DRILL HOLE 17.

On the basis of composition and physical characteristics and upon consideration of firing tests, the clay samples were classified as marl, clayey sand, sandy clay, rich clay, or vitreous clay. Each type is discussed below with emphasis on the effect it would have in the manufacture of brick.

Marl

The materials classified as marl (Table 11) were obviously high in calcium carbonate content. These samples fired to an off-white color and all showed a very sudden melting point. At low firing temperatures these samples showed a very low shrinkage. Then, within a span of approximately 100° F. increase in temperature, the test bars showed very high shrinkages and would melt and deform.

The materials classed as marl would be unsatisfactory as the major ingredient in brick because of the sudden melting behavior and also because they would tend to slake in water if fired at temperatures lower than their melting temperature. Although these materials would be objectionable for brick manufacture by themselves, they could serve a useful purpose as a minor addition to other materials. Thus, the addition of about 10 percent marl to sandy clay might produce a stronger brick than could be obtained from the sandy material alone. The maximum quantity of marl that could be tolerated would vary with individual samples but might be expected to be about 20 percent of the mixture. The marl might also serve to produce different color effects than could be obtained from clay alone.

Clayey sand

The quantity and size of quartz sand grains in a clay influence its suitability for brick manufacture appreciably. The clay samples from Medway Plantation varied considerably in sand content, but grain size of the sand was much the same from sample to sample.

The clay samples classified as clayey sand (Table 11) contained so much sand that the fired test specimens showed no coherence or strength, but instead would crumble apart like a very loosely consolidated sandstone. The presence of so much sand would make this material unsuitable as a raw material for brick by itself, but the clayey sand might possibly be used for sanding mold boxes to provide both a surface texture for the brick and to facilitate release of the clay from the mold. The materials classed as clayey sand might also be of interest as foundry sand.

Quartz sand is usually objectionable in brick clay because of its deleterious effect on fired strength. The larger the particle size of the sand, the greater is the reduction in fired strength for a given sand content. In some cases, however, sand has beneficial effects on the manufacturing properties of clay. Rich clay that is free from sand is difficult to dry and has a high drying shrinkage. Rich clay tends to crack and warp during drying and also requires an excessive amount of time for the removal of water from molded brick. Additions of sand will reduce the drying shrinkage and the cracking tendency of rich clay and will also reduce the amount of time required for water removal. Thus, the materials listed as clayey sand in Table 11 might serve as desirable additives to rich clays of very low sand content. The amount of clayey sand that could be added would depend on the reduction in fired strength that could be tolerated. This amount would have to be determined for particular samples or mixtures of materials, but perhaps somewhere between 30 and 70 percent +200 mesh sand could be tolerated in the clay depending on the end use desired.

It is interested to note that sample 12-10-18, classed as clayey sand, contained 53 percent +150 mesh sand and that sample 3-5-17, classed as vitreous clay, contained 6 percent +150 mesh sand.

Sandy clay

The samples classed as sandy clay (Table 11) all contained appreciable amounts of sand and showed very low total shrinkages of less than 4 percent. However, these materials contained sufficient clay to make the sand grains bond together; and it is thought that these clays would be satisfactory for making unusually attractive face brick. It is intended that these face brick would not be required to meet structural specifications for either strength or absorption, but instead would be used only for facing purposes and not in load-bearing walls.

Rich clay

The materials classified as rich clay (Table 11) contained a relatively high proportion of clay matter and would make very strong brick capable of meeting any structural specifications. Although these clays would make very good brick, they would probably cause more manufacturing problems than the sandier materials because of the slow drying time, high drying shrinkage, and tendency to crack and warp during drying. This means their use would require proper manufacturing facilities and expert skill in order to turn out a good product.

Vitreous clay

The materials classified as vitreous clay (Table II) have properties similar to those classified as rich clay except that the vitreous clays tend to produce a glassy or glazed surface at the firing temperatures tested. These materials probably contain a certain amount of soluble salts which concentrate on the surface during drying and cause the development of the glassy surface on firing. Vitreous clays should produce brick with good structural properties such as low absorption and high strength. They would also be desirable additives to sandy materials to make them stronger and to reduce their fired absorption.

COLOR OF FIRED BRICK

The samples tested indicate that a great variety of fired colors can be produced from the various clays on Medway Plantation. Most of the colors present in the old, handmade brick can be duplicated with these materials. It is important to emphasize, however, that the fired color obtained depends on the manufacturing procedure as well as on the raw material used. The major variables of manufacture are the time-temperature schedule used and the time-furnace atmosphere employed.

The maturing temperature or top temperature is an important variable of color development. In general, the higher the temperature, the darker is the color. Most red-burning clays will go from a more-or-less salmon color up through red to dark red and then to chocolate or black with increasing temperature. This change in color because of temperature would apply to all the Medway materials other than the marl.

Another important manufacturing variable in color production is the atmosphere in the kiln. The red color is produced by iron oxide. Iron oxide is red in color when it is oxidized to the ferric condition. Reduction of the iron to a lower oxidation state will cause a change in its color. Reduction can be accomplished in a kiln by the introduction of an excess of fuel which will exhaust all of the oxygen in the kiln atmosphere and then compete with the iron in the clay for oxygen available within clay ware. The use of the oxygen deficient or reducing atmosphere is the means of producing many new colors. The reducing atmosphere will cause the brick to be black or gray in color. These colors are maintained when the brick are cooled in a reducing atmosphere. If the brick are first reduced and then exposed to excess oxygen, the brick will re-oxidize and turn shades of orange, pink, tan, and yellow. The final color depends on the length of time of re-oxidation and the temperature at which the re-oxidation is accomplished.

THE COLOR OF FIRED BRICK IS ALSO INFLUENCED BY THE QUANTITY OF GLASS PRESENT. THIS IS A FUNCTION OF BOTH THE RAW MATERIAL AND THE FIRING TEMPERATURE. THE GLASSIER THE MATERIAL, THE MORE DIFFICULT IT IS TO RE-OXIDIZE IT. SOMETIMES THIS GLASSY QUALITY IS PURPOSELY OBTAINED BY INTRODUCING SALT VAPORS INTO THE KILN TOGETHER WITH THE REDUCING ATMOSPHERE. THIS PROCEDURE WILL TEND TO PRODUCE VERY DEEP BLACKS AND SOMETIMES TO GIVE A SOMEWHAT METALLIC LUSTER TO THE SURFACE OF THE BRICK.

FROM THE TESTS MADE, IT IS THOUGHT THAT A LARGE ASSORTMENT OF COLORS CAN BE PRODUCED FROM THE CLAYS ON MEDWAY PLANTATION, BOTH BY CONTROLLING THE RAW MATERIAL AND BY CONTROLLING THE FIRING PROCEDURE.

BLENDING OF RAW MATERIALS

ECONOMICAL PRODUCTION OF BRICK FROM THE CLAYS ON MEDWAY PLANTATION WOULD PROBABLY REQUIRE THE MIXING OF DIFFERENT TYPES OF MATERIAL FROM DIFFERENT LOCATIONS. STUDY OF THE DRILL HOLE LOCATIONS (FIG. 1) AND THE PROPERTIES OF THE SAMPLES OBTAINED THEREFROM SUGGEST TWO GENERAL AREAS FOR OBTAINING BRICK RAW MATERIALS. THE DRILL HOLES APPROXIMATELY DELINEATING THESE AREAS ARE LISTED IN TABLE III UNDER THE HEADINGS STRUCTURAL BRICK AND FACE BRICK.

THE AREA ROUGHLY DELINEATED BY DRILL HOLES 17 THROUGH 21 (FIG. 1) CONTAINS CLAYS WHICH ARE PREDOMINANTLY CLASSED AS RICH OR VITREOUS AND WHICH CORRESPOND IN GENERAL TO THE "MEDWAY" TYPE CLAYS DISCUSSED IN THE SECTION ON FIELD INVESTIGATIONS. BLENDS OF CLAYS FROM THIS AREA WOULD PRODUCE BRICK THAT WOULD PASS ALL STRUCTURAL SPECIFICATIONS. IT WOULD ALSO BE POSSIBLE TO PRODUCE A MORE SANDY BRICK THROUGH ADDITION OF SAND TO THESE CLAYS.

THE AREA ROUGHLY DELINEATED BY DRILL HOLES 1 THROUGH 15 CONTAINS CLAYS WHICH ARE PREDOMINANTLY SANDY AND WHICH CORRESPOND IN GENERAL TO THE "SPRING GROVE" TYPE CLAYS DISCUSSED IN THE SECTION ON FIELD INVESTIGATIONS. THESE CLAYS WOULD BE SUITABLE FOR THE PRODUCTION OF FACE BRICK WHICH WOULD NOT BE REQUIRED TO MEET STRUCTURAL SPECIFICATIONS.

LIGHTWEIGHT AGGREGATE

THE TESTS FOR DETERMINATION OF FIRED COLOR INDICATED THAT SOME SAMPLES COULD REPRESENT A SUITABLE RAW MATERIAL FOR THE PRODUCTION OF LIGHTWEIGHT AGGREGATE. TO FURTHER EVALUATE THE CLAYS ON MEDWAY PLANTATION AS A POTENTIAL SOURCE OF LIGHTWEIGHT AGGREGATE MATERIAL, TWO TEST BATCHES WERE PREPARED BY BLENDING SAMPLES AS INDICATED UNDER A AND B IN

TABLE III. THE TWO TEST MIXTURES WERE EXTRUDED INTO BARS WHICH WERE THEN FIRED AT 50° INTERVALS FROM 2000° TO 2300° F.

SAMPLE A, A BLEND OF THE SANDY "SPRING GROVE" TYPE CLAYS, STARTED BLOATING AT 2200° F. AND PRODUCED AN EXCELLENT BLOAT AT 2250° F. THE ADDITION OF FLOUR TO TEST BARS OF SAMPLE A RESULTED IN INCREASED BLOATING.

SAMPLE B, A BLEND OF THE RICH AND VITREOUS CLAYS OF THE "MEDWAY" TYPE, PRODUCED AN EXCELLENT BLOATED MATERIAL AT 2150° F. THE ADDITION OF FLOUR TO TEST BARS OF SAMPLE B DID NOT CAUSE INCREASED BLOATING.

RESULTS OF THESE TESTS INDICATE THAT LOW COUNTRY CLAYS OF THE TYPES FOUND ON MEDWAY PLANTATION ARE POTENTIAL SOURCES OF LIGHTWEIGHT AGGREGATE RAW MATERIAL AS WELL AS BEING SUITABLE FOR BRICK MANUFACTURE.

TABLE 1 - TOTAL LINEAR SHRINKAGE OF MEDWAY PLANTATION CLAYS

SAMPLE	2100° F. SHRINKAGE (%)	2200° F. SHRINKAGE (%)
1-3-9	0.8	0.8
1-9-16	3.5	5.1
1-16-35	5.1	7.5
2-2-8	0.0	0.8
2-10-12	2.4	3.5
3-0.5-17	9.8	10.3
3-17-24	5.9	---
4-0.5-12	1.6	1.6
5-4-9	0.0	0.4
8-5-15	15.6	---
10-6-14	11.0	---
13-3-10	0.8(EXPANSION)	0.4(EXPANSION)
14-0-12	2.2	3.2
15-0-9	2.0	2.8
16-0-4	3.5	4.7
16-5.5-20	16.9	---
17-0-7	3.2	4.7
17-7-10	7.5	6.7
18-0.5-3	3.2	4.7
20-0-10	6.7	6.7
21-0-3	2.0	3.5
21-3-10		1.6(EXPANSION)

TABLE II - CLASSIFICATION OF MEDWAY PLANTATION CLAYS

Marl	Clayey sand	Sandy clay	Rich clay	Vitreous clay
3-17-24	3-0.5-5	1-3-9	16-0-4	1-9-16
8-22-29	12-0-9	2-2-8	17-0-7	1-16-35
10-6-14	12-10-18	2-10-12	18-0.5-3	3-0.5-17
16-5.5-20	21-3-10	4-0.5-12	21-0-3	7-4-10
		5-4-9		17-7-10
		13-3-10		20-0-10
		14-0-12		
		15-0-9		

STRUCTURAL BRICK	FACE BRICK
17-0-10	1-3-9
18-0.5-3	2-2-12
20-0-10	3-0.5-17
21-0-10(UP TO 30% OF MIX)	4-0.5-12
	5-4-9
	7-4-10
	13-3-10
	14-0-12
	15-0-9

LIGHTWEIGHT AGGREGATE

A	B
1-9-16	20-0-10
1-16-35	22-0-9
2-2-8	
3-0.5-17	
7-4-10	
15-0-9	
16-0-4	

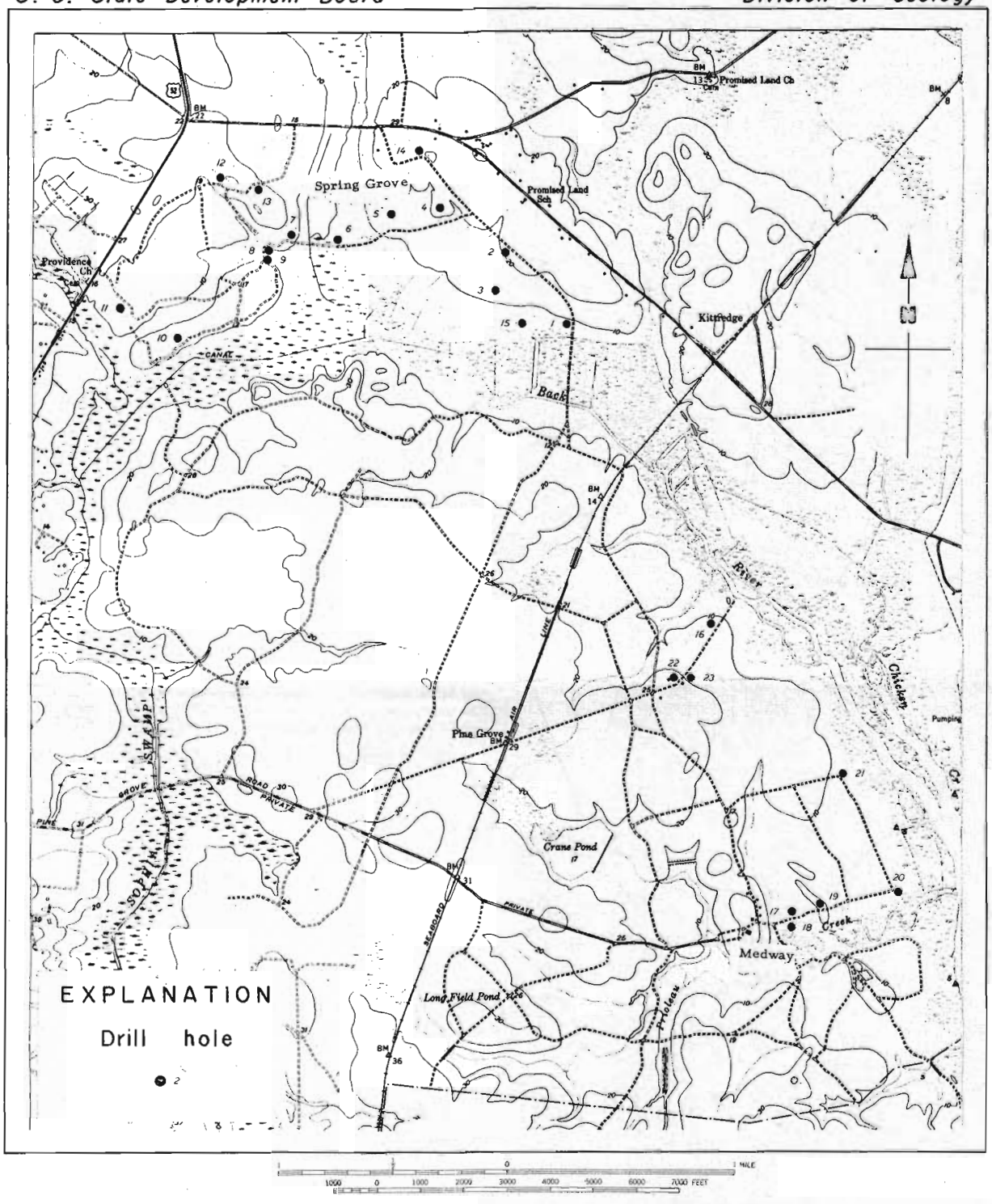

Figure 1. Location of Drill Holes on Medway Plantation Berkeley County, S. C.