Sourcing a Stone Paver from the Colonial St. Inigoes Manor, Maryland

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The objective of this study is to determine the source of a limestone paver recovered from the colonial era Old Chapel Field archaeological site (18ST329-183) in St. Inigoes, Maryland. The site is in the Coastal Plain physiographic province, where there are no viable local sources of rock. As the site was a Jesuit manor, the primary hypothesis is that the stone came from England, the emigration origin point for the Maryland colonists. The secondary objective is to determine whether the stone paver was from the Jesuit Brick Chapel at St. Mary's City (18ST1-103), reused after the chapel was torn down by 1705. Based on paleontological, lithological, and chemical analysis of the paver, sources in the Florida Platform (U.S.), Hampshire Basin (UK), Paris Basin (France), and the Belgian Basin were ruled out. The most likely source is the Aquitaine Basin in southwest France. Comparison with limestone fragments from the chapel supports reuse of the paver from the St. Mary's City Brick Chapel.

L'objectif de cette étude est de déterminer la provenance des pierres calcaires d'un pavé découvert au site colonial de Old Chapel Field (18ST329-183) à St. Inigoes, au Maryland. Le site est dans la province physiographique des plaines côtières, où il n'y a pas de sources locales viables de pierres. Comme le site était un manoir de Jésuites, l'hypothèse principale était que les pierres provenaient d'Angleterre, le lieu de départ des colons qui émigraient vers le Maryland. L'objectif secondaire était de déterminer si les pierres du pavé provenaient de la Jesuit Brick Chapel à St. Mary's City (18ST1-103), ayant été réutilisées après que la chapelle ait été détruite vers 1705. Les résultats d'analyses paléontologiques, lithologiques et chimiques sur les pierres permettent d'écarter la plate-forme floridienne (É.-U.), le bassin de Hampshire (R.-U.), le bassin de Paris (France), et le bassin Belge. La source la plus probable est le bassin d'Aquitaine au sud-ouest de la France. Des comparaisons avec les fragments de calcaire de la chapelle jésuite supportent l'hypothèse de la réutilisation des pierres provenant de la chapelle en briques de St. Mary's City.

Introduction

The provenance of lithic artifacts refers to their geologic source (Rapp and Hill 2006). Knowing the provenance of lithic artifacts is beneficial for addressing important archaeological and historical questions, as well as providing useful information for architectural restorations. The provenance provides insight into commercial shipping trade practices, especially in constraining the locations and distances of trade routes (Andrefsky 2008; Marra et al. 2013). Perhaps the most famous example of this type of analysis is the determination of the source of the Stonehenge sarsens and blue stones (Johnson 2008; Bevins, Pearce, and Ixer 2011). Stones, as tools for determining shipping routes, can provide additional insights for historical archaeologists to allow them to augment written records (or lack thereof) and to fill in existing gaps.

Use of non-native stone in architecture usually reflects something about the owners and builders in terms of their economic status (ability to afford to use imported stone), their aesthetic preferences, and the skills of the craftsman available to utilize the imported materials. It also can provide insights into the owners' cultural background by identifying their motivations to include a particular imported stone in the construction. A particular stone may have been selected because it had significance and meaning to them and, perhaps, the larger social group. Imported stone also may have been used because it had superior characteristics, as compared to locally available materials (Hicks and Beaudry 2010).

In recent years there has been an proliferation of studies devoted to dimension-stone conservation: determining the factors that cause stone decay (Přikryl and Smith 2005), the provenance of historical building materials (Waelkens, Herz, and Moens 1992; Doehne and Price 2010), their variability (Fronteau et al. 2010), and recognizing and, thus, reducing the problems of poor substitute-stone selection (Rozenbaum et al. 2008). This has become an important aspect of the work of conservation architects and others, as they attempt to find suitable replacement material for conservation and restoration work.

Geoarchaeologists use a variety of paleontological, lithological, geochemical, and geophysical parameters to determine the provenance of lithic artifacts. Methods include both destructive and nondestructive approaches, such as petrographic analysis, scanning electron microscopy (SEM; i.e., imaging), x-ray fluorescence (XRF; i.e., chemical composition), x-ray diffraction (XRD; i.e., mineralogical composition), induction coupled plasma–mass spectroscopy (ICP–MS; i.e., isotopic composition), and laser-induced breakdown spectroscopy (LIBS; i.e., elemental composition) (Ray 2007; Colao et al. 2010). Due to wider availability and lower cost, most studies are often still based on petrographic analysis; e.g., Flügel and Flügel (1997) and Dreesen and Dusar (2004). Following the work of Rice (1987), many studies use the fossil content of the lithic artifact to determine its provenance. The key is to choose an approach with sufficient discriminatory ability to distinguish the various possible source localities of the lithic artifact. All approaches fail unless the variation within and between replicate specimens is less than that between possible source materials (Rapp and Hill 2006).

In a single outcrop, rock can vary both laterally and vertically in texture, color, composition, and, if present, fossil content (Meeks 2000). This variability makes tracing a lithic artifact back to an exact location in a specific outcrop essentially impossible, but it is often possible to attribute the artifact to a particular stratigraphic formation. This is complicated by secondary sources (e.g., downstream gravel bars and glacial till) being exploited in addition to the primary deposit (i.e., the original exposed bedrock outcrop) (Rapp and Hill 2006).

This study includes fossils as a discriminating parameter because the evolutionary process creates fossil taxa with distinct temporal and geographic distributions. As a result, fossil taxa are often unique in time and space and, thus, more useful for sourcing compared to physical or chemical parameters. For example, Hannibal (1995) used trace fossils preserved in dimension stone to determine its source. Quinn (2008, 2013) applied the same principle to microfossils found in ceramics and other artifacts to determine the sources of artifacts. The use of fossils and other methods in thin-section petrography of ceramic materials is more common (Reedy 2008; Peterson 2009). For example, Rodríguez-Tovar, Morgado, and Lozano (2010a, 2010b) used ichnofossils in lithic artifacts to source Neolithic and Copper Age cherts back to their geologic formations, while Hannibal et al. (2013) used fossils to correlate 18th- and 19th-century Ohio millstones to source locations in France. More commonly, body fossils are used to source artifacts, such as prehistoric lithic artifacts, e.g., Key et al. (2014); and historical building stone, e.g., Key and Wyse Jackson (2014). The successful use of fossils in sourcing artifacts has greatly improved with the advent of centralized searchable paleobiogeographic databases, e.g., the Paleobiology Database (Alroy 2000).

The primary objective of this study is to use historical, archaeological, paleontological, lithological, and chemical evidence to determine the original source of a stone paver from the Old Chapel Field site in St. Inigoes, Maryland. The secondary objective is to determine whether the stone paver was reused from the Brick Chapel in St. Mary's City, Maryland.

History of St. Mary's City and St. Inigoes Manor

St. Mary's City was established in 1634 on the banks of the St. Mary's River, 19 km north of the confluence of the Potomac River and Chesapeake Bay (FIG. 1). It was the first capital of Maryland, which was the fourth permanent English colony in North America. Maryland was founded under a charter from King Charles I granted to Cecilius Calvert, the Second Lord Baltimore (Farrelly 2012). The initial settlers included Catholic priests from the Jesuit order (White 1910). Catholic masses were first said by Jesuit Father White in a longhouse purchased from the Yaocomaco Indians until a larger wooden chapel was built by 1637; this was the first Roman Catholic church built in English America (Forman 1938). The church was likely burned in 1645 by Englishmen aligned with the anti-Catholic Parliament during England's Civil War (Beitzell 1976). Despite this, by around 1667, the Maryland colony had grown sufficiently large and prosperous to warrant the construction of a larger brick church by the Jesuits on their own land (Bossy 1982; Miller

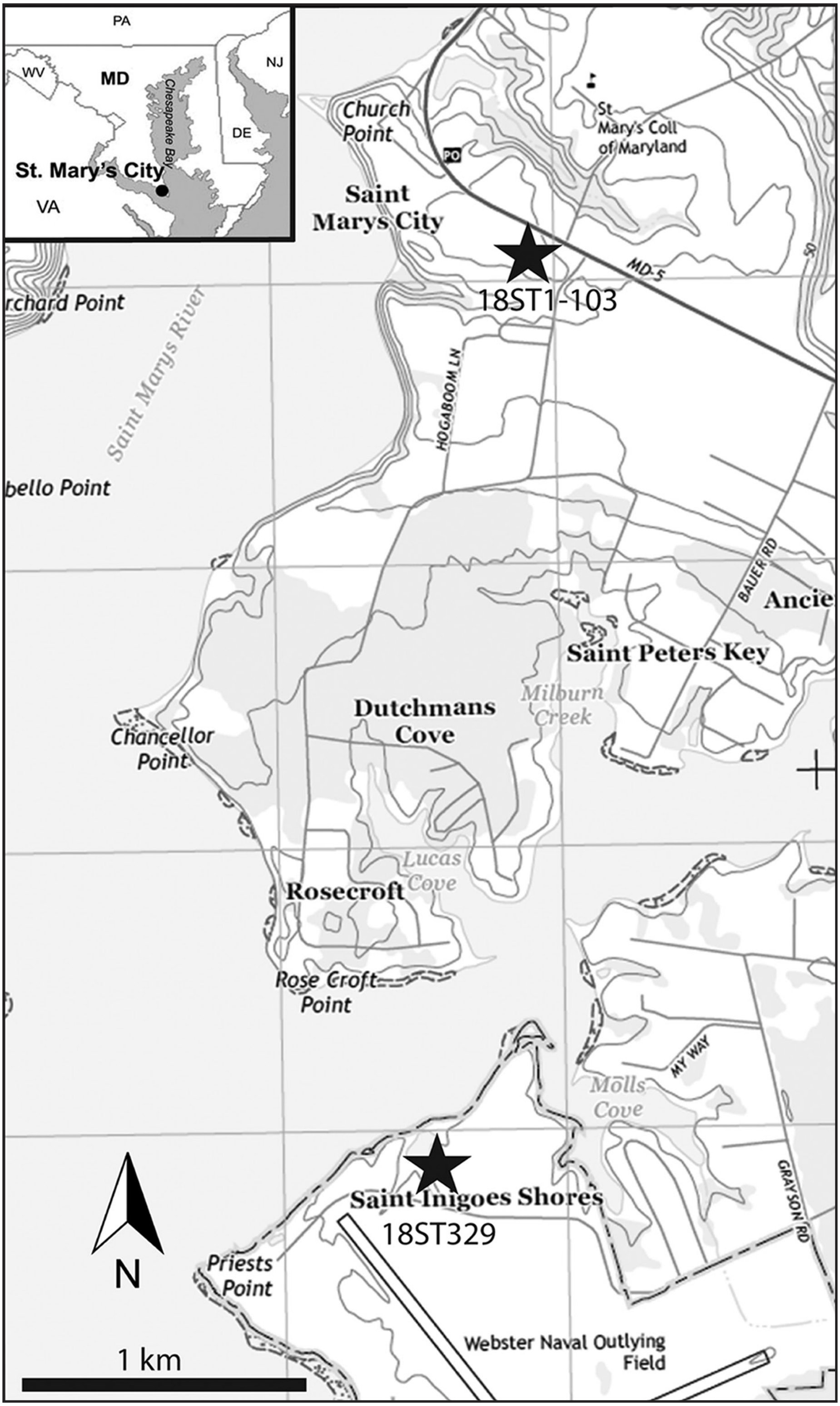

Figure 1. Location map of the Old Chapel Field Site 18ST329 in St. Inigoes, Maryland, on Webster Field U.S. Naval Base, relative to the St. Mary's City Brick Chapel Site 18ST1-103, located 3 km north. The contour interval is 10 ft. (Map modified by Marcus Key, 2015, from U.S. Geological Survey [2014].)

2003; Krugler 2004). This first brick church in St. Mary's City (Site 18ST1-103) will be referred to hereafter as the "Brick Chapel."

By comparison with the average building in the colony at the time, the Brick Chapel represented a different scale of building type, permanence, and cost. This was the largest brick building in a colony dominated by small wooden houses that often lacked even brick chimneys. The combined use of stone and stucco, rendered to appear as solid stone, bespeaks a level of permanence and a statement of the significance of this building. The Brick Chapel had an imported metagraywacke stone floor (Riordan, Hurry, and Miller 1995). Imported stone was not the norm, and certainly the inclusion of imported stone in the construction of this massively expensive building represented a significant cultural statement by the Jesuits and colonists (Carson et al. 1981; Riordan, Hurry, and Miller 1995).

Following the Protestant Revolution of 1689 and the move of the capital from the more Catholic St. Mary's City to the more Protestant Annapolis in 1695, a series of anti-Catholic penal laws were passed prohibiting the public practice of the Catholic religion and prohibiting Catholics from serving in government (Brugger 1988). John Seymour, Protestant and royal governor, ordered the sheriff to close the Brick Chapel in 1704 (Curran 2014).

According to local historical tradition, the Jesuits had dismantled 98% of the Brick Chapel, down to ground level, by the end of 1705 (Miller 1997, 2007a, 2007b). Historical and archaeological evidence constrain the dismantling period to within the first decade of the chapel's closure (Riordan, Hurry, and Miller 1995). Regardless of the exact timing, the raw materials, including the hard-to-come-by stone pavers, were reused elsewhere, including at the Jesuit's St. Inigoes manor. This was commonly done with stone pavers in the colonial Chesapeake area due to the lack of appropriate local stone. For example, Robert Carter reused limestone pavers from the smoldering ruins of his Corotoman mansion in his new Christ Church, 60 years after the deconstruction of the Brick Chapel and just over 50 km to the south (Key, Teagle, and Haysom 2010).

Following the closure of the Brick Chapel, the antagonistic environment in Maryland forced the Jesuits to move their religious center to their private manor, 3 km south in St. Inigoes (FIG. 1) (Galke and Loney 2000). St. Inigoes manor was patented in 1634 by Richard Gerard, one of the investors in Lord Baltimore's New World adventure (Beitzell 1976). Gerard soon tired of life in frontier Maryland, and in 1637 he sold the 2,000 ac. tract of land to the Society of Jesus to serve as the headquarters of its mission effort, as well as a major, working tobacco plantation (Beitzell 1976). The property remained in the possession of the Jesuits for over 300 years until World War II. At that time, the northern 850 ac. of the manor lands were sold by the Jesuits to the U.S. Navy, which built Webster Field, an outlying airfield for Naval Air Station Patuxent River. The portion of the manor acquired by the navy included the original Jesuit home farm with many archaeological sites, including an area of 17th- and 18th-century occupation known as the Old Chapel Field (Pogue and Leeper 1984).

Pogue and Leeper's (1984) excavations at St. Inigoes found distinctive bricks from the Brick Chapel that had been reused by the Jesuits. The archaeology on St. Inigoes Sites 18ST330 and the southern part of 18ST329 points to an early- to mid-18th-century occupation. The dismantling of the St. Mary's Chapel in the early 18th century is consistent with the beginning of the occupation in this part of the Old Chapel Field (Pogue and Leeper 1984). Site 18ST331 consists almost entirely of brick fragments, and this may have been a staging area for bricks from the dismantled St. Mary's Chapel used in the St. Inigoes manor house and various plantation out-buildings (Pogue and Leeper 1984). Presumably a residence with an attached chapel was built in the early 18th century in this area of the Old Chapel Field (King and Pogue 1987). In 1753, the Jesuits sold the Brick Chapel land to William Hicks, who converted the former church site and cemetery into agricultural fields (Lucas 1995; Young, Gualtieri, and Hurry 2006). With all the St. Mary's government offices moved to Annapolis, nearly every trace of the former capital, including the Brick Chapel, had disappeared under plowed agricultural fields (Krugler and Riordan 1991).

Currently, the Brick Chapel site is in St. Mary's City National Historic Landmark cultural resource management Zone 1. This zone includes the Governor's Field and the Chapel Lands. The Governor's Field was initially part of the plantation of Leonard Calvert, the first governor of the colony and the brother of Lord Baltimore, the colonial proprietor. The Governor's Field was subsequently subdivided in the 17th century and grew to encompass the center of the capital. The Chapel Field was the tract taken up by the Jesuits in the early 17th century and served as the site for a succession of Roman Catholic chapels (Young, Gualtieri, and Hurry 2006).

Materials

The paver studied here came from the Old Chapel Field site in St. Inigoes, Maryland. The "Old Chapel Field" is an historical reference to the center of activity (a.k.a., the Home Farm or Church Farm) of the first colonial Maryland Jesuit manor (Smolek, Pepper, and Lawrence 1983). It is 3 km south of St. Mary's City. The Old Chapel Field site is now on the U.S. Naval Air Station Patuxent River's Webster Field Annex in St. Inigoes, St. Mary's County, Maryland (FIG. 1). There were two main areas of Jesuit occupation in the Old Chapel Field, on the east and south side of Scholar's Creek. Over time, the mouth of the creek silted up and the body of water came to be known as Scholar's Pond (Sperling, Galke, and Pyne 2001). On the east side of the pond is Site 18ST233. This is the oldest section and is where the 1630s St. Inigoes House stood. This area was archaeologically tested in 2000 (Sperling, Galke, and Pyne 2001). The newer section of the Old Chapel Field is south of the pond and includes Sites 18ST329 and 18ST330. Site 18ST329 was originally defined by Smolek (1981) as a Native American site. Galke and Loney (2000) extended the boundary of 18ST329 south to include everything north of Villa Road, including the area that Pogue and Leeper (1984) had already excavated as the northern part of 18ST330. Site 18ST330, south of Villa Road, was originally discovered by Smolek (1981). The paver was excavated in 2000 as 18ST329 (Sperling, Galke, and Pyne 2001), under a brick floor originally discovered by Pogue and Leeper (1984) and excavated as 18ST330. The site from which the stone came was originally numbered 18ST330. In the later excavation (2000), reported by Sperling et al. (2001), the site was incorrectly assigned to 18ST329. As the artifact is still listed in the collection of the Maryland Archaeological Conservation Laboratory at Jefferson Patterson Park and Museum as being from Site 18ST329, we will use that reference number. The differentiation between 18ST329 and 18ST330 is arbitrary, as they are contemporaneous, based on the discovery of early 18th-century artifacts and features on both sides of Villa Road (Smolek 1981; Sperling, Galke, and Pyne 2001).

During the Sperling, Galke, and Pyne (2001) Phase II excavation of Site 18ST329's Unit 25324, at 60 cm (2 ft.) below Pogue and Leeper's (1984) brick floor, a light olive-brown loamy sand with plaster inclusions (Stratum H) that contained a paved stone floor was reached. Based on the suite of artifacts recovered, this feature was interpreted as the cellar of an agricultural outbuilding, possibly a dairy (Rivers-Cofield 2010). Of the four in situ limestone pavers exposed during the excavation, one (Lot 183) was removed for further analysis (FIG. 2). It is designated 18ST329-183 and is henceforth referred to as the "paver."

The paver (18ST329-183) is 54.1 cm long, 36.6 cm wide, 10.6 cm thick (FIG. 3A), and weighs approximately 50 kg. The sides are tapered (FIG. 3B) so the bedding plane that forms the top surface has a greater surface area than the bottom. The top surface has remnants of plaster (FIGS. 2 and 3A) interpreted as reflecting the collapse of the south wall into the cellar (Sperling, Galke, and Pyne 2001). The bottom surface includes two marks; one, a pair of parallel lines or the Roman numeral two, is squarely in the center and is clearly: II (FIG. 3C). This type of hand-dressed paver was typically sold by the square foot (Knoop and Jones 1935). The size measurement, called a quarry or assembly mark, was usually cut (using a simple Roman numeral system) on the middle of the bottom surface (Brooks 1961; Clifton-Taylor and Ireson 1983; Alexander 1996). This indicates the paver had an upper surface area of 2 sq. ft. (2000 cm^2). Our measurements indicate the upper surface is 1980 cm^2 (2.13 sq. ft.). Sometimes the stonecutter cut his personal mark, called a mason's or banker's mark, on the bottom. This was done

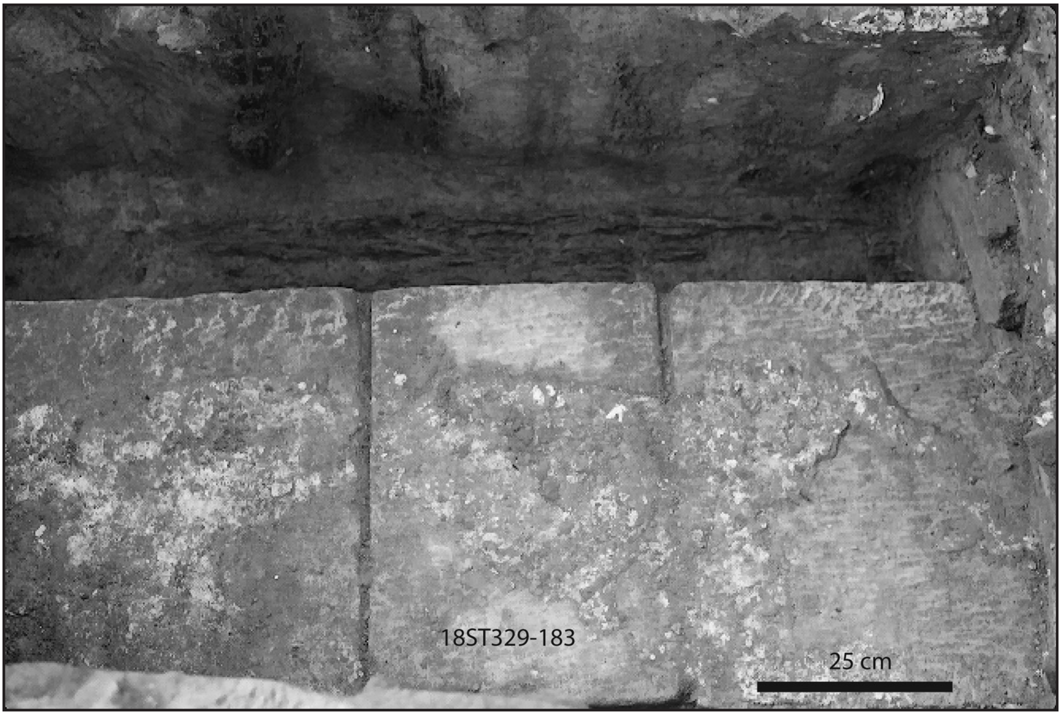

Figure 2. Exposed, paved cellar floor and south wall of 18ST329's Excavation Unit 25324, from the Sperling, Galke, and Pyne (2001) Phase II excavation. Note the three stone pavers partially covered with white plaster, including the focus of this study, 18ST329-183. Note also the wooden horizontal sill and vertical lathing in the wall. (Photo courtesy of the U.S. Navy, 2000.)

using a simple combination of intersecting straight lines made with a chisel to ensure he was identified for payment (Brooks 1961; Harvey 1971; Clifton-Taylor and Ireson 1983; Tyson 1994; Alexander 1996). The second mark on the bottom surface looks vaguely like an F (to the left of the II in FIG. 3C) and may be the stonecutter's mark.

Methods of Investigation

As the paver is on display in the Maryland Archaeological Conservation Laboratory's visitors' center, we were allowed to take samples for analysis only from the bottom surface, which is oriented parallel to bedding. Fortunately, what appeared to be circular *Nummulites* fossils were apparent on the bottom surface (FIG. 4A). *Nummulites* is a genus of large, lenticular, shallow-marine, benthic foraminifera that houses symbiotic photosynthesizing algae (Sen Gupta 1999). The use of *Nummulites* fossils to constrain sources of archaeological artifacts has been applied to the limestones of the Egyptian pyramids (Liritzis et al. 2008; Aubry et al. 2009; Boukhary, Hussein, and Hussein-Kamel 2010). In this study, three cf. *Nummulites* specimens were selected for sampling by cutting three 30 × 20 × 5 mm billets from the bottom of the paver. Billet 1 (18ST329-183-1) was so thin it yielded only one thin section. Billets 2 and 3 were thick enough to be cut down the middle parallel to the bedding, so they each produced two thin sections (18ST329-183-2A and B, 18ST329-183-3A and B). The thin sections and remnants from the paver are curated with the Federal Collection at the Maryland Archaeological Conservation Laboratory, St. Leonard, Maryland.

To test the hypothesis that the paver was reused from the Brick Chapel at St. Mary's City, stone fragments from the chapel that appeared similar to the paver were analyzed. Plowzone excavations of the Brick Chapel (Site 18ST1-103) in St. Mary's City from 1983–1992 (Riordan 1988; Riordan, Hurry, and Miller 1995; Young, Gualtieri, and Hurry 2006) yielded 2.9 kg of limestone fragments. Four fragments, ranging from 43 to 225 g, were selected to

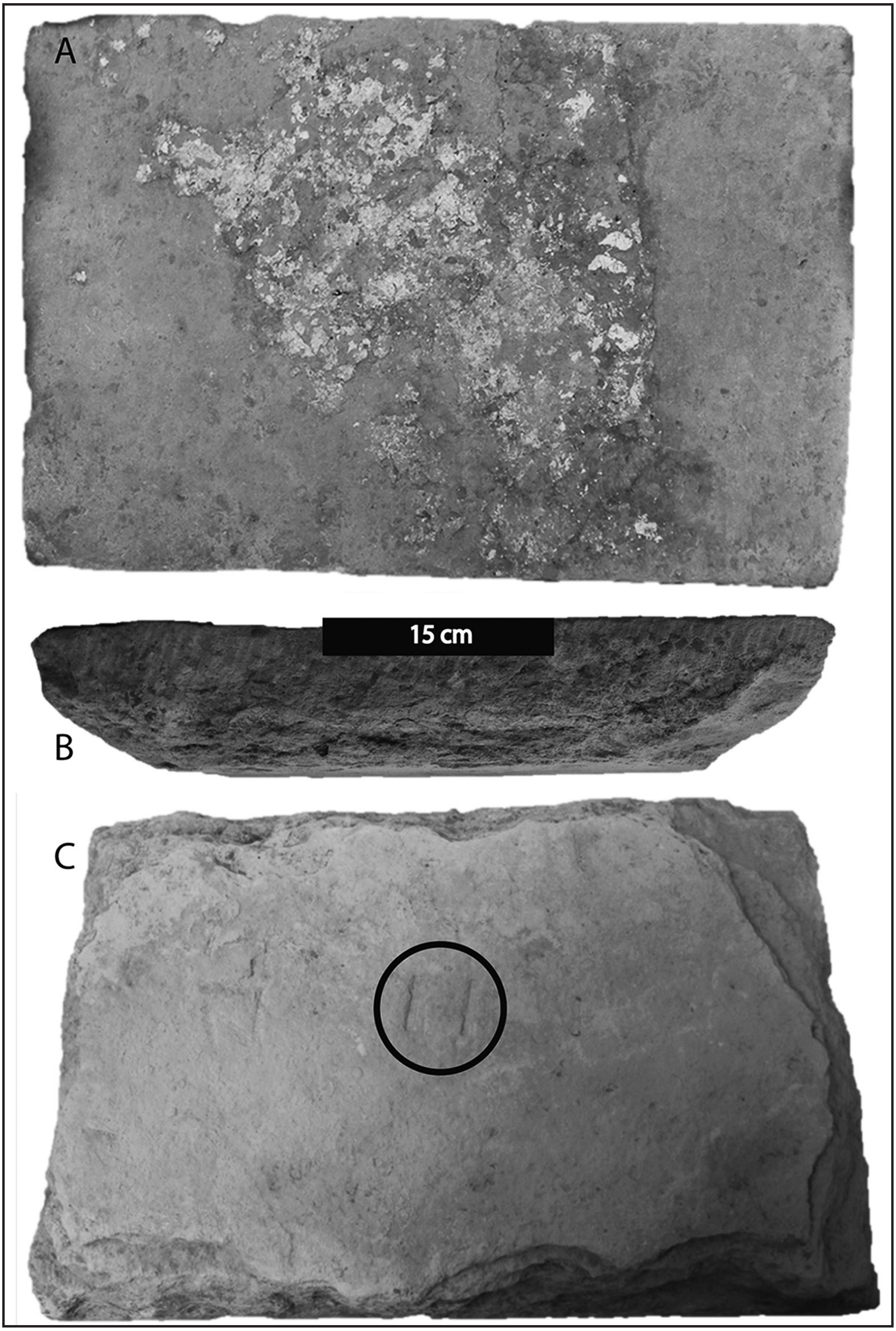

Figure 3. (*A*) Top surface of paver 18ST329-183; (*B*) side view of the paver; and (*C*) bottom surface of the paver showing the II quarry mark (circled). (Photos by Marcus Key, 2013.)

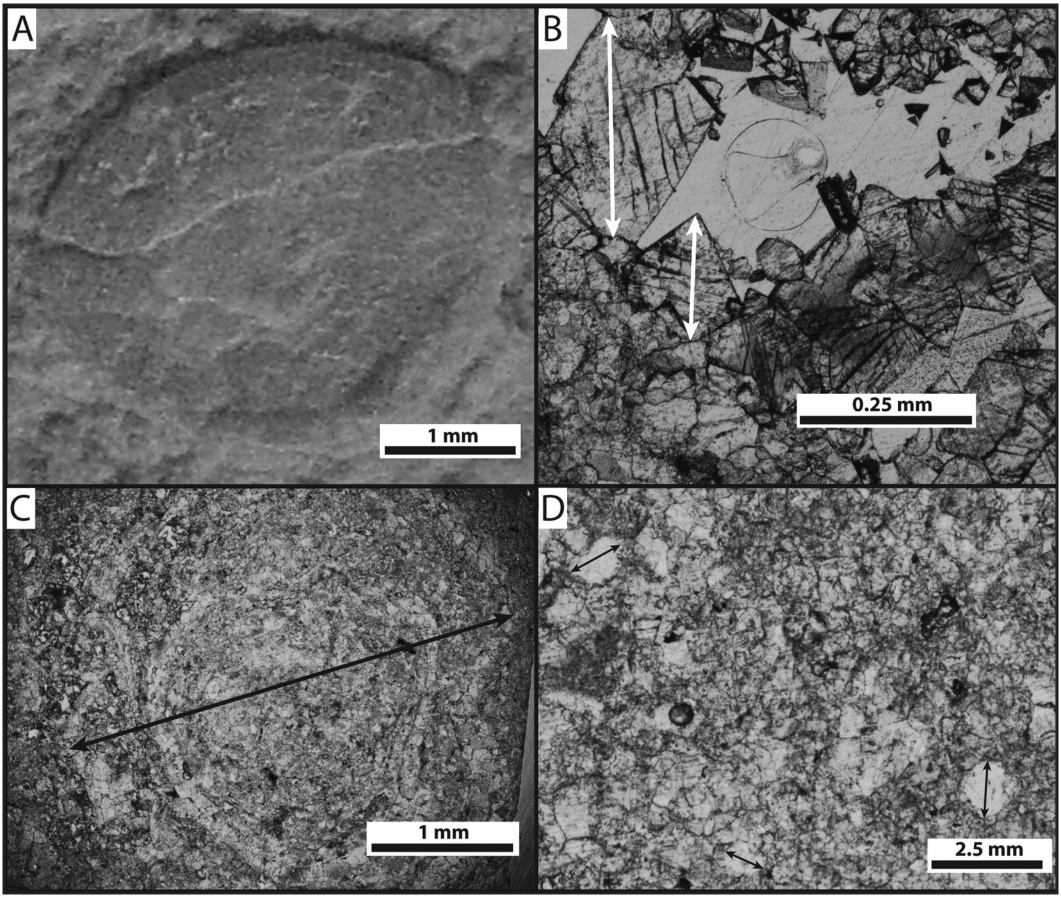

Figure 4. Details of stone paver 18ST329-183: (*A*) Poorly preserved cf. *Nummulites* sp. foraminiferan visible on the bottom surface of the paver; (*B*) dolomite rhombs in thin section showing diameter measurements; (*C*) poorly preserved cf. *Nummulites* sp. fossil in thin section showing diameter measurement; and (*D*) quartz sand grains in thin section showing diameter measurements. (Photos by Marcus Key, 2013.)

compare with the paver. From each of these, a ca. 30 × 20 × 5 mm billet was cut for oriented thin sectioning. Two of the samples were cut parallel to bedding (18ST1-103-2417A and 18ST1-103-2728C), and two were cut perpendicular to bedding (18ST1-103-1416C and 18ST1-103-2524C). The thin sections and remnants from the Brick Chapel are curated at the Historic St. Mary's City Archaeological Laboratory, Maryland.

The billets from the paver and the Brick Chapel were vacuum impregnated with epoxy resin. Standard (46 × 27 × 0.03 mm) petrographic thin sections were prepared from each billet. Optical petrographic analytical techniques, using plane- and cross-polarized light, were used to determine the mineral assemblage. Grain mineralogy and morphology (i.e., size and shape) were determined with a Nikon Eclipse E400 polarizing petrographic microscope. The Folk (1980) carbonate classification scheme was used to determine a rock name. Examination revealed dolomite as rhombic crystals, so we also measured the five largest dolomite rhombs to the nearest 10 μm using ImagePro Express 5.0 software (*Media Cybernetics*) (FIG. 4B). This allowed us to compare samples statistically. Rock color was described using the *Munsell Rock Color Book* (Munsell Color 2009).

The thin sections were sent to specialists, who examined them for body fossils to allow separation of potential source regions in the Florida Platform, U.S. (Pamela Muller 2014, pers. comm.),

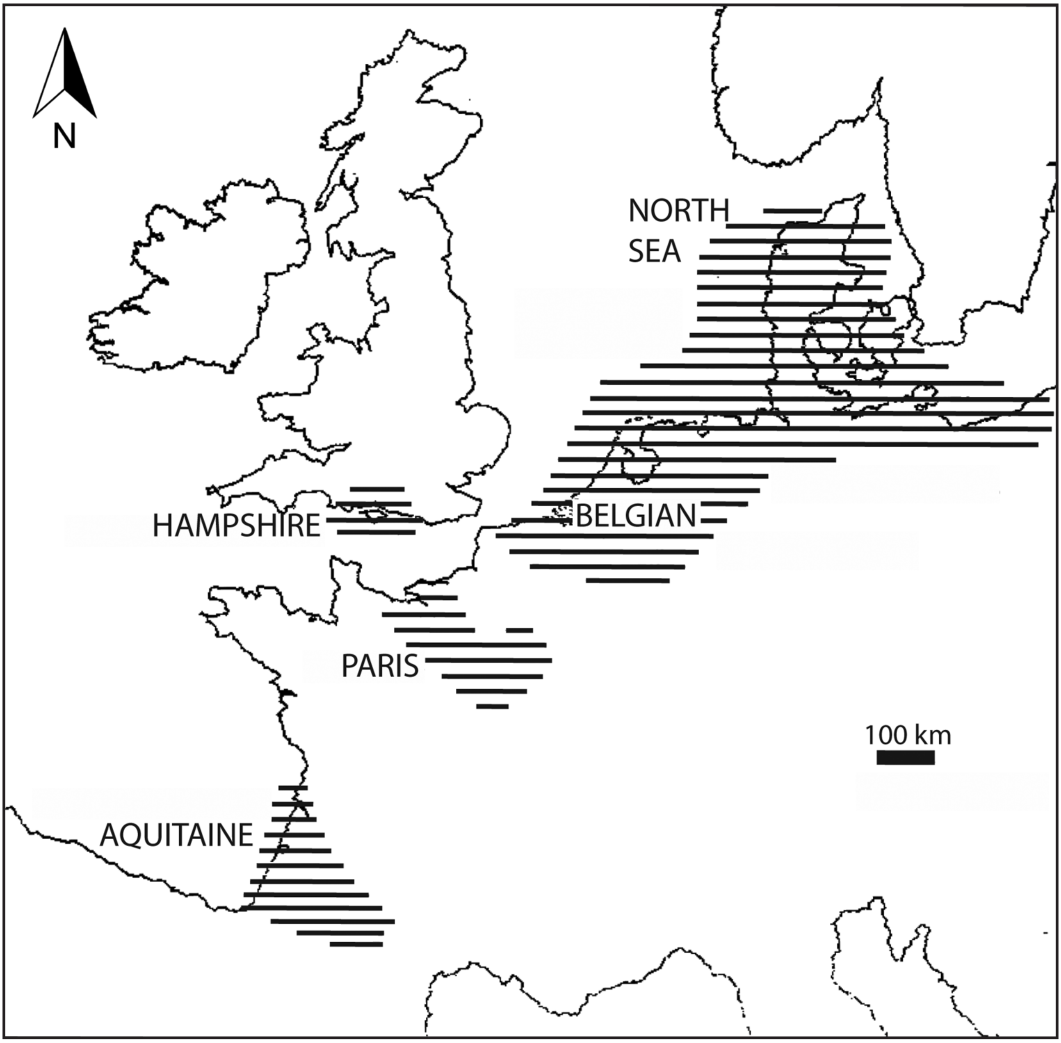

Figure 5. *Nummulites*-bearing Eocene marine basins of northwestern Europe. (Image modified by Marcus Key, 2015, from Drooger et al. [1971: fig. 1].)

as well as the Hampshire Basin, UK (William A. Berggren 2014, pers. comm.), Paris Basin, France (Gilles Fronteau 2014, pers. comm.), and the Belgian Basin (Tim De Kock, 2015, pers. comm.) (FIG. 5). In addition, two samples from the paver (18ST329-183-2 and -3), as well as two samples from the Brick Chapel (18ST1-103-2524C and -2728C) were evaluated for nannofossils, using standard smear slides (Aubrey 2014, pers. comm.).

To compare the cf. *Nummulites* morphometrically, the maximum and minimum diameter of each shell was measured to the nearest 0.1 mm. Shell-diameter measurements were made in the thin sections oriented parallel to bedding (FIG. 4C), and the shell thickness was measured in the thin sections oriented perpendicular to bedding. Shell diameter was calculated as the average of the measured maximum and minimum diameters.

As these are carbonate rocks, siliciclastic grains are rare. Therefore, up to five of the largest quartz grains in each thin section were chosen for grain-size analysis and to compare samples statistically. The maximum diameter of each grain was measured to the nearest 10 μm (FIG. 4D). This was done to best characterize grain diameter in thin-section views that do not

Table 1. *Nummulites*, quartz grain and dolomite rhomb size summary statistics, color, and lithology of the Old Chapel Field stone paver at St. Inigoes compared to the fragments from the Brick Chapel at St. Mary's City. (Table by the authors, 2015.)

Sample	Number of thin sections analyzed	Number of cf. *Nummulites* measured	Mean cf. *Nummulites* diameter (mm)	Number of quartz grains measured	Mean quartz grain size (μm)	Grain size	Number of dolomite rhombs measured	Mean dolomite rhomb size (μm)	Munsell color	Lithology
Old Chapel Field stone paver at St. Inigoes	5	23	3.1	68	152	fine sand	185	167	very pale orange (10YR 8/2)	dolomitized unsorted biosparite
Limestone fragments from Brick Chapel at St. Mary's City	4	8	3.2	63	141	fine sand	65	154	very pale orange (10YR 8/2)	dolomitized unsorted biosparite

necessarily pass through the largest part of the grain. Grain-size descriptive statistics were determined using Gradistat software (Blott and Pye 2001).

The chemistry was evaluated by using a Rigaku ZSX Primus II x-ray fluorescence spectrometer (XRF) on two thin sections of the paver (Samples 18ST329-183-2A and 18ST329-183-3A) and two thin sections of the limestone fragments from the Brick Chapel (Samples 18ST1-103-1416C and 18ST1-103-2417A). Major elements–sodium (Na), magnesium (Mg), aluminum (Al), silicon (Si), phosphorus (P), sulfur (S), chlorine (Cl), potassium (K), and calcium (Ca)—and trace elements—titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), rubidium (Rb), strontium (Sr), zirconium (Zr), barium (Ba), and uranium (U)—were analyzed. Using thin sections instead of pressed pellets or fused glass disks creates three problems for XRF analysis (Rammlmair et al. 2006; Shackley 2011). Because there is the potential for the x-rays to penetrate through the 30 μm thin section, the excitation volume may extend into the glass slide and thus incorporate the trace-element composition of the glass into the results. This was corrected by analyzing a blank glass slide and subtracting its chemical composition from the results. Secondly, because there is a lack of homogenization of the sample for bulk analysis, the thin section was rotated during analysis, although there could still be errors due to matrix effects. Thirdly, there are no thin-section standards for XRF analysis. To address this, the machine's internally calibrated sensitivity library was used to correct for frequency drift before running each sample. Four pressed pellet standards (USGS GSP-2, AGV-2, QLO-1, and NIST-278) were analyzed and used to correct the frequency drift.

Results

The Munsell colors for the paver and the limestone fragments from the plowzone excavations are all very pale orange (10YR 8/2) (Munsell Color 2009). In the thin sections from the paver, 23 cf. *Nummulites* fossils were measured (TAB. 1). They ranged in diameter from 1.2 to 5.9 mm (mean=3.1 mm; standard deviation [σ]=1.6 mm). In the thin sections from the Brick Chapel, eight cf. *Nummulites* fossils were measured (TAB. 1). They ranged in diameter from 1.6 to 4.7 mm (mean=3.2 mm; σ=1.2 mm).

Nummulites lived during the Cenozoic and were most abundant from the Late Paleocene (Thanetian Age) until the end of the Early Oligocene (Rupelian Age) (Berggren 1998). This genus-level identification is based on their dimensions (ca. 3 mm in diameter, 0.3 mm thick) and planispiral coil of chambers separated by septa (FIG. 4A). However, we were unable to identify the exact species of *Nummulites* present in the paver and chapel fragments. The problem was twofold. First, species of *Nummulites* are ordinarily quite hard to differentiate in thin section, and, second, the preservation is poor due to partial dissolution and coarse recrystallization of the nummulitic structures. The original shell material was rarely preserved, and dolomite rhombs were present, indicating at least some dolomitization. Despite this, the source of the limestone for the paver probably cannot be from the Florida Platform (U.S.) or the Hampshire (UK), Paris (France), and Belgian basins (William A. Berggren 2014, pers. comm.; Gilles Fronteau 2014, pers. comm.; Pamela Muller 2014, pers. comm.; Tim De Kock 2015).

Alteration of the originally high Mg-calcite *Nummulites* shells into low Mg-calcite is well known in dolomitized nummulitic limestones (Whittle and Alsharhan 1994; Swei and Tucker 2012). As a result, all the species-specific, diagnostic features of the bioclasts, including coccoliths in the smear slides, are not available (Marie-Pierre Aubry 2014, pers. comm.). Fortunately this diagenetic recrystallization created very dense, very low-porosity rock, ideal for paving stones.

In the thin sections from the paver, 68 subangular quartz grains were measured (TAB. 1) (FIG 4D). They ranged in diameter from 60 to 990 μm (mean=152 μm; σ=175 μm). This represents a moderately well-sorted fine sand. In the four thin sections from the Brick Chapel, 63 subangular quartz grains were measured (TAB. 1). They ranged in diameter from 43 to 248 μm (mean=141 μm; σ=133 μm). This represents a well-sorted, but texturally immature, fine sand.

In the thin sections from the paver, 185 angular, equidimensional dolomite rhombs were measured (TAB. 1). They ranged in diameter from 71 to 371 μm (mean=167 μm; σ=62 μm). In the Brick Chapel thin sections, 65 angular, equidimensional dolomite rhombs were measured (TAB. 1). They ranged in diameter from 72 to 376 μm (mean=154 μm; σ=55 μm).

Of the 23 elements analyzed by the XRF, only 13 returned results across all four samples above the lower limit of quantification for that element. These were the elements Ca, Mg, Fe, Al, Cl, S, Si, K, Mn, Sr, Zr, P, and Rb. These 13 represent, on average, 99.1% of the normalized weight percentage (wt%) for the four samples (range=98.3–100.0 wt%; σ=0.6 wt%). As expected for a dolomitic limestone (Wheeler 1999), the two most common elements, Ca and Mg, represented, on average, 97.8% of the normalized wt% (range=96.9–98.5 wt%; σ=0.6 wt%). The mean normalized Ca wt% for the paver (97.2) is similar to that of the chapel fragments (97.1). The mean normalized Mg wt% for both the paver and chapel fragments is 0.6. As Mn and Zr should be more immobile with respect to the dolomitization process than the other elements (Ford 1976), we also examined these in greater detail. The normalized Mn wt% for both the paver and chapel fragments is 0.056. The normalized Zr wt% for the paver is 0.053, and for the chapel fragments it is 0.051. Thus, the chemistry of the paver and chapel fragments is similar and what would be expected for a dolomitic limestone.

As the paver and chapel fragments are, on average, 97.1 wt% Ca and 0.6 wt% Mg, we classify them as limestones. As dolomite rhombs are present, they are classified as partly dolomitized limestones. The matrix is coarse, primarily a microsparite calcite with minor amounts of micrite. Based on Folk's (1980) classification, these rocks are best described as partly dolomitized unsorted biosparite. The rarity of siliciclastic (e.g., quartz) grains (0.1 wt% Si) suggests they are not sandy limestones.

What Was the Original Source of the Paver?

Most building stone is locally sourced, as transportation costs have traditionally been higher than material and production costs (Bowles 1934; Cassar et al. 2014). When local stones are unavailable, stone must be imported. Most imported manufactured goods in the English American colonies came from England (Morriss 1914), and this holds true for Maryland (Stone 1987). Residents of St. Mary's County were importing gravestones from

England at this time (Mackie 1988), so, why not stone pavers? The stone paver could have been brought over by the English colonists as a specific, imported product. For example, during the construction of the Capitol in Williamsburg, Virginia, a newspaper advertisement for stone pavers was placed (*Virginia Gazette* 1756). Morriss's (1914) detailed accounting of English customhouse records of manufactured goods exported to Virginia and Maryland from 1698–1699 does include Purbeck stone, an English stone paver used in the colonial Chesapeake (Key, Teagle, and Haysom 2010).

Alternatively, the pavers could have been ballast. Ballast, carried near the keel, was usually emplaced during the building of the vessel and was often called permanent ballast. To extract it, one would have had to take the vessel apart, which might occur as a result of a wreck or a fire. If the pavers came over as ballast, it is more likely they would have been temporary ballast, placed to control the position of the ship in water with its cargo load. This would suggest deliberate emplacement necessary to keep colonial ships upright. Transatlantic vessels at the time typically carried ¼ of their tonnage in ballast (Riebe 2002; Burdette and Smith 2014). The nature of the colonial tobacco trade meant that many incoming ships had to carry ballast to America. There was more cargo going east across the Atlantic from tobacco-producing colonies than coming west from England (Morriss 1914). Exported tobacco filled many ships to Europe, while incoming ships were sometimes only partially loaded with imports. Ballast stone was an important commodity, with ballast-stone brokers in the major east-coast ports during the colonial period (Burdette and Smith 2014). Stone and, less commonly, brick, carried as ballast in the holds of European ships, were used in the construction of buildings and roads in colonial America (Townsend 1904; Burdette and Smith 2014).

The pavers could have been brought over as ballast as finished items that could be sold upon arrival. This type of dual purposing of the stones would have reduced the cost of importing them. Because of laws against dumping ballast in Maryland rivers or ports (Middleton 1984; Greeley 2005; Burdette and Smith 2014), ship captains preferred to use ballast that they could unload and sell. Records show that bricks, slate, coal, and flagstones were used as ballast for resale in the colonies (Theobald 2012). Flint cobbles from Europe brought over as ballast stones were reused as building material in Georgia and Maryland, and as paving stones and grave markers in South Carolina (Emery et al. 1968; Theobald 2012; Burdette and Smith 2014).

Due to the lack of good building stone in the Chesapeake region, when stones are found in construction they are often assumed to have been ballast from Europe. For example, Barka (1976) and Deetz (1993) attributed the siltstone foundation walls of Flowerdew Hundred in Virginia, built about 1620, to ballast material brought over from Bristol, England, but they did not provide any convincing evidence (Carson et al. 1981; Brown 1998). In contrast, using microfossils, Emery et al. (1968) traced flint-nodule ballast stones from North American Atlantic-coast seaports to southern England and northern France geologic-source rocks.

The study location, in the Coastal Plain physiographic province of the eastern United States, means there are no viable local or regional natural sources for limestone pavers. Due to the relatively young age (<145 million years ago), and shallow burial of the Maryland coastal-plain sediments, the local sediments are generally unlithified (Glaser 1968; McCartan 1989; Andreasen, Staley, and Achmad 2013). There are local clays that were used to make the bricks for St. Mary's Brick Chapel (Armitage et al. 2006). The nearest (geographic) source is the weakly cemented sedimentary rocks in the St. Mary's County outcrop along the St. Mary's River, and elsewhere in southern Maryland along the banks of the Potomac River. These are Quaternary-aged surface formations made of limonite-cemented, ferruginous sandstones that range from very fine to coarse grained, incorporating quartz and quartzite cobbles (Glaser 1968; McCartan 1989). But these are siliciclastic rocks, not carbonate like the paver. They have been used in local colonial building foundations, to support sills, and in pier-type construction. These sandstones are not very strong or particularly good stone for building purposes. They are more commonly seen in chimney construction, under outbuildings, and for slave or tenant houses. These sandstones were used in the stone-walled cellar of St. John's house in St. Mary's City, built in 1638 by John Lewger, the first secretary of the colony (Carson et al. 1981; Stone 1982; Miller 2003).

Better-cemented sedimentary rocks, 25 km north of our study site, are from the Miocene Choptank Formation, which has outcrops along the Patuxent River (McCartan 1989). This formation is dominated by unconsolidated dense, gray-green clay to yellowish-brown sand, but two beds (17 and 19) are locally indurated to form molluscan calcareous sandstones (Glaser 1968; Andreasen, Staley, and Achmad 2013). These have been used locally as crude foundation stone and as chinking in a Native American palisade trench. This mollusk-rich rock does not match the stone paver and lacks *Nummulites*.

The closest well-lithified sedimentary rocks are 80 km to the northwest at the fall line, but are siliciclastic rocks (Glaser 1969), not carbonate like the paver, so not a possible source. There are good, competent carbonate rocks 200 km to the northwest in the Great Valley Section of the Ridge and Valley physiographic province in western Maryland, but they are the wrong age and lithology, and also lack *Nummulites* (Reger and Cleaves 2008).

At the regional scale, there is no local source of *Nummulites*-bearing limestone anywhere in the Chesapeake region. *Nummulites* has not been reported from Maryland, Virginia, and the Carolinas (Kazmer and Campbell 2001), and is not found in this region in the Paleobiology Database (Alroy 2000). However, it has been reported from the southeastern United States, in Georgia, Florida, and Mississippi (Cooke 1915; Mornhinveg and Garrett 1935; Puri and Vernon 1964; Barnett 1973; Coleman 1983; Alroy 2000; Bryan 2001).

One possibility is that these *Nummulites*-bearing pavers were acquired in the Caribbean region. Throughout the 17th century, the standard route from England to the Chesapeake was to sail south from England toward the Canaries and Azores to pick up the trade winds, and then, following the prevailing tropical easterlies, cross the Atlantic to the West Indies (Middleton 1984; Greeley 2005). In the West Indies, shipping often stopped in Jamaica and Barbados (Andrews and Powell 1925, Middleton 1984), where *Nummulites* have been reported (Vaughan 1919; Alroy 2000). It is unlikely that stone pavers would have been picked up in the Caribbean, however, unless large amounts of cargo were unloaded there. Unloading cargo was unlikely, as the voyage's cargo was destined for the new colony in Maryland, not the Caribbean. Therefore, it is unlikely the stone paver had a Caribbean or an American source, as confirmed by a specialist familiar with the Florida Platform microfossil fauna (Pamela Muller 2014, pers. comm.).

From the West Indies, English ships would travel north along the coast of America to the Chesapeake (Middleton 1984; Greeley 2005). However, due to Spanish colonial activity, it was unlikely that English ships would have stopped anywhere along the southeast coast of America until after 1663 with the rise of the British Carolina ports (Galgano 2005; Murphree 2006). In fact, they actively avoided contact with the Spanish during their voyages (White 1910; Semmes 1937) and, because of the geopolitical situation at the time, Spanish merchants did not trade in the Chesapeake, where the trade was dominated by the English and Dutch (Price and Clemens 1987; Wilcoxen 1987). Even if these vessels had stopped at one of the Spanish settlements, such as St. Augustine, the oldest European settlement in the U.S., they would have found a coquina limestone used in colonial construction, such as the Castillo de San Marcos fort (Manucy 1983). This limestone is from the Pleistocene Anastasia Formation and of the wrong age and lithology to be a potential source for our paver. Although *Nummulites*-rich limestones from the Upper Eocene Ocala limestone that have been quarried in Florida are a possibility, they were not quarried until the late 19th century (Portell and Hulbert 2011). Furthermore, they form an outcrop farther west on the Florida Peninsula (Scott et al. 2001) and not along the Atlantic coast where the English ships sailed.

Since an American source for the paver is unlikely, an English source is a plausible hypothesis. The reasons are both coincidental and geological. First, the Maryland colonists were from England. Second, *Nummulites* occurs in the Hampshire Basin in southern England (Murray and Wright 1974; Curry et al. 1977; Daley 1999; King 2006). The *Nummulites*-bearing beds are rare and poorly lithified sandy clays, so they are not suitable for building stone and have never been commercially quarried (Lott and Cameron 2005; Fenn 2008; Hopson 2011; Lott 2011; David Bone 2013, pers. comm.). Based on the microfossil fauna, it is unlikely the stone paver had a Hampshire or London Basin provenance (William A. Berggren 2014, pers. comm.).

If not England, what about the Continent? Although the Jesuit Maryland Mission was administered by the English Province, most English Jesuits were in exile in Belgium and France following the Protestant Reformation (Taunton 1901; Hughes 1907; Farrelly 2012). This hypothesis suggests that the stone paver came from northwestern Europe where the Jesuits had more connections than in England. Beitzell's (1976: appendix A) data on the Maryland colonists Jesuits sent abroad to study in religious houses and seminaries from 1684 to 1788 notes that 71 of the 89 listed their destinations. According to this data, 50% studied in Belgium, 27% in England, 16% in France, 6% in Rome, and 1% in Ireland. During the time of the stone paver's installation, 50% had gone to Belgium, 25% to England, and 25% to Rome. Thus, roughly half of all Maryland Catholics who studied abroad did so in Belgium. This suggests the Maryland Jesuits had closer ties to Belgium than England. In addition, other artifacts recovered from St. Mary's City were sourced to Flanders (Miller 2003), the northern part of present Belgium. Therefore, the stone paver may have been imported from Belgium.

Nummulites limestones are common in the Belgian Basin, and Belgian nummulitic limestones have been commercially quarried for over a hundred years, and explicitly quarried for stone pavers (Lyell 1852). *Nummulites* limestones occur in the Eocene formations of the Belgian Basin (Kaasschieter 1961; Blondeau 1967; Jacobs and De Batist 1993; Jacobs and Sevens 1993; Goethals et al. 2009). Unfortunately, geologist Tim De Kock (2014, pers. comm.) was unable to verify if the paver could be attributed to *Nummulites* limestones from the Belgian Basin.

To complicate the question of a Belgian provenance for the paver, the geopolitical situation at this time was complex. What is Belgium today was under the control of Roman Catholic Spain and known as the Spanish Netherlands until 1713 (Cook 2005). The 1651 British Acts of Trade and Navigation required their colonies to trade exclusively within the British Empire, using British merchants, British-flagged ships, and disallowed direct trade with any other European powers (e.g., Spain and France) (Morriss 1914; Canny and Low 1998). For example, in 1672, a Swedish ship sailed into the Wicomico River (Maryland) with a reported cargo of 50,000 yellow bricks. The ship's captain was found guilty of violating the Navigation Acts and the cargo was seized (Strickland and King 2011). Therefore, any stone pavers from Belgium or France should have been transshipped in a British port. This does not preclude illegal trade or redistribution of cargos taking place between ships in the Caribbean.

Artifacts from the Spanish or Dutch Netherlands are rare at Old Chapel Field (King et al. 2006). So, could the stone paver have come from the Paris Basin? There are *Nummulites* limestones in the Paris Basin (Veillon 1967; Murray and Wright 1974; De Kock et al. 2013). There was extensive shipping between England and France, since tobacco was the most valuable British import from North America and France was the most important re-export market for that tobacco (Price 1957, 1973). Maryland tobacco was customarily sold in Holland, whereas Virginia tobacco went to France (Price 1957). Early in Maryland's history, tobacco was exported to England from St. Mary's City and transshipped to the Continent (Stone 1987). France began trading in the Chesapeake later in the mid-1700s (Price 1964). But, at that time, the French Jesuits were focused on their missions to the north in New France (Canada) and to the south in the West Indies (Hughes 1907). Therefore, the Maryland Jesuits had more interaction with their Belgian colleagues than their French colleagues in Paris. This is supported by the fact that geologist Gilles Fronteau (2014, pers. comm.) was unable to identify our *Nummulites* species, nor attribute the paver to a Paris Basin formation.

The final *Nummulites*-bearing marine basin of northwestern Europe that could have provided a suitable limestone for the paver is the Aquitaine Basin in southwestern France (FIG. 5). *Nummulites* limestone is known from the Aquitaine Basin (Cuvillier 1961; Blondeau 1983). If the stone pavers were quarried in the Aquitaine Basin, they could have been sent to England as ballast and later transshipped to Maryland. Since France purchased most of its tobacco from England and most of that came from the Chesapeake, there was frequent shipping between England and France, including to Bordeaux (Price 1973). Bordeaux and La Rochelle are the major shipping ports in the Aquitaine Basin and were important ports for exporting wine to and importing tobacco from England (Price 1973). There was even trade directly between the Chesapeake and Bordeaux, and Bordeaux-based ships were typically "in ballast" (Frese 1973: 282; Burdette and Smith 2014: figure 3). "In ballast" means they were laded mostly with ballast so they could purchase tobacco on arrival, but this was not until the American Revolution. The Aquitaine/England connection goes back to the 12th–15th centuries, when southwestern France was occupied by the English, the inheritance of Eleanor of Aquitaine, who eventually became queen of England (Evans 2014). Coincidentally, the Aquitaine region was home to the Jesuit's Aquitaine Province, which, like Leuven (Louvain) and northern France, had a Jesuit college in Bordeaux (Mitchell 1980; Hollis 1992). We were unable to reject, based on fossil assemblage or lithology, the Aquitaine Basin as the source of the paver.

Was the Paver Reused from the Brick Chapel in St. Mary's City?

If the paver from the Brick Chapel was reused at St. Inigoes, what evidence would support this hypothesis? The lithology of the Old Chapel Field stone paver from St. Inigoes, Maryland, is indistinguishable from the limestone fragments from the Brick Chapel in St. Mary's City (TAB. 1). They are both dolomitized, unsorted biosparite with the same Munsell color (very pale orange) and contain similar cf. *Nummulites* fossils. A quantitative evaluation of the cf. *Nummulites* fossils indicates that the mean diameter of the cf. *Nummulites* in the paver (3.1 mm) is not statistically different (t-test, P=0.87) from the mean diameter of those in the Brick Chapel (3.2 mm), suggesting high similarity. The mean size of the detrital quartz grains in the paver (152 μm) is not statistically different (t-test, P=0.06) from the mean size of those in the Brick Chapel (141 μm). In addition, the mean size of the dolomite rhombs in the paver (167 μm) is also not statistically different (t-test, P=0.14) from the mean size of those in the Brick Chapel (154 μm). These lithological criteria suggest the pavers may have the same provenance.

Historical evidence also provides indications that the St. Inigoes paver was reused from the Brick Chapel at St. Mary's City. Site 18ST329 was the center of activity for the Jesuit manor at St. Inigoes in the early 1700s (Sperling, Galke, and Pyne 2001). This occurs during and after the closure (1704) and inferred dismantling (≥1705) of the Brick Chapel at St. Mary's City, which was never rebuilt (Beitzell 1976; Pogue and Leeper 1984; Riordan, Hurry, and Miller 1995). This suggests that the limestone pavers in the Brick Chapel could have been removed and made available for reuse at the St. Inigoes manor. Since the Brick Chapel and the St. Inigoes manor were financed and constructed by the Jesuits on land that they owned, these materials would have been available at no additional cost. Pogue and Leeper's (1984) excavations at St. Inigoes found distinctive bricks from the Brick Chapel that had been reused by the Jesuits. This reuse of imported goods was common in the colonial Chesapeake society, as it was cheaper than importing new material from Europe, especially for the simple cellar of a dairy barn. This was also done with stone pavers, due to the lack of appropriate local stone (Mountford 2012). Based on this historical and archaeological evidence, the potential reuse of the pavers is supported.

These data and observations suggest that the stone paver was reused from the Brick Chapel at St. Mary's City. Our results cannot certify for what the limestone in the Brick Chapel was used, as all the limestone pieces recovered are fragmentary. The primary stone paver in St. Mary's City Brick Chapel has been interpreted as a grayish green metagraywacke (Riordan, Hurry, and Miller 1995; Miller 1997), which is an immature sandstone that has experienced low-grade metamorphism. Due to the nondescript, non-fossiliferous, and geologically ubiquitous metagreywacke nature of the sandstone used to make the pavers in the Brick Chapel, the source has never been determined. Like the limestone paver in this study, there is no local or regional source. The limestone pavers from the Brick Chapel may have been a secondary type of paver in a patterned floor or had some other unknown use.

The lighter-colored limestone could have been interlaid with the darker-colored metagraywacke pavers. This is possible, as the three exposed limestone pavers (FIG. 2) are similar in size, 1,980–2,415 cm^2 (2.13–2.60 sq. ft.; mean

2,221 cm^2, or 2.39 sq. ft.), to the one remaining metagraywacke paver, which is 2,565 cm^2 (2.78 sq. ft.) (Riordan, Hurry, and Miller 1995). Given the relative amounts of metagreywacke (11.4 kg) and limestone (2.9 kg) fragments recovered from the Brick Chapel excavations (Riordan, Hurry, and Miller 1995), a full checkerboard pattern is unlikely. Alternatively, it may have been that the limestone was used for accent points or to demarcate burials at the Brick Chapel.

In Jesuit baroque churches in Europe, contrasting dark/light stone floor patterns running down the middle of the main aisle of the sanctuary were common, as found in St. Michael's Church in Leuven, which was constructed 1650–1666 (Briggs 1914; Louw 1981; Callebaut et al. 2001; Schoonjans 2009). Leuven is in Flanders, which was also where the Jesuits first settled and built the first novitiate for their Flanders Province (Mitchell 1980; Hollis 1992). Many of the churches in Leuven have similar patterned floors (e.g., St. Michael's and St. Gertrude's). The Jesuits in Maryland would have known of these churches, as they were educated in Flanders (Mesick 2007).

The connections between Maryland and Flanders go back to 1593, when the Protestant Reformation in England forced the Jesuits to open the College of Saint-Omer in Artois, France (then part of the Spanish Netherlands) (Taunton 1901; Mitchell 1980; Hollis 1992). Additionally, when founding Jesuit, Father White, was captured in 1644/5 in Maryland by invading Puritans from Virginia and sent to England in chains to be tried as a Catholic (Taunton 1901; Beitzell 1976; Fogarty 1976; Schroth 2007), he took refuge and taught in Leuven, where he had previously pursued his Jesuit studies (Semmes 1937). The second superior of the Jesuit's Maryland Mission, Father Thomas Copley, was also educated in Leuven (Krugler 2004). Finally, one of the eight St. Mary's City Council members, William Calvert, was also educated in Flanders (Miller 1999). Although much of this historical evidence is coincidental, it suggests that the builder could have incorporated our paver in a similar floor design.

Summary

The objective of the study was to determine the source of a limestone paver recovered from the colonial period Old Chapel Field archaeological site in St. Inigoes, Maryland, a Jesuit manor. As the site is in the Coastal Plain physiographic province, there are no viable local sources of rock. The primary hypothesis was that the stone came from England, the emigration point of origin for the Maryland colonists. Based on paleontological, lithological, and chemical analysis of the paver, a source in the Florida Platform (U.S.), Hampshire Basin (UK), Paris Basin (France), and the Belgian Basin was ruled out. The most likely source, supported by geologic and historical evidence, is the Aquitaine Basin in southwest France. The secondary objective was to determine whether the stone paver was reused from the Jesuit Brick Chapel at St. Mary's City after the chapel was torn down by 1705. Comparison of limestone fragments from the chapel with the limestone of the paver supports reuse of a paver from St. Mary's City Brick Chapel. This conclusion is further reinforced by paleontological, lithological, chemical, archaeological, and historical evidence.

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