Weathering in Sandstone Shelters in the Sydney Basin and the Survival of Rock Art

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Introduction

In an earlier paper presented in 1973 and based on the preliminary findings of a study of the sedimentary environments of archaeological sites in sandstone shelters in southern N.S.W., it was argued firstly that while the sites were occupied the rates of weathering and roof-fall in the shelters were much higher than the present apparently very low rates, and secondly, that the products of roof-fall were generally much coarser than at present.[1]

On this basis it was concluded that:

1. in shelters used as habitations and where occupation resulted in accelerated rates of weathering and roof-fall, any surviving rock art is likely to be very young;
2. given the very low present rates of roof-fall at the study shelters, surviving paintings, drawings and rock engravings should undergo little significant deterioration due to rock weathering over the next decade or so.
3. just as usage of the shelters by Aborigines accelerated rates of weathering and roof-fall in the past, any more intensive 'use' of decorated shelters by tourists and rock art experts is similarly liable to accelerate weathering and roof-fall, to the detriment of the rock art. The use of such shelters should therefore be restricted and the decorated surfaces protected from rubbing by people and animals.

The broader study on which these preliminary conclusions were based has now been completed[2] and this has allowed a quantitative estimate to be made of natural compared with man-induced accelerated rates of weathering in sandstone shelters in the Sydney Basin. The evidence presented in this study and summarised here was drawn from the following sources:

1. detailed geomorphological investigations by the writer of four shelter sites in southern N.S.W.; Burrill Lake Shelter, Currarong Shelters 1 and 2 and Sassafras Shelter I;
2. a recent preliminary geomorphological study by the writer, in conjunction with an archaeological study by J. Clegg, of Milligan's Cave, 40 km north of Sydney;
3. a reconnaissance by the writer of other shelters formed in sandstones of the Sydney Basin, including shelters not used as habitations and shelters containing archaeological deposits;
4. previous studies by Lawrence[3] and Johnson[4] of similar caverns formed in sandstones of the Sydney Basin.

The Origin and Development of the Shelters

The location of these study areas is shown in Fig. 1. Shelters have formed in a range of quartz-rich Permian and Triassic sandstones, commonly feldspathic and with matrices of silt, clay and soluble cements such as iron carbonate (siderite). These sandstones are subject to granular disintegration and flaking on shaded surfaces, especially inside tafoni and caverns, and to case-hardening on exposed rock-faces. The most important cavernous weathering process operating is hydration of the clay matrix of the sandstone. Johnson[4] suggested that in addition to causing breakdown of the clay matrix by expansive forces, hydration releases iron, silica and other elements from the clays for reaction with organic acids in any seepage waters, resulting in further chemical destruction in the clay matrix. The removal of any soluble cement will also aid in the breakdown of the matrix. In this study and in those of Johnson[4] and Lawrence[3] little evidence was found in inland shelters of weathering by NaCl salts, such as salt encrustation, and this is taken to indicate that salt weathering is not commonly an active process, whereas in contrast, sandstone outcrops along the coastline and directly exposed to sea spray are strongly affected by weathering through salt crystallisation.

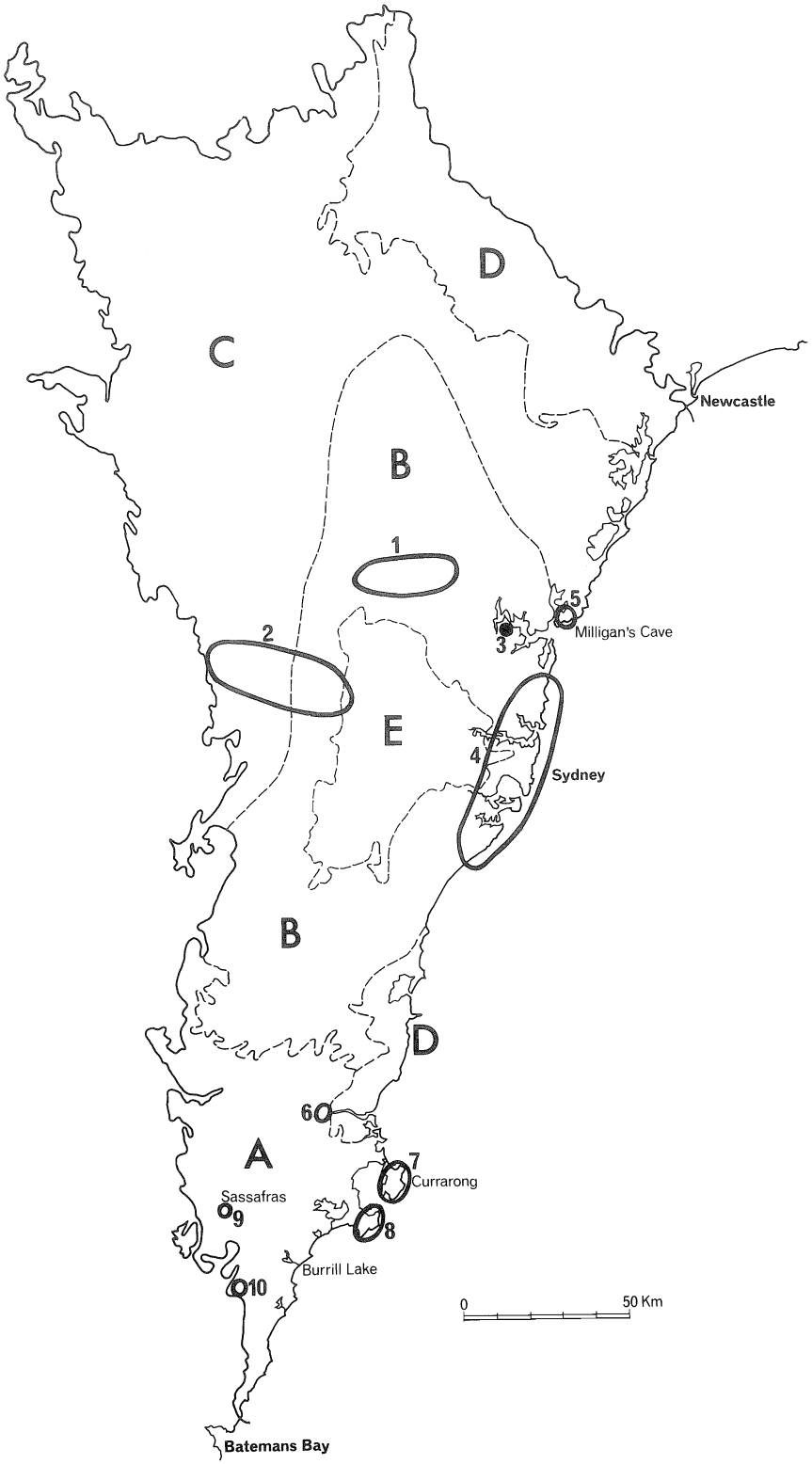

Figure 1: The Sydney Basin

All the shelters studied in detail by the writer had entrance overhangs, arched or back-sloping roofs, and outward-sloping rock floors, features which are consistent with an origin by cavernous weathering (Fig. 2). The roofs are commonly either loosely crusted with yellowish-grey, limonite-stained weathered rock that readily falls as small flakes on contact, or is so softened that the surface layer can be brushed away as individual grains. However the amount of material that can be dislodged by brushing the rock surfaces varies greatly between shelters (Table 1). In respect of their forms, the condition of their roof-rocks and their outward sloping floors these shelters closely resemble Milligan's Cave, the shelters visited in the reconnaissance, and the caverns attributed to cavernous weathering by Lawrence[3] and Johnson[4].

It is envisaged that the case-hardened rock faces in which these Sydney Basin shelters have formed were breached through the formation of tafoni by selective cavernous weathering, perhaps at points particularly subject to wetting and drying. These were then progressively enlarged by cavernous weathering of their roofs and walls. In the case of near-coastal shelters it is likely that their development was accelerated by wave action and/or weathering through salt crystallisation when the sea stood at a higher level than at present during the last interglacial about 120,000 years ago.

Natural Rates of Weathering

The detailed studies of the four southern N.S.W. sandstone shelters and their contained archaeological deposits give four indications of natural rates of weathering and roof-fall (Table1):

1. the thickness of weathered crusts formed in the last 100 years or so assumed to have elapsed since the shelters were abandoned;
2. the lack of fresh roof-fall on the surface of the deposits;
3. the collection of roof-fall in four trays in the Burrill Lake shelter, which indicates a range in the rate of roof-fall over a period of four years of 0.03 to 0.13 mm/100 y, the average rate being 0.07 mm/100 y. No seasonal variation in the rates was apparent. The trays had been emptied one week before an earthquake on 10 March 1972[5] and were re-examined the following week, but no measurable additional amount of roof-fall resulted from the earthquake;
4. the rate of accumulation of roof-fall in the archaeological deposits. Since it was claimed that the rates of cavernous weathering and roof-fall were enhanced during man's occupation of the shelters, these set maximum rates of natural weathering before occupation.

	Average thickness of weathered rock formed since abandonment 100 y BP (mm)	Wt. of rock dislodged by brushing (gm/m^2)	Time span of occupation (years)	Average thickness of rock that fell with occupation (m)	Inferred rate of accelerated weathering with occupation (mm/100y)	Inferred natural rate of weathering (mm/100y)	Ratio of max. accl. rate of weathering to natural rate of weathering
Burrill Lake Shelter	5	103 - 141	25,000	0.38	0.3 – 4.2	< 0.2	> 21
Currarong Shelter 1	< 1	6.1	7,000	0.30	0.5 – 5.7	< 0.5	> 11
Currarong Shelter 2	< 1	4.0	7,000	0.17	0.5 – 6.6	< 0.5	> 13
Sassafras Shelter 1	2	13.5	4,000	0.10	2.0	<< 2.0	>> 1
Milligan's Cave	< 1	5.0	< 1,000	0.05	> 5.00	< 1.0	> 5

Table 1: Rates of weathering in sandstone shelters in southern New South Wales

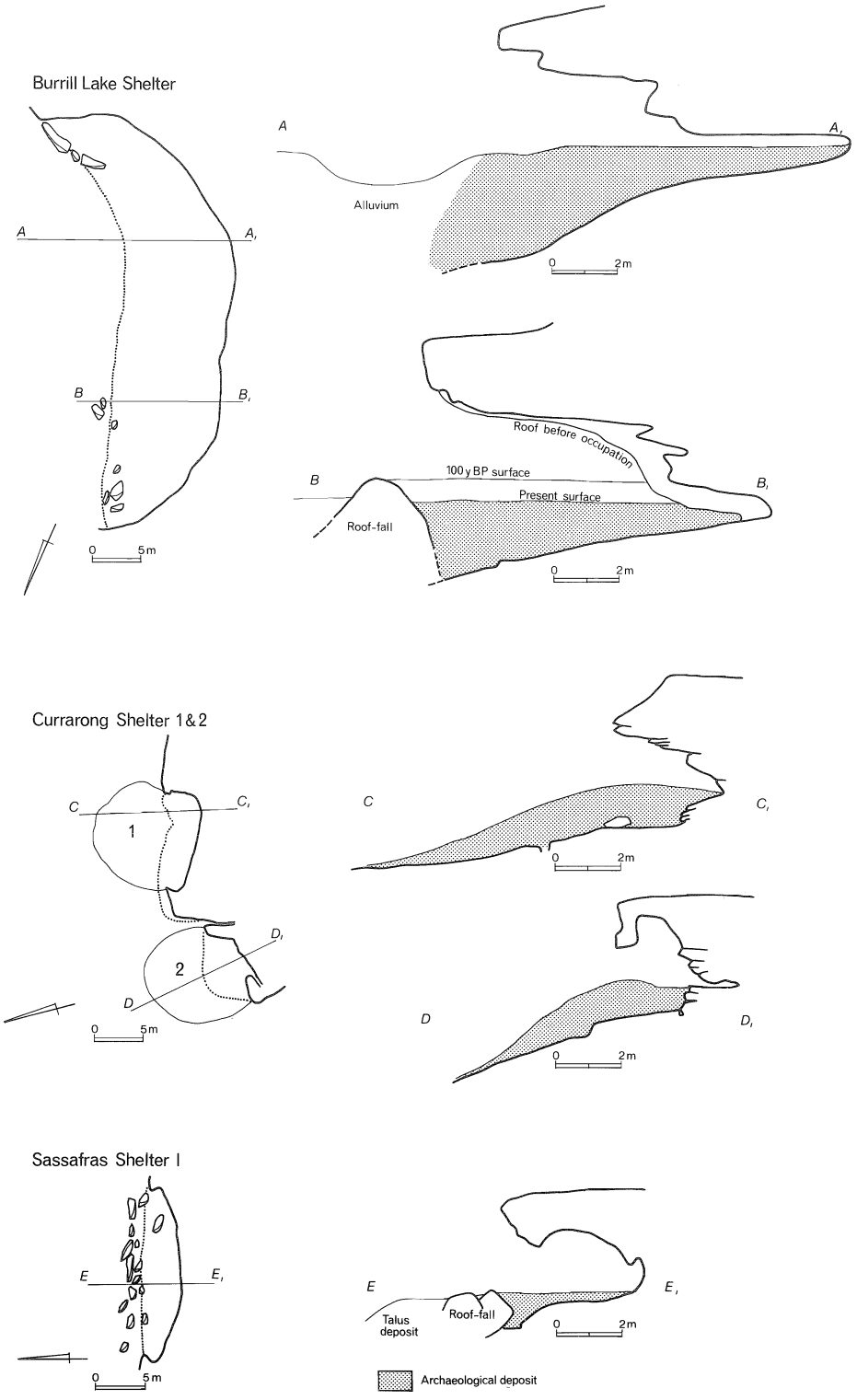

Figure 2: Shelter Characterics

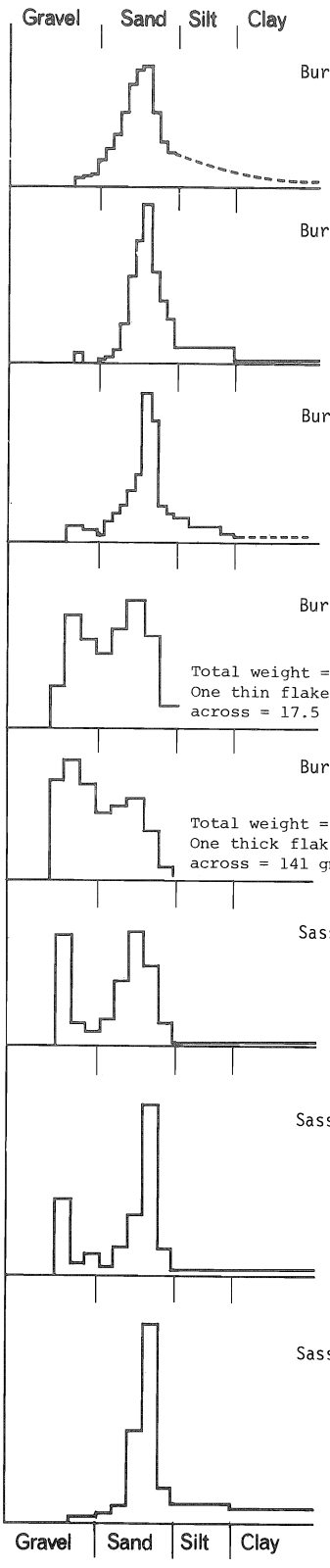

Figure 3: Roof-fall characteristics

On this evidence it was concluded that the present natural rates of weathering are very low, as were those immediately before occupation. In all cases the *maximum* natural rates have been less than 2.0 mm/100 y and in most cases the actual rates have probably been on average 0.1 to 0.5 mm/100 y. Elsewhere in the Sydney Basin the general absence of deposits of roof-fall in shelters not used as habitations indicates that in these shelters also the rates of weathering and yields of roof-fall under natural conditions have been very low and that the rock detritus is normally swept out of the shelters as fast as it falls.

At such low rates of weathering and roof-fall, decorated surfaces in shelters not used as habitations, especially engravings, might well have survived for hundreds or thousands of years. Furthermore any rock art surviving in rock shelters today should not undergo further deterioration due to rock weathering over the next few decades if the shelter environments are left unchanged.

Man's Influence on Weathering and Roof-fall

The occurrence of stone artefacts down to the base of the deposits in many sandstone shelters in the Sydney Basin (and elsewhere in eastern Australia) indicates that the deposits accumulated as a consequence of occupation. It seems that man's use of the shelters either led to increased rates of weathering and roof-fall or to increased accumulation of roof-fall or both. At the sites studied in detail there was found to be a direct relationship between the rate of accumulation of roof-fall and the intensity of site usage[2], and it was postulated that man had influenced roof-fall and weathering in the following ways:

1. by knocking down any pre-existing layer of weathered rock;
2. by maintaining the roof and walls in a clean state through physical contact and hence exposing the rock to further weathering;
3. by influencing the shelter environments through changes in temperature and humidity, particularly by the lighting of fires.

The accelerated rates of weathering with occupation compared with the natural rates are shown in Table 1. Furthermore, the products of man-induced roof-fall are likely to have been much coarser than those resulting from natural roof-fall, as illustrated in Fig. 3. Given the large increases in the accelerated rates of weathering and roof-fall that have occurred, especially late in the histories of most of the sites, and given the coarse nature of the products of roof-fall, it is unlikely that painting and drawings in such occupied shelters would have survived more than a few decades and even rock engravings would probably have been completely removed within a few hundred years. These results suggest that the 'use' of shelters with decorated surfaces should be restricted and precautions taken against contact with such surfaces if the rock art is not to deteriorate further due to roof-fall and weathering.

Acknowledgements

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References

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