POOLE'S CAVERN, BUXTON — INVESTIGATION OF A ROMANO-BRITISH WORKING ENVIRONMENT

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INTRODUCTION

Poole's Cavern is situated in the suburbs of modern Buxton, and is today a show cave. It has been explored archaeologically on several occasions since the late nineteenth century, most recently by the Peakland Archaeological Society (Bramwell *et al.*, 1983). A recent study drew attention to the exceptional richness and quality of the Romano-British metalwork found there (Branigan and Bayley, 1989). As a result of that study, and with support from the Leverhulme Trust, a two-year research project was established to investigate the wider phenomenon of Romano-British cave occupation (Branigan and Dearne, forthcoming). As part of that programme, it was decided to gain a better understanding of cave environments, and that Poole's Cavern was an appropriate site to monitor temperatures through the year. An earlier pilot study in another cave with evidence for utilisation in the Roman period — Robin Hood's Cave, Creswell Crags (Gentles and Smithson, 1986) — had produced useful results demanding further research, and the opportunity now presented itself to pursue these enquiries.

THE SITE

The evidence of pottery, coins and metalwork from the cavern points very clearly to a major phase of occupation broadly within the period *c.* AD 120-220, with the possibility of small-scale usage in the decades before and after these dates. The total assemblage of Romano-British material has all the appearances of a domestic one — a range of pottery which includes: storage-, cooking- and table-vessels; a variety of personal ornaments, mostly made of bronze; and various household tools and implements. The bronzework is remarkable, however, for its quantity and quality, for it comprises more than thirty brooches, a similar number of other items of jewellery and many other artefacts. The compact manicure set (Branigan and Bayley, 1989: fig. 3:64) is perhaps the finest yet discovered in Roman Britain.

The quantity and quality of the bronzework, indeed, point to the cave as the place of its manufacture rather than of its wear and use — a suspicion confirmed by: unfinished examples of brooches; three lead models for lost-lead casting of fibulae; waste droplets; and a casting sprue. Supporting evidence comes from the discovery of a crucible, many pieces of waste metal, two doming punches, and a doming cup (Fig. 1). It is clear, therefore, that Poole's Cavern was used as a workshop by the Romano-British people who occupied it. The exact location of their bronzeworking activities may be indicated by the hearth with "plenty of charcoal, ash and cinders" recorded by Bramwell (Exc. Notebook: 1981-August 1984). This hearth, and the rest of the Romano-British remains, was situated on a terrace at the north-west corner of the cavern in what is now called the 'Roman Chamber' (Fig. 2). The terrace where Romano-British activity was focussed is well inside the cave, and, due to the narrow and winding entrance passage, receives no light. Questions inevitably arise as to why this place was selected as the site of a bronzesmithing workshop, and what it was like as a working environment. It was in order to collect data which might help to answer these questions that the environmental monitoring programme was designed and implemented.

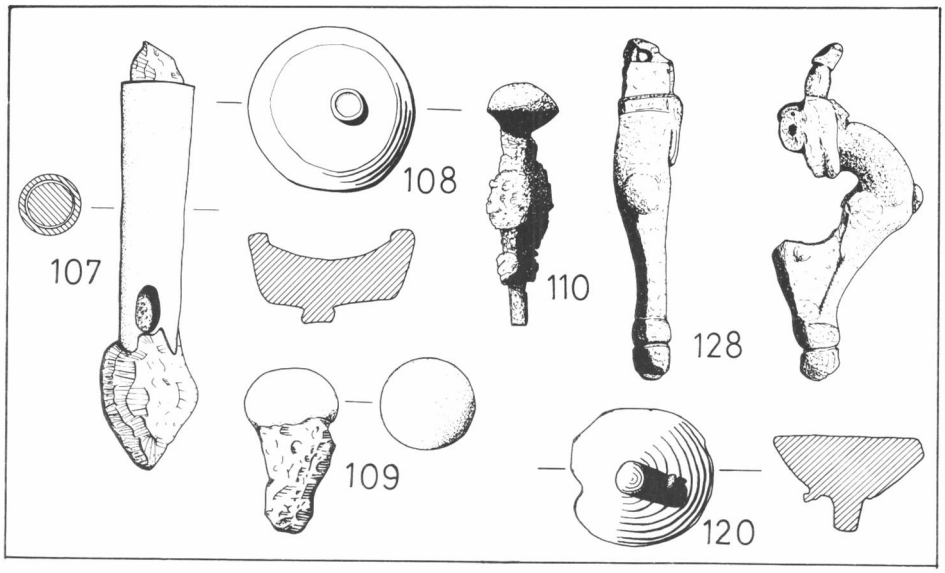

Fig. 1 Poole's Cavern: evidence of metalworking. 107: iron punch; 108: bronze doming bowl; 109-10: doming punches; 120: bronze casting sprue; 128: lead fibula model (numbers refer to the catalogue in Branigan and Bayley, 1989). *Scale 1:1.*

THE TEMPERATURE MONITORING PROGRAMME

As it is impossible to recreate the Romano-British environment, the purpose of this programme was to determine the current relationship between the cave climate and external conditions. Since it is plausible to assume that a similar relationship existed in the past, inferences about the nature of the cave climate in Romano-British times might then be drawn from the modern data.

External monitoring

Fortunately, a climatological station has been in operation in Buxton for a considerable time. Its site is about 1.2 kilometres north-east of the cave entrance, at a similar elevation. It is located in a park with the nearest building some distance away, so that its observations record conditions pertaining to a semi-rural position, rather than in a typical urban site. Data from the station used in this study included daily maximum, daily minimum, grass minimum and 9 a.m. GMT temperatures, together with wind speed and direction, also recorded at 9 a.m. GMT.

Internal monitoring

Within the cave, temperatures were recorded with electrical thermometers. Following calibration, sensors were placed at nine sites within the cave (Fig. 2): three (2, 3, 9) were close to the access path; three (4-6) in a vertical profile from the terrace floor to a height of 2 metres; and two (7, 8) were close to the back of the terrace. One (1) was also placed outside on a bank above the path, where it was shielded from the direct rays of the sun in order to record shade temperature. The data were sampled at each site every ten minutes, then averaged every thirty minutes before being stored on a data logger. For each site, a total of 48 observations was taken each day. Because of the great stability of temperatures at Sites 7 and 8, one sensor (7) was moved to the

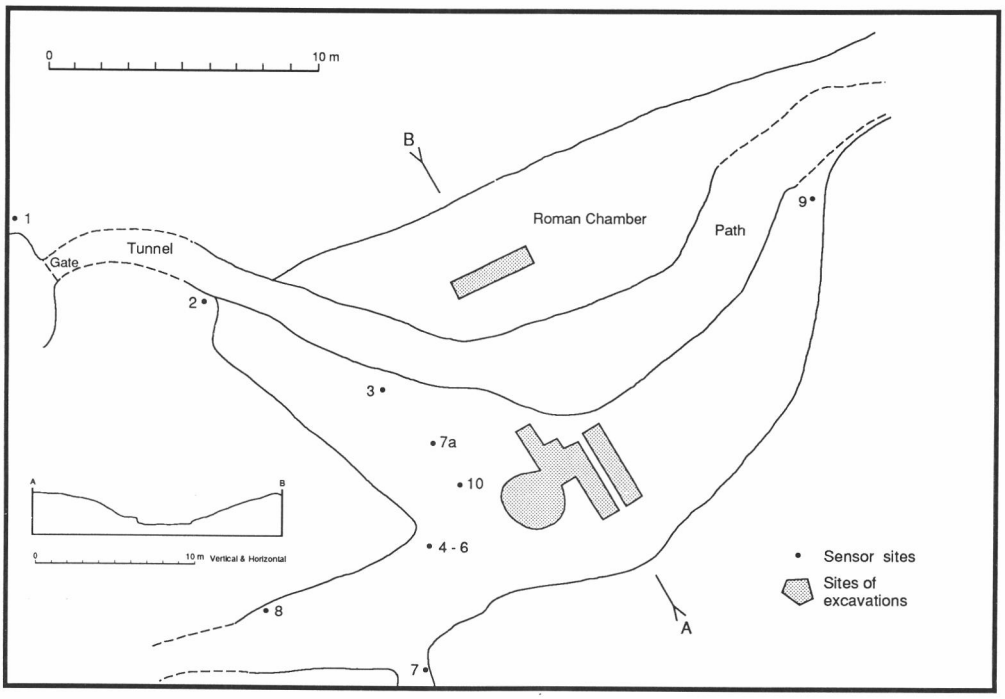

Fig. 2 Poole's Cavern: the Roman Chamber, showing the areas excavated and the location of the 9 sensor points.

slope between the path and the terrace (7a). A dry/wet sensor was added at Site 10 to improve the vertical resolution of temperature variations in the cave, and to provide humidity measurements. To avoid the production of vast quantities of data by continuous operation, samples were taken on 193 days during August, September, November, December, January, February, April and June, 1989/90.

Temperature patterns

Mean temperatures at each site are shown in Fig. 3. As expected, the cave showed great stability of temperature throughout the year, especially in summer. Over the course of the year, the smallest variation in temperature occurred on the terrace, where the range was from about 7.0° (Celsius) in summer to 6.0° in winter. At lower levels of the cave, and near the entrance, temperatures were similar in summer, but fell to about 4.5° in winter as a result of the periodic inflow of cold air.

Away from the cave entrance and access path, the range of temperature in August and June was minimal, with a variation of no more than 1° throughout the period. The reason for the stability was the lack of interaction between external and internal air. Normally, since inside temperatures were cooler than those outside, a steady current of cool air flowed out of the cave at speeds of less than 0.1 metre per second. This prevented warmer external air penetrating the cave system. The interior cave temperature at this time was quite close to the long-term mean temperature of Buxton (7.5°) as predicted from theoretical work (Wigley and Brown, 1971).

During autumn and winter, as outside temperatures fell, there was an increasing number of occasions when external temperatures fell below the mean cave temperature. Under such circumstances, the outside air was denser than that inside, and so was able to flow into the cave,

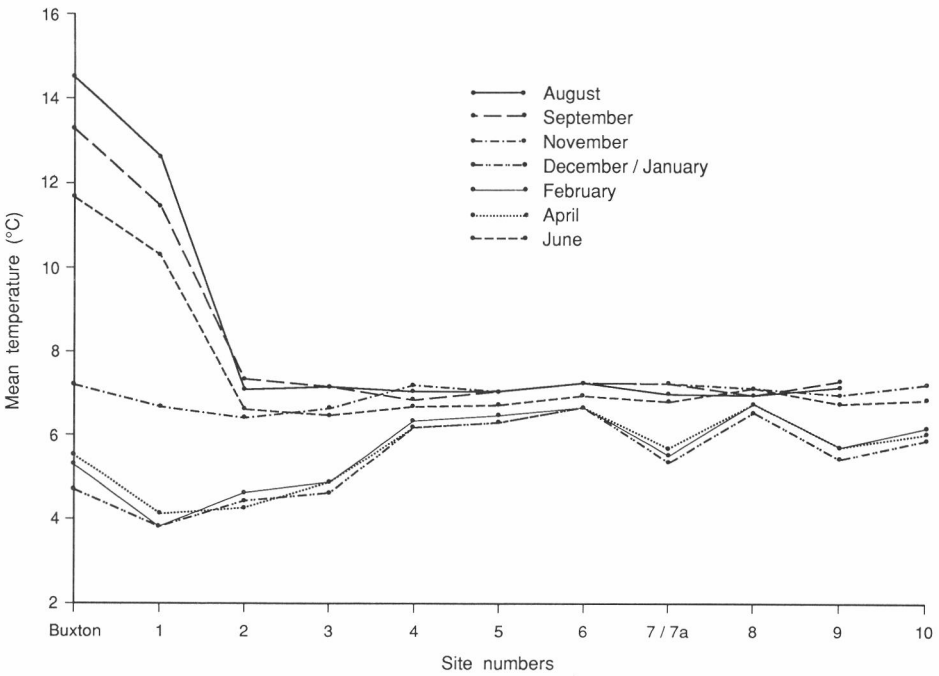

Fig. 3 Poole's Cavern: mean temperatures recorded at Sites 1-9 in the Roman Chamber, August 1989-June 1990.

reversing the normal outflow. The inflowing cooler air then affected temperature levels within the cave. Lower parts of the cave and those nearer the entrance were affected first. Site 9, which was furthest from the entrance but close to the access path, and so at a low level within the cave, had lower mean temperatures than Sites 4-6, which were nearer to the entrance, on the terrace near the bronzeworking. Unfortunately, the winter of the sampling period was relatively mild, with mean temperatures well above average, so that there was no prolonged frost. However, photographs of icicles hanging from the roof of Poole's Cavern at the entrance to the Roman Chamber demonstrate that, under severe conditions, air entering the chamber can be sufficiently cold to maintain sub-zero temperatures for a considerable time. It may be assumed that a prolonged and intense cold spell would eventually result in very low temperatures on the terrace floor. Throughout the sampling period in question, temperatures at Site 4, about 5.0 cms above the terrace floor, varied between 7.2° and 5.8° — an annual temperature range of only 1.4°. At Site 6, 2.0 metres above the ground on the terrace, the annual temperature range was similar, though temperatures were slightly higher as warm air tends to rise.

The other factor found to be significant in affecting temperatures within the cave was inward-blowing winds. The cave entrance faces north and is relatively sheltered. Northerly winds were infrequent during much of the monitoring period, but when they blew strongly, they had an impact on cave temperatures, as they forced external air into the entrance passage, and, to a lesser extent, the Roman Chamber. In summer and autumn, this external air was generally warmer than that within the cave, so that its intrusion raised the temperature of sites near the entrance. In winter and spring, it was normally cooler, and had an effect similar to that of cold air drainage into the cave during nights of low temperatures.

The main controls of temperatures within the cave would appear to be: (1) the mean outside temperature, which determines the mean temperature levels within the cave; (2) occasions on which outside temperatures are below the general cave temperature levels, which allow cold air inflow into the cave, leading to a fall of temperature at sites in its lower part; and (3) occasions on which winds blow directly into the cave, either (in summer and autumn) warming it, or (in winter and spring) cooling it.

DISCUSSION

Implications for Romano-British cave climate

Information about the climate during the period AD 100-200 is limited. Lamb (1982) suggests that winters may have been slightly colder than those of today, with the summers possibly slightly wetter. In the Somerset Levels, the climate appears to have been scarcely different from that of today, with little peat growth, though Applebaum (1972) argues for the possibility of a minor shift to drier conditions, followed by a return to a wetter climate about AD 200. From this limited evidence, it seems valid to assume that Romano-British Buxton experienced mean temperatures similar to those of today. Thus, the temperature pattern in Poole's Cavern during the time of bronzeworking was probably very close to that of today. If the winters had been slightly colder, then cold air inflows may have been more frequent and more prolonged, giving lower mean temperatures in the entrance passage and lower parts of the Roman Chamber. The frequency of northerly winds in Romano-British times is not known, though with similar mean temperatures they probably had a frequency similar to that of today.

Archaeological implications

As expected, the cave proved to be relatively cold in summer, and damp throughout the year. In winter it was relatively warm, and, perhaps more important, its temperature was remarkably stable, with little diurnal variation and a mean which remained the same throughout the months from December to April. These observations apply in particular to the terrace on which the Roman occupation and bronzeworking was located (Sites 4-6 — see Table 1); and they prompt the suggestion that this area was deliberately chosen with such conditions in mind. It is, indeed,

	Temperatures in °C				
Month	Mean	Standard deviation	Maximum	Minimum	Range
August (1989)	7.0	<0.1	7.1	7.0	0.1
September	6.8	0.1	7.2	6.8	0.4
November	7.1	0.1	7.2	6.8	0.4
December/January (1990)	6.2	0.2	6.5	5.8	0.7
February	6.3	0.1	6.5	6.0	0.5
April	6.2	0.2	6.5	5.8	0.7
June	6.7	<0.1	6.9	6.6	0.3

Table 1: Poole's Cavern: Temperature details at Site 4 on the terrace floor of the Roman Chamber.

plausible that the particular attraction of the cave as a workshop was its stable temperature, which would have been of advantage in the casting of bronze. This would have been especially important in winter, when sudden changes of temperature at an external work-site might occur, and create problems for the bronzesmith. If cold air penetration presented any problems for working, the relatively narrow entrance passage along which the inflowing cold air passes could have been partially blocked to reduce its impact.

Any occupation, and certainly any craft activity, on the terrace in the Roman Chamber would have required artificial light, and far more than that which might be provided by the odd oil lamp. Burning torches or substantial fires would be needed, quite apart from the controlled fire needed to smelt the raw materials. Experiments at Robin Hood's Cave, Creswell Crags, showed how difficult it is to light fires and maintain a living and working environment in a cave (Gentles and Smithson, 1986, 214-15). It was noted, however, that the problems of smoke and ventilation — and incidentally, that of condensation — were less in winter than in summer. Although it must be emphasised that the patterns of airflow vary from one cave to another, it may nevertheless be suggested that the industrial exploitation of Poole's Cavern may have been a seasonal (winter) phenomenon. The products produced here almost certainly found a welcome market in the spa centre of Roman Buxton, Aquae Arnemetiae.

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