With the odour of a cesspool and bad horseradish: the mineral waters of Daviesville Spa, Burnham-on-Sea, Somerset, UK

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Mather, J.D. and Prudden, H.C. 2014. With the odour of a cesspool and bad horseradish: the mineral waters of Daviesville Spa, Burnham-on-Sea, Somerset, UK. *Geoscience in South-West England*, **13**, 267-273.

In 1800, the Reverend David Davies, the local curate, built a lighthouse to aid navigation in Bridgwater Bay. He used the income generated in dues and the later sale of his rights to build the small hamlet of Daviesville. Considering that the underlying strata resembled that of Cheltenham, Davies sank a well to 22.9 m which encountered saline water, within calcareous laminated clays, considered to have medicinal properties. A shallower well, completed at 7.6 m, yielded a sulphurous water. Both sources were exploited and a pump room and baths built. The spa operated from 1832 into the early 1870s after which the wells were neglected and the buildings demolished or put to alternative uses. Organic pollution was found in 1938 and the wells had been filled in by 1949. Lithological logs from modern site investigation boreholes suggest that the saline water was derived from clays of the Middle Lias and the sulphurous water from sandy horizons within the overlying Quaternary estuarine deposits. Saline groundwaters are widely distributed within Liassic clays and the spa owes its origin more to the enterprise of the Reverend Davies rather than to the geochemistry of its waters.

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Keywords: Burnham-on-Sea, hydrogeology, mineral waters, history of geology.

Introduction

Burnham on Sea, which was simply Burnham prior to 1917, is situated on the Somerset coast to the north of the confluence of the Rivers Parrett and Brue (Figure 1). These rivers subsequently flow northwards as one, almost parallel to the town's Esplanade, before swinging westwards, across the Gore Sands, into the waters of the Bristol Channel. The early settlement was protected from the sea by a high sandy ridge and, to the east, Emanuel Bowen's 1750 map of Somerset (reproduced in McDermott and Berry, 2011) shows undrained land known as Brent Marsh. Land communication with the outside world was confined to two sandy tracks and Burnham was isolated and remote, even from other parts of Somerset. Changes began to take place towards the end of the 18th Century as drainage and sanding of the land increased its agricultural value. When Edmund Rack visited in the early 1780s he found a "*considerable parish*" of 100 houses and nearly 580 inhabitants. The land was mostly down to pasture and the marshland had become a fine moor in which great numbers of cattle were grazed (McDermott and Berry, 2011). Improved links to the turnpike road (now the A38) to the east made access easier and Burnham began to develop as a seaside resort. According to John Rutter, by 1829, "*Burnham* [was] *resorted to by many families in the summer season, for whose accommodation an hotel and several new houses* [had] *been created near the beach*" (Rutter, 1829, p.89).

Amongst the developers was the stipendiary curate the Reverend David Davies who arrived in Burnham during the 1790s, first as curate for the Reverend John Golden, vicar from 1768-99, and then for the succeeding incumbent, Dr. Walter King. Both vicars were non-resident and probably came to Burnham infrequently. Combining his curacy with those of

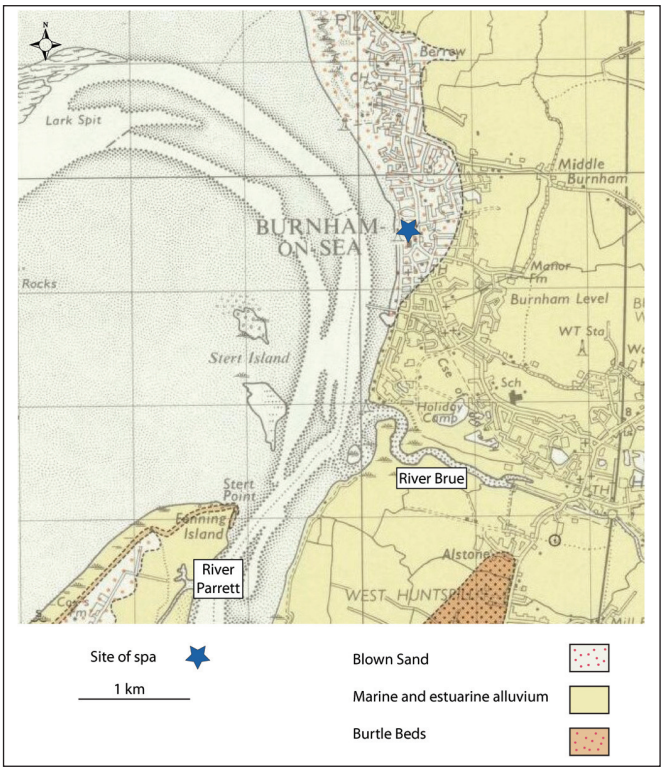

Figure 1. *Map of Burnham on Sea and the surrounding area, showing the geology and the site of Daviesville Spa (contains British Geological Survey materials © NERC 2014; © Crown copyright and database rights 1980 Ordnance Survey 100021290).*

Berrow and Brean, along the coast to the north, which also had non-resident vicars, his joint income was sufficient to acquire land to the west and north of St. Andrew's Church. Although appointed to a living at Cliddesden in Hampshire in 1813, he seems to have maintained his interest in Burnham, continuing to acquire land and building a group of houses which became known as Davies' Ville or Daviesville (Henning, 1836; Nixon, 1938; Wrigley, 1998; Thomas, 2003; Body and Gallop, 2005; Thomas and Thomas, 2011). Within the small hamlet he established a spa which attracted visitors from across the county and beyond to drink and bathe in the mineral waters. The spa was arguably unique as mineral waters of very different character were pumped from wells only 20 m apart. This paper outlines the history of the spa, which operated for some 40 years from about 1830 to 1870, and examines the source and chemistry of the mineral waters.

History of the spa

The origins of the spa are inextricably linked with the story of Burnham's first lighthouse. Local tradition claims that a fisherman's wife originally placed a light in her window to guide her husband home. The church sexton decided that he could improve on this and hung a light in the tower of St Andrew's Church for which he was paid a small fee by local mariners. The Reverend Davies recognised that there was a need for a better light which would benefit larger vessels passing into the River Parrett en route to Bridgwater. He financed the construction of a tower some 40 ft (12 m) in height, on land he owned to the west of the church, which was completed in 1800 (Henning, 1836). The operation of his light was franchised by Trinity House, which allowed him to charge ships passing the light at rates depending on their tonnage; a lucrative source of income.

The high charges made by some light owners led to complaints and a parliamentary investigation. As a consequence the rights to operate lights, including that at Burnham, were bought back by Trinity House. According to Thomas (2003), in 1829 the Reverend Davies was paid £13,681, which included both the value of the property itself plus the future income which would be lost to him through surrender of his rights. Conversion to 2012 prices on the basis of historic standard of living values (Officer and Williamson, 2014) equates to around £1 million, which would have made Davies a wealthy man. Unfortunately the lighthouse proved to be poorly sited and Trinity House built a replacement some 30 m in height about 0.8 km to the north, which became operational in 1832. The top two floors of Davies' lighthouse were removed, the top castellated, and as the Round Tower, it became incorporated into a dwelling house which still overlooks the churchyard today (Figure 2).

The sale left Davies with the money and land for the further development of Daviesville. According to a contemporary report he "*conceived the idea, from a comparison of the strata of Burnham with that at Cheltenham, that a mineral water might be found at no great depth below the surface, and under that impression proceeded to dig a well on some property he had purchased near his light-house*" (Phelps, 1836, p.37). The site chosen to the north of the churchyard was a warren, underlain by about 8 ft (2.5 m) of sand.

It may have been in 1829, when he received his windfall from Trinity House, that Davies started sinking his first well. At a depth of 75 ft (22.9 m) he arrived at a spring of saline mineral water possessing "*active medicinal properties*" (Phelps, 1836, p.37). This was analysed by Mr. H. Potter, a London chemist; it had no odour but a very saline taste. During the work, an inflow was observed at a higher level which smelt sulphurous and another well was sunk a short distance away to a depth of 25 ft (7.6 m) to capture this flow. Thus rather than one mineral water Davies had both saline and sulphur sources to offer clients. The positions of the two wells are shown on the 1890 Ordnance Survey map (surveyed in 1884) in Figure 3. The Saline Well, marked 'Spring (Chalybeate)' on the map, is at National Grid Reference ST 30431 49504, and the Sulphur Well, marked 'Spring (Sulphur)', at ST 30409 49505.

Unfortunately, the presence of two different waters confused the local press whose early reports lumped them together as one saline/sulphur source. In its issue of 29 December 1831 the *Bath Chronicle and Weekly Gazette* reported that "*A saline spring impregnated with sulphur, and not inferior to any spa in England, has recently been discovered at Burnham on the Bridgwater Bay*" adding that the proprietor was presently erecting a pump room for drinking the waters. By the time of its issue of 19 July 1832 this had become a fine "*saline, sulphurous and chalybeate spring*", the pump room had been erected and was to be immediately opened for the accommodation of visitors.

By the spring of 1834 a bath house was under construction with a series of hot and cold baths and apartments for the accommodation of patients. An article dated 10 April 1834, in the *Bath Chronicle and Weekly Gazette*, sings the praises of Burnham and its spa, identifying the two medicinal springs, "*one a saline with a chalybeate impregnation, the other a sulphurous with a saline impregnation*". The former was "*much esteemed for its efficiency in removing obstinate complaints of the stomach and bowel*" and the latter was possessed of "*singular properties in softening the skin; clearing it of troublesome eruptions, and promoting the insensible perspiration over the whole body*". Both waters were said to be most effective during May and the four ensuing summer months and the pump room was attended by a physician who resided "*within a moderate distance*".

What any newly promoted spa required was the patronage of the medical profession and this was encouraged by the publication of a 115-page booklet authored by Dr. George Henning, a retired physician of the Taunton and Somerset County Hospital (Henning, 1836). He was a good choice for the task as he had previously published on the pathology of scrofula (a form of tuberculosis) in which he had advocated the cold bath as a preventive measure (Henning, 1815). Much of his booklet is devoted to a discussion of the diseases which could be treated by the spa waters both through bathing and drinking. By this time the spa complex seems to have been complete with dwelling houses, pump room (sometimes referred to as the pump house) and bath house. The latter was fitted with both heated and cold sea water baths and also baths for bathing in hot water from the sulphurous well. An undated handbill, from the early years of the spa and reproduced in Thomas and Thomas (2011), shows that the baths were open daily from 06.00 to 21.00 hours with the exception of Sundays, when they were open only between 06.00 and 09.00 hours. Prices ranged from 1/- (about £4 at today's prices) for a cold sea water "*shower bath*" to 3/6 (about £15) for a sulphurous bath.

Figure 2. *The Round Tower from the Churchyard. Originally built in 1800 as a lighthouse by the Reverend David Davies, it operated until 1832, after which the two upper stories were removed (photograph John Mather, 2013).*

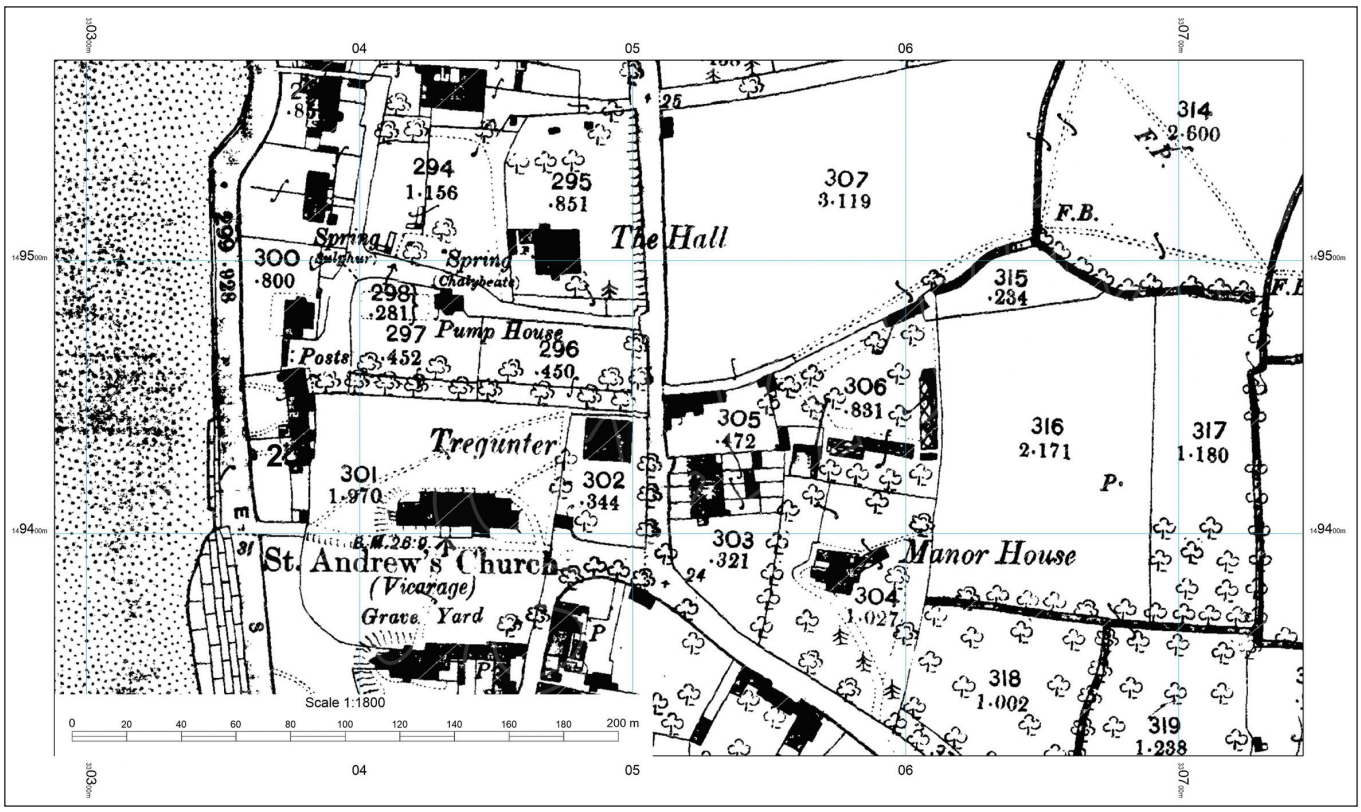

Figure 3. *Extract from the 1890 Ordnance Survey map of the area around St. Andrew's Church, Burnham, showing the location of the wells (marked as springs) and the Pump House. The Bath House is the building 50 m to the west of the Pump House, with the beach a further 35 m away (Digimap © Landmark Information Group Ltd and Crown copyright 2014).*

In addition pure water could be "*variously mixed to meet any particular morbid state of the surface of the body*".

The handbill was printed for "*MR JOHN at the baths*" and it seems that William John was the proprietor of the spa complex from about 1833 as, in an advertisement in the *Bath Chronicle and Weekly Gazette* of 10 July 1851, he thanked patrons for supporting him over the past 18 years, whilst announcing that he had recently completed several improvements to the premises. William John and his wife Margaret are listed as living at The Baths in both the 1841 and 1851 censuses, in the latter as lodging house keepers.

Perhaps because of its relative isolation the spa seems to have attracted mainly local patrons. An article in the *Bristol Mercury* of 14 August 1852, which reports on the elections to a new Local Board of Health (to which William John was elected), laments that the virtues of the mineral waters are not more widely published. John died in 1860 at Burnham (FreeBMD, 1837-1915), and the business seems to have been carried on by his wife who is listed in the 1861 census, living at The Baths as Bathkeeper. The census records also show that, living in Marine House, the dwelling house built alongside his lighthouse by Davies, was a General Practitioner and widower, Henry Hayman. In the *Bath Chronicle and Weekly Gazette* of 7 August 1862, Hayman advertised that he had taken the Burnham Mineral Springs from the late proprietress, Mrs John. In a further advertisement the following year he announced that he had "*fitted up Marine House for the Reception of Invalids wishing to partake of the Benefit of the Waters, the Baths and the pure invigorating Air of Burnham*" and had engaged an efficient superintendent under his direction.

Hayman seems to have been unable to make a success of the baths as a brief item in the *Bristol Mercury* of 30 July 1870 reports under Burnham that "*The baths and mineral waters, which have been in disuse for some time past, were offered for sale on Tuesday last, at Hick's Clarence Hotel. Unfortunately they were not purchased, as the reserve price (£1,610) was considered to be too high a figure*". The 1871 census shows Hayman to have remarried and to be living at Stokenchurch in Oxfordshire. Both the Bath House and Marine House at Burnham are listed as unoccupied. A young General Practitioner, John J. Mathews, was living in the cottage attached to Marine House where he is listed as Bath Master, so perhaps the baths were still operational at this time. However, even if the spa was continuing to trade, this was soon to change. On 25 December 1874 an item in the *Western Gazette* announced the formation of a new limited company, the Burnham Baths and Mineral Spa Company, with a capital of £20,000 to erect baths, boarding houses, etc., at Burnham. It would appear that their initiative was unsuccessful, as the *Somerset County Gazette* of 5 January 1878 notes that "*Mr H J Summers, who had recently established extensive brickyards at nearby Highbridge, has taken the mineral wells adjoining the pump room, and intends to re-open them in the forthcoming spring*". This initiative seems to have been even shorter-lived, as on 18 September that year both the brick works and the mineral springs and pump room were offered for sale by auction at Highbridge (*Bristol Mercury*, 11 September 1878).

Both announcements in 1878 refer only to the mineral springs and pump room without any reference to the baths, which seem by now to have become a separate messuage. This is confirmed by the 1881 census, in which the Bath House, now called Steart House, is listed as a school with 10 pupils. Marine House is occupied by the family of a brick and tile maker and the cottage by a 79 year old spinster. Thus all connection between these properties and drinking and bathing in the mineral waters seems to have been severed.

During 1890 Burnham was visited by Alan Cameron, an Assistant Geologist with the Geological Survey of Great Britain, now the British Geological Survey (BGS). Notes on his visit were published in the *Bridgwater Mercury* of 28 January 1891 and reproduced by Richardson (1928). He found the mineral waters neglected although "*The bath and pumproom, with the bricked shafts or wells, and the pumping machinery*" still remained. As far as the wells were concerned this remained the position for the next 50 years. However, the pump room seems to have been demolished around the turn of the century, as it is not shown on

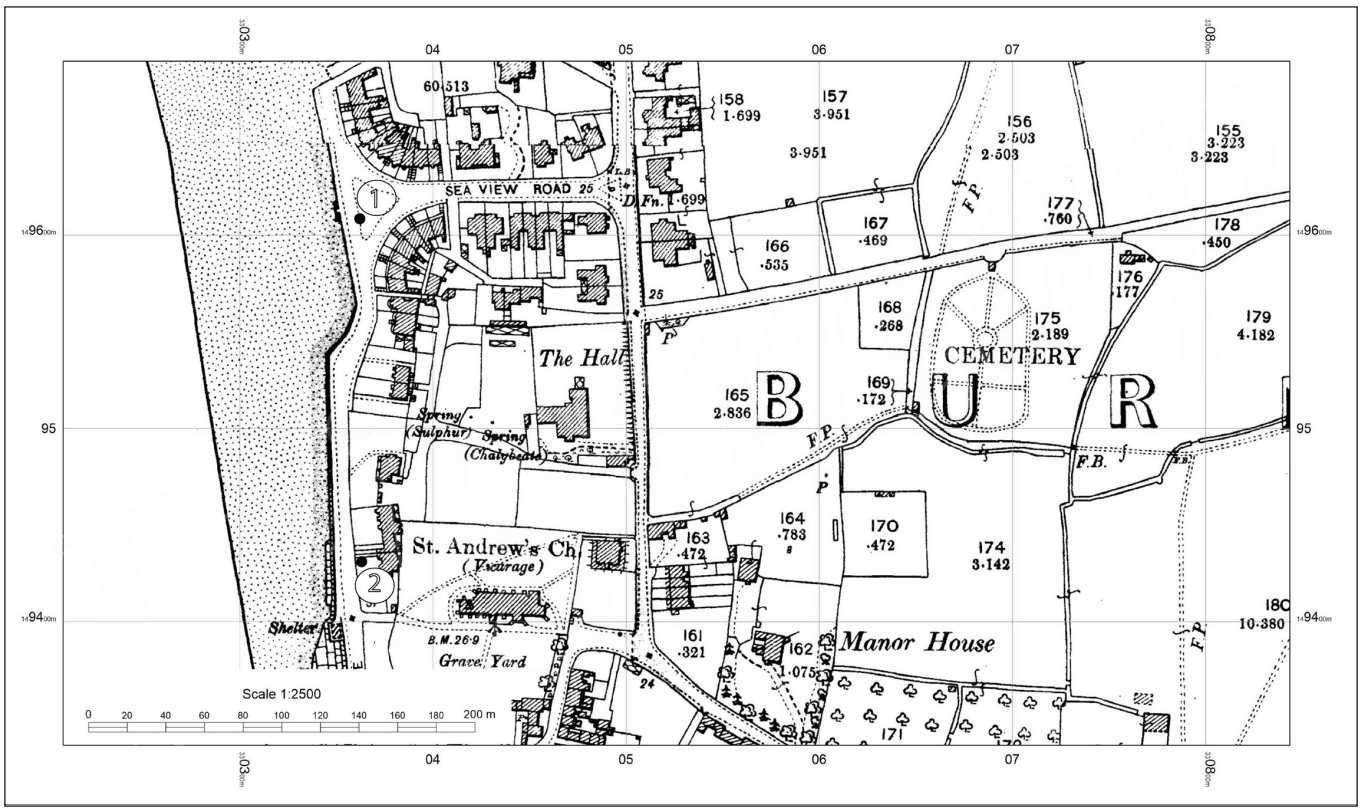

Figure 4. *Extract from the early-1900s Ordnance Survey map showing the wells (marked as springs). No Pump House is shown. The two site investigation boreholes drilled for Wessex Water Authority in 1862 are marked 1 and 2. (Digimap © Landmark Information Group Ltd and Crown copyright 2014).*

Ordnance Survey maps of the early 1900s (Figure 4).

According to a report in the *Western Daily Press* of 13 July, the wells were still there in 1938 when the Urban District Council decided to have water from one of the wells analysed to investigate the possibility of re-establishing Burnham as a spa. Unfortunately the water was condemned on the grounds of heavy *B. Coli* contamination (Nixon, 1938) and no further action was taken. The presence of bacterial contamination is unsurprising as the wells were only 55 m from the edge of the churchyard which in 1883 was so full of bodies that new burials disturbed earlier ones (Blaxall, 1884). The following 10 years seem to have seen the final demise of the wells. The site was visited on the 2 August 1949, by an officer of the Geological Survey, as part of the countrywide survey to collect basic information on groundwater carried out following World War II (see Mather, 2012). The Bath House was by now the Steart Hotel but there was no evidence of pump room or wells, which were thought to be under a garage.

Apart from the pump room, the buildings which made up the spa complex are still extant. Marine House and Marine Cottage, together with the Round Tower, still face the sea to the west of the churchyard, where for many years they were used as a residential nursing home. Steart House faces inland (Figure 5), and the broad carriage drive by which it was once approached, is partly followed by the present Myrtle Drive. It is now divided into flats and accessed on its seaward side via the Esplanade, which did not exist when it was built. The sites of the pump room, and the pretty wooded gardens around it, are now occupied by Steart Court and a small housing development. The Sulphur Well lies beneath a utility enclosure and the Saline Well beneath a car park.

Geology

According to Phelps, during the excavation of his first well, Davies "*watched carefully the progress of the workmen, and the component parts of the soil thrown out*", noting the strata (Phelps, 1836, p.37). Writing about the same time, Henning

Figure 5. *The front elevation of the old Bath House, now Steart House and converted into apartments (photograph John Mather, 2013).*

(1836) also recorded the same sequence with similar thicknesses but slight variations in lithology. The succession noted by Phelps is given in Table 1 with alternative or additional details given by Henning added in square brackets.

The well was bottomed at a depth of 75 ft (22.9 m) when a saline mineral spring was intercepted. A second well was then sunk to 25ft (7.6 m) to capture a sulphurous inflow which had been observed during the sinking of the first well. The thickness of strata described was 64 ft 2 in (19.5 m) out of a total well depth of 75 ft (22.9 m), meaning that 10 ft 10 in (3.4 m) remained unaccounted for. Following Cameron's visit in 1890, he drew up a simplified section (Richardson, 1928) in which he assumed that clay continued to the base of the well (Table 2). On the basis of Cameron's classification both the saline mineral water, intercepted at 75 ft (22.9m) below surface and the sulphurous mineral water from 25 ft (7.6 m) below surface were derived from clays of the Jurassic Lower Lias. This

Unit	Thickness
Sand [running and sliding]	8 ft (2.5 m)
Black greasy loam	*c.* 5 ft (1.5 m)
Quicksand running in veins	*c.* 2 in (0.05 m)
Clay marl [hard clay, softened on exposure to air]	25 ft (7.6 m)
Bluish clay marl which effervesced with vinegar and gave out carbonic acid plentifully [bluish clay, soft at start but rapidly became dry and indurated, reaction with vinegar proved it to be calcareous, but no iron]	26 ft. (7.9 m)

Table 1. *Strata penetrated in the Mineral Wells, after Henning (1836) and Phelps (1836).*

Unit	Thickness
Alluvium	
Blown sand	8 ft (2.5 m)
Black loam	5 ft (1.5 m) or thereby
Quicksand	2 in (0.05 m)
Total thickness	**13 ft 2 in (4.0 m)**
Lower Lias	
Clay marl	25 ft (7.6 m)
Bluish clay marl	26 ft (7.9 m)
Clay and mineral water	10 ft 10 in (3.4 m)
Total thickness	**62 ft (18.9 m)**

Table 2. *Strata penetrated in the Mineral Wells, as modified by Alan Cameron in 1891 and quoted by Richardson (1928).*

stratigraphical interpretation was accepted by Richardson (1928) and in the Geological Survey Memoir for the Weston-super-Mare district (Whittaker and Green, 1983). From 19th Century maps the surface level at the wells is estimated at 7.5 m above O.D. which means that the surface of the Lower Lias is at about +3.5 m O.D. at this locality. This 'high' beneath Burnham on Sea was thought to define the northern slopes of the proto-Brue valley to the south (Whittaker and Green, 1983, figure 17, p.88). Although the authors of the memoir did consider that the strata classified as Lias by Cameron could be alluvial clays, they were influenced by observations made by Ussher and reported by Woodward (1876) that blue Lias clay with beds of limestone could be seen under beach sand at Burnham.

In 1982 boreholes were drilled for the then Wessex Water Authority during site investigations to improve sea defences at Burnham. Two of these boreholes were on the Esplanade about 130 m from the Saline Well, to its northwest and southwest (locations are shown in Figure 4). Both boreholes proved about 3 m of loose sand then penetrated sandy silty clays with peaty inclusions and occasional thin beds of peat, which were underlain by stiff or hard laminated clays. Interpretations of the succession in these two boreholes, together with a reinterpretation of that in the mineral wells, are given in Table 3.

In both boreholes the base of the alluvium is taken to be the gravel or gravelly clay indicated in the borehole logs at about -8.5 m O.D. This separates clays containing peat inclusions above, from hard laminated clays without peat beneath. The laminated clays included a calcareous siltstone at the base of Borehole 2, and a chisel was needed to complete the final 0.5 m of the hole. Beneath the gravel in Borehole 1 the clays were a mottled brown and the surface immediately below the gravel is interpreted as the iron-stained weathered top of the Lias. According to the Geological Map (British Geological Survey, 1996) this part of Burnham lies on the southern limb of the east/west trending Brent Knoll Syncline and is underlain by the lowest beds of the Middle Lias. The Burton Row Borehole drilled in 1971 to the west of Burnham proved brownish grey laminated shales and calcareous mudstones in the lowest part of the Middle Lias (Whittaker and Green, 1983), similar lithologies to those described at Burnham.

Correlation of the succession in the boreholes with that in the mineral well is made difficult by the missing 3.4 m in the well log. Cameron assumed these missing strata to be below those described by Phelps (1836) and Henning (1836). However, Phelps states clearly that the bluish calcareous clay was the last stratum penetrated and, if this is correct, the surface of this clay, at -7.6 m O.D., is comparable with the Middle Lias surface in Borehole 1 at -8.6 m O.D. and in Borehole 2 at -8.4 m O.D. If the missing 3.4 m is reclassified, together with the overlying black loam and clay marl in the well section, as alluvium, this yields an overall succession in the well similar to that in the boreholes.

The evidence suggests that rather than the top of the Middle Lias being close to the surface in this part of Burnham, it is at about -8 ±1 m O.D. This means that the Sulphur Well drew water from the grey estuarine clays of the alluvial deposits whereas the Saline Well derived its inflow from the calcareous laminated clays of the Middle Lias.

Unit	Borehole 1	Borehole 2	Mineral Wells
Ground Level (m O.D.)	+8.0	+7.7	+7.5
Loose Sand	3.2 (+4.8)	2.8 (+4.9)	2.5 (+5.0)
Alluvium			
Sandy, silty clays with peaty inclusions	13.3 (-8.5)	12.6 (-7.7)	9.2 (-4.2)
Undescribed			3.4 (-7.6)
Gravel or gravelly clays	0.1 (-8.6)	0.7 (-8.4)	
Total thickness of alluvium	**13.4**	**13.3**	**12.6**
Lias			
Laminated silty clays	2.6 (-11.2)	2.0 (-10.4)	7.9 (-15.4)
The saline inflow was at -15.4 m O.D. and the sulphurous inflow at -0.2 m O.D.			

Table 3. *Thickness of strata (m) penetrated in site investigation boreholes drilled in 1982 compared to the succession in the Mineral Wells. Figures in parentheses show elevation of base (m relative to O.D.).*

Hydrochemistry

Contemporary accounts of the Sulphur Well record that "*The smell was very offensive resembling that of a cesspool, mixed with an odour not unlike bad horseradish*" (Henning, 1836, p.49). In contrast the Saline Well water possessed no odour. Analytical results for the two well waters are given by Phelps (1836) and Henning (1836). These are quoted in terms of weight per Imperial pint for the Saline Well and per Imperial gallon for the Sulphur Well. The unit of weight is not specified but is assumed to be grains, following the general practice at that time. The results are presented in terms of a hypothetical mixture of salts and have been recalculated in terms of mgl^{-1} of individual ions in Table 4. The methods used in the interconvertion of units and the interpretation of historic analyses are discussed by Lloyd and Heathcote (1985). Analytical techniques were relatively unsophisticated at this time and would have been based on the quantitative analysis of evaporative residues. However, the data give a general idea of water chemistry and allow comparisons between waters to be made.

The two well waters differ considerably in their concentrations of dissolved ions. A concentration of *c.* 12,000 mgl^{-1} in water from the Saline Well is some six times greater than that in water from the Sulphur Well, but only about a third of that in seawater (Table 4). Compositionally the saline water has characteristics similar to seawater but there are significant variations. There are higher concentrations of Na^+ than would be expected and the Saline Well water is depleted in Mg^{2+} and enriched in Fe^{3+} and HCO^- compared to seawater. It is difficult to assign an origin to the salinity, but it may have resulted from the modification, by water-rock interaction, of water which recharged more permeable calcareous siltstone horizons during deposition of the overlying alluvium during the Holocene. Alternatively, or additionally, some interstitial formation water may remain. The Middle Lias sediments contain bituminous matter and pyrite, the oxidation of which would result in dissolution of carbonate and increased total-Fe and HCO^- concentrations. Cation exchange would increase Na^+ concentrations at the expense of Ca^{2+} and increase the Na^+/Cl^- ratio.

Henning described the Saline Well water as "*a tonic aperient*" [more easily understood as an invigorating laxative] and compared its composition to that of water from Cheltenham (Henning, 1836). However, Cameron (in Richardson, 1928) felt that this comparison was misplaced because of the lower SO_4^{2-} concentration at Burnham. The Lower/Middle Liassic Clays which yield the saline water crop out in a band across England from Somerset to Lincolnshire and give rise to at least 22 mineral waters (Edmunds *et al.*, 1969), some of which, including Gloucester Spa (Table 1 analysis from Richardson, 1930) have compositions close to that of Daviesville Spa. Even at a single location, such as Cheltenham, there are considerable variations in the concentrations of individual sources. These variations are likely to result from differences in the proportions of soluble minerals, such as calcite and gypsum, in individual beds within the succession.

In 2006, a borehole 39.6 m in depth was drilled into Liassic clays, to irrigate the greens, at Brean Leisure Park Golf Course, about 5 km north of Burnham. With a Na^+ concentration of about 5,000 mgl^{-1} the water was not dissimilar to that from the Saline Well and was unsuitable for irrigation.

The water of the Sulphur Well is geochemically distinct from both seawater and water from the Saline Well (Table 4), and Henning (1836) considered that it was of greater value. Na^+ and Cl^- no longer dominate the hydrochemistry and the rotting cesspool odour suggests that this is a reduced groundwater in which hydrogen sulphide is present. The water is probably derived from sandy horizons within the alluvial deposits, with the hydrochemistry controlled by the brackish water depositional environment and subsequent water/rock interaction. The site has also been periodically inundated by the sea over the past 1,000 years, which will have affected groundwater compositions. There is little flow under present conditions, an ideal environment for the oxidation of organic material and the concomitant reduction of SO_4^{2-}.

Discussion and conclusions

Daviesville Spa was the brainchild of the Reverend David Davies, who arrived in Burnham [on Sea] during the 1790s as a stipendiary curate. A Georgian entrepreneur, he acquired land to the north and west of the churchyard, building dwelling houses and a lighthouse. The sale of the latter in 1829 provided him with the resources to begin work on the development of a spa. By 1832 two wells had been sunk and a pump room

Species	**Saline Well**		**Sulphur Well**		**Typical Sea Water**		**Gloucester Saline Well**	
	mgl^{-1}	$mmol^{-1}$	mgl^{-1}	$mmol^{-1}$	mgl^{-1}	$mmol^{-1}$	mgl^{-1}	$mmol^{-1}$
Sodium (Na^+)	4,036	176	201	8.8	10,800	470	3,518	153
Calcium (Ca^{2+})	224	5.6	335	8.4	411	10	152	3.8
Magnesium (Mg^{2+})	87	3.6	24	0.99	1,290	53	101	4.2
Iron (Fe^{3+})	131	2.3	8	0.14	3	0.05	Trace	Trace
Chloride (Cl^-)	6,313	178	252	7.1	19,400	547	5,335	151
Sulphate (SO_4^{2-})	349	3.6	548	7.7	1,356	14	690	7.2
Bicarbonate (HCO_3^-)	685	11.2	572	9.4	142	2.3	281	4.6
Total determined	11,825		1,940		33,402		10,077	
Ratios		Ratios		Ratios		Ratios		Ratios
Na^+/Ca^{2+}		31		1.0		47		40
Ca^{2+}/Mg^{2+}		1.6		8.5		0.18		0.90
Na^+/Cl^-		0.99		1.2		0.85		1.01
Cl^-/SO_4^{2-}		49		0.92		39		21
Cl^-/HCO_3^-		16		0.75		238		33

Table 4. *Geochemical data for the Burnham wells, together with that for seawater and the Saline Well at Gloucester Spa, quoted as both mgl^{-1} and $mmol^{-1}$.*

erected. These were joined two years later by a Bath House with provision for hot and cold baths and apartments for patients.

He supposedly conceived the idea for his spa from a comparison of the strata at Burnham with that of Cheltenham. There is no outcrop of the rocks underlying the sand in the vicinity of the church, and it is not immediately apparent how he was able to make such geological comparisons. However, the foundations of his lighthouse would have needed to be seated in strata below the sand, and the underlying alluvial clays, described as occasionally firm to stiff in well logs, might have reminded him of the Lower Lias succession of Cheltenham.

The spa seems to have been operational from the summer of 1832 until about 1870, and for the first 30 of those years until 1862, was supervised by William John and his wife Margaret. During the 1870s various attempts were made to re-establish the spa, but by the end of the decade the bath house had become a school and the associated dwelling houses were occupied by local people, rather than patients. The wells lay neglected for the following 60 years or so until in 1938 an analysis commissioned by the Urban District Council proved severe contamination. All trace of the wells had gone by 1949.

A reinterpretation of the geological succession encountered in digging the wells has been made, on the basis of borehole logs acquired in 1982 as part of a site investigation to improve Burnham's sea defences. This indicates that the shallower Sulphur Well drew water from the Quaternary alluvial deposits and the deeper Saline Well from the calcareous laminated clays of the Middle Lias. The commercial development of mineralised waters in Quaternary deposits, other than gravels, is uncommon and Edmunds *et al*. (1969) did not identify any in their review of UK mineral and thermal waters. In contrast, mineralised waters are common over the entire outcrop of the Liassic clays, which provide the source of other small historic spas in Somerset, such as Alford, Capland, Queen Camel and Skipperham (Mather and Prudden, 2005). In such formations the location of a spa has more to do with land ownership and the drive of a local entrepreneur than to hydrogeology (Mather, 2013). At Burnham, David Davies was that entrepreneur, but his initiative was too late; by the 1830s spas were already in decline with people increasingly turning to the new seaside resorts for their entertainment. With the arrival of the railway in 1853 it was seaside holidays which were to be the future for Burnham, rather than fame as a spa town.

Acknowledgements

Very many thanks to Jenny Bennett for her help with the diagrams and to two referees for their constructive comments on the first draft of this paper. My co-author Hugh Prudden died on 8th January 2015, on his 86th birthday, whilst this paper was at the proof stage. A long-time supporter of the Ussher Society and contributor to our Journal, Hugh had an encyclopaedic knowledge of Somerset geology and was a wonderful companion in the field. I shall miss him. JDM.

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