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THE CHANGING TECHNOLOGY OF POST MEDIEVAL SALT PRODUCTION IN HAMPSHIRE

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ABSTRACT

The techniques of saltmaking in Hampshire evolved to try to match the threats from salt production not only in the UK but also from other sites around the North Atlantic. This is an account of these changes during the post medieval period compiled from first-hand accounts by those with hands-on experience of saltmaking or scientists investigating the processes involved. A (brief) first hand description of Hampshire salt making was not published until 1682 (Collins 1682, 15–31, 69) whilst a fuller report only appeared in the mid eighteenth century (Brownrigg 1763, 32–41) and was not updated until the beginning of the following century (Vancouver 1813, 420).

INTRODUCTION

Salt (sodium chloride) is essential for human existence. Whilst hunter-gatherer societies have no need to supplement the salt occurring naturally in their diet, others require the use of additional salt for both dietary (domestic) and – increasingly – industrial reasons.

Modern commentators on the commercial manufacture of salt in Britain have generally regarded the industry in southern England as little more than a curiosity and sea salt production generally has not received the attention it warrants compared with that paid to manufacture from rock salt (Adshead 1992; Kurlansky 2003). English salt has been produced both from sea water and from rock salt (or natural brine springs emanating from the latter) although low grade salt from the French Atlantic coast was also refined to make 'salt on salt', as at Southampton in the late 16th century (HRO 44M69/G2/526). Commercially significant rock salt (halite) deposits are almost unknown in southern England and salt in Hampshire has almost always been made from sea water (Notholt 1973).

Rock salt consists of virtually pure halite (sodium chloride) – with organic inclusions – whilst sea water contains various other evaporites; notably the sulphates of magnesium and sodium as well as magnesium chloride. Known as bittern salts, these have a bitter, unpleasant taste as well as making salt deliquescent so that it 'melts' when stored (Henry 1810).

Salt was (and is) obtained from sea water by fractional crystallisation. As the sea water is evaporated small amounts of calcium carbonate and calcium sulphate are first deposited (Balarew 1993). Sodium chloride is the next to appear but it eventually overlaps partly with the deposition of magnesium sulphate (Epsom salt). The empirical art of the salt boiler was to extract the maximum amount of salt without evident contamination by bittern salts (Aral 2004).

PREHISTORIC SALTMAKING

There is a comparatively little evidence for pre Conquest saltmaking in Hampshire although comprehensive archaeological surveys have been carried out. The results of archaeological investigations in Dorset and Hampshire are currently being researched (S J Hathaway, pers. comm.). At sites with a possible history of production (intermittently) of upwards of 2000 years, archaeological evidence of early workings has often been destroyed by new saltworks construction over the centuries, erosion and the rising sea level (Wessex Archaeology 2002; Momber 2004).

The earliest known method of coastal saltmaking in Hampshire has been found from the late Bronze Age onwards and involved boiling seawater in crude clay dishes, supported by clay firebars. This technique was widespread throughout the world and these coarse ceramic items (briquetage) comprise the main archaeological evidence for early salt making and trade (Poole 1987, 178; Tomalin 1989). This technique continued through the Iron Age and into the Roman period (at least), with variations inevitably occurring (Hathaway 2005). A wide range of types of briquetage items is known although interpretation continues to be a matter of dispute (Morris 1994).

No unequivocal evidence has been found for the use of evaporation ponds in this era (Prehistoric Salt Production Methods, http://www.seillevalley.com/Production.htm; S J Hathaway 2012 pers. comm.)

MEDIEVAL SALTMAKING

A major change in salt production technology occurred from Roman times (in Cheshire at least) when brine began to be heated in wood-fired lead pans instead of primitive ceramic containers, although evidence for such pans has not been found on the South coast until the Anglo-Saxon period (Keen 1988; Holden & Hudson 1981). How and when the new technology was introduced remains unknown although the technique possibly spread from southwest France (Ridgeway 2000; Penney 2001). This development was accompanied by a major (possibly roughly concomitant) change in that seawater was no longer used as the brine was first concentrated. Almost universally around the English coast, brine was made by sand washing or 'sleeching' although this latter term was not used in Hampshire and appears to have been invented by archaeologists. Between successive maximum spring tides, the sea water impregnated ground, near the high water mark, can dry out by natural evaporation so that its surface contains dried salt. This surface sand, or alluvial deposit, (known as *crast* or crust) was scraped off the beach (or other littoral site) and stored in barns until needed (Ridgeway 2000; HRO 1570B/020). It was then placed in pits and usually washed with water (or occasionally seawater) to produce brine and filtered into sunken receptacles or 'sumps'. Leland describes the process in Lancashire:

> 'At the end of the sands I saw divers saltcotes, where were divers heaps of sands taken of salt strands, out of the which, by often wetting with water they pike out the saltness, and so the water is derived into a pit, and after sodde'
>
> (Smith 1963, 98).

The dumping of washed sand led to mound formation which is often the only surviving archaeological feature. No specific descriptions of the process exist as used in Hampshire although it continued in use elsewhere well into the 19th century (Collins 1682, 14; Brownrigg 1763, 47). Much of the evidence for this technique has been destroyed by erosion, agriculture or industrial development. The chronology of this change and its geographical spread is unknown although its dissemination is likely to have taken centuries rather than decades (Wessex Archaeology 2002). Iron pans were beginning to replace lead by the end of the 16th century although they had been in use in Durham since the 15th century (Surtees 1820, 94–104).

Thomas Wilkins obtained a description of a variation of this technique from old saltworkers in Lymington, before 1700, although it was obsolete by then; there is no indication as to when this variation came to be practised:

'The old saltworks were no bigger than one man could manage; they had only a small feeding pond and one large sun pan, which they covered over with sand; and letting the water out of the feeding pond into it to wet the sand only; they let it dry in the sun after raking it to make it dry the faster; and then they wet it again and this work they repeated until the sand was very full of salt.

This sand they shovelled up and carried it to their clearer; and putting water to it, they extracted a strong brine which they boiled up in iron pans with a slow fire of wood or turf or other fuel they could get; this made the salt very large grained.

> I have seen the remains some of these old saltworks which answer the aforesaid description but as the same grounds are now generally (espe-

> cially at Lymington) turned into the new works; there are no more to be seen of them that the neat heaps of their sand used in the making their brine and even these would not be known to have been sands but in the tradition of the people of those places for the salt has so corroded the same and altered it; that it appears to be a rich mellow black soil and is very fertile for cabbages beans and suchlike garden stuff and many farmers have carried great quantities away to improve their lands' (Wilkins).

This technique enabled a flexible approach to be made to saltmaking by the producers who were predominantly small farmers as shown by the inventory evidence (e.g. HRO 1594 AD/50 John Parsons of Downton, Hordle, husbandman). Before 1600, no person has been found who was exclusively engaged in commercial salt production. The salt 'crust' (or *crast*) could be more easily stored and transported (short distances) than brine and the salt could be extracted at any time; as required. No large capital investment was required; inventories in Hampshire typically value saltern leads at about 15–20 shillings and utensils at around 15 shillings; for example that of Thomas Fox of Milford, husbandman, in 1590 records 'a saltern lead 13s 4d: sand and wood at saltern, tools 26s 8d'. (HRO 1590B/17). The technique could be used in areas of reduced salinity, such as tidal rivers away from the coast, without increasing costs although the major disadvantage was the limited productivity.

POLITICAL CHANGES

English commercial salt production had declined rapidly during the 14th century, for a number of different reasons; including chronic adverse weather patterns, epidemic diseases and the Hundred Years war. Ships from England, supplying the army in Gascony, regularly returned with salt from Saintonge leading to the virtual elimination of the commercial South coast salt industry by 1400 (Pelham 1930 184; Bridbury 1955 105). The Abbey of Beaulieu had been importing salt from Poitou since at least 1270 although it also used local salt (Hockey 1975, 188–190, 208). During the 15th and 16th centuries, England continued to be dependent on Continental salt suppliers until the French religious wars of the 1570s disrupted trade (Hughes 1934, 45). This stimulated the setting up of many new coastal saltworks in England, particularly on the East Coast, from the 1560s onwards, with Crown patents of monopoly (Hughes 1925, 334–51; BL Lansd. MS 59 no 66–70, 73 no 48–51; Lewis 1953). This trend was later accentuated by the prohibition on French and Spanish salt exports in 1630, after the disastrous English expedition to the Ile de Ré in 1627 (TNA SP 78/82).

POST MEDIEVAL CHANGES

Several of these patentees were from the Low Countries and claimed to have knowledge of various 'new' and 'superior' methods of saltmaking but as these are never specified, there is rarely any description of them. In 1564, Francis Berti of Antwerp began shipping iron pans and other implements for making salt to England, from Bergen op Zoom, consequent to his exclusive grant of making white salt in England for 20 years (TNA SP 12/36 f. 201–225). As part of this, it was ordered that 'works according to the new plan of furnaces and pans for making salt be erected' at Portsmouth (CSPD 1547–80 238, 255, 274). This is the only plan to survive but makes little sense (TNA SP 12/40 f30). However, a later report describes the outcome:

> 'in 5 or 6 Elizabeth, sundry pans of iron were devised by advice of some strangers which being made at Her Majesty's charge were to have been set up at Portsmouth but were afterwards carried to Tynemouth; their insufficiency to make good salt being apparent, they were left in Tynemouth castle where they have been for more than twenty years' (CSPD 1586–1625: Add. 198).

The reign of James I saw an explosion in the granting of patents of monopolies before restrictions were imposed by the Statute of Monopolies (21 Jas.1 c.3) in 1623. A grant was made to Thomas Molesey in 1614 of 'making bay and white salt by a new invention and for venting of salt in more advantageous manner' although again the details are not recorded. In November, he petitioned the mayor of

Lymington stating that he had made a successful trial of making salt on John Dore's land near Lymington but that Dore had refused to transfer the estate to Moseley as promised. This event was overtaken by a dispute between the various other patentees for saltmaking, which resulted in the temporary ascendancy of Echard's patent of 1607 whilst Moseley's patent was declared void in law (APC 1613–4, 567, 636; APC 1615–6, 67; TNA C 66/1704; CSPD 1603–1610, 319–27).

Disputes over conflicting patents continued with John More's (MP for Lymington) being declared a 'grievance' (University of Kansas Kenneth Spencer Research Library MS P522) and the mayor and burgesses of Lymington being required to investigate a complaint to the Privy Council that 'divers unruly persons in and around Lymington endeavour to cross and hinder the due execution of three patents [of James I] granted for making of salt after new way' (*Journal of the House of Commons 1547–1629* 842–43 28 March 1626). The results of this enquiry show that both lead and iron pans were in use and floor pans 'in the new way' (TNA SP 16/3 f 80; APC 1625–6, 62). These were flat iron pans on the ground on which the coal was burnt, as described by Brereton in the northeast, and in which the combustion rate was controlled by a movable vent in the chimney; a feature retained in later works (Hawkins 1844; Royal Society Cl.P/20/40: BL Add MS 72897 fol. 62–71). It is not known if they were used in the same manner in Hampshire although they were soon replaced by more efficient conventional iron grates with firebars; the first mention of which is in the 1640 inventory of William Long of Lymington – 'salt pan with iron grates with pump and other old implements £5' (HRO 1640A/107).

POST MEDIEVAL TECHNIQUE

An almost totally new process developed using coal-fired iron evaporation pans with brine obtained from the partial evaporation of seawater by wind and sun in large, shallow ponds. These changes were not coordinated or even concurrent; taking place gradually during the 17th century but were the result of conscious attempts to find an effective, efficient and economic method of salt making. It became known as the Lymington method and was exported to various countries, together with local saltmakers, including Australia and USA. National and regional surveys show that this was the only method used for sea salt making in southern England by the eighteenth century (TNA CUST 148/15, T 1/343/26, West Glamorgan Record Office RISW Gn 3/250–272). Detailed first-hand manuscript descriptions exist by Robert Hooke FRS in c 1675 (Royal Society Cl.P 20/40), Thomas Wilkins c 1700 (Wilkins), Brown 1732 (Brown 1732a, 1732b), Brooks c 1735 (Brooks) and Charles St Barbe 1805 (St Barbe 1805) as well as a number of short printed contributions from Fiennes, Collins and Davies (Morris 1947; Collins 1682; Davis 1641; St Barbe's account is printed in Vancouver 1813, 420).

The greatest change required by the new process was the necessity of building of feeding (storage) and evaporation ponds; the siting of which demanded (optimally) a clayey alluvial gravel for successful construction; such soils being fortuitously prevalent along the Hampshire coast. Contemporary writers considered that three to four acres of land for each boiling pan was required for such ponds, by their computation, but were either reticent or inconsistent about their exact dimensions, suggesting that there were no generally agreed proportions.

A sea wall, just below the mean high water mark, was needed with sluices to allow the sea water to enter the feeding (store) ponds at high water. Normally such reclamation of the foreshore would have needed a grant from the Crown but developments in this sphere (fortuitous or not) facilitated the process. Several short term patents were granted to reclaim land overflown with fresh or salt water culminating in that granted to Robert Tipper and John Gasson, in 1627, 'for draining [etc] such grounds now subject to overflowing and inundation of fresh or saltwater ... there is a great quantity of [such] land in places in the counties of Southampton and Sussex (APC 1627 Jan – Aug, 203: TNA C 66/2437: C 66/2375). By 1628, they had to admit that they could not reclaim 2000 acres at places near Portsmouth within the time allowed (TNA SP 16/77/ 29). In competition with this project was an application by Robert Pamplyn of Lymington for a grant of lands 'being places overflown by the sea 'in the parishes of Keyhaven and Berewater and certain lands in Milford, Winnings [Wymering] and adjacent parishes'; encompassing some 5000 acres of the foreshore over large stretches of the Hampshire (and Isle of Wight) coastline (CSPD 1625–6, 41). This was made to him but he died in 1628 before he could receive the Letters patent, which thereby went to his daughters Mary and Margaret who had each married a Wandesforde brother (TNA C 66/1708 m1: BL Add. MS 16371A: PCRO DC/PM/27). There was an obvious conflict with Tipper's grant, which only had a short time remaining, so the Wandesfords sold him three parts of roughly all the grounds covered by their grant between Wymering and Emsworth; retaining the remaining part (TNA C 54/2737; Greenwood 2010) Between 1659 and 1666, the Wandesfords sold various marshlands in Milford and Lymington to Charles Guidott and Thomas Burrard of Lymington to build saltworks. Similar land sales were made elsewhere in Hampshire (HRO 52M83/2; 2M57/1; 24M61/E/T154).

From the feeding pond, sea water passed into ranks (tiers) of evaporation ponds. These had a bewildering array of names; none of which were consistently used. These included both the obvious – feeding, sunning, brine, pickle – as well as the completely unintelligible – hawkins (Wilkins; Hooke; HRO 55M72 box 7). As the water evaporated, it was fed – by gravity – into smaller ponds. The dimensions of these varied widely as did the number of ranks. Over time, there was a strong economic impetus towards reducing labour costs by simplifying the process including reducing the number of ranks to two. Small windmills were later used to transfer brine between ponds.

Wilkins describes the process:

> 'The higher parts of these lands, they separate from the rest by banks and call them feeding ponds because from them the brine works are fed or supplied with sea water reserved from one spring tide to another; because the neap tides don't rise high enough to supply them; and it is also advantageous to keep sea water long in them to improve the strength; by the sun and wind exhaling part of the water and leaving the salt' (Wilkins).

The increasing hypersaline of the evaporation ponds encouraged the growth of halophytes. Archaeobacteria provided nutritional elements for algae such as *Dunaliella salina* which gave the ponds a reddish colour as beta carotene was released by the dying organisms. Noted from the 17th century, the brine shrimp (brine worm, A*rtemia salina* L.) was encouraged as it was believed to clear detritus but it also increased solar absorption. *Artemia* was not scientifically identified until 1756 – at Lymington (Sorgeloos 1987; Bass-Becking 1931; Schlosser 1756).

The brinemakers used formerly to try (test the strength) of the brine by its ability 'to bear a new laid egg': a technique known from the 16th century, which was replaced by the only non empirical assessment of salt production by around 1700. (Smith no. 62: Hooke) Wilkins describes how:

> 'they now try it by artificial eggs, as they call them, made of wax loaded with lead in several degrees, which they call Sizes; by these they discover how much their liquor increases in strength as it proceeds through the pans; and those who are curious proprietors, know how much salt each size of brine will make with a chaldron of coals. Some use glass eggs i.e. small glass bubbles, sized by grinding them; but proprietors generally have a silver egg, made to unscrew, that they may put in divers weights to size it; by which they can try, whether the waters in their feeding ponds is better or worse than sea water; as well as the sizes of the brine' (Wilkins).

There is no record of the use of the Baumé salinometer (invented in 1768) or any other sort of hydrometer even though they were widely used to determine specific gravity by the later 18th century.

The brine was then conveyed into brine cisterns, deep pits in the earth (sometimes roofed over to preserve it from the rains), where it was kept until needed for boiling. The brine was then pumped into clearers (or fatts) from whence it could be fed into the evaporation pans. Evaporation pans used in Hampshire were of a uniform size; about 8 feet 6 inches

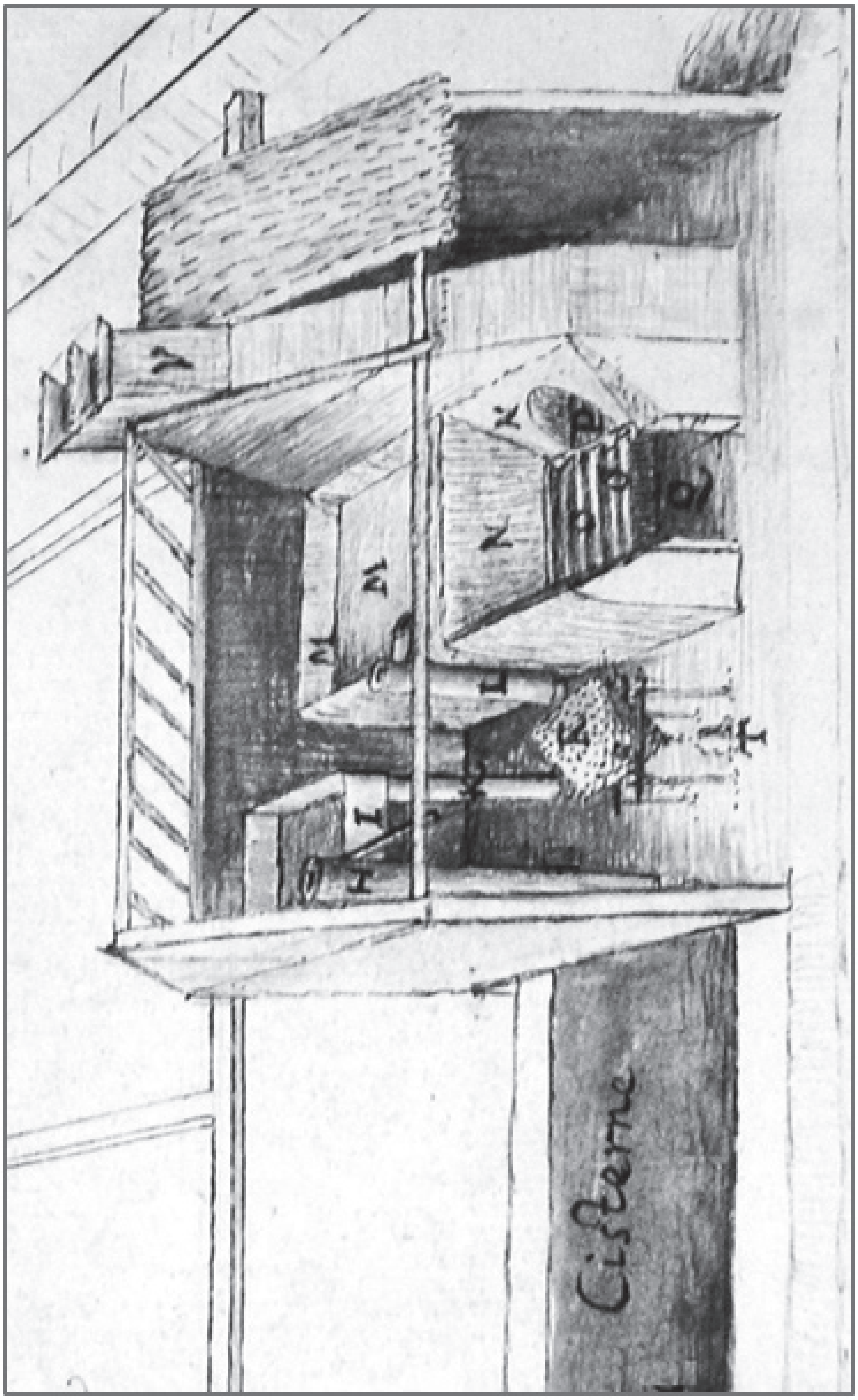

Fig.1 Robert Hooke Detail of a plan of a Hampshire saltworks. Royal Society Cl.P 20/40 (Copyright Royal Society 2012)
Key
H pump; I fatt or clearer; K descending pipe; L ascending pipe; M boiling pan; N inside of furnace; O grate; P fire hole; Q ash hole; R salt in strainer;S straining basket; T salt cat; V chimney

square, and about 11 inches deep and made of wrought iron sheets rivetted together with the joints filled with a lime putty; costing new from £36 to £40 each, and weighing about 18 cwt. (Wilkins: St. Barbe 1805) (Fig. 1).

The pans were at first made by specialist manufacturers like the Hallen family of Stanton Drew, Somerset although later they were fabricated locally from bar iron produced at Sowley or (exceptionally) imported from Sweden was used (Gerhold 2009; Greenwood 2005). Those used by Mitford in 1722 for four new pans at Exbury consisted of 84 plates of iron weighing 27 cwt 1 qtr 19 lb and cost £28 a ton. He describes them:

> 'The plates are 5 feet long and 1 foot broad and of the best Swedish metal made in Sweden using Oreground iron and thinner than is usually struck and therefore the better so that they are esteemed to be the best saltern plates that ever came to England and they have power to be so by their long duration'. They lasted about 25 years, compared with about ten for ordinary bar iron' (HRO TD/685/1) (Fig. 2).

Various substances such as beaten egg whites, stale beer or ox blood were added to clarify the solution in the pans and the resultant scum skimmed off. Small amounts of calcium carbonate and sulphate were the first to crystallise and were raked out although most adhered to the pan bottom and 'in a fortnight the whole bottom of the pan will be crusted with it and the workmen are obliged to break it off with their crusting hammers' otherwise hot spots could develop and the pan burn through' (Wilkins). As this contained about 60% salt it was sometimes redissolved in the brine (Henry 1810, 101).

When the first salt appeared the pan was filled up again and this process repeated, as often as was considered necessary, during a drift (boiling period) of eight hours, after which time, the entire contents of the pan were emptied into conical wicker baskets. There were sixteen drifts a week. This stage was determined empirically, based on the skill and experience of the saltboiler on whom depended the economic success of the venture which faced fierce competition from Newcastle (and later) Cheshire salt. As Wilkins put it:

> 'It required the nicest Skill and Attendance of the Operator to determine the Time when to take out the Sea Salt from the Pans, before the Bittern incorporated with it, which would otherwise spoil the whole Making.'

The bittern (the liquid containing other evaporites) drained from the salt into troughs with perpendicular sticks 'to receive what runs through. According to the Quantity of Sea Salt still left in it, this crystallized onto the Sticks, which they called *Salt-Cats'*, and which contained a proportion of bittern salts. For every ton of salt produced, about one ton of salt cats was created. This was powdered and was claimed to have a niche market among the gentry but the greatest amount went to the soap boilers. As there are no records of the sale of salt cats, it must be presumed that its market was insignificant as such salt was more usually just re dissolved in brine and re boiled (St Barbe).

Later the brine was simply almost entirely evaporated, and the whole mass of salt taken out at once every eight hours, and removed into troughs with holes in the bottom. Through these the bittern drained into underground pits where it remained until the winter when it was processed. This only occurred in the larger works otherwise it was allowed to drain away.

About 16–18 cwt of coal was used to produce about 1 ton of salt, each pan yielding about 8 bushels every eight hours. When the salt was first taken out of the pans, the quantity would measure more than 8 bushels, but as it was left to drain for 8 hours, about 10 gallons of bittern ran from it. The salt was then stored in cribs (wood lined stalls) in a secure building where a certain amount of further drainage of bittern occurred. Following the Salt duty Act of 1694, onwards transfer came under the control of the officers of the Salt Duty Collection Office who could fine transgressors (1693 5 & 6 William & Mary c 7).

Salt crystals occur in two different sizes, between which there is an important commercial difference, with distinct roles for each (Balarew). Large grained salt is produced by the slow evaporation of brine, such as occurs naturally in the wholly solar salt production areas, and was widely used for fish curing.

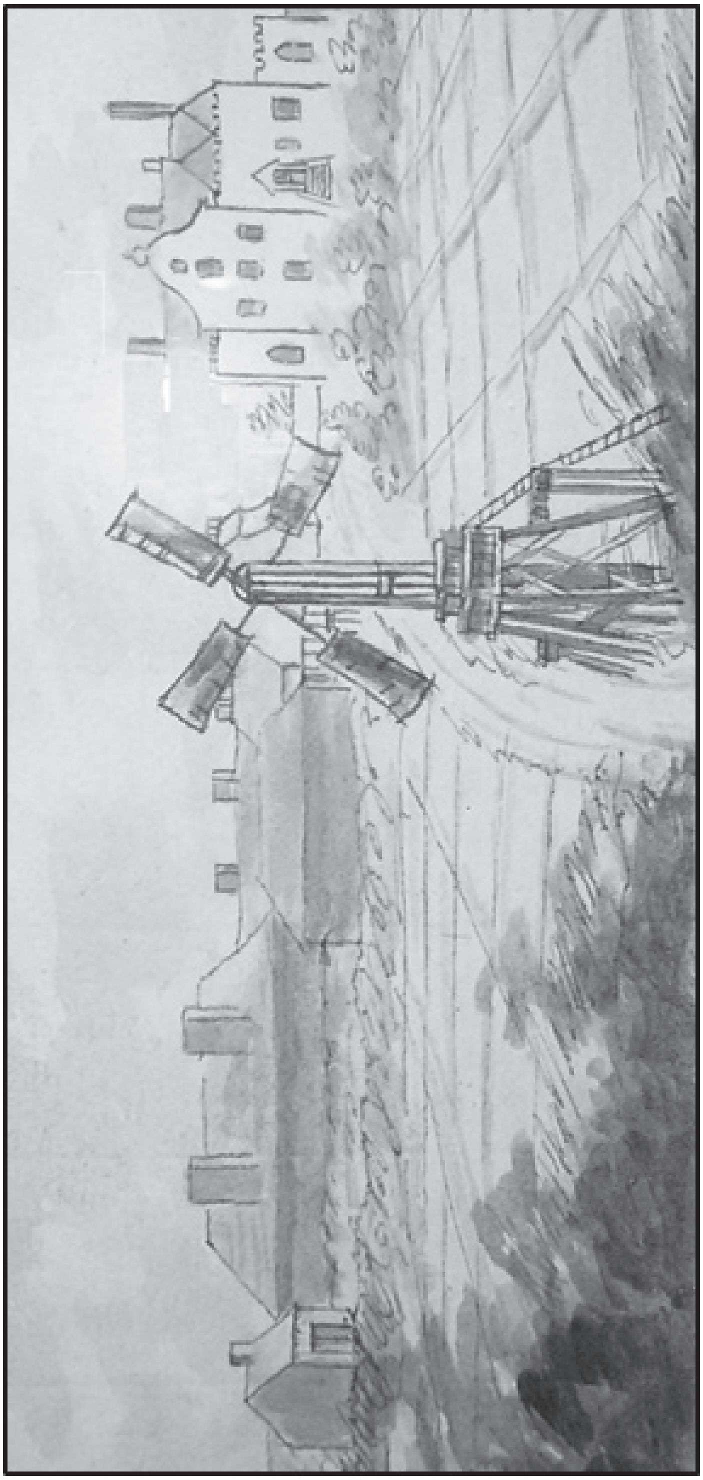

Fig. 2 Detail of Copnor saltworks Portsea island c 1700. Portsmouth City Museums Service PORMG: 1958/20 (Copyright Portsmouth City Museums)

Small-grained salt is produced by the rapid boiling of brine and was more characteristic of salt produced in Great Britain; being almost solely used domestically as exemplified by the 13th century accounts of Beaulieu Abbey. The abbey obtained its table salt (*sal minutus* or *finus*) from its local saltworks (*salinarii de Limington*) whilst fisheries salt (*sal grossum* or *pictaviense*), for its fishing rooms in Great Yarmouth, was imported in the abbey's own ship from the Bay of Bourgneuf in France (Hockey 1975, 52,188). However, much Hampshire salt was made for both the English herring fishery as well as the northwest Atlantic cod fishery in the post medieval period, as exemplified by the ports books (TNA E190/819–863 passim).

Only one complete account of building a saltworks has survived; for a four pan work at Exbury in 1722. William Mitford engaged John Dore to:

> 'strengthen the marsh wall and make 80 ranks of pans; each rank of 3 pans; each pan to contain 4 lugs also 26 ranks for sun pans, to make 2 brine pits and 2 cisterns and to make a good wharf and a sufficient lake up to said wharf and also to dig a feeding pond at 30s per rank and 18d per lug for the feeding pond Paid for 8¼ acres dug and made into pans and sun pans, 110 ranks at 30s: £165.
> 4½ acres 3 perches dug and made into a feeding pond at 18d a lug £54 4 6.
> [in total] 12¾ acres 3 perch for which paid Dore and partner £219 4 6.
> Building the salthouse and saltwork buildings cost £76 11 6; various implements cost £32 10 5, whilst a smith was paid £16 for making 4 pans from 84 iron plates (64 plates to a tun) £39 10; grates cost £11 10 which, together with various miscellaneous items, came to £517.16.10'.
> Swedish iron plates for the boiling pans cost an extra £38 (HRO TD 685/20–21).'
> (NB 13 ⅓ rank is one acre)

LATER DEVELOPMENTS

The process described remained in use fundamentally unchanged throughout the 18th century although a number of developments occurred. Saltworks were necessarily in exposed positions and the feeding pans were especially subject to damage by storms and tidal surges so (in west Hampshire particularly) the sea walls were raised and strengthened and cuts (canals) built, of a few hundred yards length, leading to inland wharves. In this way, vessels bringing coal or taking away salt could be more safely accommodated whilst also providing a convenient supply of seawater. It also provided an opportune way to drain off the fresh water of the area.

Coal was the largest cost and it was essential to minimise this so as to compete with Newcastle saltworks that had virtually free 'small coal' but needed at least 150 cwts of it to produce a ton of salt from sea water (Tyne & Wear Archives Service Cotesworth MSS CM/2/405. 1911 1723; Carr Ellison MSS ZCE 10/2). More advanced 19th century techniques were never used in Hampshire because proprietors were unwilling to make the necessary capital investment in what was obviously a decaying local industry. A brief foray into the use of steam heat with the formation of the Hampshire Steam Salt Co in 1846, by the St Barbe family, was unsuccessful (*Hampshire Advertiser* January 1846, July 1847; Jump & Court Patent no. 4967 1824).

PROCESSING OF BITTERN

Nehemiah Grew described his isolation of Epsom salt (*sal amarum catharticum*, magnesium sulphate) from spa water in 1695 but could not identify the compound chemically (Sakula 1984). In view of subsequent events, it may not be a coincidence that Thomas Guidott had made rudimentary analyses of other spa waters some years earlier; his father Charles Guidot, owned several Hampshire saltworks (Coley 1979; HRO 31M67/P17; 55M72 box 7). Wilkins claimed that he discovered Epsom salt in the waste channels of the Portsea saltworks when he took over in 1700 although his predecessor had sent samples to Hoy for identification. They proposed to keep the information secret and market the Epsom salt but the venture crumbled into a heap of mutual recrimination. The situation was complicated by an ultimately sterile discussion of the assertion that Epsom salt from Epsom well waters was somehow 'better' and 'purer' than that made in the laboratory or derived from bittern (Johns 2004: Sakula 1984).

Brown described the process of processing the bittern:

> '[it] is carry'd by Channels into Pits made tight with Clay, where it stands for some Months, and there will shoot again: What Liquor remains is boyled down, till such Time as it is observed to be in a Disposition to crystallize, and then is. conveyed into wooden Coolers lined with Lead: The Liquor, which will not shoot there, is boyled down after the same Manner, in order for another Crystallization. By this Time the Liquor seems to have alter'd its Property, and becomes of a very pungent biting Taste. The Liquor, that produces this Salt, is always flung away, wherever the *Sal Catharticum* is made.
>
> The Liquor decanted from this Shooting, may be boil'd down again in order for a second Shooting, and after that a third but as the Liquors from these Shootings are boyled away more or less, so you will sooner or later meet again with the pungent Liquor, which contains the third Salt...to distinguish a *Sal Mirabile* made at these Works, from that made with *Ol. Vitriol.* [sulphuric acid] and common Salt. They take any Quantity of coarser grain'd Crystals boyled from the *Bittern,* which when dissolve and evaporated, more than they would otherwise do for making, the *Sal Catharticum,* they throw into a wooden Bowl, with some Oil *of Vitriol,* where it stands for ten Days, and shoots into large Crystals, transparent and like the *Sal Mirabile'* (Brown, 1723, 1723a).

Glauber's and Epsom salts were both usually termed 'purging salt' and bore the same rate of Excise duty as common salt. This was a major disadvantage as Glauber's salt made in the laboratory was not so liable (Viel 1997; TNA T 64/233; 22 Geo. III c39).

From the bittern in the pits, magnesium sulphate (Epsom salt) was manufactured during the winter season, when the production of salt was suspended. The bitter liquor was boiled for some hours in the pans, which were used in summer to prepare common salt, and the impurities which rose to the surface were removed by skimming. During the evaporation a portion of common salt separated, and this being too impure for use, was re dissolved in brine in the following summer. The evaporated bitter liquor was then removed into wooden coolers one foot deep, where it remained twenty four hours, during which time, in clear and cold weather, the magnesium sulphate crystallized at the bottom, in quantity equal to about one-eighth of the boiled liquor. The remaining fluid was then let off through plug holes at the bottom of the coolers, and the Epsom salt, after being drained in baskets, was deposited in the store-house. This formed single Epsom salts, and after being dissolved and crystallized a second time, it was termed double Epsom salts. Four or five tons of magnesium sulphate were produced from a quantity of brine that had yielded 100 tons of common salt. (Henry 1810: St Barbe) Shipments of 'purging salt' were sent coastwise from Lymington from 1713 to London and elsewhere although Dublin became the main destination by 1750 (TNA E 190/855/6: Southampton Archives Office SC5/4/101). Only one instance is known of an exclusive refiner of purging salt; probably it was a winter occupation for salt boilers (1757A/077 Will of John Mitchell of Lymington).

Whilst Wilkins never identified his 'fiery salt', Brown realised that his 'third salt' was Glauber's salt (*sal mirabile*, sodium sulphate) which was beginning to be processed from the residual bittern. Unfortunately another cloud of suspicion came over this product when it was stated that sodium chloride was being treated with sulphuric acid to produce a 'false' Glauber's salt but it was not until 1815 that it was realised that what had been marketed as 'Lymington Glauber's salt' was the double sulphate of magnesium and sodium (Gray 1821; Ayrton 1823; Heales 1816).

Due to the propensity for sodium sulphate to form double sulphates and the limited ability of 18th century chemists to identify the constituents of bittern, the ability of manufacturers to produce pure Epsom and Glauber's salts must be doubted. The sequence of crystallisation of evaporites from brine varies and the parameters of the process need to be strictly defined but the evidence of Charles St Barbe and others shows it to have remained purely empirical. Without defining the specific gravity reached in boiling and the temperature to which it was cooled, quite apart from the effect of climatic variables, this suggests that a product of variable composition ensued. As the main market for the bittern salts was medicinal and as both Epsom and Glauber's salts are similar; being bitter tasting and aperient; the inconsistencies were of no material significance. What was left after all the various processing was sold as 'manure salt' to farmers as advertised in *Salisbury & Winchester Journal* (Monday, January 1, 1827).

Sea salt production peaked around 1750 in both Newcastle and Hampshire as cheaper transport enabled Cheshire salt to successfully compete in the London market with more local production centres and those of the northeast (Ellis: TNA AO 1/2104/152). Its overseas markets severely disrupted by war, the coastal salt industry of Hampshire had died out commercially by around 1870 when it was stated 'The last of the Lymington salterns have been closed, and the site converted to an oyster-breeding pound' (*A handbook for travellers in Surrey, Hampshire, and the Isle of Wight*, 1870). The last known shipment of salt left Lymington in 1873 (Southampton Archives Office DCrew ELIZA). Many of the ponds were used for oyster rearing or temporary shellfish storage but recurrent outbreaks of typhoid, due to raw sewage being discharged into the sea, put an end to that industry particularly as there was an increasing demand for yacht moorings and (in the late 20th century) marinas (HRO 70M86/W/22; PP HC 1818 (115) 299 Report on laws relating to salt duties; PP HC 1836 (528) list of saltworks by parish).

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Abbreviations

APC Acts of the Privy Council
BL British Library
Brooks, West Glamorgan Archive Service RISW Gn 3/260 Mr Brooks account of making salt at Limington.
CSPD Calendar of State Papers, Domestic
HRO Hampshire Record Office
PCRO Portsmouth City Record Office
St Barbe, Red House Museum, Christchurch. Charles St. Barbe notebook 1805
TNA The National Archives
Wilkins, University of Glasgow Special collections MS Hunter D155

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Portsmouth City Record Office (PCRO)
DC/PM/27 Map by Daniel Favreau de la Fabvollière of foreshore of east Hampshire, c.1665. Royal Society
Cl.P/20/40 Robert Hooke FRS, Making salt in a Hampshire Saltern 1675.
Cl.P/25/121 Of Salt from Brine.
RBO/11/12 'Observations and Experiments on the 'Sal catharticum amarum' commonly called Epsom Salt' by John Brown, chemist 1723.

University of Glasgow Special collections
MS Hunter D155 Thomas Wilkins' description of saltmaking in Hampshire c 1700.

University of Kansas Kenneth Spencer Research Library
MS P522 John More; notes for a speech in the House of Commons, 1626.

West Glamorgan Archive Service
RISW Gn Mackworth of Gnoll MSS.

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