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# A STUDY OF SUITABILITY OF DACCA CLAYS FOR LIGHT-WEIGHT AGGREGATE PRODUCTION IN EAST PAKISTAN

by

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Geological Survey of Pakistan

and

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1. Preliminary structure map of the Paint Lick quadrangle, east central Kentucky, by Gordon W. Weir. 1 sheet, scale 1:24,000. USGS, 710 West High St., Lexington, Ky. 40508; Kentucky Geological Survey, 307 Mineral Industries Bldg., University of Kentucky, Lexington, Ky. 40506. Material from which copy can be made at private expense is available in the USGS office in Lexington.

2. Potential for potash and other evaporite mineral resources in West Pakistan, by C. L. Jones and Asrarullah. 17 p., 2 figs.

3. A study of suitability of Dacca clays for light-weight aggregate production in East Pakistan, by M. A. Maroof Khan and N. A. Parker. 85 p., 1 fig., 5 tables.

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4. Provisional topographic map, Isla Desecheo, Puerto Rico, by the U. S. Geological Survey, 1 sheet, scale approx. 1:10,000.

* * * * *

# A STUDY OF SUITABILITY OF DACCA CLAYS

# FOR

# LIGHT-WEIGHT AGGREGATE PRODUCTION IN EAST PAKISTAN

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## ABSTRACT

The following report covers field work and muffle furnace tests on clays in the immediate vicinity of Dacca, East Pakistan, to determine clay amenability to bloating for the commercial production of light-weight aggregates. It has been established that such clays exist in at least three areas; reserves are sufficient in each area for 20 years or more of operation of a light-weight aggregate plant, if the plant were designed to produce 1,000 cubic yards of expanded material per day for 330 operating days per year. Reserves in any of the three areas can be expanded further or new deposits can be found by additional exploratory work.

# INTRODUCTION

## Purpose and scope of the report

A common characteristic of nations throughout the world is their ever increasing demand for construction materials of all kinds, especially sand, gravel, and crushed stone. Increasing sophistication in building and structural design in turn demands more exacting specifications in the requirements for concrete aggregates. If large buildings are to be constructed, the reduction in weight through the use of light-weight but strong aggregate assumes an increasingly important role.

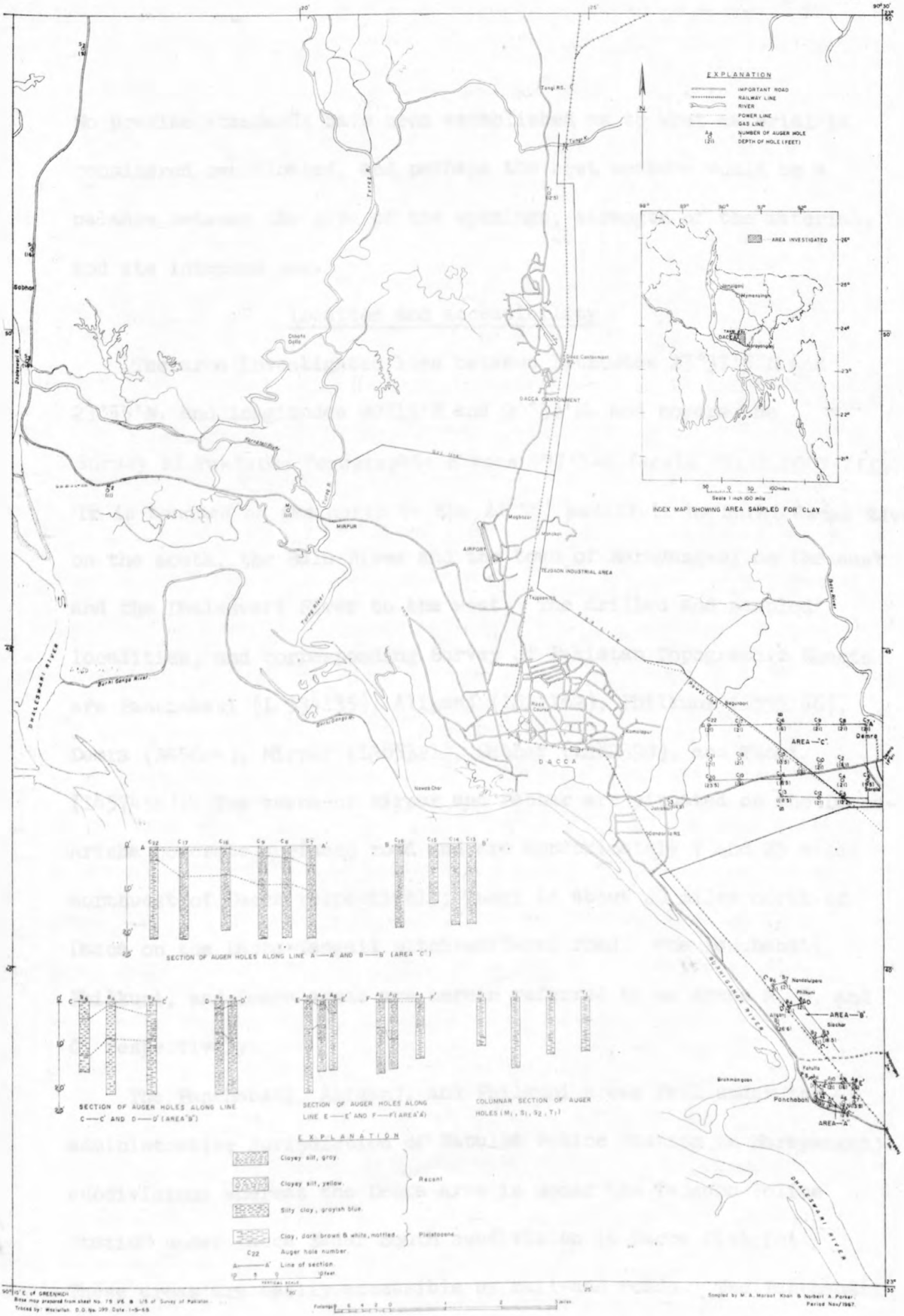
Over most of East Pakistan, the surface geologic formations are unconsolidated alluvial deposits or weakly indurated, easily crushed rocks of late Tertiary age. Rocks suitable for use as concrete aggregate are limited. In such an area, where natural aggregate materials are lacking, but where clay and shale are present, the development of a light-weight aggregate industry offers a means of filling many of the demands for construction material. Synthetic aggregates are produced by heating clay or shale in a rotary kiln; the resulting product is in the form of a fused porous cinder which is ready for crushing to desired screen sizes.

In view of the scarcity of natural aggregates in East Pakistan, the field and laboratory investigations described in this report were undertaken in an attempt to locate clay deposits in the immediate vicinity of Dacca that were amenable to bloating for the

commercial production of light-weight aggregate. / The work was done as part of a program undertaken cooperatively by the Geological Survey of Pakistan and the U. S. Geological Survey, under the auspices of the Government of Pakistan and the Agency for International Development, U. S. Department of State. | Factors considered in the study of the clay deposits included the location of the deposit in respect to market, transportation, gas or other fuel sources, and the present land utilization. Preliminary reconnaissance drilling, sampling and testing showed that several areas near Dacca contain clay suitable for bloating, and three areas (designated A, B, C. on fig. 1) were selected as being most favorable for more detailed study and possible development. Many other areas containing suitable clay are also likely to exist in the vicinity, but no effort has been made to determine the bloating characteristics of all clays near Dacca, inasmuch as the three designated areas contain adequate resources for starting a light-weight aggregate industry.

The term bloating clays as used throughout this report refers to the ability of certain clays to produce vesicular structure when they are heated to sufficiently high temperatures that chemical reaction forms gases that expand the material. The size of the vesicles may range from very fine, even microscopic, to a quarter of an inch or larger. Material that oontains predominently large vesicles and is very light in weight is usually termed overbloated; it is structurally weak because of the large openings and thin walls.

FIGURE 1




MAP OF DACCA DISTRICT AREA SHOWING LOCATION OF AUGER HOLES

No precise standards have been established as to what material is considered overbloated, and perhaps the best measure would be a balance between the size of the openings, strength of the material, and its intended use.

## Location and accessibility

The area investigated lies between latitudes 23°37'5"N and 23°55'N. and longitudes 90°15'E and 90°30'E. and covers the Survey of Pakistan Topographic Sheets 79J/5-6 (scale, 1:50,000) (fig. 1). It is bounded on the north by the 23°55' parallel, by Burhi Ganga River on the south, the Balu River and the town of Narayanganj on the east and the Dhaleswari River to the west. The drilled and sampled localities, and corresponding Survey of Pakistan Topographic Sheets are Panchabati (L 534135), Aliganj (L521162), Philkuni (L535166), Demra (R45624), Mirpur (L385321), Sabhar (L282399), and Tungi (L457456). The towns of Mirpur and Sabhar are situated on the Dacca-Aricha concrete surfaced road and are approximately 7 and 25 miles northwest of Dacca respectively; Tungi is about 20 miles north of Dacca on the Dacca-Tangail pitch-surfaced road. The Panchabati, Philkuni, and Demra areas are herein referred to as Areas A, B, and C, respectively.

The Panchabati, Aliganj, and Philkuni areas fall under the administrative jurisdiction of Fatulla Police Station in Narayanganj subdivision, whereas the Demra area is under the Tejgaon Police Station under Dacca Sadar South subdivision in Dacca District. These areas are easily accessible by rail and roads. The Panchabati

and Aliganj areas are about 9 and 5 miles southeast of Dacca and lie to the east and northeast respectively of the Dacca-Narayanganj pitch-surfaced road. The Philkuni area is about one-half mile north of Aliganj and is about 1-1/2 miles northeast of the Fatulla Railway Station. The railway line borders the northern side of the Pancha-bati area and the southern side of the Philkuni area.

The western and eastern limit of the Demra area along the Dacca-Demra pitch-surfaced road is about two and five miles east of Dacca. A high voltage powerline running northwest and southeast cuts through this area. Regular bus service is maintained on the Dacca-Narayanganj and Dacca-Demra roads.

## Previous investigations

A number of clay deposits in East Pakistan have been described in previous reports of the Geological Survey of Pakistan; emphasis has been on their possible utilization for ceramic products (Khan, 1962; Roy, 1960). Impurities in ceramic clays are undesirable; however, the presence of certain impurities are necessary to cause clays to bloat, and consequently our work was of a different nature from that undertaken before by the Geological Survey of Pakistan.

Limited investigations of clays amenable to bloating in East Pakistan were made by Chew (1965); a feasibility study, prepared by Louis Berger Inc. (1966) investigated the manufacture of synthetic aggregates in East Pakistan.

Acknowledgments

The authors wish to acknowledge the assistance extended to them by agencies of the Government of Pakistan, the use of their laboratory facilities, and the laboratory tests performed by them in our behalf. In particular we wish to thank the following:

Dr. N. A. Khan, Director, East Regional Laboratories, Council Scientific and Industrial Research (CSIR) Dacca.

Dr. N. Ahmed, Senior Research Officer, Ceramic Department, East Regional Laboratories, Council Scientific and Industrial Research (CSIR) Dacca.

Mr. M. Serajuddin, Deputy Director, Hydraulic Research Laboratory, East Pakistan Water and Power Development Authority (EPWAPDA) Dacca.

Mr. M. A. Bari, Technical Officer, Hydraulic Research Laboratory, East Pakistan Water and Power Development Authority (EPWAPDA) Dacca.

Dr. M. A. Bes, Senior Research Officer, West Regional Laboratories, Council Scientific and Industrial Research (CSIR), Lahore.

## GEOGRAPHY

### Topography and relief

The area investigated is characterized by low hills to the north in the vicinity of Sabhar, Mirpur, and Tungi. The low scattered hills rise 20 to 60 feet in altitude above sea level, and have a gentle regional slope to the south.

To the south the area is mainly a plain with low relief. The Demra area is slightly higher in altitude than the Panchabati and the Philkuni areas, Panchabati lying about 16 feet above sea level.

The Panchabati, Philkuni, and Demra areas gradually slope toward the south and southwest. A small depression, locally called "bil," of about 3 square miles is present west of the Dacca-Cantonment Railway Station. Another small depression of about one square mile is near the village Begunbari.

## Drainage and water supply

The Burhi Ganga, the Balu, the Dhaleswari, and the Turag are the main rivers in the area.

The Burhi Ganga originates from the Dhaleswari near Musurikhola (AL 3030) and follows an entrenched meandering course. It flows past Dacca and joins the Dhaleswari near Brahmangoon (L 510140). The Balu, following a meandering course, joins the Lakhya near Demra. The Turag river, flowing south and southeast, divides near Chota Dalia (L 366376), the two branches rejoining near Mirpur, and enters the Burhi Ganga near Nawab Char (L 406234). Numerous small nalas (small tributary streams) discharge water from the low-lying areas to the rivers. The East Pakistan WAPDA has constructed a number of canals in the Panchabati and Demra areas for irrigating during the winter and flood control during the monsoon season.

River, canal, and pond water is widely used as a source of drinking water in the rural areas. Drilled wells locally called tube wells have also been drilled in many villages.

## Flood conditions

The Sabhar, Mirpur, and Tungi areas are above flood level throughout the year. The Panchabati, Philkuni, and Demra areas, being low,

are flooded during the wet season which generally lasts from May to October. The rivers Burhi Ganga, Turag, and Balu are silting up rapidly, which greatly reduces their water-carrying capacity, and they are subject to frequent flooding. The flooding in the vicinity of Panchabati and Demra is partially controlled by recent canal construction.

## Climate

The climate is tropical throughout most of the year and is characterized by high temperatures, heavy rainfall, and excessive humidity.

The maximum mean temperature of the area is 70° F. in January and 92° F. in April. The minimum mean temperature is 54° F. in January and 78° F. in July and August.

The nor'westers and the monsoons are the chief sources of rainfall in the area. The nor'westers usually begin in January and continue until March, and are frequently characterized by thunder and hailstorms of relatively short duration.

The major rainy season, the monsoon, begins in May and continues into October. The season of nor'westers generally marges into the monsoons with no definite break between. The average annual rainfall is about 74 inches; the dry winter and spring seasons occur from November through April.

## Vegetation, cultivation, and population

The area supports a luxuriant vegetation. The mango, jax (artocarpus integrifolia), jam (eugemia jambalana), banana, and the

betelnut palm are the common trees in the area. A small tract of forest is found in the Sabhar and Mirpur areas, and the sal (shorea yobusta) is the most economically important tree for timber. Rice is the principal cultivated crop but potatoes, mustard seed, and maize are also grown.

The southern part of the area is more thickly populated than the northern part. The density of population per square mile in the Fatulla and Tejgaen Police Stations is 3,532 and 2,401 (1962 census), respectively, whereas persons per square mile in the Subhar Police Station area is 1,120 (1962 census).

The majority of the people are Muslims. The minority group includes the Hindus and a small Christian community. Agriculture is the main profession of the rural population; the urban population is largely engaged in trades and commerce, teaching, government service, or in private agencies.

## GEOLOGY

The areas investigated are partly underlain by Recent flood-plain alluvium and partly by Pleistocene sediments. The Mirpur, Sabhar, and Tungi areas are in Pleistocene deposits whereas the Panchabati, Philkuni, and Demra areas are on the flood plain. Late Pleistocene sediments were also encountered in auger holes numbers $A_5$, $A_6$, $A_7$, $A_8$, $C_6$, $C_{12}$, $C_{13}$, $C_{14}$, $C_{15}$, $C_{19}$ and $C_{20}$ in the Panchabati and Demra areas.

## Madhupur Clay

The Madhupur Clay is regarded as a highly weathered flood-plain deposit of the earlier Ganges, Brahmaputra, and Meghra River systems and is of Pleistocene age. It forms very low hills in the Sabhar area and mostly underlies a mantle a few inches to a few feet thick of recent sediments in the Mirpur and Tungi areas. It stands topographically above the level of present active flood plains in the Sabhar and Tungi areas.

The eroded material from the Madhupur Clay has been transported and redeposited in some places. Thus, in auger holes numbers $A_5$, $A_6$, $A_7$, $C_6$, $C_{12}$, $C_{13}$, $C_{14}$, $C_{15}$, $C_{19}$, and $C_{20}$, in the Panchabati and Demra areas, reworked material believed to be from the Madhupur Clay has been observed.

Clay is the chief constituent of the Madhupur, although clayey silt is common. The clay is bluish gray, whitish gray, yellowish gray and yellowish brown to dark brown and red, and ferruginous nodules are randomly distributed through it. Organic material is confined to the surface soil profile. When wet, the clay becomes very sticky and when dry, it becomes very hard. The clay has a soapy feeling. The maximum thickness penetrated in the auger holes was 16 feet, but it is undoubtedly much thicker.

The results of the chemical analyses of the Madhupur Clay from the auger holes in the areas investigated are not available; the results of the analyses of seven samples of Madhupur Clay from different localities in East Pakistan are quoted here for reference:

"$SiO_2$ contents from 59.88 to 77.40 percent, *$R_2O_3$ contents from 20.20 to 36.00 percent, Fe contents from 3.34 + 08.90 percent, $CaCO_3$ contents from 1.00 to 2.00 percent, and Na plus Ka contents from 1.50 + 03.60 percent." (Khan, 1962).

## Flood-plain deposits

Recent flood-plain deposits cover the Panchabati, Philkuni, and Demra areas except near auger holes numbers $A_5$, $A_6$, $A_7$, $A_8$, $C_{12}$, $C_{13}$, $C_{14}$, $C_{15}$, $C_{19}$, and $C_{20}$. They are also found in the Mirpur and Sabhar areas in auger holes number $M_2$ and $S_3$ respectively. The Recent sediments have been deposited on the eroded surface of the southerly slopes of Pleistocene sediments. Recent sediments are typically dark, loosely compacted and have a moderate water content. An appreciable quantity of organic material is found in them. The Recent sediments penetrated by the auger holes are generally divisible into three distinct beds: the upper bed (1) is gray, the middle (2) is yellow, and the lower (3) is grayish blue.

Bed 1: Clayey silt is the main material comprising this bed, and the color varies from light gray to yellowish gray. The silt is loosely compacted and contains humus; the thickness ranges from 0.2 to 4.0 feet.

Bed 2: This bed is mainly clayey silt; the color varies from yellow to brownish yellow. It is loosely compacted and contains abundant yellowish-brown ferruginous material. In some holes, root openings and small decayed wood particles are also found. Thickness

*$R_2O_3$ = $Al_2O_3$, $Fe_2O_3$, and traces $TiO_2$.

of the bed ranges from 2.5 to 12.5 feet.

Bed 3: This bed is mainly silty clay which in some holes becomes clayey. Very fine grained bluish-gray silty sand is found at the bottom of this bed in holes $C_2$ and $C_4$. The thickness of the bed ranges from 5.0 to 18.0 feet. The bed contains small buff-colored ferruginous pisolites; partly decomposed wood trunks and small rotten wood particles are randomly distributed. Vegetal matter of brownish black color is concentrated. The clay has a soapy feel.

## FIELD INVESTIGATION

### Reconnaissance investigations

During the period November 27, 1967, to December 11, 1967, a reconnaissance survey was made to locate clay deposits in various strategic places along the highways, gasline, and power line within a radius of 20 miles of Dacca. The reconnaissance holes were located in part on the basis of information and maps from a report by Chew (1965) that refers to areas in which bloating clays have been found. Another and more significant guide was the presence of operating brick kilns, particularly those where fragments of "Jhama" (accidentally bloated clays) were observed.

Four auger holes were drilled in the Panchabati area, two in the Aliganj area, three in the Demra area, two in the Mirpur area, three in the Sabhar area, and one in the Tungi area. The depths of the auger holes range from 11 to 26.6 feet. Samples from the reconnaissance holes were tested for bloating characteristics in the muffle furnace. The areas of samples that bloated in these initial tests were then

expanded outward as described below.

## Detailed investigations

After the reconnaissance studies were completed and the three most favorable areas (Panchabati, Philkuni, and Demra) were selected, a program of more detailed studies was prepared for each of these areas. The Panchabati, Philkuni, and Demra areas are referred to herein as Area A, B, and C, respectively.

In Area A the holes were spaced from 670 to 1,680 feet apart. The minimum and maximum spacing between adjacent holes in Area B is 1,350 and 2,365 feet, respectively. The spacing in Area C is greater; the distance between two holes is about 3,380 feet. All the auger holes in Areas A, B, and C are shown on figure 1. In all, twelve auger holes were drilled in Area A, 7 in Area B, and 21 in Area C including the reconnaissance drill holes. The depth of auger holes ranges from 13.5 to 21 feet in Area A, 16 to 26.6 feet in Area B, and 11 to 23.5 feet in Area C. The total footage of the auger holes of Area A, B, and C is 184, 147, and 350 feet, respectively. The auger holes were drilled manually; the maximum depth was 26.6 feet, and a detailed log of each hole was written. Logs of the holes are given on pages 26 to 83.

## Sampling methods

The reconnaissance auger holes revealed that in the areas of recent clay deposits there is a thin topsoil layer that ranges in thickness from a few inches to four feet (Bed 1), underlain by a layer of yellow silty clay (Bed 2), and a lower layer of gray organic clay (Bed 3). Because of the relative thinness of Bed 1, and as much of it would be

spoiled preparatory to mining, Bed 1 and Bed 2 have been sampled as a single unit, predominently yellow in color, and designated Sample 1. Bed 3 or gray organic clay was sampled separately and designated Sample 2. Samples 1 and 2 from each reconnaissance hole were tested individually in the muffle furnace to obtain specific bloating characteristics for each sample. Muffle furnace tests were also made on composite samples from each reconnaissance hole consisting of equal amounts of clay from Samples 1 and 2. In reconnaissance holes where the clay deposit appeared to be uniform and was of Pleistocene age, only a single composite sample was taken; it represented the entire section for furnace testing. Distribution of samples in respect to geologic age and lithologic units are shown on page 26.

Since it is desirable to mine the entire deposits in actual commercial operations with a minimum of selective spoiling of any layer, only composite samples were tested from the exploration holes in Areas A, B, and C. The authors recognize that the blend used in these composite samples (equal amounts of clay from each layer) may not be the optimum mix to produce the strongest bloated material, but such an optimum mix can be determined only by use of a pilot kiln to produce enough aggregate for making concrete test cylinders.

Samples were collected in cloth bags 9 inches by 12 inches and were approximately of 5 pounds weight.

## Numbering of samples

The sample numbering system is tied to the geographic area; the letter A designates Area A as referred to on the maps and text; the

letter T indicates the holes within the vicinity of Tungi; $A_1$ means hole 1 in Area A, the next hole being $A_2$. $A_1$ followed by a dash and the number 1, 2, or 3 ($A_1$-1) indicates the sample within that hole. $A_1$-1 represents Bed 1, and $A_1$-2, is Bed 2; and $A_1$-3 is a composite sample of Bed 1 and Bed 2 in areas of recent clays or a single composite sample representing the entire section in areas of Pleistocene clays.

### Base maps

Base maps were prepared from existing topographical maps and aerial photos issued by the Survey of Pakistan.

## LABORATORY PROCEDURE

### Sample preparation

Samples were placed in an iron pan and thoroughly crushed. After quartering, each sample was placed in an aluminum pan and wetted until plastic. The plastic clay was then run through a manually driven meat grinder and extruded. Approximately fifty small balls and fifty cylindrical pellets were formed by hand from the plastic material from each sample and allowed to air dry for two or three days. These balls and pellets were placed in an electric furnace operating at 200°C (417°F) for complete drying. This was necessary to prevent their decrepitation when placed in a furnace at high temperatures.

### Quick-firing tests

Quick-firing tests following procedures outlined by Hamlin and Templin (1962), and those of South West Research Institute, San Antonio,

Texas (personal communication) were followed. Two dried balls and two cylindrical pellets were placed in a fireclay crucible in an electric muffle furnace. The periods of exposure for samples were 15, 20, 25, and 30 minutes at temperatures ranging from 1800° to 2300° F. When a particular sample began to overbloat and fuse together or to the crucible, no further tests were run. After cooling, samples were broken and examined with the naked eye and with a hand lens to determine the degree of bloating for each of the temperatures to which they had been exposed, as described under Quick-firing tests (p. 46). Fired samples from Areas A, B, and C are shown in plates 1-3. The estimation of strength for each bloated sample as given in the Appendix is an arbitrary one based on hardness and resistance to breaking with a hammer; reliable strength tests can be made only after the preparation of sufficient aggregate for the making and crushing of concrete test cylinders.

## Laboratory results

Bloating was achieved in the samples collected at temperatures ranging from 1800° F. to a maximum of 2300° F. but the majority of the samples bloated between 1800° F. to 2000° F.; this is a favorable temperature range for a commercial operation.

It was not possible to test some samples through the entire range of temperatures desired, owing to failure of the electric furnace used.

A total of 604 individual muffle furnace tests were made, the results of which are compiled in the quick-firing tests, page 46.

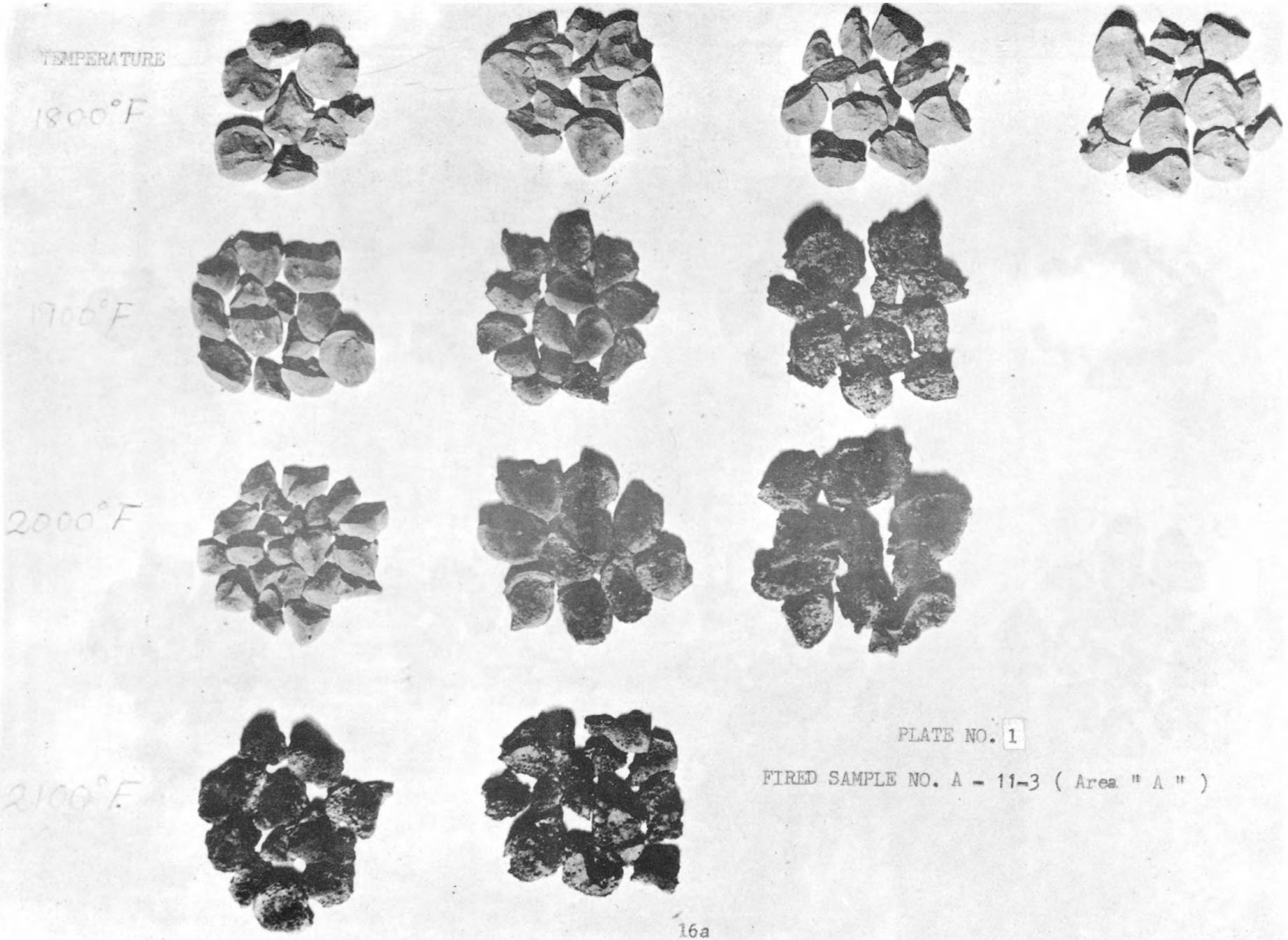



PLATE NO. 1

FIRED SAMPLE NO. A - 11-3 ( Area " A " )

15 min 20 min 25 min 30 min

TEMPERATURE

1800 F

1900 F

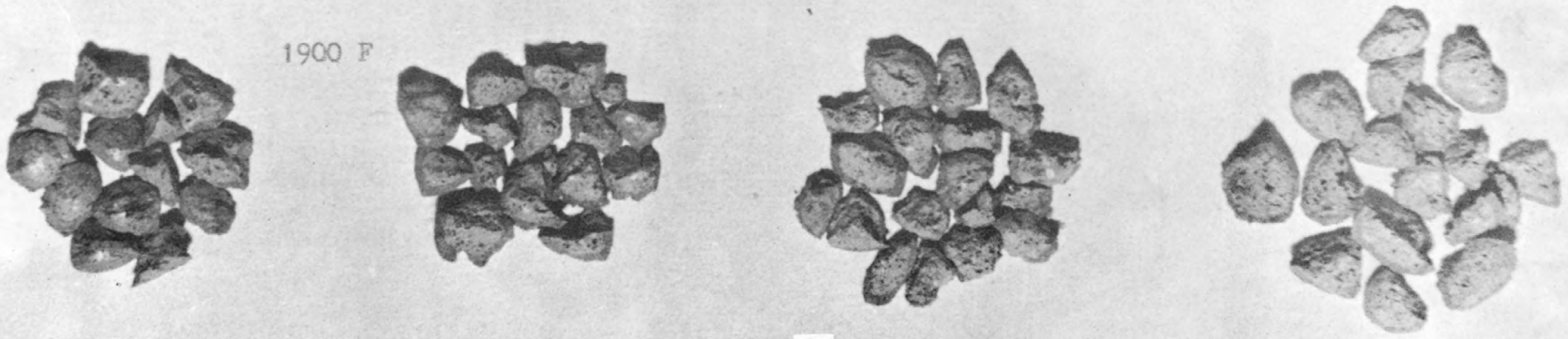


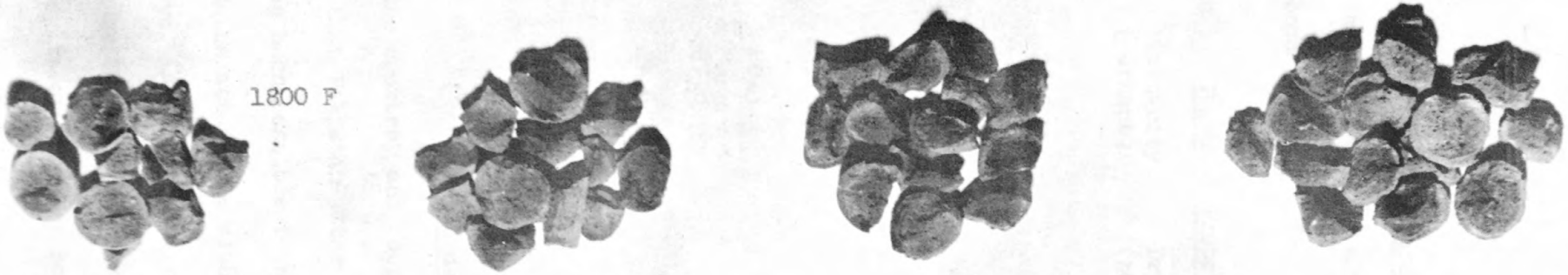
PLATE NO. 2

FIRED CLAY SAMPLE NO. $B_7$ -3 ( Area " B " )

TEMPERATURE

15 min 20 min 25 min 30 min

1800 F



1900 F

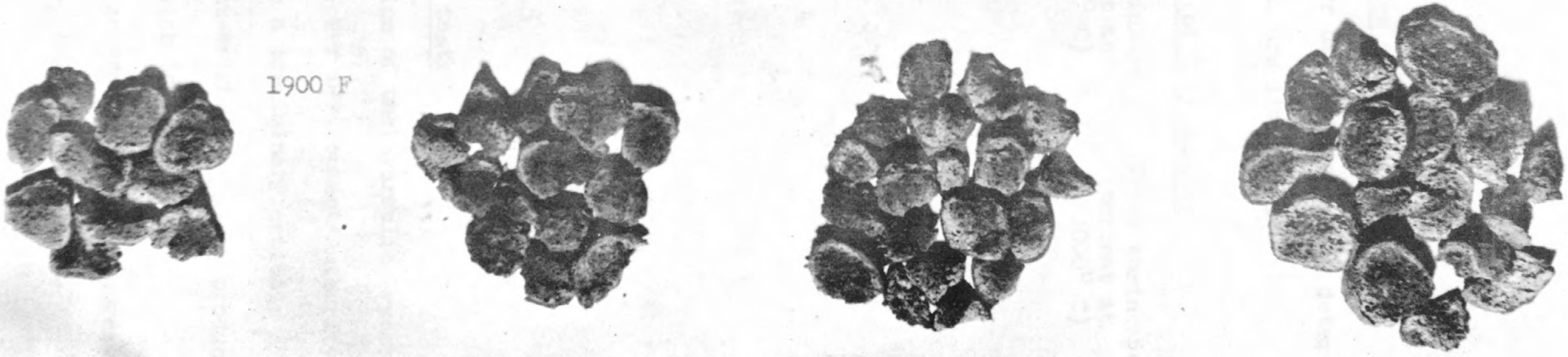


PLATE NO. 3

FIRED SAMPLE NO. $C_7$ -3 ( Area " C " )

## Physical properties

Some physical properties of a number of clay samples as determined in the laboratories of CSIR, Dacca, are listed below:

Table 1. Physical Properties of Clay Samples.

| Sample No. | Plasticity (percent) | Dry shrinkage (percent at 110° C) | Final shrinkage (percent at 1000° C) |
|---|---|---|---|
| $A_5$-3 | 26.6 | 8 | 12 |
| $A_8$ | 15.9 | 5 | 10 |
| $A_{11}$ | 26.9 | 6 | 15 |
| $B_2$-3 | 20.8 | 2 | 7 |
| $B_7$-3 | 26.1 | 9.4 | 12 |
| $C_6$-3 | 28.3 | 6.2 | 13.6 |
| $C_7$-3 | 27.8 | 5 | 13 |
| $C_{13}$-3 | 24.6 | 8 | 12 |
| $C_{15}$-3 | 21.6 | 7 | 11.4 |
| $C_{22}$-3 | 26.9 | 4.8 | 13 |

## Crushing tests

Through the courtesy and cooperation of the Hydraulic Research Laboratory of East Pakistan Water and Power Development Authority in Dacca it has been possible to secure a preliminary estimate of crushing strengths attainable with light-weight aggregates produced from Dacca clays. Again, the writers wish to emphasize that the aggregate used or the concrete mix design probably do not represent the optimum results attainable; however, the performed tests

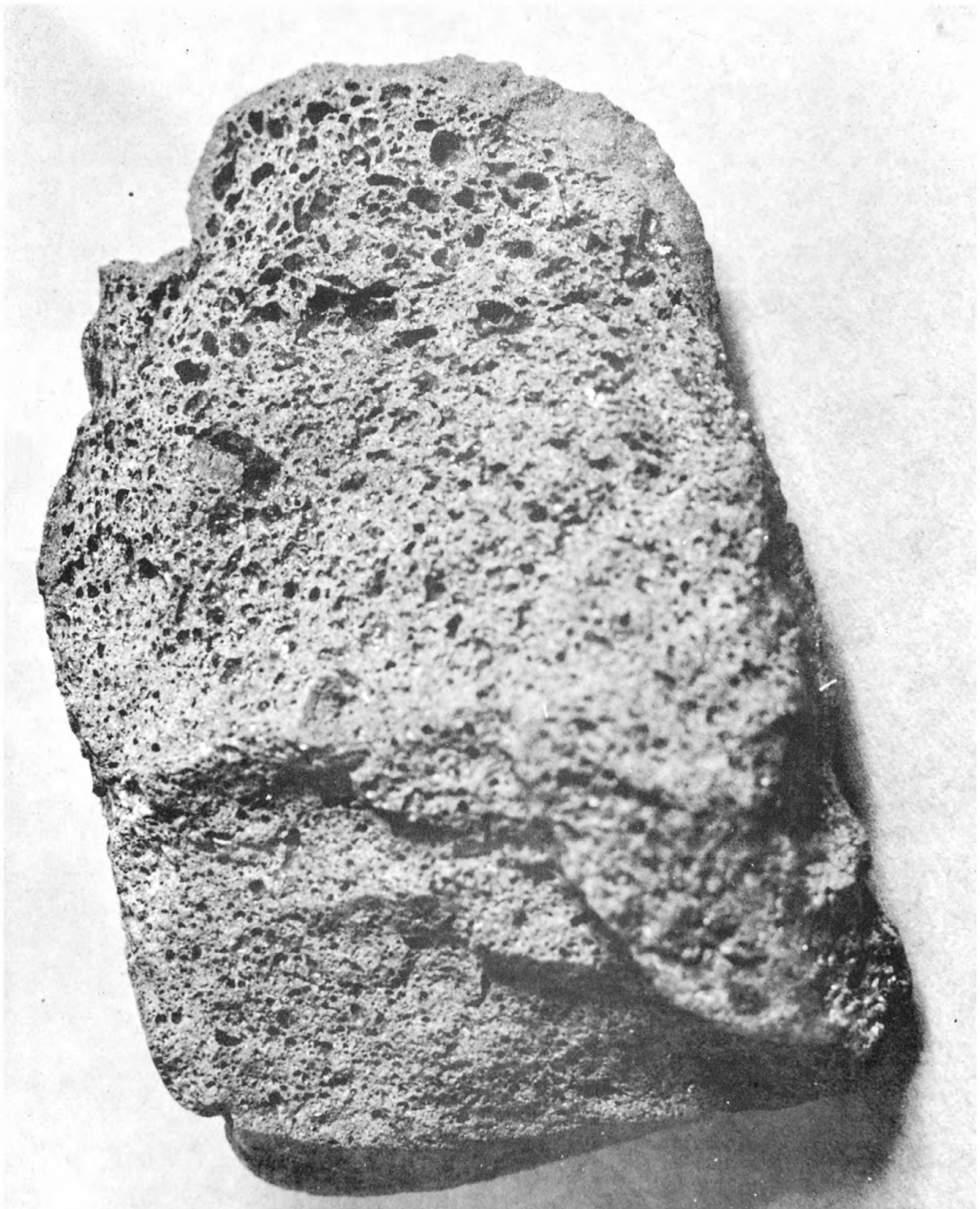
provided an indication of possible crushing strengths possibly as much as 2 years sooner than any other information could have been obtainable through access to a pilot kiln.

In many of the country brick kilns, clays of the Dacca area have frequently bloated by accident (pl. 4) owing to the unevenness of firing temperatures. Some of this material, called Jhama (Bengali meaning tough and deformed bricks), was collected and broken into aggregate. A concrete mix was designed for 5,000 pounds per square inch by EPWAPDA and cast into standard concrete test cylinders (pl. 5) 6 in. x 12 in. in size, and subjected to 3, 7, and 28 day crushing tests, the results of which follow:

Table 2. Physical properties of Jhama aggregate.

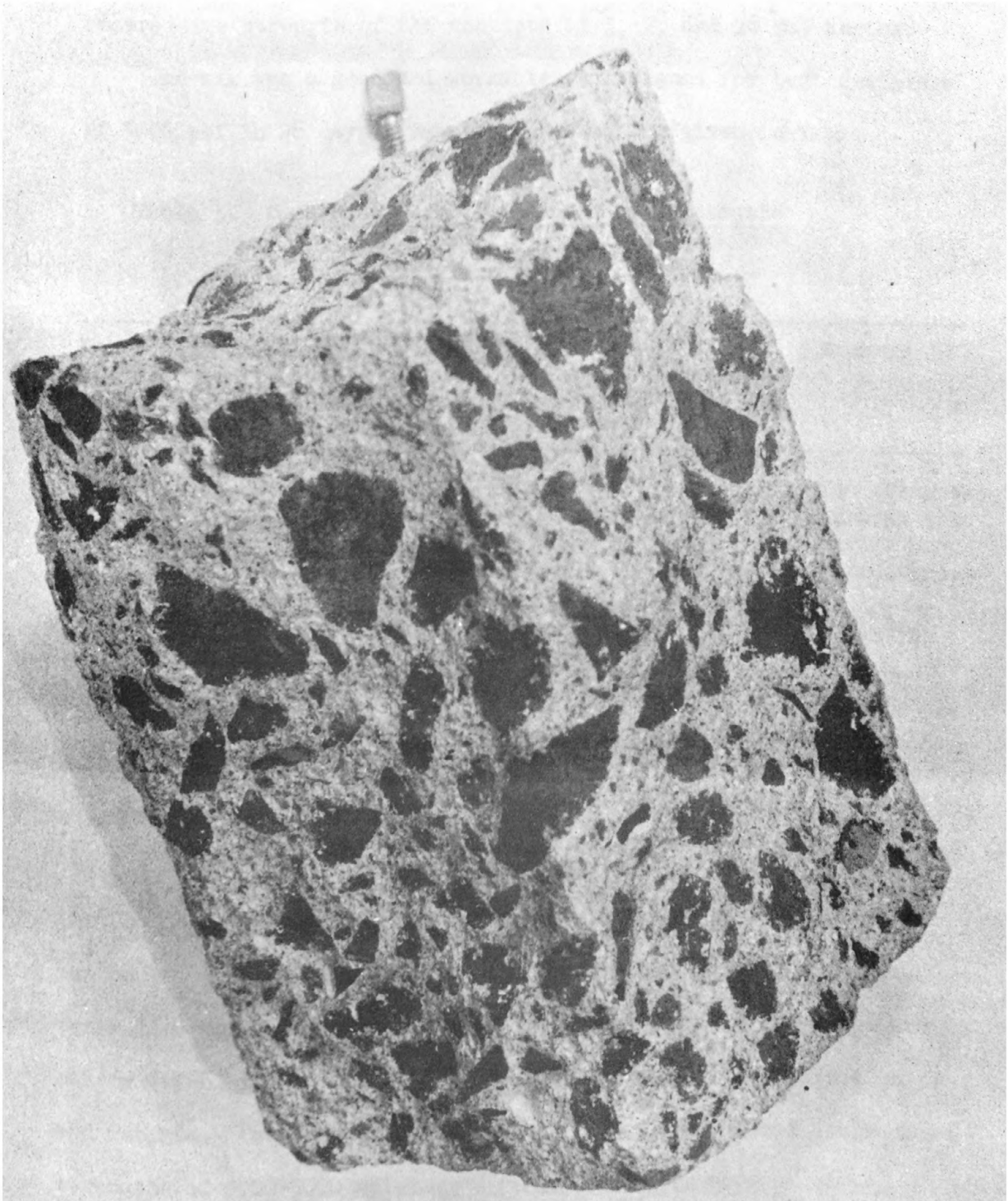
| Sample No. | Sample location | Specific gravity | Absorption (S.S.D.) (saturated surface dried) | Unit weight (lb./cu.ft.) | |
|---|---|---|---|---|---|
| | | | | Loose | Rodded |
| 1 | Mr. Ghafoor's brick field, Panchabati, Fatullah, Dacca (as stated by the client) | 1.41 | 6.05 | 40.00 | 45.75 |

One trial mix was run in the Hydraulic Research Laboratory to observe the development of compressive strengths of concrete test cylinders using a good quality Type 1 cement, coarse sand, and the supplied light-weight aggregates at a water-cement ratio of 0.44. The object of this trial mix was to determine the



"JHAMA" CLAY BLOATED BY ACCIDENT IN BRICK KILN.

PLATE NO. 4



SECTION OF CONCRETE TEST CYLINDER USING "JHAMA"

AGGREGATE SHOWING FRACTURED SURFACES.

PLATE NO. 5

compressive strength of the concrete at 3, 7, and 28 day curing.

The mix was a good and workable one designed for text cylinders of 5000 psi in 28 days. Results obtained are given in Table 3.

Table 3. Compressive strengths of Jhama aggregate concrete test cylinders.

| No. of days | Compressive strengths (psi) | Unit weight of fresh concrete (lbs./cu.ft.) | Water cement ratio | Slump (inches) | Remarks |
|---|---|---|---|---|---|
| 3 | 1344 | 117.50 | 0.44 | 1-3/4 | The break was through both mortar and aggregates. |
| 7 | 2688 | 117.50 | 0.44 | 1-3/4 | Do. |
| 28 | 4352 | 117.50 | 0.44 | 1-3/4 | Do. |
| | 4104 | 117.50 | 0.44 | 1-3/4 | Do. |

(Apr. 23, '68)

It is hoped that additional test cylinders can be made using the Jhama as aggregate in one series of cylinders and the locally broken brick in others, for comparative crushing strengths under controlled and uniform conditions. However, Louis Berger, Inc., and others (1966) tested concrete made using an aggregate of brick chips and reports, "Concrete made with brick chips has produced compressive strengths of 2000-3000 psi."

Some comparative information on compressive strength tests of cylinders containing commercially produced light-weight aggregates

is listed below. However, it is necessary to bear in mind that these results are with a different concrete mix design and were designed for 3000 psi. in 28 days.

Table 4. Compressive strength of concrete test cylinders.

| Sample No. | Slump (inches) | Compressive strength (psi) 7 days aging | 28 days aging |
|---|---|---|---|
| 1 (4 cylinders) | 4 (mixture rather wet) | 2087 | 3643 |
| | | 2122 | 3537 |
| | | 2122 | 3537 |
| | | 2158 | 3608 |
| 2 (2 cylinders) | 4 | 2759 | 3572 |
| | | 2653 | 3502 |
| | | | 4103 |
| 3 (4 cylinders) | 3-1/2 | 2618 | 4157 |
| | | 2688 | |
| | | 2546 | 4103 |
| | | 2582 | 4068 |
| 4 (4 cylinders) | 4 | 2405 | 3219 |
| | | 2193 | 3290 |
| | | 2211 | 3325 |
| | | 2193 | 3360 |

From the foregoing it can be seen that the compressive strengths of the light-weight aggregate test cylinders of this investigation compare favorably with commercially produced light-weight aggregates.

The unit weight of the Jhama aggregate given by EPWAPDA at 45.75 lbs. per cu. ft. is comparable to commercially produced light-weight aggregate. The average weight of concrete using conventional

aggregate is 150 lbs. per cu. ft.; that of the Jhama aggregate is 117.5 lbs. per cu. ft., a difference of 32.5 lbs. per cu. ft., a weight reduction of approximately 22 percent.

## RESERVES AND DEVELOPMENT

### Reserves

Reserve estimates have been made for areas A, B, and C, in cubic yards and on the basis of 1 cubic yard of raw material to produce one cubic yard of expanded aggregate. The areal extent has been scaled from maps and the average depth of all the holes augered in a particular area was used to estimate cubic yardage. Undoubtedly, the reserves in any particular area could be expanded by further augering. All the auger holes ended in clay, and deeper drilling would undoubtedly increase the established depth of the clay deposit with consequent increase of reserves.

Table 5. Reserves.

| Area | Dimensions (in yards) | | | Volume |
|---|---|---|---|---|
| | Length | Width | Depth | (Cubic yards) |
| A | 2000 | 1500 | 5 | 15,000,000 |
| B | 2500 | 700 | 7 | 12,250,000 |
| C | 6000 | 2700 | 6 | 97,200,000 |
| | 3600 | 500 | 6 | 10,800,000 |
| Total ..... | | | | 135,250,000 |

A commercial plant producing 1000 cubic yards per day of light-weight aggregate and operating 330 days per year would require 330,000 cubic yards of raw material per year. A 20-year clay reserve would require 6,600,000 cubic yards of proven reserves. On this basis, Area A would have a life of 40 years, Area B, 35 years, and Area C approximately 300 years. In estimating the above reserves it should be kept in mind that they are not necessarily all minable reserves, owing to encroachment on village sites or other cultural features; however, there is no doubt that sufficient reserves for a commercial plant can be confirmed as well as the reasonable belief that any of these areas can be extended or new deposits found equal in quality to those tested.

## Development

The selection of Areas A, B, and C for exploration drilling, aside from the amenability of the clay to bloating, was also guided by their proximity to market, all being located within a radius of 10 miles from central Dacca. Presently existing highways, river fronts, railways, power and gas lines are all in the near vicinity of the described deposits.

The country side is flat agricultural land, the only relief being local mounds oppupied by villages and houses, and is entirely flooded during the monsoon season.

The maximum depth of presently existing clay pits dug by hand to supply the country kilns has been reported to be 35 feet, and we have seen them as deep as 23 feet. During the dry season water entering the pit does not appear to be a problem, and can be bailed

out with buckets. During the rainy season the pits are completely flooded and abandoned and new pits are dug the next dry season. Clay pits could be diked to keep out flood waters and reduce pumping to the actual rain falling into the pit; or mining could be done under water with equipment such as a slack-line scraper. The seasonal flooding of clay pits requires careful consideration in any mining plans.

It is the writer's belief from the tests made that the higher the percentage of gray organic clay in the sample, the lower the bloating temperature will be, but such clays tend to produce a weaker and overbloated product. An increase in the amount of yellow or red clays will produce a stronger aggregate with wider range of bloating temperatures, but will also necessitate higher temperatures.

## RECOMMENDATIONS

The next step in the evaluation of these clays is the establishment of a standard method of rotary-kiln processing through access to a pilot kiln. The information secured by pilot kiln testing is necessary for design and operating procedure for a full size commercial installation. Pilot kiln testing will determine the following kiln variables: kiln slope, rate of feed, retention time, kiln speed, required draft, type of flame (oxidizing, reducing, natural), range of bloating temperatures, and processing qualities such as agglomeration, adherence to the kiln, decrepitation, etc.

In addition, the proper blending of different clay horizons to produce a optimum product can be determined. Sufficient aggregate can also be produced for all testing purposes required such as

weight per cubic foot, crushing strength, water absorbtion for mix design, or other desired tests.

Pilot kilns used for such testing are in the general dimensions of 6 to 14 inches in internal diameter, and 10 to 15 feet in shell length. Some descriptions follow:

Pilot kilns: Kiln No. 0-3, "this kiln, used for testing samples weighing twenty-five pounds to several hundred pounds, is a shop made, continuous rotary kiln designed especially for the aggregate work. The kiln, 0.5 foot inside diameter by approximately ten feet long, may be adjusted for feed rates of about five to 125 pounds per hour." (Conley and others, 1948).

"The rotary kiln used was 13 feet long and 10 inches in inside diameter." (Harris and others, 1962).

"The kiln employed in the present study measures 12-1/4 feet long by 2 feet in outside diameter. It is lined with 4-1/2 inches of firebrick and has an inside diameter of 14 inches." (Written communication from Southwest Research Institute).

"A total of 28 runs on 14 materials was made in the 8-inch by 12-foot rotary kiln." (Conley and others, 1948).

"The kiln used in making the tests was designed and built at the Norris Research Laboratory. Length 14 feet, diameter, inside 16 inches," (Hamlin and others, 1962).

Such pilot-kiln work can be done either by shipping some clay samples abroad where such facilities exist or by establishing a pilot kiln within the country. Which of the above procedures should be followed is best determined by how soon the information is needed

and the ultimate estimate of how many commercial light-weight aggregate plants may be built.

The shipping of samples abroad would provide the desired pilot kiln information in a matter of 3 to 5 months at a minimum cost. If only one commercial plant is foreseen in the next few years this would certainly be the most economical procedure to recommend. If the production of light-weight aggregate is considered to be a growing industry with a number of plants, the information and training to be secured by access to a pilot kiln within the country would be desirable. It may be desirable to send some samples abroad to obtain needed information quickly for developing the Dacca clay, and meanwhile to consider establishing a pilot kiln for the testing of clays in other areas.

Clay samples for shipment abroad would require approximately 4 cubic yards weighing approximately 5 tons.

## CONCLUSIONS

Large reserves of clays in the immediate vicinity of Dacca are amenable to bloating for the production of light-weight aggregate. Although the writers have described three areas in which sizable reserves exist, our auger holes were widely spaced and we did not attempt to pinpoint a specific site for a commercial operation. Before building a commercial light-weight aggregate plant, however, some additional drilling and sampling at closer intervals would be necessary. Following this drilling, it would be necessary to secure large samples for pilot kiln testing as described above.

## GEOLOGIC AGE OF SAMPLES

| Hole No. | Sample No. | Recent | | Pleistocene |
|---|---|---|---|---|
| | | Bed 1 | Bed 2 | |
| $T_1$ | $T_1$-3 | | | x |
| $S_2$ | $S_2$-3 | | | x |
| $M_1$ | $M_1$-3 | | | x |
| $A_2$ | $A_2$-3 | x | x | |
| $A_4$ | $A_4$-1 | x | | |
| | $A_4$-2 | | x | |
| | $A_4$-3 | x | x | |
| $A_5$ | $A_5$-3 | | | x |
| $A_6$ | $A_6$-3 | | | x |
| $A_7$ | $A_7$-3 | | | x |
| $A_8$ | $A_8$-3 | | | x |
| $A_9$ | $A_9$-3 | x | x | |
| $A_{10}$ | $A_{10}$-3 | x | x | |
| $A_{11}$ | $A_{11}$-3 | x | x | |
| $A_{12}$ | $A_{12}$-3 | x | x | |
| $B_1$ | $B_1$-1 | x | | |
| | $B_1$-2 | | x | |
| | $B_1$-3 | X | x | |
| $B_2$ | $B_2$-3 | x | x | |
| $B_3$ | $B_3$-1 | x | | |
| | $B_3$-2 | | x | |
| | $B_3$-3 | x | x | |

| Hole No. | Sample No. | Recent | | Pleistocene |
|---|---|---|---|---|
| | | Bed 1 | Bed 2 | |
| $B_4$ | $B_4$-3 | x | x | |
| $B_5$ | $B_5$-3 | x | x | |
| $B_6$ | $B_6$-3 | x | x | |
| $B_7$ | $B_7$-3 | x | x | |
| $C_1$ | $C_1$-1 | x | | |
| | $C_1$-2 | | x | |
| $C_2$ | $C_2$-1 | x | | |
| | $C_2$-2 | | x | |
| $C_3$ | $C_3$-1 | x | | |
| | $C_3$-2 | | x | |
| | $C_3$-3 | x | x | |
| $C_4$ | $C_4$-3 | x | x | |
| $C_6$ | $C_6$-3 | | | x |
| $C_7$ | $C_7$-3 | x | x | |
| $C_8$ | $C_8$-3 | x | x | |
| $C_9$ | $C_9$-3 | x | x | |
| $C_{10}$ | $C_{10}$-3 | x | x | |
| $C_{12}$ | $C_{12}$-3 | | | x |
| $C_{13}$ | $C_{13}$-3 | | | x |
| $C_{14}$ | $C_{14}$-3 | | | x |
| $C_{15}$ | $C_{15}$-3 | | | x |
| $C_{16}$ | $C_{15}$-3 | x | x | |
| $C_{17}$ | $C_{17}$-3 | x | x | |

| Hole No. | Sample No. | Recent | | Pleistocene |
|---|---|---|---|---|
| | | Bed 1 | Bed 2 | |
| $C_{18}$ | $C_{18}$-3 | x | x | |
| $C_{19}$ | $C_{19}$-3 | | | x |
| $C_{20}$ | $C_{20}$-3 | | | x |
| $C_{21}$ | $C_{21}$-3 | x | x | |
| $C_{22}$ | $C_{22}$-3 | x | x | |

RECONNAISSANCE AUGER HOLE

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $T_1$ | $T_1$-3 | 0.0 - 0.5 | Silty clay, grayish yellow |
| | | 0.5 - 3.5 | Silty clay, yellowish brown |
| | | 3.5 - 7.2 | Silty clay, brownish yellow |
| | | 7.2 - 8.0 | Silty clay, reddish brown |
| | | 8.0 - 12.2 | Silty clay, brownish yellow |
| $S_1$ | $S_1$-3 | 0.0 - 1.0 | Silty, brownish yellow |
| | | 1.0 - 16.0 | Silty clay, red |
| $S_2$ | $S_2$-3 | 0.0 - 4.0 | Silty clay, red |
| | | 4.0 - 13.0 | Clay, white and reddish brown mottled. |
| $S_3$ | No Sample | 0.0 - 6.0 | Silty sand, greenish gray |
| | | 6.0 - 7.0 | Sand, light gray, very fine grained. |
| | | 7.0 - 11.0 | Clayey silt, blackish gray |
| | | 11.0 - 11.5 | Clayey silt, yellowish brown |
| | | 11.5 - 12.5 | Silty sand, yellowish brown very fine grained. |
| | | 12.5 - 14.0 | Sand, light gray brown, very fine grained. |
| | | 14.0 - 14.5 | Sand, greenish, very fine grained |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $S_3$ -Cont'd | | 14.5 - 16.0 | Sand, bluish gray, very fine grained. |
| $M_1$ | $M_1$-3 | 0.0 - 0.3 | Clay silt, whitish gray |
| | | 0.3 - 4.3 | Clay, chocolate colored |
| | | 4.3 - 6.8 | Clay, light chocolate color |
| | | 6.8 - 11.0 | Silty clay, brownish chocolate |
| $M_2$ | No Sample | 0.0 - 3.5 | Clay silt, gray |
| | | 3.5 - 6.0 | Clay silt, brownish gray |
| | | 6.0 - 11.0 | Silty Sand, blackish gray, very fine grained. |
| $A_1$ | No Sample | 0.0 - 3.5 | Silt, light yellow |
| | | 3.5 - 6.0 | Clayey silt, light yellow |
| | | 6.0 - 12.0 | Silt, light yellow |
| | | 12.0 - 16.0 | Silt, greenish gray |
| $A_2$ | $A_2$-1 | 0.0 - 2.0 | Clayey silt, yellowish gray |
| | | 2.0 - 7.5 | Clayey silt, light yellow |
| | $A_2$-2 | 7.5 - 21.0 | Silty clay, bluish gray |
| | $A_2$-3 | Composite Sample of $A_2$-1 and $A_2$-2 | |
| $A_3$ | $A_3$-1 | 0.0 - 3.2 | Clayey silt, gray |
| | | 3.2 - 7.2 | Silt, light brownish yellow |
| | $A_3$-2 | 7.2 - 21.0 | Silt, bluish gray |
| | $A_3$-3 | Composite Sample of $A_3$-1 and $A_3$-2. | |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $A_4$ | $A_4$-1 | 0.0 - 3.5 | Silt, yellowish gray and grayish yellow |
| | | 3.5 - 4.0 | Clayey silt, yellowish gray |
| | | 4.0 - 6.0 | Silt, yellow. |
| | | 6.0 - 8.0 | Clayey silt, brownish yellow |
| | | 8.0 - 8.5 | Clayey silt, light grayish yellow. |
| | $A_4$-2 | 8.5 - 11.0 | Clayey silt, grayish blue |
| | | 11.0 - 21.0 | Silty clay, grayish blue |
| | $A_4$-3 | Composite of $A_4$-1 and $A_4$-2. | |
| $B_1$ | $B_1$-1 | 0.0 - 2.5 | Clayey silt, gray to yellowish gray. |
| | | 2.5 - 5.0 | Silt, yellow to brownish yellow. |
| | | 5.0 - 5.8 | Silty clay, blackish gray |
| | | 5.8 - 10.1 | Silt, yellow to brownish yellow. |
| | | 10.1 - 10.8 | Clayey silt, blackish gray. |
| | | 10.8 - 14.1 | Clayey silt, brownish yellow. |
| | $B_1$-2 | 14.1 - 14.6 | Clay, carbonaceous, black. |
| | | 14.6 - 24.1 | Clay, bluish gray. |
| | | 24.1 - 26.6 | Clay, light yellow to yellow. |
| | $B_1$-3 | Composite of $B_1$-1 and $B_1$-2. | |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $B_3$ | $B_3$-1 | 0.0 - 1.0 | Clayey silt, light gray. |
| | | 1.0 - 8.5 | Clayey silt, yellow to brownish yellow. |
| | | 8.5 - 13.5 | Silty clay, brownish yellow. |
| | $B_3$-2 | 13.5 - 18.5 | Clay, blue and brown. |
| | $B_3$-3 | Composite of $B_3$-1 and $B_3$-2. | |

## AUGER HOLE LOGS

### AREA "A" PANCHABATI (L 534135)*

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $A_1$ | | 0.0 - 3.5 | Silt, light yellow |
| | | 3.5 - 6.0 | Clayey silt, light yellow |
| | | 6.0 - 12.0 | Silt, light yellow |
| | | 12.0 - 16.0 | Silt, greenish gray |
| $A_2$ | $A_2$-1 | 0.0 - 2.0 | Clayey silt, yellowish gray |
| | | 2.0 - 7.5 | Clayey silt, light yellow |
| | $A_2$-2 | 7.5 - 21.0 | Silty clay, bluish gray |
| | $A_2$-3 | Composite Sample of $A_2$-1 and $A_2$-2 | |
| $A_3$ | $A_3$-1 | 0.0 - 3.2 | Clayey silt, gray |
| | | 3.2 - 7.2 | Silt, light brownish yellow |
| | $A_3$-2 | 7.2 - 21.0 | Silt, bluish gray |
| | $A_3$-3 | Composite Sample of $A_3$-1 and $A_3$-2 | |
| $A_4$ | $A_4$-1 | 0.0 - 3.5 | Silt, yellowish gray and grayish yellow |
| | | 3.5 - 4.0 | Clayey silt, yellowish gray |
| | | 4.0 - 6.0 | Silt, yellow. |
| | | 6.0 - 8.0 | Clayey silt, brownish yellow |
| | | 8.0 - 8.5 | Clayey silt, light grayish yellow. |

*Survey of Pakistan, Topo Sheet Grid No.

| uger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $A_4$-Cont'd | $A_4$-2 | 8.5 - 11.0 | Clayey silt, grayish blue |
| | | 11.0 - 21.0 | Silty clay, grayish blue |
| | $A_4$-3 | Composite of $A_4$-1 and $A_4$-2. | |
| $A_5$ | $A_5$-1 | 0.0 - 2.5 | Clayey silt, gray |
| | | 2.5 - 5.2 | Clayey silt, yellowish gray |
| | | 5.2 - 8.5 | Silty clay, brownish yellow |
| | $A_5$-2 | 8.5 - 13.5 | Clay, chocolate. |
| | $A_5$-3 | Composite of $A_5$-1 and $A_5$-2. | |
| $A_6$ | $A_6$-1 | 0.0 - 4.3 | Clayey silt, yellowish gray |
| | | 4.3 - 9.0 | Clayey silt, yellow |
| | $A_6$-2 | 9.0 - 13.5 | Clay, chocolate |
| | $A_6$-3 | Composite of $A_6$-1 and $A_6$-2. | |
| $A_7$ | $A_7$-1 | 0.0 - 4.0 | Clayey silt, yellowish gray |
| | | 4.0 - 7.5 | Clayey silt |
| | $A_7$-2 | 7.5 - 13.5 | Clay, chocolate |
| | $A_7$-3 | Composite of $A_7$-1 and $A_7$-2. | |
| $A_8$ | $A_8$-1 | 0.0 - 3.5 | Clayey silt, gray to yellowish grey |
| | | 3.5 - 6.0 | Silty clay, yellowish brown. |
| | | 6.0 - 7.5 | Clay, light clocolate |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $A_8$ - Cont'd | $A_8$-2 | 7.5 - 16.0 | Clay, yellowish gray |
| | $A_8$-3 | Composite of $A_8$-1 and $A_8$-2. | |
| $A_9$ | $A_9$-1 | 0.0 - 1.0 | Clayey silt, light gray |
| | | 1.0 - 4.0 | Clayey silt, light yellow |
| | | 4.0 - 5.0 | Clayey silt, blackish gray |
| | | 5.0 - 5.5 | Clayey silt, light yellowish gray |
| | $A_9$-2 | 5.5 - 8.5 | Silty clay, grayish black |
| | | 8.5 - 16.0 | Silty clay, grayish blue |
| | $A_9$-3 | Composite of $A_9$-1 and $A_9$-2 | |
| $A_{10}$ | $A_{10}$-1 | 0.0 - 0.3 | Clayey silt, gray |
| | | 0.3 - 2.9 | Clayey silt, yellow |
| | | 2.9 - 3.4 | Clayey silt, blackish gray |
| | | 3.4 - 6.4 | Clayey silt, yellow |
| | $A_{10}$-2 | 6.4 - 12.4 | Clayey silt, grayish blue |
| | | 12.4 - 13.8 | Clay, grayish black, carbonaceous. |
| | | 13.8 - 18.5 | Silty clay, gray |
| | | 18.5 - 21.0 | Clay, blackish gray |
| | $A_{10}$-3 | Composite of $A_{10}$-1 and $A_{10}$-2 | |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $A_{11}$ | $A_{11}$-1 | 0.0 - 0.5 | Silty clay, gray |
| | | 0.5 - 1.7 | Clayey silt, gray and yellow |
| | | 1.7 - 6.2 | Clayey silt, yellowish brown |
| | $A_{11}$-2 | 6.2 - 10.0 | Clayey silt, greenish blue |
| | | 10.0 - 10.3 | Clay, blackish gray, carbonaceous. |
| | | 10.3 - 17.0 | Silky clay, ash gray |
| | $A_{11}$-3 | Composite of $A_{11}$-1 and $A_{11}$-2. | |
| $A_{12}$ | $A_{12}$-1 | 0.0 - 0.5 | Silty clay, gray |
| | | 0.5 - 1.7 | Clayey silt, gray and yellow |
| | | 1.7 - 11.0 | Clayey silt, yellow. |
| | $A_{12}$-2 | 11.0 - 11.5 | Silty clay, blackish gray, carblnaceous. |
| | | 11.5 - 15.6 | Clayey silt, grayish blue |
| | | 15.6 - 16.0 | Silty clay, blackish gray, carbonaceous. |
| | $A_{12}$-3 | Composite of $A_{12}$-1 and $A_{12}$-2. | |
| | | AREA "B" PHILKUNI (L 535166)* | |
| $B_1$ | $B_1$-1 | 0.0 - 2.5 | Clayey silt, gray to yellowish gray. |
| | | 2.5 - 5.0 | Silt, yellow to brownish yellow. |

*Survey of Pakistan, Topo Sheet Grid Number

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $B_1$ - Cont'd | $B_1$-1 | 5.0 - 5.8 | Silty clay, blackish gray |
| | | 5.8 - 10.1 | Silt, yellow to brownish yellow. |
| | | 10.1 - 10.8 | Clayey silt, blackish gray. |
| | | 10.8 - 14.1 | Clayey silt, brownish yellow. |
| | $B_1$-2 | 14.1 - 14.6 | Clay, Carbonaceous, black. |
| | | 14.6 - 24.1 | Clay, bluish gray. |
| | | 24.1 - 26.6 | Clay, light yellow to yellow. |
| | $B_1$-3 | Composite of $B_1$-1 and $B_1$-2. | |
| 2 | $B_2$-1 | 0.0 - 3.0 | Clayey silt, gray. |
| | | 3.0 - 3.5 | Silty clay, yellowish gray. |
| | | 3.5 - 9. 0 | Clayey silt, yellow. |
| | $B_2$-2 | 9.0 - 11.5 | Clayey silt, grayish blue. |
| | | 11.5 - 14.7 | Silty clay, dark gray. |
| | | 14.7 - 21.0 | Clay, blackish gray, carbonaceous. |
| | $B_2$-3 | Composite of $B_2$-1 and $B_2$-2. | |
| 3 | $B_3$-1 | 0.0 - 1.0 | Clayey silt, light gray. |
| | | 1.0 - 8.5 | Clayey silt, yellow to brownish yellow. |
| | | 8.5 - 13.5 | Silty clay, brownish yellow. |
| | $B_3$-2 | 13.5 - 18.5 | Clay, blue and brown. |
| | $B_3$-3 | Composite of $B_3$-1 and $B_3$-2. | |

| ger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| | $B_4$-1 | 0.0 - 1.2 | Clayey silt, gray. |
| | | 1.2 - 4.0 | Clayey silt, gray and yellow. |
| | | 4.0 - 8.5 | Clayey silt, yellow to brownish yellow. |
| | $B_4$-2 | 8.5 - 11.0 | Clayey silt, grayish blue. |
| | | 11.0 - 13.5 | Clay, black to grayish blue. |
| | | 13.5 - 21.0 | Silty clay, gray to bluish gray. |
| | $B_4$-3 | Composite of $B_4$-1 and $B_4$-2. | |
| | $B_5$-1 | 0.0 - 1.2 | Clayey silt, gray. |
| | | 1.2 - 3.5 | Clayey silt, grayish yellow. |
| | | 3.5 - 7.0 | Clayey silt, yellow. |
| | $B_5$-2 | 7.0 - 13.5 | Clayey silt, dark gray. |
| | | 13.5 - 14.0 | Silty clay, dark gray, carbonaceous. |
| | | 14.0 - 21.0 | Silty clay, gray to bluish gray. |
| | $B_5$-3 | Composite of $B_5$-1 and $B_5$-2. | |
| | $B_6$-1 | 0.0 - 0.5 | Clayey silt, gray. |
| | | 0.5 - 4.0 | Clayey silt, dark gray. |
| | | 4.0 - 6.0 | Clayey silt, light yellow. |
| | | 6.0 - 6.5 | Silty clay, grayish white. |
| | | 6.5 - 12.3 | Silty clay, dark yellow. |
| | $B_6$-2 | 12.3 - 13.5 | Silty clay, grayish blue. |
| | | 13.5 - 16.0 | Silty clay, bluish yellow. |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $B_6$ - Cont'd | $B_6$-3 | Composite of $B_6$-1 and $B_6$-2. | |
| $B_7$ | $B_7$-1 | 0.0 - 0.5 | Clayey silt, light gray. |
| | | 0.5 - 2.5 | Clayey silt, grayish yellow. |
| | | 2.5 - 5.5 | Clayey silt, yellow. |
| | | 5.5 - 6.5 | Silty clay, brownish gray. |
| | | 6.5 - 8.0 | Clayey silt, yellow. |
| | $B_7$-2 | 8.0 - 16.0 | Clayey silt, bluish gray. |
| | | 16.0 - 21.0 | Silty clay, grayish blue |
| | $B_7$-3 | Composite of $B_7$-1 and $B_7$-2. | |
| | | AREA "C" DEMRA (RL 5624)* | |
| $C_1$ | $C_1$-1 | 0.0 - 0.2 | Clayey silt, blackish gray. |
| | | 0.2 - 5.0 | Clayey silt, yellow. |
| | | 5.0 - 6.5 | Silty clay, grayish yellow. |
| | $C_1$-2 | 6.5 - 12.0 | Silty clay, blackish gray. |
| | | 12.0 - 16.0 | Clay, grayish blue. |
| $C_2$ | $C_2$-1 | 0.0 - 2.2 | Silty clay, blackish gray. |
| | | 2.2 - 6.9 | Clayey silt, yellow. |
| | $C_2$-2 | 6.9 - 13.4 | Clay, grayish blue. |
| | | 13.4 - 14.1 | Silty sand, bluish gray, very fine grained. |

*Survey of Pakistan, Topo Sheet Grid Number

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $C_3$ | $C_3$-1 | 0.0 - 2.5 | Clayey silt, gray |
| | | 2.5 - 6.5 | Silty clay, brownish chocolate and yellowish gray. |
| | $C_3$-2 | 6.5 - 14.5 | Clay, gray to grayish blue. |
| | $C_3$-3 | Composite of $C_3$-1 and $C_3$-2. | |
| $C_4$ | $C_4$-1 | 0.0 - 1.5 | Silty clay, dark gray. |
| | | 1.5 - 3.5 | Clayey silt, grayish yellow. |
| | | 3.5 - 7.2 | Silt, brownish yellow. |
| | $C_4$-2 | 7.2 - 8.4 | Silty clay, grayish blue. |
| | | 8.4 - 9.6 | Clay, black, carbonaceous. |
| | | 9.6 - 16.0 | Silty clay, blackish blue. |
| | | 16.0 - 21.0 | Silty clay, greenish blue. |
| | $C_4$-3 | Composite of $C_4$-1 and $C_4$-2. | |
| $C_5$ | $C_5$-3 | 0.0 - 1.5 | Silty clay, dark gray. |
| | | 1.5 - 5.0 | Clayey silt, light grayish yellow. |
| | | 5.0 - 12.5 | Silt, yellow. |
| | | 12.5 - 13.7 | Silty sand, bluish gray, very fine grained. |
| $C_6$ | $C_6$-3 | 0.0 - 0.2 | Silty clay, gray. |
| | | 0.2 - 1.5 | Silty clay, yellow. |
| | | 1.5 - 11.0 | Silty clay, chocolate. |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $C_7$ | $C_7$-1 | 0.0 - 2.5 | Clayey silt, yellowish gray. |
| | | 2.5 - 3.5 | Silty clay, gray. |
| | | 3.5 - 4.0 | Silty clay, light yellow. |
| | | 4.0 - 8.5 | Clayey silt, light yellow. |
| | $C_7$-2 | 8.5 - 13.5 | Clayey silt, bluish gray. |
| | | 13.5 - 16.0 | Silty clay, blackish gray. |
| | | 16.0 - 21.0 | Silty clay, light bluish gray. |
| | $C_7$-3 | Composite of $C_7$-1 and $C_7$-2. | |
| $C_8$ | $C_8$-1 | 0.0 - 2.5 | Clayey silt, dark gray. |
| | | 2.5 - 5.0 | Clayey silt, yellowish gray. |
| | | 5.0 - 8.5 | Silt, yellowish brown. |
| | $C_8$-2 | 8.5 - 21.0 | Clayey silt, bluish gray, micaceous. |
| | $C_8$-3 | Composite of $C_8$-1 and $C_8$-2. | |
| $C_9$ | $C_9$-1 | 0.0 - 2.0 | Clayey silt, dark gray. |
| | | 2.0 - 5.0 | Clayey silt, yellowish gray. |
| | | 5.0 - 8.5 | Silt, yellowish brown. |
| | $C_9$-2 | 8.5 - 21.0 | Clayey silt, bluish gray. |
| | $C_9$-3 | Composite of $C_9$-1 and $C_9$-2. | |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $C_{10}$ | $C_{10}$-3 | 0.0 - 3.5 | Silty clay, blackish gray. |
| | | 3.5 - 9.0 | Silty clay, light bluish yellow. |
| | | 9.0 - 16.7 | Silty clay, bluish yellow. |
| | | 16.7 - 21.0 | Silty clay, brownish yellow. |
| $C_{11}$ | | NOT AUGERED | |
| $C_{12}$ | $C_{12}$-1 | 0.0 - 0.5 | Silty clay, yellowish gray. |
| | | 0.5 - 2.5 | Silty clay, light yellow. |
| | | 2.5 - 9.5 | Silty clay, yellowish gray. |
| | | 9.5 - 14.5 | Silty clay, dark yellow. |
| | | 14.5 - 17.0 | Silty clay, brownish red. |
| | $C_{12}$-2 | 17.0 - 19.0 | Silty clay, grayish blue. |
| | | 19.0 - 21.0 | Clayey silt, bluish gray. |
| | $C_{12}$-3 | Composite of $C_{12}$-1 and $C_{12}$-2. | |
| $C_{13}$ | $C_{13}$-1 | 0.0 - 1.0 | Silty clay, dark yellow. |
| | | 1.0 - 3.5 | Silty clay, light grayish chocolate. |
| | | 3.5 - 8.0 | Silty clay, gray. |
| | $C_{13}$-2 | 8.0 - 18.5 | Silty clay, grayish yellow. |
| | $C_{13}$-3 | Composite of $C_{13}$-1 and $C_{13}$-2. | |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $C_{14}$ | $C_{14}$-1 | 0.0 - 3.1 | Silty clay, yellow. |
| | | 3.1 - 10.0 | Silty clay, grayish yellow. |
| | $C_{14}$-2 | 10.0 - 18.5 | Silty clay, light brownish yellow. |
| | $C_{14}$-3 | Composite of $C_{14}$-1 and $C_{14}$-2. | |
| $C_{15}$ | $C_{15}$-3 | 0.0 - 3.0 | Silty clay, yellow. |
| | | 3.0 - 8.0 | Silty clay, light yellowish gray. |
| | | 8.0 - 13.5 | Silty clay, bluish yellow. |
| $C_{16}$ | $C_{16}$-3 | 0.0 - 0.5 | Clayey silt, dark gray. |
| | | 0.5 - 6.5 | Silt, yellow |
| | | 6.5 - 19.0 | Clayey silt, light blackish gray, micaceous. |
| $C_{17}$ | $C_{17}$-3 | 0.0 - 0.7 | Clayey silt, gray. |
| | | 0.7 - 6.7 | Silt, yellow. |
| | | 6.7 - 21.0 | Clayey silt, dark gray. |
| $C_{18}$ | $C_{18}$-1 | 0.0 - 0.6 | Clayey silt, gray. |
| | | 0.6 - 5.6 | Clayey silt, yellow. |
| | | 5.6 - 6.4 | Silty clay, yellowish gray. |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $C_{18}$ - Cont'd | $C_{18}$-2 | 6.4 - 10.9 | Clay, dark gray. |
| | | 10.9 - 12.4 | Clay, black, carbonaceous. |
| | | 12.4 - 21.0 | Clay, grayish blue. |
| | $C_{18}$-3 | Composite of $C_{18}$-1 and $C_{18}$-2. | |
| $C_{19}$ | $C_{19}$-3 | 0.0 - 3.0 | Silty clay, yellow. |
| | | 3.0 - 8.0 | Silty clay, yellow and brownish gray. |
| | | 8.0 - 15.0 | Silty clay, bluish yellow. |
| $C_{20}$ | $C_{20}$-3 | 0.0 - 1.5 | Silty clay, gray. |
| | | 1.5 - 23.5 | Silty clay, yellowish brown, with bluish gray. |
| $C_{21}$ | $C_{21}$-1 | 0.0 - 0.5 | Clayey silt, gray. |
| | | 0.5 - 4.5 | Clayey silt, light yellow. |
| | | 4.5 - 5.5 | Silty clay, light yellowish gray. |
| | $C_{21}$-2 | 5.5 - 10.5 | Clay, gray. |
| | | 10.5 - 12.5 | Clay, dark black, carbonaceous. |
| | | 12.5 - 21.5 | Clay, grayish blue. |
| | $C_{21}$-3 | Composite of $C_{21}$-1 and $C_{21}$-2. | |

| Auger Hole Number | Sample Number | Depth of Sample in Feet | Description of Sample |
|---|---|---|---|
| $C_{22}$ | $C_{22}$-1 | 0.0 - 0.5 | Clayey silt, gray. |
| | | 0.5 - 3.5 | Clayey silt, light yellow. |
| | | 3.5 - 4.0 | Silty clay, yellowish gray. |
| | $C_{22}$-2 | 4.0 - 8.5 | Clay, blackish gray. |
| | | 8.5 - 11.0 | Clay, dark gray, carbonaceous. |
| | | 11.0 - 21.0 | Clay, grayish blue. |
| | $C_{22}$-3 | Composite of $C_{22}$-1 and $C_{22}$-2. | |

RECONNAISSANCE SAMPLES, QUICK FIRING TESTS

Auger Hole No. $T_1$. Sample No. $T_1$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Light red inside, red outside, moderately strong, no bloat. | Light red inside, red outside, moderately strong, no bloat. | Light red inside, red outside, moderately strong, no bloat. | Light red inside, red outside, moderately strong, no bloat. |
| 1900°F. | Red throughout, moderately strong, no bloat. | Light red inside dark red outside, moderately strong, no bloat. | Dark red throughout, moderately strong, no bloat. | Dark red throughout, moderately strong, no bloat. |
| 2000°F. | Dark red throughout, fairly strong, no bloat. | Dark red throughout, fairly strong, no bloat. | Dark red throughout, fairly strong, no bloat. | Dark red throughout, fairly strong, no bloat. |
| 2100°F. | Dark red throughout, fairly strong, no bloat. | Dark red throughout, fairly strong, no bloat. | Light brown throughout, very strong, no bloat. | Light brown throughout, very strong, no bloat. |
| 2200°F. | Dark red throughout, fairly strong, no bloat. | Dark red throughout, fairly strong, no bloat. | Light brown throughout, fairly strong, no bloat. | Brown throughout, fairly strong, no bloat. |
| 2300°F. | Light brown throughout, fairly strong, no bloat. | Brown throughout, fairly strong, no bloat. | Light brown inside, dark brown outside, very strong, no bloat. | Light brown inside, dark brown outside, very strong, very fine bloat. |

Auger Hole No. $S_2$. Sample No. $S_2$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 1800°F | Red throughout, Moderately strong | Red throughout, Fairly strong, No bloat. | Red throughout, Fairly strong, No bloat. | Red throughout, Fairly strong, No bloat. |
| 1900°F | Red throughout, Moderately strong, No bloat. | Red throughout, Fairly strong, No bloat. | Red throughout, Fairly strong, No bloat. | Red throughout, Fairly strong, No bloat. |
| 2000°F | Red throughout, Fairly strong, No bloat. | Dark red throughout Fairly strong, No bloat. | Light brown throughout, Fairly strong, No bloat. | Brown throughout, Fairly strong, No bloat. |
| 2200°F | Dark red throughout, Fairly strong, No bloat. | Light brown throughout, Fairly strong, No bloat. | Brown throughout, dense, vitreous edge, very strong, No bloat. | Brown throughout, dense, vitreous edge, very strong, No bloat. |
| 2300°F | Dark red throughout, Moderately strong, No bloat. | Red outside, brown inside, Chocolate outside, Fairly Strong, No bloat. | Brown throughout, Fairly strong, Very fine bloating. | Dark brown throughout, Fairly strong, Slightly sticks together, Fine bloating. |

Auger Hole No. $M_1$. Sample No. $M_1$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 1800°F | Red throughout, Moderately strong, no bloat. | Red throughout, Moderately strong, no bloat. | Red throughout, Moderately strong, no bloat. | Red throughout, Moderately strong, no bloat. |
| 1900°F | Red throughout, Moderately strong, no bloat. | Dark red throughout, Moderately strong, no bloat. | Dark red throughout, Moderately strong, very little bloat. | Dark red throughout, Moderately strong, very little bloat. |
| 2000°F | Red throughout Moderately strong, no bloat. | Red throughout Moderately strong, no bloat. | Dark red throughout, Fairly strong, no bloat. | Dark red throughout, Fairly strong, no bloat. |
| 2100°F | Red throughout, Moderately strong, no bloat. | Dark red throughout, Fairly strong, no bloat. | Dark red throughout, Fairly strong, no bloat. | Dark red throughout, Fairly strong, no bloat. |
| 2200°F | Dark red throughout, Fairly strong, no bloat. | Light chocolate, throughout, Fairly strong, no bloat. | Chocolate throughout, dense, very strong, no bloat. | Chocolate throughout, dense, very strong, no bloat. |
| 2300°F | Chocolate throughout, Fairly strong, very fine bloat. | Chocolate throughout, Fairly strong, slightly sticks together, very fine bloat. | Chocolate throughout, Fairly strong, slightly sticks together, fine bloating. | Dark chocolate throughout, Fairly strong, slightly sticks together, fine bloat. |

## AREA "A" SAMPLES - QUICK FIRING TESTS

### Auger Hole No. $A_2$. Sample No. $A_2$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Central portion finely bloated, dark red inside, light red outside moderately strong. | Central portion very finely bloated, dark red inside, red outside, moderately strong. | Central portion very finely bloated, dark gray inside, red outside, moderately strong. | Some finely bloated, dark gray inside, red outside, fairly strong. |
| 1900°F. | Finely bloated, dark gray inside, red outside, fairly strong. | Finely bloated, dark gray inside, red outside, fairly strong. | Well bloated, dark gray inside, red outside, fairly strong. | Well bloated, dark gray inside, red outside, fairly strong. |
| 2000°F. | Finely bloated, dark gray inside, red outside, fairly strong. | Well bloated, gray inside, dark red outside, fairly strong. | Over bloated, gray inside, dark brown outside, not strong, sticks together. | Over bloated, gray inside, brown outside, weak, sticks in crucible. |

Auger Hole No. $A_4$. Sample No. $A_4$-1

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Some finely bloated, light red throughout, moderately strong, dark brown specks, fine mica flakes throughout. | Some very finely bloated, red throughout, moderately strong, dark brown specks, fine mica flakes throughout. | Some finely bleated, red outside, dark red outside, moderately strong, dark brown specks, fine mica flakes. | Finely bloated, red outside, dark red inside, moderately strong, dark brown specks. |
| 1900°F. | Some finely bloated, red outside, dark gray inside, moderately strong, fine mica flakes throughout. | Finely bloated,tan red outside, dark gray inside, fairly strong. | Well bloated, tan red outside, dark gray inside, fairly strong. | Finely bloated, red to tan red outside, dark gray inside, fairly strong. |
| 2000°F. | Some very finely bloated, red outside, dark red inside, moderately strong, a few white spots. | Fine even bloating, dark red outside, gray inside, fairly strong, a few brownish cream spots. | Well bloated, some over-bloated, dark brown outside, light gray inside, moderately strong, sticks together. | Well bloated, some over-bleated, brown outside, gray inside, moderately strong, slightly sticks together. |

Auger Hole No. $A_4$. Sample No. $A_4$-2

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Not bloated, light red outside, grayish red inside, moderately strong. | Central portion very finely bloated, light red outside, gray inside, fairly strong. | Central portion very finely bloated, light red outside, gray inside, fairly strong. | Central portion very finely bloated, light red outside, dark red inside, fairly strong. |
| 1900°F. | Central portion very finely bloated, light red outside, dark gray inside, moderately strong. | Finely bloated red to light red outside, dark gray inside, moderately strong. | Finely bloated, red outside, dark gray inside, fairly strong. | Fine to medium bloated, light red outside, dark gray inside, fairly strong. |
| 2000°F. | Central Portion a little bloated, red outside, light gray inside, moderately strong. | Fine evenly bloated, dark red outside, gray inside, fairly strong. | Well bloated, some overbloated. dark brown outside, whitish gray inside, moderately strong, sticks together | Overbloated, brown outside, gray inside, moderately strong, sticks together. |

Auger Hole No. $A_4$. Sample No. $A_4$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Central portion very finely bloated, dark red inside, light red out-side moderately strong, red brown specks. | Central portion very finely bloated, dark red inside red outside, moderately strong dark brown specks. | Central portion finely bloated, dark gray inside, red outside moderately strong, dark brown specks. | Some finely bloated, dark gray inside, red outside fairly strong, dark brown specks. |
| 1900°F | Finely bloated, dark gray inside, red outside, fairly strong, black specks. | Finely bloated, dark gray inside, red outside, fairly strong. | Well bloated, dark gray inside, red outside, fairly strong. | Well bloated, dark gray inside, red outside, fairly strong, black specks. |
| 2000°F | Finely bloated, dark gray inside, red outside, fairly strong, a few brown specks. | Well bloated, gray inside, dark red outside, fairly strong. | Over bloated, gray inside, dark brown outside, not strong, sticks together. | Over bloated, gray inside, brown outside, not strong, sticks together. |

Auger Hole No. $A_5$. Sample No. $A_5$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 800°F. | Red, medium hard, no bloat. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, no bloat. |
| 900°F. | Reddish brown, medium hard, gray centre, no bloat. | Reddish brown, medium hard, no bloat. | Brownish red, medium hard, some gray centre, trace very fine bloat. | Brownish red, medium hard, gray centre, fine bloat. |
| 1000°F. | Reddish brown, medium hard, gray centre, no bloat. | Reddish brown, medium hard, trace gray centre, no bloat. | Brownish red, medium hard, gray centre, very fine bloat. | Brownish red, medium hard, gray centre, fine bloat. |
| 1100°F. | Reddish brown, medium hard, some light gray centre, no bloat. | Brownish red, medium hard, light gray centre, no bloat. | Brownish red, medium hard, gray centre, fine bloat. | Brownish red, medium hard, gray centre, fine to medium bloat. |

Auger Hole No. $A_6$. Sample No. $A_6$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800° | Brick red, medium strong, no bloat. | Brick red, medium strong, no bloat. | Dark brick red, medium strong, no bloat. | Dark brick red, medium strong, no bloat. |
| 1900°F. | Brick red, medium strong, no bloat. | Brick red, medium strong, no bloat. | Dark brick red, medium strong, no bloat. | Dark brick red, medium strong, no bloat. |
| 2000°F. | Reddish brown, strong, no bloat. | Dark reddish brown, strong, some dark gray centre, no bloat. | Dark reddish brown, strong, dark gray centre, very fine bloat. | Dark reddish brown, strong, no bloat. |
| 2100°F. | Reddish brown, strong, no bloat. | Dark reddish brown, strong, trace gray centre, some fine bloat. | Dark brown, strong, dark gray centre, fine to medium bloat. | Dark brown, strong, no bloat. |

Auger Hole No. $A_7$. Sample No. $A_7$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Brownish red, medium hard, no bloat. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, no bloat. |
| 1900°F. | Brownish red, medium hard, gray centre, no bloat. | Reddish brown, medium hard, no bloat. | Brownish red, medium hard, gray in centre, fine bloat. | Brownish red, medium hard, gray centre, fine bloat. |
| 2000°F | Brownish red, medium hard, gray centre, no bloat. | Brownish red, medium hard, gray centre, no bloat. | Brownish red, medium hard, gray centre, fine bloat. | Brownish red, medium hard, gray centre, fine bloat. |
| 2100°F. | Reddish brown, medium hard, some light gray centre, no blout. | Brownish red, medium hard, gray centre, some very fine bloat. | Brownish red, medium hard, gray centre, good fine bloat. | Brownish red, medium hard, gray centre, fine to medium bloat. |

Auger Hole No. $A_8$. Sample No. $A_8$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Reddish brown, medium hard, gray in centre, no bloat. | Reddish brown, hard, no bloat. | Reddish brown, hard, trace gray centre, no bloat. | Reddish brown, hard, no bloat. |
| 1900°F. | Reddish brown, hard, light gray centre, no bloat. | Reddish brown, hard, gray centre, no bloat. | Reddish brown, hard, gray centre, no bloat. | Reddish brown, hard, gray centre, trace fine bloat. |
| 2000°F. | Reddish brown, medium hard, trace gray centre, no bloat. | Brownish red, medium hard, gray centre, some fine bloat. | Brownish red, medium hard, gray centre, fine bloat. | Brownish red, medium hard, gray centre, fine bloat. |
| 2100°F. | Reddish brown, medium hard, gray centre, some fine bloat. | Reddish brown, medium hard, light gray centre, fine bloat. | Dark reddish brown, medium hard, light gray centre, fine to medium bloat. | Dark reddish brown, medium hard, light gray, centre fine bloat. |

Auger Hole No. $A_9$. Sample No. $A_9$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Brownish red, Medium strong, gray centre, no bloat. | Brownish red, medium strong, gray centre, no bloat. | Brownish red, medium strong, dark gray centre, no bloat. | Brownish red, medium strong, dark gray centre, trace fine bloat. |
| 1900°F. | Light brown color, medium strong, gray centre, no bloat. | Brownish red, medium strong, dark gray centre, trace fine bloat. | Brownish red, medium strong, dark gray centre, fine bloat. | Brownish red, medium strong, dark gray centre, fine bloat. |
| 2000°F. | Light brown color, medium strong, dark gray centre, fine to medium bloat. | Dark brown, weak, dark gray centre, fine to medium bloat. | Dark brown, weak, dark gray centre, fine to medium bloat, sticking the crucible. | Dark brown, weak, dark gray centre, fine to medium bloat, sticking in crucible. |
| 2100°F | Tan color, medium strong, dark gray centre, fine bloat. | Dark brown, weak, dark gray centre, fine to medium bloat. | Dark brown, weak, dark gray centre, over-bloated, sticking in crucible. | No sample run. |

Auger Hole No. $A_{10}$. Sample No. $A_{10}$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F | Light brown color, medium strong, gray centre, no bloat. | Brownish red, medium strong, gray centre, very vine bloat. | Brownish red, weak, grey centre, fine bloat. | Brownish red, weak, brittle, gray centre, fine bloat. |
| 1900°F. | Light brown color, medium strong, gray centre, some very fine bloat. | Brownish red, medium strong, gray centre, fine bloat. | Dark brownish red, medium strong, light to dark gray centre, fine to medium bloat. | Dark brick red, weak, dark gray centre, fine bloat. |
| 2000°F. | Light brown, medium strong, gray centre, fine to medium float. | Dark brown, weak, grey centre, medium bloat. | Dark brown, weak, dark gray, medium to overbloat. | No sample run. |
| 2100°F. | Reddish brown, medium hard. dark gray centre, fine bloat. | Dark brown, weak, dark gray centre, medium bloat. | Dark brown, weak, dark gray centre, overbloat, sticking in crucible. | No sample run. |

Auger Hole No. $A_{11}$. Sample No. $A_{11}$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Light brown color, medium strong, some gray centre, no bloat. | Light brown color, medium strong, some gray centre, no bloat. | Light brown color, medium strong, no bloat. | Light brown color, medium strong, no bloat. |
| 1900°F. | Light brown medium strong, dark gray centre, some very fine bloat. | Brown color, medium strong, dark gray centre, fine to medium bloat. | Dark brown, weak, dark gray centre, overbloat, fusing in crucible. | No sample run. |
| 2000°F. | Light brown color, medium strong, gray centre, very fine to medium bloat. | Dark brown, medium strong, gray centre, medium bloat. | Dark brown, weak, gray centre, overbloated, fusing in crucible. | No sample run. |
| 2100°F. | Dark brown, weak, gray centre, fine to overbloat, beginning to stick and fuse. | Dark brown, weak, gray centre, fine to overbloat, beginning to to stick and fuse. | No sample run. | No sample run. |

Auger Hole No. $A_{12}$. Sample No. $A_{12}$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Light brown color, medium strong, some gray centre, no bloat. | Light brown color, medium strong, some gray centre, no bloat. | Light brown color, medium strong, no gray centre, no bloat. | Light brown color, medium strong, no gray centre, no bloat. |
| 1900°F. | Light brown color, medium strong, dark gray centre, no bloat. | Brown color, medium strong, dark gray centre, fine to medium bloat. | Dark brown, weak, dark gray centre, overbloat, fusing in crucible. | No sample run. |
| 2000°F. | Darkbrown, weak, brown centre, poor to overbloat, sticking in crucible. | Dark brown, weak, dark gray, overbloat, sticking in crucible. | No sample run. | No sample run. |

AREA "B" SAMPLES - QUICK FIRING TESTS

Auger Hole No. $B_1$. Sample No. $B_1$-1

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Red throughout, weak, not bloated. | Red throughout, weak, not bloated. | Dark red throughout, moderately strong, not bloated. | Red throughout, moderately strong, not bloated. |
| 1900°F. | Red throughout, moderately strong, not bloated. | Dark red throughout, moderately strong, not bloated. | Dark red throughout, moderately strong, not bloated. | Dark red through, moderately strong, not bloated. |
| 2000°F. | Reddish brown, fairly strong, light gray centre, not bloated. | Dark brownish red, fairly strong, light gray centre, not bloated. | Dark red throughout, fairly strong, not bloated. | Light chocolate throughout, very hard, not bloated. |
| 2100° | Red throughout, moderately strong, not bloated. | Light brown throughout, fairly strong, not bloated. | Brown throughout, dense, vitreous edge, very hard, not bloated. | Brown throughout, dense vitreous edge, very hard, not bloated. |
| 2200°F | Dark red throughout, fairly strong, not bloated. | Brown throughout, very hard, very fine irregular bloating. | Brown throughout, fairly strong, slightly sticks together, well bloated. | Dark brown throughout, moderately strong, sticks together, well to overbloated. |

Auger Hole No. $B_1$. Sample No. $B_1$-2

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Red, Moderately strong, dark red centre, very fine bloating. | Red, moderately strong, light red centre, very fine to fine bloating. | Red, moderately strong, light red centre, fine bloating. | Red throughout, moderately strong, fine bloating. |
| 1900°F | Red, fairly strong, dark gray centre, well bloated. | Dark red, fairly strong, dark gray centre, well bloated. | Dark red, fairly strong, dark gray centre, well bloated. | Dark red, fairly strong, dark gray centre, well bloated. |
| 2000°F. | Dark red, fairly strong, dark gray centre, well bloated. | Dark red, fairly strong, dark gray centre, well bloated. | Dark red, fairly strong, dark gray centre, well bloated. | Dark red, fairly strong, dark gray centre, slightly sticks together, well bloated. |
| 2100°F. | Red, fairly strong, gray centre, well bloated. | Red, fairly strong, dark gray centre, well bloated. | Brown, weak dark gray centre, sticks together, over bloated. | Brown, weak, whitish gray centre, sticks together, over bloated. |

Auger Hole No. $B_1$. Sample No. $B_1$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1900°F | Red through, moderately strong, not bloated. | Red through, moderately strong, not bloated. | Red throughout, moderately strong, some finely bloated. | Red throughout, moderately strong, some finely bloated. |
| 2000°F. | Dark red, fairly strong, light gray centre, finely bloated. | Dark red, fairly strong, light gray centre, finely bloated. | Chocolate, fairly strong, light gray centre, well bloated. | Chocolate, moderately strong, light gray centre, slightly sticks together, well to over bloated. |
| 2100°F. | Red, fairly strong, light gray centre, finely bloated. | Red, fairly strong, light gray centre, well bloated. | Brown, fairly strong, light gray centre, slightly sticks together, well bloated. | Brown, moderately strong, light gray centre, sticks together, well to over bloated. |

Auger Hole No. $B_2$. Sample No. $B_2$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, some gray centre, trace fine bloat. | Reddish brown, medium hard, no bloat. |
| 1900°F. | Reddish brown, medium strong, some gray centre, no bloat. | Reddish brown, medium strong, gray centre, fine bloat. | Brown, medium strong, gray centre, fine bloat. | No recovery. |
| 2000°F. | Reddish brown, medium strong, some gray centre, no bloat. | Brown, medium strong, gray centre, fine bloat. | Dark brown, medium strong, gray centre, medium bloat. | Dark brown, medium strong, light gray centre, medium bloat. |

Auger Hole No. $B_3$. Sample No. $B_3$-1

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Red outside, dark red inside, moderately strong, very fine bloating. | Red outside, dark red inside, moderately strong, very fine uneven bloating. | Red outside, dark red inside, moderately strong, very fine uneven bloating. | Red outside, dark red inside, moderately strong, very fine uneven bloating. |
| 1900°F. | Red outside, dark red inside, fairly strong, very fine bloating. | Red outside, dark red inside, fairly strong, very fine bloating. | Red outside, dark red inside, fairly strong, very fine bloating. | No sample run. |
| 2000°F. | Red outside, dark red inside, moderately strong, no bloating. | Light brown throughout, fairly strong, a little bloating. | Brown throughout, very strong, very fine bloating. | Brown throughout, very strong, very fine bloating. |
| 2100°F. | Dark brown, outside, light gray inside, fairly strong, well bloated. | Dark brown throughout, fairly strong, vitreous edge, a little bloating. | Brown throughout, fairly strong, no bloating. | Dark brown outside, light gray inside, very strong, well bloated. |

Auger Hole No. $B_3$. Sample No. $B_3$-2

| perature renheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 00°F. | Red throughout, moderately strong, no bloating. | Red outside, dark red inside, moderately strong, no bloating. | Red outside, dark red inside, moderately strong, no bloating. | Red outside, light red inside, fairly strong, no bloating. |
| 00°F. | Red outside, dark red inside, moderately strong, no bloating. | Dark red throughout, fairly strong, no bloating. | Dark red throughout, fairly strong, no bloating. | Dark red throughout, fairly strong, no bloating. |
| 00°F. | Red outside, dark red inside, moderately strong, no bloating. | Dark red throughout, fairly strong, no bloating. | Dark red throughout, very hard, no bloating. | Light brown outside, dark gray inside, very hard, a little irregular bloating. |
| 00°F. | Dark brown outside, light gray inside, fairly strong, well bloated. | Dark brown outside, gray spots inside, fairly strong, a little bloating. | Dark brown outside, gray spots inside, fairly strong, a little bloating. | Dark brown throughout, fairly strong, a little bloating. |

Auger Hole No. $B_3$. Sample No. $B_3$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Red outside, dark red inside, moderately strong, no bloating. | Red outside, dark red inside, moderately strong, no bloating. | Red outside, red inside, moderately strong, no bloating. | Red outside, light red inside, fairly strong, no bloating. |
| 1900°F. | Red outside, light red inside, fairly strong, no bloating. | Red outside, light red inside, fairly strong, no bloating. | Red outside, light red inside, fairly strong, no bloating. | Red outside, light red inside, fairly strong, no bloating. |
| 2000°F. | Red outside, dark red inside, fairly strong, no bloating. | Dark red to light brown throughout, very hard, no bloating. | Brown throughout, very hard, no bloating. | Brown throughout, very hard, a little bloating. |
| 2100°F. | Brownish red, fairly strong, black centre, no bloating. | Dark red throughout, fairly strong, no bloating. | Brown throughout, fairly strong, no bloating. | Dark brown throughout, fairly strong, no bloating |
| 2200°F. | Dark red throughout, very strong, no bloating. | Brown throughout, very hard, slightly sticks together, no bloating. | Brown throughout, very hard, very fine irregular bloating. | Brown throughout, fairly strong, fine bloating. |
| 2300°F. | Dark red throughout, very strong, no bloating. | Brown throughout, very strong, very fine irregular localized bloating. | Brown throughout, fairly strong, slightly sticks together, fine bloating. | Brown outside, light brown inside, fairly strong, sticks together, good bloating. |

Auger Hole No. $B_4$. Sample No. $B_4$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, some gray centre, trace fine bloat. | Reddish brown, medium hard, no bloat. |
| 1900°F. | Reddish brown, medium hard, no bloat. | Reddish brown, medium hard, dark gray centre, fine bloat. | Brown, medium hard, dark gray centre, fine bloat. | No sample run. |
| 2000°F. | Reddish brown, medium hard, gray centre, fine bloat. | Dark brown, medium hard, gray centre, medium bloat. | Dark brown, medium hard, gray centre, medium bloat. | Dark brown, medium hard, gray centre, medium bloat. |

Auger Hole No. $B_5$. Sample No. $B_5$-3

| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
|---|---|---|---|---|
| 1800°F. | Brownish red, medium strong, light gray centre, no bloat. | Brownish red, medium strong, no bloat. | Brownish red, medium strong, no bloat. | Reddish brown, medium strong, some gray centre, no bloat. |
| 1900°F. | Reddish brown, medium strong, gray centre, no bloat. | Brown, medium strong, gray centre, fine bloat. | Dark brown, medium strong, gray centre, fine to medium bloat. | Dark brown, medium strong, gray centre, fine to medium bloat. |
| 2000°F. | Dark brown, medium strong, light to dark gray centre, medium to large bloat. | Reddish brown, medium strong, light gray centre, fine to medium bloat. | Brick red, medium strong, light gray centre, fine to medium bloat. | Dark brown, medium strong, light gray centre, fine to medium bloat. |

Auger Hole No. $B_6$. Sample No. $B_6$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Red, medium strong, gray centre, no bloat. | Red, medium strong, gray centre, no bloat. | Brownish red, medium strong, gray centre, no bloat. | No recovery. |
| 1900°F. | Reddish brown, medium strong, gray centre, no bloat. | Reddish brown, medium strong, gray centre, some fine bloat. | Brown, medium strong, gray centre, fine bloat. | Dark brown, medium strong, light gray centre, medium bloat. |

Auger Hole No. $B_7$. Sample No. $B_7$-3

| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
|---|---|---|---|---|
| 1800°F. | Brick red, weak, trace gray center, no bloat. | Brick red, weak, trace gray center, trace fine bloat. | Brick red, weak, some gray centre, trace fine bloat. | Brick red, weak, trace grey center, no bloat. |
| 1900°F. | Brown, moderately strong, light gray centre, fine bloat. | Brown, moderately strong, light gray centre, fine to medium bloat. | Brown, moderately strong, light gray centre, medium bloat | Dark brown, moderately strong, light gray centre, well bloated. |

AREA "C" SAMPLES - QUICK FIRING TESTS

Auger Hole No. $C_1$. Sample No. $C_1$-1

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Light red throughout, moderately strong, not bloated. | Red throughout, moderately strong, not bloated. | Red throughout, moderately strong, not bloated. | Red throughout, moderately strong, not bloated. |
| 1900°F. | Brownish red inside, light red outside, moderately strong, not bloated. | Brownish red inside, light red outside, moderately strong, not bloated. | Light brown inside, light red outside, moderately strong, not bloated. | Dark red throughout, moderately strong, not bloated |
| 2000°F. | Dark red throughout, moderately strong, not bloated. | Dark red throughout, fairly strong, not bloated. | Dark brownish red throughout, fairly strong, not bloated. | Dark brownish red throughout, fairly strong, not bloated. |
| 2100°F. | Light red throughout, moderately strong, not bloated. | Dark red throughout, fairly strong, not bloated. | Light brown throughout, dense, very strong, not bloated. | Brown throughout, dense, vitreous edge, very strong, not bloated. |
| 2200°F. | Dark red throughout, fairly strong, not bloated. | Brown throughout, fairly strong, dense, vitreous edge, not bloated. | Light brown throughout, fairly strong, very finely bloated. | Brown throughout, very strong, finely bloated. |
| 2300°F. | Brownish red, moderately strong, black centre, sticks together, well to over bloats. | Reddish brown, moderately strong, black centre, sticks together, well to over bloated. | Shining black outside, black inside, not strong, completely fused together, over bloated. | Lustrous black outside, black inside, not strong, completely fused together over bloated. |

Auger Hole No. $C_1$. Sample No. $C_1$-2.

| mperature/ hrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 00°F | Light cream inside, cream outside, moderately strong, not bloated. | Light cream inside, cream outside, moderately strong, not bloated. | Light cream inside, cream outside, moderately strong, not bloated. | Cream throughout, moderately strong, not bloated. |
| 00°F | Cream throughout, moderately hard, not bloated. | Dark cream throughout, moderately strong, not bloated. | Light red inside, reddish cream outside, moderately strong, not bloated. | Light red inside, reddish cream outside, moderately strong, not bloated. |
| 00°F | Cream red throughout, moderately hard, not bloated. | Red throughout, fairly strong, not bloated. | Red throughout, fairly strong, not bloated. | Red throughout, fairly strong, not bloated. |
| 00°F | Gray to red inside, light red outside, moderately strong, a little bloated. | Gray inside, red outside, fairly strong, finely bloated. | Gray inside, dark red outside, fairly strong, finely bloated. | Light gray inside, dark red outside, fairly strong, slightly sticks together, well bloated. |

Auger Hole No. $C_2$. Sample No. C2-1

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Dark red inside, light red outside, moderately strong, no bloating. | Dark red inside, red outside, moderately strong, no bloating. | Dark red inside, red outside, moderately strong, no bloating. | Dark red inside, red outside, moderately strong, no bloating. |
| 1900°F. | Dark red inside, red outside, moderately strong, no bloating. | Dark red inside, red outside, moderately strong, no bloating. | Gray spots inside, red outside, moderately strong, no bloating. | Gray spots inside, dark red outside, moderately strong, no bloating. |
| 2000°F. | Black to dark gray inside, dark brownish red outside, moderately strong, very fine bloating. | Gray inside, dark brownish red outside, moderately strong, fine bloating. | Gray inside, dark brownish red outside, fairly strong, well bloated. | Light gray inside, brownish red outside, fairly strong, well bloated. |
| 2100°F. | Dark gray inside, brownish red outside, moderately strong, fine bloating. | Gray inside, dark brownish red outside, fairly strong, fine bloating. | Gray inside, dark brownish red outside, fairly strong, well bloated. | Light gray inside, dark brownish red outside, fairly strong, well bloated. |
| 2200°F. | Gray inside, dark red outside, fairly strong, some finely bloated. | Light gray inside, brown outside, very strong, well bloated. | Gray inside, brown outside, very strong, well to over bloated. | Light gray inside, brown outside not strong, slightly sticks together, over bloated. |

Auger Hole No. $C_2$. Sample No. $C_2$-2

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Dark cream inside, light cream outside, weak, no bloating. | Dark cream inside, cream outside, weak, no bloating. | Dark cream inside, cream outside, moderately strong, no bloating. | Dark cream inside, light cream outside, moderately strong, no bloating. |
| 1900°F. | Cream color throughout, moderately strong, no bloating. | Dark cream inside, cream outside, moderately strong, no bloating. | Gray inside, light red outside, moderately strong, very fine bloating. | Dark gray inside, red outside, moderately strong, very fine bloating. |
| 2000°F. | Gray inside, dark red outside, fairly strong, well bloated. | Gray inside, dark red outside, fairly strong, well bloated. | Gray inside, brownish red outside, fairly strong bloated. | Gray inside brownish red outside, fairly strong, fine bloating. |
| 2100°F. | Black inside, red outside, fairly strong, fine bloating. | Black inside, brown outside, fairly strong, sticks together, bloated. | Black inside, brown outside, fairly strong, sticks together, bloated. | Black inside, brown outside, fairly strong, sticks together, bloated. |

Auger Hole No. $C_3$. Sample No. $C_3$-1

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Light red, moderately strong, very fine bloating. | Light red, moderately strong, very fine bloating. | Light red, moderately strong, very fine bloating. | Light red, moderately strong, a little bloating. |
| 1900°F. | Cream, moderately strong, a little bloating. | Light red moderately strong, very fine bloating. | Dark red, fairly strong, dark gray center, very fine bloating. | Dark red, fairly strong, dark gray center, very fine bloating. |
| 2000°F. | No recovery. | Dark red, fairly strong, gray center, very fine bloating. | Dark gray, fairly strong, gray center a little bloating. | Dark red, fairly strong, gray center, a little bloating. |
| 2100°F. | Light red, fairly strong, gray center, very fine bloating. | Dark red, fairly strong, gray center, very fine bloating. | Light red, fairly strong, red center, no bloating. | Light red, fairly strong, red center, no bloating. |

Auger Hole No. $C_3$. Sample No. $C_3$-2

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 1800°F. | Cream, moderately strong, no bloating. | Cream, moderately strong, no bloating. | Cream moderately strong, no bloating. | Cream, moderately strong, no bloating. |
| 1900°F. | Cream, fairly strong, light gray center, very fine bloating. | Cream, fairly strong, light gray center, very fine bloating. | Dark red, fairly strong, gray center, very fine bloating. | No recovery. |
| 2100°F. | Dark red, fairly strong, light gray center, dense, fine bloating at edge. | Red, fairly strong, black center, dense, edge finely bloated. | Red outside, fairly strong, grayish black center, dense, no bloating. | Light red, fairly strong, blackish gray center, dense, no bloating. |

Auger Hole No. $C_3$. Sample No: $C_3$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 1800°F | Light red, Moderately strong, Light gray centre, Very fine bloating. | Light red, Moderately strong, Light gray centre, Very fine bloating. | Light red Moderately strong, No bloating. | Light red, Moderately strong, No bloating. |
| 1900°F | Light red, Fairly strong, Gray centre, very fine bloating. | Light red, Fairly strong, Gray centre, very fine bloating. | Light red, Fairly strong, Gray centre, very fine bloating. | Light red, Fairly strong, Gray centre, very fine bloating. |
| 2000°F | Light red, Fairly strong, Gray centre, very fine bloating. | Light red, Fairly strong, Gray centre, very fine bloating. | Dark red, Fairly strong, Gray centre, very fine bloating. | Dark red, Fairly strong, dark Gray centre, very fine bloating. |
| 2100°F | Light red, Fairly strong, Light gray centre, Fine bloating. | Dark brown, Fairly strong, Light gray centre, Good bloating. | Dark brown, fairly strong, gray centre, good bloating. | Brown, fairly strong, gray centre, good bloating. |
| 2200°F | Brown, Strong, No bloating. | Brown, Very strong, No bloating. | Brown, Very strong, Blackish gray centre, a little bloating. | Brown, Very strong, Whitish gray centre, Good bloating. |
| 2300°F | Dark brown, Fairly strong, No bloating. | Light brown, Fairly strong, No bloating. | Brown, Fairly strong, gray centre, fine to well bloated. | Light brown, Fairly strong, Well bloated. |

Auger Hole No. $C_4$. Sample No. $C_4$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 900°F | Light brown colour, weak, dark gray centre, some very fine bloat. | Light brown colour, weak, dark gray centre, trace very fine float. | Brick red, Weak, dark gray centre, Trace very fine bloat. | Brick red, Weak, dark gray centre, Trace very fine bloat. |
| 900°F | Light brown, Weak, dark gray centre, some fine bloat. | Light brown, Weak, dark gray centre, fine to medium bloat. | Light brown, Weak, dark gray centre, slightly sticks together, fine to medium bloat. | Light brown, Weak, dark gray centre, slightly sticks, together, fine to medium bloat. |
| | Auger Hole No. $C_6$. Sample No. $C_6$-3. | | | |
| 800°F | Brick red, Weak, trace dark gray centre, No bloat. | Brick red, Weak, no bloat. | Brick red, Weak, no Bloat. | Brick red, Weak no bloat. |
| 900°F | Brown, moderately strong, trace gray centre, no bloat. | Brown, moderately strong, some fine gray spots at centre, no bloat. | Brown, moderately strong, trace gray centre, no bloat | Brown, moderately strong, some gray centre, some very fine bloat. |
| | Auger Hole No. $C_7$. Sample No. $C_7$-3. | | | |
| 900°F | Light red, moderately strong, gray centre, no bloat. | Brownish red, moderately strong, gray centre, very fine bloat. | Reddish brown, moderately strong, gray centre, fine bloat. | Reddish brown, moderately strong, gray centre, fine bloat. |
| 900°F | Dark brown, Weak, gray centre, medium bloat. | Dark brown, Weak, gray centre, medium bloat. | Dark brown, Weak, gray centre, medium bloat. | Dark brown, Weak, gray centre, sticking in crucible, over bloat. |

Auger Hole No. $C_8$. Sample No. $C_8$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 1800°F | Brownish red, Weak, some trace gray, centre, no bloat. | Brownish red, moderately strong, gray centre, very fine bloat. | Brownish red, moderately strong, Trace gray centre, Trace very fine bloat. | Brownish red, Moderately strong, Gray centre, very fine to fine bloat. |
| 1900°F | Dark brown, medium strong, light gray, Medium bloat. | Dark brown, Medium strong, light gray, Medium to well bloat. | Dark brown, Medium strong, light gray, Well to over bloat. | Dark brown, weak, light gray, begins to stick, well to over bloat. |
| | Auger Hole No. $C_9$. Sample No. $C_9$-3. | | | |
| 1800°F | Brownish red, Weak, Some gray centre, no bloat. | Brownish red, Weak, some gray centre, no bloat. | Brownish red, Moderately strong, gray centre, very fine bloat. | Brownish red, moderately strong, gray centre, very fine bloat. |
| 1900°F | Brown, medium strong, pinkish gray centre, medium bloat. | Brown, medium strong, light gray centre, medium bloat. | Dark brown, weak, light gray centre, well bloat. | Dark brown, Weak, gray centre, well bloat. |
| | Auger Hole No. $C_{10}$. Sample No. $C_{10}$-3. | | | |
| 1800°F | Brick red, Moderately strong, Light gray centre, No bloat. | Brick red, Moderately strong, Light gray centre, No bloat. | Brick red, Moderately strong, Light gray centre, No bloat. | Brick red, Moderately strong, Light gray centre, No bloat. |
| 1900°F | Brown, Moderately strong, Light gray centre, fine bloat. | Brown, moderately strong, Light gray centre, fine bloat. | Brown, moderately strong, Light gray centre, fine bloat. | Brown, moderately strong, Light gray centre, fine bloat. |

Auger Hole No. $C_{12}$. Sample No. $C_{12}$-3

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 1800°F | Light red, Moderately strong, No bloat. | Light red, Moderately strong, No bloat. | Light brownish red, moderately strong, No bloat. | Light brownish red, moderately strong, No bloat. |
| 1900°F | Brown, strong, Some light black centre, No bloat. | Brown, strong, Trace light black centre, No bloat. | Brown, strong, Trace black centre, No bloat. | Brown, strong, No bloat. |
| | Auger Hole No. $C_{13}$. Sample No. $C_{13}$-3 | | | |
| 1800°F | Light red, Moderately strong, Trace gray centre, No bloat. | Light brownish red, moderately strong, No bloat. | Brownish red, Moderately strong, No bloat. | Brownish red, Moderately strong, No bloat. |
| 1900°F | Light brown, Strong, black centre, No bloat. | Light brown, Strong, Some light black, centre, No bloat. | Brown, strong, Trace Black centre, No bloat. | Dark brown, Strong, black centre, No bloat. |
| | Auger Hole No. $C_{14}$. Sample No. $C_{14}$-3. | | | |
| 1800°F | Light red, Strong, Trace light gray centre, No bloat. | Light red, Strong, No bloat. | Brownish red, Strong, No bloat. | Brownish red, Strong, No bloat. |
| 1900°F | Brown, Moderately strong, Some light black centre, No bloat. | Brown, Moderately strong, No bloat. | Brown, Moderately strong, Trace black centre, No bloat. | Brown, moderately strong, Trace black centre, No bloat. |

Auger Hole No. $C_{15}$. Sample No. $C_{15}$-3.

| perature renheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 00°F | Light brown, Moderately strong, No bloat. | Light brown, Moderately strong, No bloat. | Light brown, Moderately strong, No bloat. | Brown, Moderately strong, No bloat. |
| 00°F | Light brown, Moderately strong, No bloat. | Light brown, Moderately strong, No bloat. | Brown, Moderately strong, No bloat. | Dark brown, Moderately strong, No bloat. |

Auger Hole No. $C_{16}$. Sample No. $C_{16}$-3

| | | | | |
|---|---|---|---|---|
| 00°F | Light red, Weak, No bloat. | Light red, Weak, No bloat. | Light red, Weak, No bloat. | Light red, Weak, No bloat. |
| 00°F | Light red, Moderately strong, Gray centre, fine bloat. | Brown, Moderately strong, Gray centre, medium bloat. | Brown, Moderately strong, Gray centre, medium bloat. | Dark brown, Moderately strong, Gray centre, well bloat. |

Auger Hole No. $C_{17}$. Sample No. $C_{17}$-3.

| | | | | |
|---|---|---|---|---|
| 00°F | Light brown, Weak, dark gray centre, No bloat. | Light brown, Weak, Trace dark gray centre, No bloat. | Light brown, Moderately strong, Gray centre, Very fine to fine bloat. | Light brown, Moderately strong, Some gray centre, Some very fine to fine bloat. |
| 00°F | Light brown, Moderately strong, Light gray centre, Medium bloat. | Light brown, Moderately strong, Light gray centre, Medium bloat. | Dark brown, Moderately strong, Light gray centre, Medium bloat. | Dark brown, Moderately strong, Light gray centre, Medium to over bloat. |

Auger Hole No. $C_{18}$. Sample No. $C_{18}$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 800°F | Light red, Weak, gray centre, No bloat. | Light red, Weak, gray centre, No bloat. | Red, Moderately strong, Gray centre, very fine bloat. | Brown, Moderately strong, Gray centre, fine bloat. |
| 900°F | Light red, Weak, gray centre, very fine bloat. | Brownish red, Moderately strong, gray centre, medium bloat. | Brown, Moderately strong, Gray centre, medium bloat. | Dark brown, Moderately strong, Gray centre, well bloat. |

Auger Hole No. $C_{19}$. Sample No. $C_{19}$-3.

| | | | | |
|---|---|---|---|---|
| 800°F | Light brown, Moderately strong, No bloat. | Light brown, Moderately strong, No bloat. | Light brown, Moderately strong, No bloat. | Brown, Moderately strong, No bloat. |
| 900°F | Light brown, Moderately strong, No bloat. | Light brown, Moderately strong, No bloat. | Brown, Moderately strong, No bloat. | Dark brown, Moderately strong, No bloat. |

Auger Hole No. $C_{20}$. Sample No. $C_{20}$-3

| emperature ahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 Minutes | 20 Minutes | 25 Minutes | 30 Minutes |
| 800°F. | Light cream red, moderately strong, no bloat. | Light red, moderately strong, no bloat. | Light red, moderately strong, no bloat. | Light red, moderately strong, no bloat. |
| 900°F. | Red, moderately strong, no bloat. | Red, moderately strong, no bloat. | Brick red, moderately strong, no bloat. | Brick red, moderately strong, no bloat. |

Auger Hole No. $C_{21}$. Sample No. $C_{21}$-3.

| Temperature Fahrenheit | Time | | | |
|---|---|---|---|---|
| | 15 minutes | 20 minutes | 25 minutes | 30 minutes |
| 1900°F | Light red, Weak, gray centre, no bloat. | Light red, Weak, gray centre, very fine bloat. | Light red, Moderately strong, gray centre, fine bloat. | Brown, Moderately strong, gray centre, fine bloat. |
| 2000°F | Light red, Weak, Light gray centre, fine bloat. | Reddish brown, Moderately strong, light gray centre, Medium bloat. | Brown, Moderately strong, light gray centre, Medium bloat. | Dark brown, Moderately strong, light gray centre, well bloat. |

Auger Hole No. $C_{22}$. Sample No. $C_{22}$-3.

| | | | | |
|---|---|---|---|---|
| 1900°F | Light red, Weak, gray centre, no bloat. | Light red, Moderately strong, gray centre, no bloat. | Light brown, Moderately strong, gray centre, very fine bloat. | Brown, Moderately strong, dark gray centre, fine bloat. |
| 2000°F | Brown, Weak, gray centre, fine to medium bloat. | Brown, Weak, gray centre, fine to medium bloat. | Brown, Weak, light gray centre, medium bloat. | Brown, Moderately strong, light gray centre, Well bloat. |

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