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Warping Marble in New Orleans and Other Cemeteries: A Review

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Warping Marble in New Orleans and Other Cemeteries: A Review

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ABSTRACT
Erhard Winkler noted the warping of marble tablets in the cemeteries of New Orleans in various editions of his classic work *Stone: Properties, Durability in Man’s Environment*, and others in the United States and Europe have noted and commented on the striking marble deformation seen in these and other cemeteries. This paper briefly reviews marble warping in New Orleans cemeteries and puts these observations into a larger context of marble warping in cemeteries in general (which is not rare but is generally not well documented) and into that of marble cladding used for buildings (which is well known and has become increasing well documented). This study also brings together disparate sources that discuss, note, or illustrate marble warping, particularly that in cemeteries.

The configuration of warping marble tablets in New Orleans is similar to that of other gravestones and cemetery monuments in which marble tablets are somehow constrained, as well as that of warping marble used for building cladding. In these cases, one face of the marble tablets is exposed to more extreme atmospheric conditions, whereas the other face is nearer to a partition or wall. The New Orleans tablets are less like classic upright gravestones, which are exposed on both sides to the atmospheric conditions. The fact that even these less constrained marble tablets in cemeteries can warp, however, indicates that remedies proposed to lessen the warping of marble tablets in New Orleans are not likely to work well because the presumed underlying causes of warping (cycles of heating and cooling, and humidity) cannot easily be mitigated in New Orleans. Warped upright marble gravestones are probably underreported for two reasons: (1) warping is present but not noticeable unless one is looking for warping, and (2) warped marble tombstones tend to break over time and so are discarded.

INTRODUCTION
In the three editions of his classic text *Stone: Properties, Durability in Man’s Environment*, Erhard Winkler, an expert on the physical properties of stone used in construction, noted and figured (1973, p. 57; 1975, p. 43, Figure 53; 1988; 1996; 1997, p. 209) the deformation of marble closure tablets in New Orleans cemeteries. This has resulted in the New Orleans example becoming the most cited example of marble warping in North American cemeteries. Winkler also noted this warping in a 1988 paper (p. 729) and later (1996) published a more expansive note on the deformation of marble, concentrating on the deformation of marble closure tablets in New Orleans’s Metairie and Greenwood Cemeteries.

This review brings together disparate references to warping marble in cemeteries in New Orleans and elsewhere. It also notes key studies on the warping of building cladding. Additionally, this review reports on warping marble in a large sampling of New Orleans cemeteries based on a variety of sources as well as personal observations (four New Orleans cemeteries were visited in March 2011: Metairie and Greenwood Cemeteries, both located near the 17th Street Canal in the western part of New Orleans; St. Louis Cemetery No. 1, located just outside of the French Quarter and the oldest remaining cemetery in Saint Louis; and Lafayette Cemetery No. 1, located in the New Orleans Garden District). Several previously undocumented examples of marble warping are also illustrated.

WARPING MARBLE IN CEMETERIES AND AS BUILDING CLADDING

Types of Marble Warping in Cemeteries
Bowing and other warping of marble is not unusual in cemeteries, but this deformation has not been widely noted or investigated in North America, especially in comparison with the widely investigated surficial deterioration of marble in cemeteries (see discussion in Livingston and Baer 1990). Warping can be seen in several cemetery contexts, including warping of horizontal tablets, warping of upright gravestones, and warping of upright tablets or slabs that are constrained.

Warping of Horizontal Tablets
Dramatic bowing may occur when marble tablets are set in a horizontal position, as are some tablets (tomb tables) in older cemeteries in cities such as Philadelphia (Figure 1a). This phenomenon has been noticeable since at least the 19th century, when Julien (1884, p. 366) noted its occurrence in New York. The bowing seen in these marble tablets tends to be downward, but Kessler (1919, p. 31–32, Figures 5–8) noted upward as well as downward warping among a great number of warped horizontal tomb covers in a cemetery in Cuba.

Warping of Upright Gravestones (Tombstones)
Upright (vertical) cemetery gravestones (also known traditionally as tombstones and more recently as headstones) made of marble and other carbonate rocks also show evidence of warping and other deformation. The flexibility of marble...
Figure 1  Bowed (warped) marble in cemeteries. (a) Bowed horizontal marble tablet (tomb table) in St. Peter’s Churchyard, Philadelphia. Deformation is clearly delineated by the bathtub-ring-type stains. October 2006 photograph. (b) Deformed marble gravestone and other less deformed gravestones in St. Peter’s Churchyard cemetery, Philadelphia. Also note the deformed tomb table in the upper left. The person in the upper right is 5 ft 2 in. (1.6 m) tall. October 2006 photograph. (c–e) Bowed upright marble gravestone in Cleveland’s Erie Street Cemetery. Scale is marked in 3.9-in. (1-dm) segments. Note the curved shadow cast by the Jacob’s staff that delineates curvature of the tablet in Figure 1c, side view of the gravestone showing displacement from the vertical (the entire gravestone is also tilted) in panel d, and detail showing weathered edge of the gravestone in panel e. November 2011 photographs.

has been known for some time (e.g., Blagrove 1888, p. 8; Anonymous, 1894), and it is likely that marble workers knew of this flexibility—and the concomitant warping—of marble. A footnote in Rayleigh’s (1934) study of marble bending discussed the opinion of J.B. Slythe, a marble merchant, that marble such as tombstones in old cemeteries “often showed flexibility” (p. 265).

Julien (1884, p. 368) measured flexure in marble in New York City cemeteries. Later, Drewes et al. (1956) described and illustrated a spectacular example of bending and bowing of fine-grained marble gravestones in the New Haven, Connecticut, Grove Street Burial Ground. In this cemetery, upright gravestones greater than 3 ft (9 dm) tall and less than 0.2 ft (6 cm) thick were most likely to bend. They described the marble used as being white and equigranular. Drewes et al. (1956) cited the cemetery superintendent as indicating that this marble originated as ballast.
in ships arriving from Italy. It is likely that this stone was from Italy, but it is unlikely that it was shipped as ballast because large amounts of marble were exported from the Carrara area in the 1800s (e.g., Hawes 1884, p. 397–398; Seeley 1885, p. 51–52), and advertisements and other sources indicate the widespread use of Italian marble in the United States (see discussion in Bauer et al. 2002, p. 90). The bowing of upright gravestones made of limestone has been figured by Grimm (e.g., 1999, Figure 22) in a cemetery in Paris.

Bowing of upright marble gravestones can be found in other older North American cemeteries that have utilized slabs of marble that are relatively thin compared with their length and width, for instance in Philadelphia (Figure 1b) and Cleveland (Figure 1c–e). Typically, such gravestones are less than 3.2 in. (8 cm) thick. Bowing of these gravestones can be observed most easily by placing a straightedge against the side of the warped slab (Figure 1d–e). This provides a vertical (or horizontal) frame of reference from which maximum deviation from the vertical can be measured. Warping of upright gravestones is typically most strongly developed along a horizontal fold axis, but is often accompanied by lesser developed warping along a vertical fold axis. The principal fold axis is normally perpendicular to the longest dimension (i.e., length) of the gravestone. Warping of these gravestones is also typically accompanied by acid-precipitation loss of surface thickness, especially, but not only, toward the top (Roberts 2005) and middle of the tablet compared with the base. This warping can also be accompanied by the development of fractures (Grimm 1999, Figure 22).

Several examples of bowing marble can be seen in the Erie Street Cemetery in Cleveland, Ohio (see Bauer et al. 2002 for a discussion of other aspects of stones used in this cemetery). The most bowed tablet in this cemetery is about 3.3 ft (1 m) high and 17.9 in. (45.5 cm) wide at its base (Figure 1c–e). Its thickness is about 2.8 in. (7 cm) at the base and 2.4 in. (6 cm) at the center. Maximum deviation from the horizontal is about 0.8 in. (2 cm; Figure 1d–e). Some of the deflection can be attributed to differential surficial reduction (see Roberts 2005 for a discussion of this phenomenon), but most of this deflection is from warping. The side of the slab that has experienced relative expansion (right side in Figure 1e) has developed a series of cracks. Such warping is not unique to the cooler, northern part of Ohio, however. Similar examples can be found in cemeteries in warmer parts of Ohio, including Marietta and Locust Grove Cemeteries in Adams County.

### Warping of Tablets or Slabs That Are Constrained

The warping of upright tablets or slabs that are constrained in some way (such as placed in or attached to a frame of another stone as part of a gravestone or a cemetery monument) has received much attention. The warping of closure tablets of tombs in New Orleans cemeteries is now the best known example of this type of warping, but this type of deformation has long been noted elsewhere. One of the earlier reports of such stone deformation is that of Geikie (1880, p. 195–199), who cited a number of examples of warping in Scotland, where marble slabs were constrained by sandstone. Julien (1884, p. 367), however, noted that this type of gravestone was not used in the United States. Geikie’s work was excerpted by Merrill (1891, p. 368–369) in his classic book *Stones for Building and Decoration*. In recent years, European workers have again brought attention to the warping of constrained panels in cemeteries (as in the examples in Grimm 1999; Siegesmund et al. 2000; TEAM Project in Siedel et al. 2011, Figure 6.7a).

### Warping of Building Facing and Interior Marble Cladding

It is now widely known that thin marble building facing can warp, and many examples can be found around the world. The classic example is that of the Amoco (now Aon) Building, a 1,135-ft-tall (346-m-tall) rectangular skyscraper located in downtown Chicago. This example has been widely cited in the geological, engineering, and architectural literature (e.g., Logan et al. 1993; Wolfe 1996; Winkler 1997, p. 209, Figure 7.23; Logan 2004, 2006). Other examples known from a variety of cities include Rochester, New York (Winkler 1997, p. 209); Toronto, Canada (Logan 2004, 2006); Helsinki, Finland (Grelk et al. 2008); Munich, Germany (Grimm 1999); Vienna, Austria (Widhalm et al. 1996); Zagreb, Croatia (TEAM Project in Siedel et al. 2011); and Evansville, Indiana (Hannibal et al. 2008). More examples have been documented, and many more undocumented instances exist. Carrara marble is the chief marble discussed in the literature (e.g., Logan et al. 1993; Logan 2006), but other marbles used for cladding are also known to deform. Recently, Hannibal and Saja (2007a,b) have noted incidences of marble bowing inside historic 19th-century structures. The marble they investigated was either Carrara or a stone much like Carrara.

### NEW ORLEANS CEMETERIES AS A CLASSIC EXAMPLE OF WARPING MARBLE

Although warping of marble has not been widely noted in cemeteries in the United States, warping of marble closure tablets in New Orleans cemeteries has been noted by scientists, architectural historians, and preservation specialists. This is, in part, from the relatively large amount of attention that New Orleans cemeteries have received. The European-style cemeteries of New Orleans are among the Crescent City’s major attractions. Winkler’s (1973, 1975, 1988, 1996, 1997) documentation of marble warping in New Orleans cemeteries has made New Orleans the classic case example of such warping in cemeteries. Winkler (1973) was the first to bring this warping to the attention of the scientific community, but others (Hunt 2004, p. 115) have also noted warping in New Orleans. Huber (1974/2004) and Lemann (1974/2004) mentioned warping of marble in the cemeteries of New Orleans in *New Orleans Architecture: The Cemeteries* (Christovich 1974/2004b). Huber described this as occurring in New Orleans’s St. Louis Cemetery No. 1. He also provided an interpretation for this warping: “Unfortunately, from exposure to the sun and rain of a century and a half,
many inscriptions have become illegible, and some of the slabs have become warped or have perished completely* (p. 6). In the same book, Lemann noted that “on swampy soil . . . marble slabs curl out of line” (p. 191).

Marble bowing in New Orleans cemeteries is so distinct that it can be seen in photographs in general publications about New Orleans cemeteries. This bowing, although not noted in the text of these publications as occurring, can be distinguished in photographs because bowing is delineated by curved shadows. Warping marble closure tablets can be seen, for example, in illustrations in *New Orleans Architecture* (Christovich 1974/2004b, p. vi, 82, 86, 138). The tablet on the tomb of Homer Plessy in St. Louis Cemetery No. 1 is shown to be distinctly bowed (Florence 1996, p. 35). Several tablets are seen as bowed in a view of tombs in St. Louis Cemetery No. 2 (Florence 1997, p. 37), and at least one distinctly bowed tablet can be seen in a photograph of St. Roch Cemetery (Florence 1997, p. 116). Because new replacement tablets are installed over time, such photographs (as in the case of the stone used for Homer Plessy’s tomb) document warping when the primary evidence (earlier marble tablets) has been removed and replaced with new tablets. These and other references to, or illustrations showing, warped marble tablets in New Orleans cemeteries are listed in Table 1.

*Sass (1988) documented warping marble in Lafayette Cemetery No. 1, noting outward and inward bending as well as distortion of closure tablets in an S-curve. More recently, Matero et al. (2002) noted and discussed bowing in *St. Louis Cemetery No. 1: Guidelines for Preservation and Restoration.*

**Table 1** References to and illustrations showing warped marble tablets in New Orleans cemeteries

<table>
<thead>
<tr>
<th>New Orleans cemetery</th>
<th>References to warping, illustrations showing warping, or both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cypress Grove Cemetery</td>
<td>McDowell 1974/2004, Figure 33</td>
</tr>
<tr>
<td>Greenwood Cemetery</td>
<td>Winkler 1996</td>
</tr>
<tr>
<td>Lafayette Cemetery No. 1</td>
<td>Sass 1988; Florence 1996, figures on p. 35, 38; this study</td>
</tr>
<tr>
<td>Metairie Cemetery</td>
<td>Winkler 1996; this study</td>
</tr>
<tr>
<td>St. Louis Cemetery No. 2</td>
<td>Florence 1997, upper figure on p. 37</td>
</tr>
<tr>
<td>St. Roch Cemetery</td>
<td>Florence 1997, figure on p. 116</td>
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</tbody>
</table>

**Type of Marble**

The predominant marble used for closure tablets is fine-grained white marble, probably Carrara marble. The name Carrara marble encompasses a variable group of mostly light-colored calcitic marbles quarried in the Apuan Alps of Italy (Bradley, 1997, p. 52–53). Carrara marble is noted as having been used in New Orleans cemeteries (Winkler 1997, p. 209), and the reported petrologic characteristics of the stone (Sass 1988) are consistent with Carrara marble. Additionally, advertisements in 19th-century New Orleans newspapers and directories noted the use of Italian marble (Stroud and Company 1844). Joseph Viau (1844), a “manufacturer of tombs, monuments, grave stones, etc.,” for example, noted in an advertisement that he imported Italian and French marble. Carrara marble is specifically noted for various funerary uses (Anonymous 1887). New Orleans was also one of the ports known for handling imported marble in the early 20th century (Sewell 1923, p. 4).

**Marble Use**

New Orleans cemeteries are well known for having aboveground tombs (Florence 1997, p. 9–19). These tombs, or vaults, are typically constructed of brick and concrete and covered on the exterior with stucco. Some, however, are constructed of stone (Huber and Huber 1929, 1930). Thin (~0.8- to 1-in.-thick (~2- to 2.5-cm-thick) tablets of fine-grained marble, also known as marble plaques (Florence 1996, p. 17) or inscription tablets (Florence 1997, p. 24), have been widely used as vertical covers for the entrances to these tombs. The tombs are made so that two or more sets of remains can be placed in them at any one time (Figure 2a). Thus, they typically have two or more spaces for caskets and a space for remains below the space for caskets. When a casket is placed in a tomb, the opening is typically closed using bricks and mortar (Figure 2b), and finally, the outer tablet is attached. More details on this can be found in Sass (1988) and Matero et al. (2002).

The tablets used as covers in the New Orleans cemeteries are roughly similar in thickness to that of the bowed marble used for exterior cladding of large buildings [1.3 in. (3.2 cm) thick in the case of the Amoco Building in Chicago; Logan 2006] and for bowed tablets inside the Cuyahoga County Soldier’s and Sailor’s Monument [1 in. (2.5 cm) thick] in Cleveland, Ohio (Hannibal and Saja 2007a,b).

**Warping of the Marble**

Several modes of marble deformation can be seen in New Orleans cemeteries. Winkler (1996) noted convex and concave warping. Sass (1988) noted three types of bowing: convex (outward), concave (inward), and S-shaped bowing. Simple concave (Figures 2c–d) and convex (Figures 3a–c) bowing are the most common types of bowing. These tablets have a strongly developed horizontal fold axis. Tablets bowed into an S-shape (Figure 3d) have two strongly developed, parallel horizontal fold axes. This is similar to Grimm’s (1999, Figure 27) wavelike deformation. Some tablets have more complex bowing (upper left of Figure 2c). This four-fold classification (concave, convex, S-shaped, complex) simplifies the bowing of these tablets because bowing tablets tend to have some vertical and horizontal components (Figure 3a). Generally, the horizontal fold axes tend to dominate.
Figure 2  Tombs in New Orleans cemeteries.  (a) Configuration of typical New Orleans tombs, Lafayette Cemetery No. 1. Tomb on the right shows empty compartments. Tomb on the left has a loosely attached closure tablet. (b) Typical New Orleans tomb, St. Louis Cemetery No. 1. Compartments have been bricked in and the closure tablet, which would normally cover the bricked-in area, is missing. (c) Concave warping in New Orleans Lafayette Cemetery No. 1. The earliest date on the large marble closure tablet is 1868. Scale near the bottom of the tablet is marked in 1-cm (0.39-in.) segments. One of the small cover tablets to the upper left of the adjacent structure is complexly deformed and broken. (d) Concave warping in New Orleans Lafayette Cemetery No. 1. Part of the tablet has broken, exposing brick. Scale is marked in 1-cm (0.39-in.) segments. March 2011 photographs.
Figure 3 Warped closure tablets in New Orleans cemeteries. Scales are marked in 1-cm (0.39-in.) segments. (a) Convex warping (outward doming) in St. Louis Cemetery No. 1. No date of death is noted on this tablet. (b) Convex warping of marble tablet of a granite tomb, Metairie Cemetery. (c) Detail of panel b showing convex warping and concomitant cracking in the marble tablet. (d) S-shaped warping in Lafayette Cemetery No. 1. March 2011 photographs.
Other Examples of Bowing Marble in the Southeastern United States

If marble tablets are bowed in New Orleans cemeteries, it makes sense that marble slabs used for building cladding would be similarly bowed in the region. New Orleans is not noted for having buildings clad with thin marble veneer. One such New Orleans building, however, is the old Oil and Gas Building at 1100 Tulane Avenue, clad in Vermont marble (Slagle 1982, p. 24). The exterior shows some deformation (Figure 4a). More dramatic examples of warped exterior cladding can be found in several buildings in Houston, Texas, where marble has been used more extensively for cladding of buildings and which is located in a similar hot, humid environment (Figures 4b–c). In Alabama, marble cladding on the Houston Cole Library of Jacksonville State University in Jacksonville had to be taken down and replaced with granite in 2002 (Hubbard and Walter 2005, p. 51).

Causes of Warping

Experimental work with warping marble and other building stones extends at least back into the early 19th century. These range from the very simple experiments of Brindley (1890, p. 239) to the more complex experiments of Bartlett (1832) and Rayleigh (1934). The last few decades have seen an intense revival of such investigations (e.g., Erlin 2000; Logan 2006; Marini and Bellopede 2007, 2009). The European Union’s TEAM Project consortium supported a number of these studies. Experimental studies have also been conducted on limestone and dolomites (e.g., Harvey 1967). A consensus among researchers has long ascribed the root causes of warping marble to heat cycling aided by
humidity (e.g., Winkler 1997, p. 208–211; Marini and Bellopede 2007). Anisotropic thermal expansion caused by heat cycling has remained one of the most viable theories for marble warping (e.g., Siegesmund et al. 2000). Winkler (1997, p. 210) also added the requirement of marble dissolution as a first step in the process of warping, and some authors (e.g., Logan 2004) have emphasized the release of stored residual strain in the process of warping. Sass (1988, p. 179–180) also discussed the occurrence of a freeze–thaw cycle, but this can be only a minor component of what is occurring in New Orleans, considering the overall climate of the city.

In the case of horizontal tablets in cemeteries (Figure 1), an argument could be made that the cause of horizontal tablet deformation is related to the weight of the tablet. Winkler (1973, p. 57; 1975, p. 57) argued that deformation is a result of the weight (load) of the tablet coupled with high humidity. Kessler’s (1919, p. 31–32, Figures 5–8) observation of upward bowing of horizontal marble tablets in Cuba, however, showed that the warping could not be ascribed simply to the weight of the tablet. Kessler (1919, p. 32) argued that diurnal temperature changes were the only way to explain this warping. Winkler (1996, p. 218) argued that outward bowing of closure tablets in New Orleans cemeteries resulted from the effects of sun and high humidity, whereas inward bowing was due to extremely high moisture behind the panels. However, it is not clear that this is the case.

**Comparison of Closure Tablets with Upright Gravestones and Building Cladding**

The orientation of closure tablets in New Orleans cemeteries is generally similar to that of marble slabs cladding buildings because, in both cases, marble tablets are installed close to a wall. Thus, the interior and exterior surfaces of the marble slabs have differential environmental conditions. Upright gravestone tablets, on the other hand, are exposed on all sides, allowing air movement to ameliorate temperature differences and to wick moisture from both sides of the gravestones. The relative frequency of bowing of closure tablets in New Orleans cemeteries appears more similar to the warping of marble cladding used for buildings and less similar to that of upright cemetery tablets, which appear to warp to a lesser degree.

**Problems with Studying Warping in New Orleans Cemeteries**

It is difficult to determine the length of time a tablet has been in place in New Orleans cemeteries. The normal assumption for those studying gravestones is that the date on the gravestone is the date of installation (e.g., Bauer et al. 2002; Mallios and Caterino 2007). However, dates are not always recorded on tablets in New Orleans cemeteries. The replacement rate of tablets in New Orleans cemeteries is probably also high because warping can lead to breakage and ultimately replacement. Replacement tablets, if they record the death date of the earliest person interred in the tomb, would not then record the correct date for the installation of the marble tablet.

Many New Orleans tablets have probably been replaced because they had become deformed, as in the case of Homer Plessy’s tablet in St. Louis Cemetery No. 1. The multiple uses of New Orleans tombs add a layer of complexity to this. In addition, some tablets cover empty or partially empty spaces, whereas other tablets lie close to enclosing brick. In recent times, some marble tablets have been replaced by granite, which does not deform to the same degree (Winkler 1996).

**What Can Be Done About the Warping Tablets in New Orleans Cemeteries?**

Guidelines established for the preservation and restoration of stone tablets at St. Louis Cemetery No. 1 (Matero et al. 2002, p. 59) call for the use of “white, preferably Carrara marble, of greater thickness [1½” [3.8 cm] if possible” as replacement tablets. They also suggest that replacement and reinstalled tablets be trimmed 0.25 in. (0.64 cm) at the base and set on lead or polyethylene-foam shims. The trimming and the shims would allow for expansion. The guidelines also discourage the use of granite and other rock types as replacements for the original marble to maintain historic usage.

Increasing the thickness of the marble tablets and using shims to allow for expansion are reasonable steps in the prevention of warping, but these steps alone may not be sufficient to ameliorate warping. Carrara marble is widely known for warping as a building veneer. Carrara, or a stone very much like it, has also been shown to warp inside structures (Hannibal and Saja 2007a,b). Hunt (2004, p. 116) has noted that efforts to date to limit warping have not worked. Reinstallation of the marble facades on Finlandia Hall in Helsinki, for example, has not been successful (Marini and Bellopede 2009, p. 259). In addition, the marble slabs known to warp on building exteriors are typically in the range of about 0.79 to 1.5 in. (2 to 4 cm) in thickness (Åkesson et al. 2006). The gravestone shown in Figure 1c–e is about 2.75 in. (7 cm) thick, much thicker than most marble cladding used on buildings, and its warping has not been successful.

Therefore, it appears unlikely that the guidelines for preserving and restoring tablets (Matero et al. 2002) at St. Louis Cemetery No. 1 will be enough to prevent future deformation because these guidelines do not address the root cause or causes of the deformation, whether that be temperature variations, humidity, the release of pressure (stress relief), or a combination of these. The guidelines may slow the deformation, however.

Although a deviation from the use of the original stone type, granite would appear to be good replacement stone for marble in the case of New Orleans cemeteries. Indeed, in recent decades, granite tablets have been used instead of marble as the closure tablets for a number of tombs, presumably as replacements for degraded marble tablets. Winkler (1996, p. 212) has measured warping granite in Greenwood Cemetery in New Orleans, and others (Siegesmund and Dürrast 2011, p. 198, Figure 3.78) have subsequently noted warping in granites and other rock types elsewhere. Presumably, the warping of the granite slabs does not occur as quickly as that of marble slabs.
The use of granite and other igneous rocks as replacement stone for marble, however, is not acceptable by historic preservationists because these igneous rocks differ in color and texture from the marble traditionally used, affecting the overall look of cemeteries (Matero et al. 2002, p. 58).

If careful records are kept of the installation dates of new replacement slabs, whatever the stone type, it would provide critical data for studying the timing, and therefore the rate, of deformation in New Orleans cemeteries.

CONCLUSIONS
Warping marble is very common and pronounced in New Orleans cemeteries, so much so that such warping can easily be recognized from photographs. New Orleans has a warm climate, so freeze-thaw cannot be critical in the bowing process. Warped-marble closure tablets in New Orleans are similar to stone used for building cladding, in that one side is exposed to more extreme atmospheric conditions, whereas the other side is nearer to a brick partition or backing. The tablets are less like classic upright gravestones, which are exposed on both sides to the open air. As others have suggested, warping of the closure tablets in New Orleans could be alleviated somewhat by installing thicker panels with length and width dimensions that would also allow for expansion. Although not desirable for historic accuracy, replacement of marble with granite, along with these other two remedies, may work even better. Even in combination, it is unlikely that warping can be eliminated: relatively thick upright marble gravestones with three unconstrained sides still can warp (Figure 1b–c). If careful records are kept of the installation dates of new replacement slabs, whatever the stone type, they would provide critical data for studying the timing, and therefore the rate, of deformation in New Orleans cemeteries.

Although marble warping has been widely recognized in New Orleans cemeteries, it has not been noted in many other cemeteries. In part, this is because it has just not been noticed. This is also probably because of the propensity of warped marble slabs to eventually develop cracks and then be replaced or simply discarded. Warped slabs may also be affected by severe concomitant surficial dissolution. The dissolution leads to the erasure of inscriptions and decorative carvings, and thus results in the replacement of highly weathered—and warped—gravestones.

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