**A Small Scale Study of the Weathering Rates of Marble Gravestones Dated from 1958-1962**

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**Abstract** Marbleis known to weather quicker when exposed to air pollution. This has led to the suggestion that gravestones could be used to study the long term degradation of marble and be used as indicators of past pollution levels. This small scale study examined the weathering rates of a group of marble gravestones of similar age and location. The study found no evidence to suggest that these gravestones could provide accurate or useful information on marble weathering rates or past pollution levels.

**Introduction**

Gravestones and usually dated and can be found in urban environments across the globe. Many of these stones have usually suffered long term exposure. Gravestones may therefore prove useful for studying the long term deterioration of stone and historic pollution levels (Livingston and Baer, 1990). Studies of contemporary stone degradation generally link relatively short term changes in the material to equally short term changes in variables such as sulphur dioxide and rainfall levels (Inkpen and Jackson, 2000). Although there is a link between air pollution and stone degradation using gravestones as accurate indicators of long term weathering may not be possible. Various other factors besides air pollution can influence stone weathering rates such as cleaning and material differences. This study examines the weathering rates of a group of Carrara marble gravestones dated from 1958-1962 in a restricted area in a cemetery in south-east England.

**Literature Review**

As far back as 1879, the Scottish geologist Archibald Geike studied the effects of pollution on gravestones (Livingston and Baer, 1990). A lack of information has led to the suggestion that gravestones could be used to estimate past pollution levels. This information could be used to measure changes in air pollution levels and possibly predict future changes in the climate (Bowden, 2009; GET website; GSA, 2009; Livingston and Baer, 1990; Okonowicz, 2001; Science Alert website).

Marble has a consistent nature and therefore has been used in previous research on gravestone weathering (McNeill, 1999). This material is known to weather quicker in polluted atmospheres. The rates and mechanisms of this decay can be influenced by factors such as original surface polish and acid and bleach cleaning (Maxwell et al., 2001).

**Method**

The data used in this study was collected at City Cemetery, Brighton, Sussex, England from a sample of twenty west facing gravestones dated from 1958-1962. These gravestones were contained in an area approximately 40 metres x 40 metres. It was assumed that as these gravestones were of a similar age they would therefore have been subjected to similar environmental conditions. The data was used to assess whether these marble gravestones had weathered at a similar rate per year. This data could be used to test the accuracy of using marble gravestones as predictors of past pollution levels.

To ensure the gravestones had not undergone re-facing and were original and not replacements information was sought from local stonemasons and the register of graves. First, the register of graves (kept at Woodvale Lodge Office, Brighton) was consulted for information regarding the issuing of a permit for the erection of the gravestones. The register showed that the issued permits were contemporary with the dates found on the gravestones (Register of Graves). No record of any maintenance carried out on these gravestones was found at the register office or the local stonemasons (Tilley pers comm.).

The weathering of the gravestones was measured using the ‘lead letter method’. To enable easy reading of the inscriptions on marble gravestones lead is often fixed into the lettering. This is carried out by drilling the cut letters and then hammering lead into them. The lead is then rubbed flush to the face of the gravestone. Over time the marble weathers and these lead letters are left protruding past the surface. This weathering can then be measured with a depth gauge. For this study, electronic gauges accurate to 0.01mm (millimetres) were used. Rates of weathering were measured in mm per year. This level of accuracy is consistent with previous studies on the weathering of marble gravestones (GET website; UCL website).

**Results**

The data revealed some wide variations in the rates of weathering (see figure 1). For example a gravestone dated December 1960 had weathered at 0.0047mm per year whilst a gravestone less than 2 metres away dated November 1960 had weathered nearly 3 times faster at a rate of 0.0135mm per year.



Figure 1. Graph showing the variations in weathering rates of gravestones of a similar age in a restricted area at City Cemetery (graph by author).

**Discussion and Conclusion**

During their time in the cemetery gravestones can undergo a number of forms of maintenance. For example, stone cleaners are acid based and can dissolve marble. Furthermore, cleaning marble with bleach can also damage the surface of the gravestone (Ashurst and Ashurst, 1998; Chicora Foundation website). Although no records were found, it is impossible to know whether the gravestones in this study had undergone any form of maintenance. The weathering rate could also have been influenced through the re-leading and re-facing of the gravestones or even differences in the original surface polish. In addition, research in Australia noted stone variations in Carrara marble. Measurements taken from a large square tombstone lettered on four faces was found to be similar on opposite sides but different on adjacent faces. These variations are may be due to planes of weakness in the material (Dragovich, 1991). Whether through variations in the material or other factors previously discussed the results from this small sample of gravestones has raised concerns over the value of using marble gravestones as indicators of historic pollution levels and long term degradation rates.

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