

## THE GEOLOGY OF THE HOT SPRINGS AT BATH SPA, SOMERSET

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The three springs that emerge under artesian head at 45-46°C beneath and adjacent to the Roman Bath in the centre of Bath Spa, Somerset are unique in the British Isles. There are only six known occurrences of thermal springs in the region, of which only that at Bath can be described as hot. The springs at Hotwells (Bristol), Taff's Well (Cardiff), Buxton and Matlock Spa (Peak District), and Mallow (Eire) all emerge at less than 30°C. The thermal springs at all six localities are hosted in the Carboniferous Limestone in structural settings that allow meteoric water to descend to sufficient depth for it to be heated by the geothermal gradient, and then return to the surface without a significant fall in temperature. Those at Bath reach the surface on the floodplain of the River Avon via 'spring pipes', collapse structures that extend down through Jurassic and Triassic rocks to the concealed Carboniferous Limestone. The source of the Bath springs is known from geochemical studies to be rain that fell several thousand years ago and descended to depths of at least 2500 m on its path to the hot springs. Hypotheses proposed to explain their mechanism include volcanic heat, a simple hydraulic model and a Europe-wide fracture zone. However, none of these hypotheses explains why the hot springs are confined to such a small (20 x 80 m) area. Their formation appears to have been dependent on a geological history that is unique to this area, one that included the formation of limestone karst in Triassic deserts and the local melting of a permafrost aquiclude in the late Pleistocene.

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### INTRODUCTION

According to legend and the historian Geoffrey of Monmouth (*Historia Regum Britanniae*, 1136), the hot springs at Bath were discovered in the 9th century BC by Bladud, a Celtic prince who was so disfigured by leprosy that he became a wandering swineherd so that his people would not have to look upon his disfigurement. When he chanced upon the springs and noticed that the sores on his pigs were healed by their waters, he cured himself. He went on to become a great king who founded the city of Bath, learned to fly and sired King Lear. Later historians noted that Mesolithic remains and Iron Age coins, probably votive offerings, have been found adjacent to the springs (Cunliffe, 1983). However, the documented history of the springs did not begin until the Romans built the magnificent baths that now lie at the heart of the Bath Spa World Heritage Site. The extent of their walled city remained little changed until the end of medieval times (Figure 1).

Like most hot springs, those at Bath have been considered since time immemorial as magical by some and medicinally valuable by many more. King Bladud reputedly built a temple there dedicated to the Celtic goddess Sul (hence the Roman name *Aquae Sulis*) who was associated with medicine and fertility. Not all medicine is efficacious. The pool formed by the King's Spring is the richest source in Britain of Roman 'curse tablets', requests to the goddess by victims of theft to afflict unpleasant, sometimes fatal, ailments on the presumed thief. In the 18th century it was claimed that the hot springs could cure complaints as diverse as piles, sciatica, migraine and sterility, and that they were especially efficacious for rheumatic and skin problems. One result of this was that the first national hospital in Britain, the Royal Mineral Water Hospital, was founded in Bath in 1738 to treat those who could not afford private treatment (Rolls, 1991).

The discovery in 1903 of significant concentrations of radium salts in the spa waters led to the belief, at least temporarily, that this was the active beneficial ingredient and a 'radium inhalatorium'

was constructed. It closed after the accident at Seascale (now Windscale) in 1959 (McNulty, 1991). Despite convincing evidence that immersion in the spa waters had beneficial effects for some conditions, treatment ceased to be available on the NHS in 1976. A new spa, the only place in the UK where one can bathe for healing, relaxation and leisure purposes in natural hot-spring water, opened in Bath in August 2006.

There are only six known occurrences of thermal springs in the British Isles, of which only that at Bath can genuinely be described as hot (>30°C). Those at Hotwells (Bristol), Taff's Well (Cardiff), Buxton and Matlock (Peak District), and Mallow (Eire) emerge at temperatures ranging from 20° to 28°C. The three hot springs at Bath, the King's Spring, Cross Bath Spring and the Hetling Spring (also known at various times as the Com[m]on Spring or Hot Bath Spring) are situated in a small (20 x 80 m) area on the floodplain of the River Avon (Figure 1). Their combined flow is currently *c.* 60 m<sup>3</sup>/hr, similar to that of a small stream. Historical records suggest that the flows were higher in the past, but few of the measurements are sufficiently accurate to make meaningful comparisons with the accurate present-day monitoring. Records of the water temperatures at the springs have shown little variation over the past 100 or so years, being highest (46-47°C) at the Hetling Spring and lowest at the Cross Bath Spring (44-45°C).

The springs have been under the care of the Civic Authority (currently Bath and North East Somerset Council) since 1590 and are now protected by an Act of Parliament (the County of Avon Act, 1982). They are currently estimated to attract over £300 million per annum of tourism benefits to the city. Successive councils have appreciated the need for independent geological advice on the nature of the springs and any possible adverse effects that building developments in central Bath might have on them. This advice was provided from about 1925 to 1977 by R. H. Rastall, from 1977 to 2002 by Dr G. A. Kellaway, and is currently supplied by the present author. Almost all the detailed knowledge of the geology of the hot springs and of the surrounding area stems from research