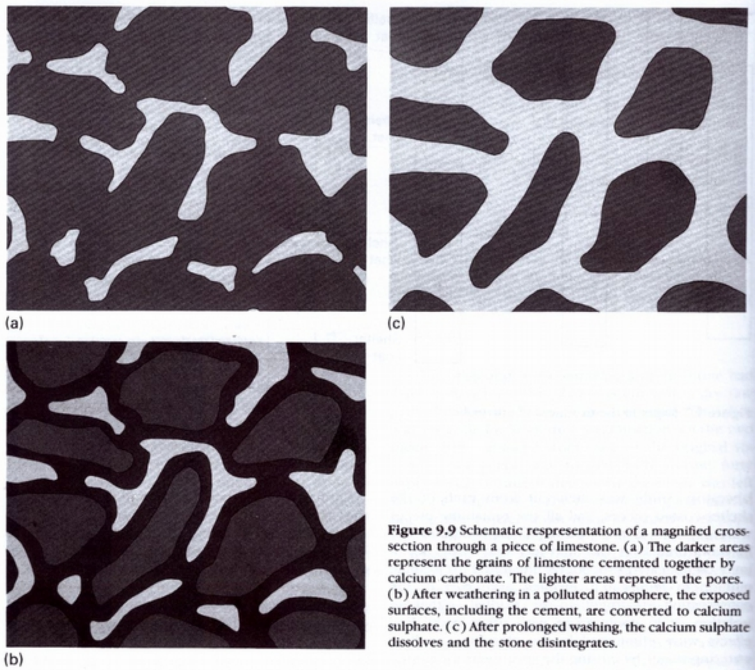

Figure 9.9 Schematic respresentation of a magnified cross-section through a piece of limestone. (a) The darker areas represent the grains of limestone cemented together by calcium carbonate. The lighter areas represent the pores. (b) After weathering in a polluted atmosphere, the exposed surfaces, including the cement, are converted to calcium sulphate. (c) After prolonged washing, the calcium sulphate dissolves and the stone disintegrates.

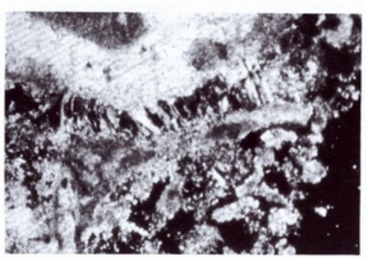

Figure 9.10 Petrological thin section: calcium sulphate crystals form a line of bridges between two grains of stone (× 130)

fact observed at Wells, when conventional water mist sprays were used to clean highly undercut architectural detail. The prolonged washing leached the calcium sulphate from the stone, which was reduced to a soft mass. (This experience led to a refinement of the technique for washing architectural stonework, in which water was sprayed onto the stone for only a few seconds at a time, with intervals of several minutes in between. The spray was controlled either by a time switch or by electronic sensors placed on the stone. This refinement enabled the stone to be kept wet, thus softening dirt, without the calcium sulphate being leached out.) One must conclude that removal of the sulphate is not necessarily beneficial, despite the fact that one would prefer the calcium sulphate not to be there in the first place.

The effects of the three cleaning techniques on sulphate distribution are shown in *Figure 9.11*, which gives the results for two of the mullions. The results show beyond doubt that none of the cleaning techniques has any influence on the quantities of sulphate contained *within* the stone. It should be remembered, however, that these results relate to specimens which are typically 7 mm (0.3 in) thick; they thus represent the average sulphate content within a 7 mm specimen. If there were to be any redistribution of the sulphate within such a specimen, it would not be discernible from these results. Nevertheless, the results clearly refute any claim that the lime poultice serves to draw calcium sulphate out of the depth of the stone.

The situation is different when the amount of sulphate on the *surface* of the stone is examined. *Table 9.6* contains the results of sulphate analyses on

Table 9.6 Sulphate content of surface scrapings, following the initial cleaning stage

	Cleaning technique	*Sulphate content* (% SO_3)
Mullion 1	Lime poultice	26.5
	No treatment (control)	28.0
	Air abrasive	22.1
Mullion 2	Lime poultice	4.4
	No treatment (control)	26.0
	Water	4.8
Mullion 3	Air abrasive	12.8
	No treatment (control)	26.3
	Water	3.8

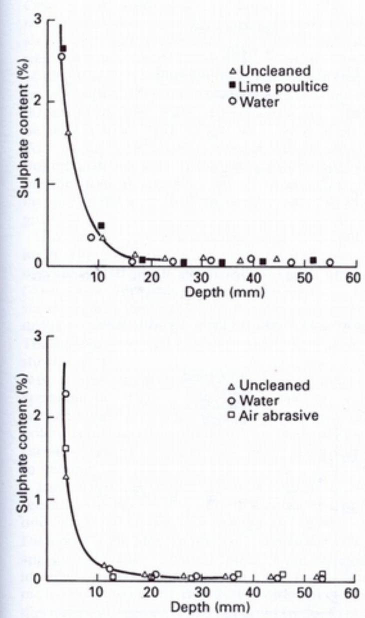

Figure 9.11 Variation of sulphate content with depth; analysis was by carbon/sulphate combustion, all sulphur being taken as sulphate

scrapings from the surface of the various samples. In both cases of water washing, the washing removes more than 80% of the sulphate skin. The effects of the air abrasive and the lime poultice, on the other hand, are more variable. In one case, the air abrasive reduced the sulphate content by 21%, in the other case by 51%. The lime poultice reduced it by 5% in one case and by 83% in the other, an even greater reduction than that caused by water washing. The variability of the results is not surprising, for some areas of stone will come clean more readily than others. In the case of the lime poultice, in particular, water is used to assist cleaning after removal of the poultice, so areas that had required a good deal of washing would be expected to give results similar to those for water washing alone.

The results of *Table 9.6* are borne out by examination of petrological thin sections. The sulphate skin is largely absent from samples that have been water washed, whereas it is present in variable amounts in those that have been cleaned by air abrasive or lime poultice.

These data confirm that water washing is potentially harmful to the stone, because it can remove the sulphate that binds surface grains together. The air abrasive and the lime poultice, on the other hand, permit a reduction in the sulphate skin without disrupting the stone below. This will facilitate the subsequent absorption of lime water but will also make the stone more vulnerable to further attack by acid rain water unless the protective shelter coat is applied. One advantage of the air abrasive over the lime poultice is that the air abrasive is more selective. It is possible to clean around traces of pigment, for example, without affecting the pigment itself.

Deposition of calcium hydroxide

This part of the investigation was aimed at detecting any calcium hydroxide or calcium carbonate that had been deposited in the stone. The lime poultice