# IV. LITHOLOGY OF THE COBBLESTONE LANDING

## GOALS AND METHODS

### Definition of the Study Area

The geological survey was restricted to that part of the Landing where the stone pavement is relatively intact and visible at the surface. Beginning at Jefferson Davis Park on the north, the study area extends south to the northern edge of the area disturbed by construction of the Tom Lee Monument relocation project. The study area extended from the water's edge on the west to the base of the embankment at Riverside Drive on the east. The embankment itself was not included. The total area included in the geological survey measures approximately 1,900 feet north-south and between 120 and 215 feet east-west. At the time of the survey, the river stage was at 2 feet above the 0 water line (approximately 186.0 feet AMSL), and the total area of the study area was approximately 379,000 square feet. Approximately 70,000 square feet of this total consists of river-deposited sediments below (west of) the present edge of the cobbled surface. This unpaved area presumably represents portions of the paved landing that have been eroded away by the Mississippi River over the last 130 years. Approximately 813,442 individual cobbles cover the remaining 309,000 square feet.

### Goals and Objectives

The overall goal of this part of the study was to assess the existing conditions and geological character of the Cobblestone Landing within its historical context. Specific objectives were to:

1) Identify and describe the types of stone used in construction and repair of the Landing;
2) Identify possible source areas of the stone;
3) Identify and describe stone patterns making up the overall fabric of the Landing, and interpret these patterns within a historical context;
4) Identify and describe natural and cultural causes affecting the preservation of the Landing.

These objectives were accomplished by mapping and recording a number of lithological variables, beginning with individual stones, the patterns in which they were laid, and the patterns in which they were repaired. These methods are discussed below.

### Methods

To begin recording the lithological character of the stone pavement, it was first necessary to clean and expose parts of the pavement buried beneath vegetation and river-deposited sediments that had accumulated at the water's edge for almost a decade. To allow the best possible photo image, the area was meticulously cleaned of sediments, drift debris, and vegetation. Areas where grass and weeds obscured the stone surface were treated with an herbicide that meets federal and state guidelines for use on riverbanks. The dead stubble was then cleaned away with string-line grass trimmers.

Heavy siltation on top of cobbles was removed using a bulldozer. Deck-mounted water cannons mounted on reserve fire department pumpers supplied the necessary waterpower to remove the remaining silt and clay overburden. During this phase of the study it became necessary to estimate the approximate buried western margin of the cobblestones. Removing the overburden completely would leave the edge of the cobblestones susceptible to immediate erosion and eventual displacement. For this reason, some areas of the western margin of the Landing may extend farther under the overburden than is indicated on the accompanying maps.

Control points were established across the study area by a survey crew from the City of Memphis, Division of Engineering. A baseline was extended from the south end of the Landing at the Beale Street Ramp (0+00) to the north end, corresponding to the base of the talus slope at Jefferson Davis Park (19+00). The baseline was marked with points at 100 foot intervals. Control points were also placed along lines perpendicular to the baseline (i.e., east-west). These points were marked on the surface of the stones with 18 x 18 inch white squares. A survey map of the study area (see Figure 4) produced by the City Engineer's office provided accurate elevations and locations of these control points and the boundary of the study area.

To create an accurate map image that would distinguish individual stones, it was necessary to apply state-of-the-art graphic arts and digital enhancement computer programs to a series of aerial photos. The Landing was photographed from a helicopter when the river had subsided below the western edge of the cobblestones. The 35 mm negatives were scanned directly into computer software that enhanced resolution and color contrast. The digital image was increased 500 percent, producing a scale of 1 inch to 9 feet. This image was printed out in a series of 10 36 x 36 inch line art images, each representing a section approximately 200 x 200 feet. This series of 10 large-scale digital images was used by the field geologists to encode information on each individual cobble. This recordation was accomplished by color coding. The photographs were also manipulated in the computer to form color and line art composite images that were used for pattern analysis and cultural impact studies (Appendix 1).

Individual stones were examined for mineralogical characteristics. To identify accurately the various lithologies used in building the Memphis Landing, thin section samples of each rock type were taken and microscopically analyzed under normal and polarizing light at the University of Memphis, Department of Geological Sciences.

In addition, paving stones were examined for variation in shape and size. Shape was described as one of three principal forms: 1) nondimensional; 2) roughly dimensional; or 3) dimensional. Size, for the purposes of this analysis, was described as one of two forms: 1) cobble (less than 38 inches circumference; or 2) boulder (larger than 38 inches circumference). These variables were derived by quantitative analysis of individual rock types from different sections of the Landing.

### Explanation of the Coordinate System

The following discussion refers to coordinate points established by City surveyors. As mentioned above, the site grid is based on a north-south baseline marked in 100 foot intervals, beginning at the Beale Street entrance ramp (0+00) and continuing to the base of the talus slope at Jefferson Davis Park (19+00) (see Figure 4). This baseline runs approximately 20 degrees east of north (magnetic). Reference points were also established at right angles from the 100 foot markers along the baseline, usually at the base of the Riverside Drive berm on the east and at the edge of the stones at the west.

All reference points in the following discussion refer to this grid system and are indicated by a pair of coordinates. For example, North 355/West 25 refers to a point that is 355 feet north of

point North 0+00 and 25 feet west of the baseline. Likewise, the coordinate North 1850/East 100 refers to a point 1,850 feet north of the beginning point at the Beale Street ramp (0+00) and 100 feet east of the baseline.

## RESULTS OF THE GEOLOGICAL SURVEY

The first step in this phase of the investigation was to identify the rocks in the study area. This was accomplished by macroscopic examination in the field and microscopic examination in the laboratory. Nine distinct rock types were recognized as comprising the existing stone pavement at the Memphis Landing (Figures 16-21):

| | |
|---|---|
| Type 1. | Limestone fossiliferous pellet grainstone |
| Type 2. | Limestone oolitic fossiliferous pellet grainstone |
| Type 3. | Sandstone quartz wacke |
| Type 4. | Limestone crinoidal bryzoan grainstone |
| Type 5. | Limestone crinoidal bryzoan grainstone |
| Type 6. | Syenite |
| Type 7. | Pink Granite |
| Type 8. | White granitic gneiss |
| Type 9. | Rhyolite |

### Type 1. Limestone Fossiliferous Pellet Grainstone

Description: Sandsize pellets of rounded and angular intraclasts. Grains are often in contact but do not compose the majority of the rock. Matrix is grainy with calcite crystals intergrown. Large nodules of chert and large nodules of calcitic crinoid fossils are common.

Age: Mississippian age is indicated by Rhynconellid Brachiopod fossils and Bryzoan fans.

Color: Dark gray to buff white on weathered surfaces, dark gray to tan on fresh surfaces.

Durability: This rock type is very resistant and durable. There is some breakdown where concentrations of fossils or large nodules create weak bedding planes that are more vulnerable to the stress of heavy traffic.

Distribution: The predominant rock type of the Memphis Landing is fossiliferous pellet grainstone (Type 1). Approximately 220,000 square feet of the Landing is cobbled with Type 1. It is the predominant rock type from North 850 to North 1900 and composes 40 percent of the Landing from North 0 to North 850. This rock type has been used as a major building component and a major repair component of the Memphis Landing.

Dimension: Type 1 (limestone) is found on the Landing in many forms. It ranges from large square mooring blocks (22 x 22 inches) and nondimensional boulders to roughly dimensional cobblestones. It is most often found as a nondimensional cobble with an average circumference at surface exposure of 25 inches. These stones are commonly set 8–12 inches to the grade and weigh about 50 pounds.

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(probably photos)

Possible Origin: This Mississippian age limestone is comparable to those members of the St. Louis limestone formation of central Tennessee, Kentucky, southern Illinois, southern Indiana, and Missouri that contain chert nodules, crinoid fossils, and intraclastic grains. The St. Louis limestone is readily available to river towns in all the areas mentioned above and has been quarried extensively in the past.

### Type 2. Limestone Oolitic Fossiliferous Pellet Grainstone

Description: Contains approximately 55 percent calcitic oolites in stratified layers.

Age: Mississippian age crinoid and brachiopod fossils.

Color: Light gray on fresh surface, white to buff gray on weathered surfaces.

Durability: Resists weathering well. Of the estimated 56,000 square feet of the Landing that is covered by Type 2 between North 0 and North 850, less than 10 percent needs repair. This stone is usually found with the bedding planes of the rock laid perpendicular to the surface, possibly to increase durability. This rock type tends to break down and erode where river silt is allowed to accumulate on top of the Landing, especially south of North 850 and below the 15 foot watermark.

Distribution: Type 2 (limestone) is the predominant rock type from North 0 to North 850, accounting for 40 percent of the total. Between North 850 and North 1900, Type 2 accounts for 4 percent of the total and is a major repair component. Three large repairs are found at North 1200/West 100; North 1200/East 0; and North 1500/West 100 (see Appendix 1). Type 2 was also used in drainage patterns at North 220 and North 875.

Dimension: Roughly dimensional cobblestones, which vary in size at surface exposure, with an average face of 5 x 13 inches. Stones usually become irregular and without rectangular form below surface level.

Possible Origin: Type 2 resembles members of the Monteagle formation of Mississippian age, which is found in central Tennessee, Kentucky, southern Illinois, and southern Indiana. Monteagle limestone, as in all geological member and formation names, is often identified with a different name from region to region; there is no set nomenclature. In Illinois, for example, Monteagle limestone is known as St. Genevieve limestone.

### Type 3. Sandstone Quartz Wacke

Description: A medium grained argilaceous sandstone with 10 percent matrix that is largely opaque hematite.

Age: Unknown.

Color: Dark gray on fresh surfaces, reddish orange on worn surfaces.

Durability: This stone resists breakdown under normal conditions at the Landing. Less than 10 percent of the sandstone cobbles have broken down along bedding planes.

Distribution: Type 3 (sandstone) was used as a major repair component from North 0 to North 1105, but predominantly south of North 700. Approximately 10,500 square feet of the Landing is cobbled in Type 3. Large repairs in sandstone (measured to center of repair) can be found at

North 130/West 75; North 175/East 20; North 375/West 15; North 660/West 20; and North 1040/East 80. It was also used in drainage patterns at North 220/West 45 and North 220/East 25.

Dimension: Type 3 is found as roughly dimensional cobbles with an average surface exposure of 4.5 x 9 inches and a depth of about 8 inches. At North 880, about 100 large, irregular boulders of Type 3 are mixed randomly with Type 1. This is the only concentration of boulder-sized Type 3 on the Landing.

Possible Origin: Because no fossils were present in this sandstone, its date of formation could not be determined for this study. However, its hematitic nature resembles many different types of Arkansas sandstone. Type 3 may be related to the Crystal Mountain sandstone, which was readily available near Little Rock. The Crystal Mountain sandstone is Ordovician (505 million to 438 million years) in age and bears medium grained, hematitic facies similar to those of Type 3. The Jackfork Sandstone of the Ouachita Mountains is also similar in lithology to Type 3.

### Type 4. Limestone Crinoidal Bryzoan Grainstone

Type 4 limestone is used in conjunction with Type 1 in repairs and building phases throughout the Landing but is most prevalent south of North 800. To the naked eye, some facies of Type 4 cobbles are indistinguishable from certain facies of Type 1. Therefore, these units are mapped as one but described separately.

Description: Crinoid and Bryzoan fossils are present in varying abundance. Granular cement is 100 percent calcite. Zones of intraclastic material are present.

Age: Mississippian in age, as indicated by the Mississippian age guide fossils.

Color: Light brown to light gray on weathered surfaces, usually brownish white on fresh surfaces but often light gray.

Durability: This stone weathers well under normal, dry surface conditions. When it is found well above the water level at the Landing, it is reasonably durable. Below the 20 foot mark on the river gauge, this rock has deteriorated in large numbers, causing up to 30 percent of the repairs south of North 800. This deterioration is accelerated where river silt, deposited by high water events, is allowed to remain on top of the cobblestones.

Distribution: Throughout the Landing, in conjunction with Type 1 building patterns and Type 2 repair patterns. A minor building and repair component of the Landing, it is especially prominent between North 100/West 90 and North 300/West 65.

Dimension: Roughly dimensional cobbles and boulders. Its average surface exposure is 5 x 11 inches with average depth to grade of 10 inches.

Possible Origin: Type 4 resembles members of the Bangor formation of the entire mid-continent of the U.S. It is readily available in the Mississippi, Ohio, and Tennessee river drainages.

### Type 5. Limestone Crinoidal Bryzoan Grainstone

Description: Grains not in contact, 100 percent calcite cement. Same fossil assemblage as Type 4. Possibly related in source area to Type 4.

Age: Mississippian.

Color: Dingy white to light tan.

Durability: Although this rock type does not tend to break along bedding planes, its overall nature tends toward dissolution. Like Type 4, it has 100 percent calcite cement and will break down easily when exposed to persistent moisture.

Distribution: Type 5 has been used as a minor repair component of the Landing. About 6,000 square feet of the Memphis Landing is cobbled with Type 5. Repair patterns of Type 5 are found from North 450 to North 1500. The largest of these repairs is at North 850 to North 990 at the western boundary of the Landing; it covers about 1,800 square feet. Other Type 5 repairs are at North 1130/West 110; North 900/East 10; and North 480/West 35.

Dimension: Type 5 is found as a dimensional paving stone, 5 3/8 x 11 inches at surface exposure, with an 8 inch depth to grade. Type 5 is the only true dimensional stone of the Landing found in uniform sizes. On rare occasions, the stone is placed with the 8 inch dimension as surface exposure.

Possible Origin: Although Type 5 does not seem to have the weak bedding planes of certain rocks of Type 4, they are remarkably similar under the microscope. For this reason, Type 5 is probably also from the Bangor limestone formation of the mid-continental U.S.

### Type 6. Syenite

Description: Intrusive igneous rock with 80–90 percent potassium feldspar, minor constituents of plagioclase opaque mafic minerals.

Age: Unknown.

Color: Grayish blue on fresh surfaces, light gray on weathered surfaces.

Durability: Extremely durable. Little or no breakdown in this environment.

Distribution: Type 6 (syenite) is used a minor component in small repairs throughout the Landing and as a subsidiary part of larger repairs. Approximately 10,000 square feet of the Landing is paved in syenite. It is often found in conjunction with Type 7 (pink granite), Type 8 (white granite), and Type 2 (limestone). The larger syenite repairs are at North 380/West 80; North 500/West 80; and North 1500/East 20.

Dimension: Roughly dimensional cobbles with punky, conchoidal fracture. Average dimension at surface exposure is 5 x 10 inches with 8 inches to grade.

Possible Origin: Type 6 is an igneous intrusive rock that in mineralogy greatly resembles the Granite Mountain syenite deposit near Benton, Arkansas.

### Type 7. Pink Granite

Description: Approximately 65 percent potassium feldspar, 30 percent quartz, 10 percent mafics (amphibolite). Exhibits a granopheric structure (micro pegmatite), which is a common texture, but not usually as coarse (large intergrowths). No evidence of metamorphic foliation.

Age: Unknown.

Color: From dark red to orange matrix with dark phenocrysts.

Durability: Extremely durable. Little or no breakdown in this environment.

Distribution: Type 7 (pink granite) was used as a minor repair component and is found throughout the Landing in small repair patterns and as an element of larger repairs. The largest concentration of Type 7 is can be found between North 390 and North 440. Approximately 1,500 square feet of the Landing is paved in Type 7.

Dimension: Roughly dimensional cobbles with an average surface exposure of 50 square inches (5 x 10 inches), with 8 inches to grade.

Possible Origin: Because the only local pink granite readily accessible to river transport comes from the St. Francis Mountains of Missouri, the pink granite of the Landing probably originates from this area. Other known sources of granopheric structure in pink granites are in the San Juan Mountains of Colorado, many outcrops in Canada, and small amounts in the Piedmont province of the Appalachians.

### Type 8. White Granitic Gneiss

Description: Approximately 50 percent quartz, 40 percent potassium feldspar, 5 percent albitic plagioclase, and 5 percent mica-like material with some calcium component. In thin section analysis, no gneissic banding is present. Therefore, on a microscopic level, this rock type may be identified as a "granitic schist." However, in macroscopic view, this rock type does exhibit gneissic structure and will be referred to as "granitic gneiss" on that basis.

Age: Unknown.

Color: Reddish white to dull white.

Durability: Extremely durable. Little or no breakdown in this environment.

Distribution: Type 8 (white granite) was used as a major and minor repair component in small amounts throughout the Landing. It is found in large homogeneous patterns at North 25/West 50; North 500/East 40; North 650/East 40; and North 800/East 80. Approximately 12,000 square feet of the Landing is paved in Type 8.

Dimension: Roughly dimensional, rectangular to square cobbles with an average surface exposure of 55 square inches (5.5 x 10 inches) and an average depth to grade of 9 inches.

Possible Origin: White granitic gneiss is a common igneous intrusive rock of the U.S. It is found locally in the Piedmont province of the Appalachians; it is also found in Michigan and Minnesota. The white granitic gneiss at the Landing probably is from eastern Tennessee and was originally brought in by rail.

### Type 9. Rhyolite

Description: Igneous rock composed of large plagioclase phenocrysts in a ground mass of quartz and potassium feldspar.

Age: Unknown.

Color: Dark pink to purple.

Durability: Extremely resistant to breakdown.

Distribution: Rhyolite is used throughout the study area as a minor repair component. Less than 500 stones of rhyolite were identified. Because of its rarity, rhyolite is not a component of the pattern analysis.

Dimension: Roughly dimensional cobbles with an average surface exposure of 49.5 square inches (5.5 x 9 inches) with an 8 inch depth to grade.

Possible Origin: The only source of rhyolite in the Mississippi River Valley is in the St. Francis Mountains of Missouri. Small amounts exist in the Piedmont province of the Appalachians.

## SOURCES OF THE STONE PAVEMENT MATERIALS

One goal of this research was to identify the origin of the stones used in paving the Memphis Landing. We have had limited success in this matter. None of these rock types resembles "ballast stone," which usually had rounded surfaces so that it would not damage the deep-draft wooden hulls of seagoing vessels. Although a large proportion of the cobblestones at the Memphis Landing have rounded features at surface exposure, they are extremely angular below the surface level of the Landing.

The historical record suggests that the original 1859 paving of the Landing was made with limestone originating in Illinois. The source of the stone paving was noted in city documents and newspaper accounts, which reported, "the towboat *Granite State* arrived from Cave-In-Rock yesterday, with another heavy tow of stone for paving purposes at the Landing" (*MDA*, 25 September 1859). However, the origins of paving stone employed after the Civil War is not as clear. Postbellum paving episodes may also have been done with limestone blocks from the Ohio River Valley, since the supplier, John Loudon, was used to dealing with the quarries of the lower Ohio River Valley. It would seem logical that he returned to these quarries for the new paving stone unless directed to do otherwise.

A survey of the minutes of the mayor and board of aldermen (later the legislative council) from 1875 to 1882 reveals occasional references to requiring a particular type of stone for a project. When the city began its massive street and wharf paving program about 1879, the city fathers apparently were not particular. Thousands and thousands of cubic yards of stone graded as dimensional, random-range rubble-quality, irregular riprap, and gravel (for Telford or McAdam paving) were purchased by the City for the various projects (CM Minutes, December 31, 1881, among others). Most of the stone used in the Landing can be considered either dimensional stone or random-range rubble stone. Unfortunately, the source of the purchased stone is rarely noted. Only a few copies of contracts for paving work or stone purchases exist from the pre-1900 "Tickler" files of petitions, contracts, bids, and other documents submitted for review by the mayor and board or the legislative council. None of these files contained information on the paving contracts or stone purchases by the City before 1885. In spite of the importance of the railroad in moving finished goods as well as bulk materials such as stone, no references to the shipment of stone via rail were noted in the minutes reviewed for this study.

Some of the stone used in the city's paving work originated from north-central Tennessee, in the vicinity of Clarksville:

> Messrs. John McNabb & Bro. have struck a bonanza in the way of a stone quarry, which meets the wants of Memphis for metaling the streets, and they have contracted for 100 carloads of stone spalls, facing eight inches and seven by twelve inches or fourteen inches, to be delivered here on the cars. The quarry [is] near Edmondson's ferry on Mr. W. O. Reynold's place. The stone is a kind of granite, very hard and sparkles like isinglass, and lies in ledges from five to fourteen inches thick. The Memphis authorities are highly pleased with the quantity, it being the very thing wanted, and will probably replace all of the old Nicholson pavements with it. McNabb has commenced work with a number of hands, getting out the stone, which is brought down river by the Gracey and loaded on the cars here. [*PL*, 28 March 1881]

As clear as the reference appears, there is room for confusion. A review of the geological formations indicates no granite anywhere near Clarksville, Tennessee. Apart from this one reference, the origin of stones imported for street or landing paving projects in the 1870s and 1880s is unknown.

However, tentative conclusions can be based on lithologic similarity of the cobblestone to known geological formations of the eastern and central U.S. For instance, Type 1 (limestone fossiliferous pellet grainstone) is similar to the Mississippian age St. Louis formation of the mid-continental U.S. Type 2 (limestone oolitic fossiliferous pellet grainstone) is very similar to the Mississippian age Monteagle formation. Both rock types could have originated in formations in central Tennessee, Kentucky, southern Illinois, southern Indiana, or Missouri. Type 4 (limestone fossiliferous crinoidal bryzoan grainstone) is also of Mississippian age and bears similarity to the Bangor limestone of the mid-continental U.S. It is also readily available in the Mississippi, Ohio, and Tennessee river drainages.

Type 5 (limestone fossiliferous crinoidal bryzoan grainstone) is generally of the same lithology as Type 4, except that thick beds of large fossils are not present. Type 5 is unique in its machined dimensionality. These same limestone blocks were used in 1983 to line the sidewalks in Jefferson Davis Park. It is quite probable that the Type 5 cobblestones were used to repair the Landing during the same period.

Type 3 (sandstone quartz wacke) is of indeterminate geologic age but is similar in lithology to several sandstone formations in Arkansas, such as the Crystal Mountain sandstone and Jackfork sandstone. Both of those are Paleozoic in age. The use of this stone for repairs suggests it was first procured late in the nineteenth century or, more probably, in the twentieth century.

A twentieth century affiliation is also suggested for use of the igneous materials. Type 6 (syenite) is similar to the igneous intrusive rocks of the Granite Mountain and the Benton, Arkansas, areas. Other intrusive bodies near Little Rock also produce syenite. It is a relatively uncommon rock type, unlike Mississippian age limestone, so the Type 6 cobbles probably were derived from one of the low quartz igneous intrusions of Arkansas.

Type 7 (pink granite) is possibly related to the igneous rocks of the St. Francis Mountains of Missouri. This is the only regional source of pink granite, although a few small deposits are in the Appalachians. Type 9 (rhyolite) is also possibly related to the igneous rocks of the St. Francis Mountains, one of the few sources of rhyolite in the mid-continental U.S. Type 8 (white gneissic granite) is possibly related to the metamorphosed igneous rocks of the Piedmont province of the Appalachians.

## PATTERN ANALYSIS

Mapping individual stones on the field maps allowed the researchers to group patterns of similar stones at various levels of analysis. The focus of the survey was on the Landing proper; the cobblestone pavement on entrance ramps and along the Riverside Drive berms are not accounted for in this analysis.

Two major parameters were considered in defining pattern units: 1) predominant rock types; and 2) direction of placement (parallel, perpendicular, or diagonal to the waterline of the Mississippi river). Other variables in the analysis included the average size and shape of the stone; the function of the stone (pavement vs. drainage); changes in the physical texture in groups of stones (i.e., variability of different types of rock within a pattern); and the nature of the boundary between patterns.

These factors were also applied in deriving relative dates for the patterns. Of particular importance were changes in texture. In some cases, a relatively pure monolithic pattern meets a pattern with greater variability, including stones from the monolithic pattern. Logic would suggest that the more variable pattern is younger, incorporating stones from an existing pavement. The nature of the contact, or boundary, between patterns also proved useful in the relative dating of the patterns. Patterns described as intrusive usually exhibit a sharp contact with surrounding patterns.

Eighteen dominant patterns were identified (see Appendix 1). Within these patterns are hundreds of patches of stone that indicate subsequent repair or infrastructural renovation after the placement of the original unit. The 18 dominant patterns are:

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|---|---|
| Pattern 1. | Predominant Type 1 (limestone)/parallel |
| Pattern 2. | Predominant Type 2 (limestone)/parallel |
| Pattern 3. | Predominant Type 3 (sandstone)/parallel |
| Pattern 4. | Predominant Type 4 (limestone)/parallel |
| Pattern 5. | Predominant Type 5 (limestone)/parallel |
| Pattern 6. | Predominant Type 6 (syenite)/parallel |
| Pattern 7. | Predominant Type 7 (pink granite)/parallel |
| Pattern 8. | Predominant Type 8 (white granite)/parallel |
| Pattern 9. | Predominant Type 1 (limestone), but more than 25 percent Type 4 (limestone)/parallel |
| Pattern 10. | Predominant Type 2 (limestone), but more than 25 percent Type 1 and Type 4 (limestone)/parallel |
| Pattern 11. | Predominant Type 2 (limestone)/diagonal (NE-SW) |
| Pattern 12. | Predominant Type 1 (limestone)/perpendicular |
| Pattern 13. | Predominant Type 2 (limestone)/perpendicular |
| Pattern 14. | Predominant Type 3 (sandstone)/perpendicular |
| Pattern 15. | Predominant Type 8 (white granite)/perpendicular |
| Pattern 16. | Predominant Type 1 (limestone)/diagonal (NW-SE) |
| Pattern 17. | Predominant Type 2 (limestone)/diagonal (NW-SE) |

Pattern 18. Predominant Type 8 (white granite)/diagonal

These pattern designations are subject to refinement with further work. In particular, larger patterns defined here may prove to be made up of smaller units, or subpatterns.

Based on the distribution and character of the major patterns, the Landing can be divided into four major subareas:

Subarea 1. North 1900–North 875 (Court Avenue to Union Avenue)

Subarea 2. North 875–North 460 (Union Avenue to Gayoso Avenue)

Subarea 3. North 460–North 0+00 (Gayoso Avenue to the Beale Street entrance ramp)

Subarea 4. The service road at the foot of the Riverside Drive embankment.

The discussion will begin at the northern end of the study area and move south, in a roughly chronological order with respect to the building phases of the Landing.

### Court Avenue to Union Avenue (North 1900–North 875)

From North 1900 (northern boundary of the mapped area at Court Street) to North 850 (the south side of Union Avenue), the Landing is composed of approximately 151,000 square feet of stone paving, the vast majority of it Pattern 1. In this section, less than 30 percent of the Pattern 1 stones show rough dimensionality. On the ground, Type 1 (fossiliferous limestone) stones appear to be laid randomly. However, in large-scale overview offered by the composite image, it is apparent that most of the original stones were laid in courses parallel to the river and that the original patterns of placement have been obscured by hundreds of small repairs over the past century.

The sharp boundaries of repair patterns indicate that they are intrusive to the original Pattern 1 fabric. There are large Pattern 2 (Type 2 [oolitic limestone]) intrusions at North 1500/West 85; North 1300/East 25; and North 1250/West 40. Pattern 5 (Type 5 [dimensional limestone]) intrusions are at North 1100/West 105; North 900/West 105; and North 905/East 10. In addition, there are smaller patches of Pattern 6 (syenite), Pattern 8 (white granite), Pattern 7 (pink granite), and Pattern 3 (dimensional sandstone).

### Union Avenue to Gayoso Avenue (North 875–North 460)

At approximately North 875 (south side of Union Avenue), there is a marked change in lithology. North of this line, Pattern 1 (nondimensional fossiliferous limestone) predominates, but south of the line stones are included with Pattern 9. Although Type 1 (limestone) is still present in large amounts in Pattern 9, it is now noticeably mixed with Type 4 (limestone) at random intervals. The original amount of Type 4 can only be approximated because much of it has been replaced by mends using other rock types.

From about North 850 to North 650, the Landing is predominantly Pattern 2 (roughly dimensional Type 2 [oolitic limestone]) laid in uniform courses parallel to the river. Pattern 2 appears to be intrusive into the surrounding Pattern 9, and therefore younger. Pattern 2 in this section defines one of the largest repair patterns of the Landing, covering approximately 17,000 square feet. South of North 620, the predominant Pattern 2 is transitional into Pattern 9.

Lesser repairs include large, well-defined patches of uniform rock types that are intrusive into Pattern 9 and Pattern 2. Pattern 3 (Type 3 [dimensional limestone]) intrusions are present at North 650/West 20; North 690/East 40; North 630/East 20; and North 635/West 70. Pattern 8 (Type 8 [white granite]) intrusions are at North 640/East 60 and North 625/East 35. In this section, the ages of Pattern 3 and Pattern 8 cannot be ascertained, but they are more recent than Patterns 9 and 2. Other repair patterns west of the baseline in this section are Pattern 2 at North 550/West 30 (covering about 2,500 square feet); Pattern 3 at North 530/West 15, North 500/West 40, and North 475/West 15; Pattern 6 at North 500/West 80 and North 630/West 75; and Pattern 5 at North 490/West 35 and North 510/West 30.

A large intrusion of Type 8 (granite) at North 500/East 95 is in contact with the Riverside Drive embankment. This intrusion is significant because the cobbles are laid with their long axes parallel to the Mississippi River waterline. North of this granite, the cobblestones on the service road are perpendicular to the waterline; this will be fully discussed later.

### Beale Street Landing (North 460–North 0)

The southernmost section of the Landing is characterized by complex patterns of original placement and repair. At about North 460 (north side of Gayoso Avenue), Pattern 9 becomes transitionally mixed with Pattern 10, comprised predominantly of Type 2 (oolitic limestone) with a mixture of Types 1 and 4 (fossiliferous limestone). This part of Pattern 10 also contains large amounts of granite, sandstone, and rhyolite, apparently laid as part of the pattern and not as repairs. Pattern 10 continues to about the North 390 line and covers the large storm drain leading west from Gayoso Street. The drain is believed to have been built about 1912, which would make Pattern 10 a relatively late repair. The terminus of this drain is at North 410/West 110.

At about North 390, at the south end of the sewer intrusion, there is a sharp contact between Pattern 10 and Pattern 11 to the south. Pattern 11 is characterized by almost pure, roughly dimensional Type 2 (oolitic limestone) from North 390 to North 105, down the center of the Landing. It covers approximately 10,000 square feet. Aside from the diagonal patterns of the service road at the base of the Riverside Drive berm, Pattern 11 is the only diagonal pattern on the Landing. It is extremely uniform in stone size and in grade. This diagonal pattern runs northeast-southwest. It is possible that a diagonal pattern was chosen to reduce slumpage of the grade due to riverbank undercutting and to allow better drainage of runoff water. The nature of the sharp contact between Patterns 10 and 11 is ambiguous but suggests that Pattern 10 (i.e., the sewer built ca. 1912) was laid after Pattern 11.

South of about North 400, Pattern 10 extends south on both the east and west sides of Pattern 11. A recent examination suggests a subtle change in Pattern 10 in these areas. Over the sewer, Pattern 10 contains a greater proportion of igneous rock (granites and rhyolite). South of the sewer, units mapped as Pattern 10 have less igneous rock and more oolitic limestone. From a lithological (and historical) perspective, then, it seems appropriate to separate Pattern 10a (the area over the sewer) from Pattern 10b (areas to the south containing less igneous rock). Pattern 10a is transitional with Pattern 10b, but the lower percentage of igneous materials suggests 10b was laid before construction of the sewer.

On the east side of Pattern 11 from about North 400 to North 350, Pattern 10b exhibits a sharp contact with Pattern 11 to the south. The contact is ambiguous, but at present we suggest Pattern 10b is later than Pattern 11. From North 400 to North 225, Pattern 10b occurs west of the diagonal Pattern 11. Stones from Pattern 10b are fitted into the contact with Pattern 11, again suggesting that Pattern 11 is older. Pattern 10b continues south along Pattern 11 until it reaches the major drainage at approximately North 220.

The northern edge of the drainage, composed of Type 3 (sandstone), is in sharp contact with Type 10 (limestone). However, the southern edge of the drainage is in transitional contact with a pattern of fossiliferous Type 1 and Type 4, shown in Appendix 1 as Pattern 9. This segment of Pattern 9 differs somewhat from the Pattern 9 north of the sewer, having a greater proportion of deteriorated Type 4. For this and other reasons discussed below, this text refers to it as Pattern 9b.

Pattern 9b extends west and south of Pattern 10b and west of Pattern 11 from North 215 to North 105. Apparently, Pattern 9b was placed after Patterns 10b and 11, as there are Pattern 9b cobbles shaped to fit into the contact with Pattern 11. In Pattern 9b, Type 4 (limestone) is present in its least durable facies. Thick, irregular bedding planes, composed of large Mississippian age fossils, create planes of weakness inside the rock vulnerable to weathering and heavy loads. Many of these Type 4 cobblestones have been replaced, but it is impossible to tell whether its breakdown has necessitated all the repairs in this pattern.

From approximately the 200 line to the asphalt drive at North 90, there is a large Pattern 3 (Type 3 [dimensional sandstone]) intrusion. This is the largest Pattern 3 repair, covering approximately 3,500 square feet. South of the North 105 line, asphalt and concrete impair accurate pattern analysis. However, many small and large intrusive repairs exist with a continuation of Pattern 9 south of the North 0 line.

### The Foot of the Riverside Drive Embankment

From North 0 to about North 500, stone patterns comprising the service road at the western base of the Riverside Drive berm are consistent with the major patterns west of the road. North of this point to North 710, orientation of the stones on the road changes from parallel to perpendicular or diagonal to the river. These patterns are probably all related to post–New Deal construction phases of Riverside Drive. The sequence of rock patterns is as follows: Pattern 12 (perpendicular Type 1) from North 500 to about North 550; Pattern 13 (perpendicular Type 2) from North 550 to North 700; Pattern 15 (perpendicular Type 8) from North 700 to North 730; Pattern 17 (diagonal Type 2) from North 730 to about North 770; and Pattern 18 (diagonal Type 8) from North 770 to about North 850. From there to the Monroe Street ramp, stones in Patterns 13, 14, and 12 have perpendicular orientations.

North of the Monroe Street entrance ramp to the Landing (North 1400–North 1700), a continuous pattern of perpendicular Type 1 (Pattern 12) is next to the Riverside Drive embankment. Large intrusive patches of Pattern 18 (parallel white granite) are at North 1445/East 45 and North 1590/West 50.

## NATURAL AND CULTURAL EFFECTS ON THE LANDING

Many areas of the Landing are presently damaged and are undergoing various degrees of degradation due to erosion and everyday use. The largest factor appears to be erosional undercutting and deterioration of the westernmost cobbles by the Mississippi River. Other damaged areas are due to infrastructure additions, commercial and public use, and street runoff from Riverside Drive.

Except for between North 875 to about North 1220, which has been maintained by the Memphis Queen Line, the western edge of the Landing shows major disrepair. The jagged edges of the pavement are primarily due to erosional undercutting by the river and the use of bow thrusters of large river craft (tugboats and steamboats). Erosion at the foot at the Landing has

caused courses of stone above the affected area to sag, causing more erosion and more necessary repairs. Erosion of individual stones accelerates when sediments are allowed to remain over the pavement after periods of high water. The acidity of the Mississippi River and the river-deposited sediments act to decompose the limestones, especially Type 4.

Of the hundreds of smaller repair patterns throughout the Landing, many are undoubtedly associated with the bow thrusters on large river craft. The thrusters push the boat backward by pulling water from under the front of the boat and impelling it forward and downward. The enormous pressure created by these thrusters easily undermines and displaces the cobbles. Since the thruster use is often prolonged to get a large vessel moving, the resulting scar on the Landing can be quite large. The jagged cleft at North 1800/West 75 reveals the damage that bow thruster can cause. Some stones on the northern edge of the scar are still partially fitted to pattern after having been lifted above the surface level of the pavement. Stones that have been completely undermined are displaced on top of the raised stones along with underlying gravels. This is definitely not a consequence of erosion. This cleft has an area of about 900 square feet.

Other commercial uses of the Landing have dislodged moorings. A crater-like hole at North 1690/East 10 was caused by a large steamboat tied to a mooring during a windstorm in the spring of 1993. The wind pushed the boat northward, pulling the mooring out of the pavement along with a 10 x 10 foot area of cobblestone. A similar crater at North 1690/West 25 may have had a similar cause. It measures about 15 x 15 feet and shows no signs of bow thruster damage. Many of the circular repairs at the Landing may represent other dislodged moorings.

Other repairs at the Landing are due to infrastructural additions. From North 400 to North 460, a subtle repair pattern exists over the large storm sewer that runs west from beneath Riverside Drive at Gayoso Avenue. The repair is described as subtle because many of the stones that were taken up to install the sewer were used in the subsequent repair. Since they were reinstalled in a professional and uniform manner, the resulting pattern is barely noticeable from East 0 to East 75. From East 0 to West 50, where the sewer repair abuts an older, intrusive Type 3 repair (Pattern 3), the contact is more easily distinguishable.

From North 515/East 25 to North 875/East 75, a 5–8 foot wide repair pattern is present in relation to the recent installation of water supply lines. This repair was substandard. The surface is highly irregular and in many areas is impassable to vehicles.

From North 1000 to North 1900, the Landing exhibits an irregular surface with many high and low areas. The problem is probably caused by differential settling of individual stones and small-scale, substandard repairs where replacement stones were not set to grade. The compaction of the stones is compounded by automobile traffic, especially during periods of grade saturation.

Runoff from Riverside Drive seems to have had minimal impact on the Landing itself, although the Riverside Drive embankment has suffered greatly. At North 1615/West 75, a teardrop-shaped scar appears due to lack of maintenance in a high runoff area. The scar is about 15 x 7 feet and is associated with an older, partially obliterated drainage pattern. Lack of maintenance has worsened the damage. Two very small repair patterns are just east of this teardrop-shaped scar.