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The changing technology of post medieval sea salt production in England

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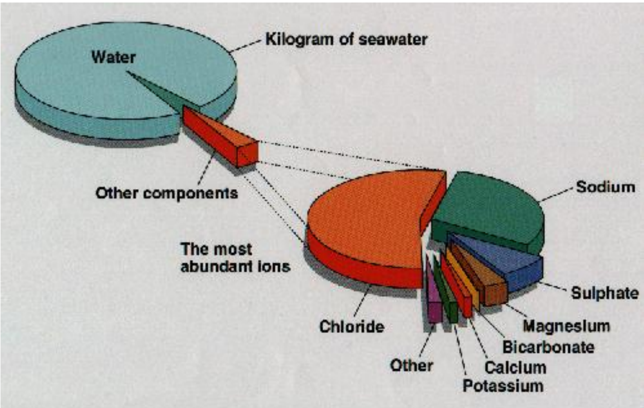
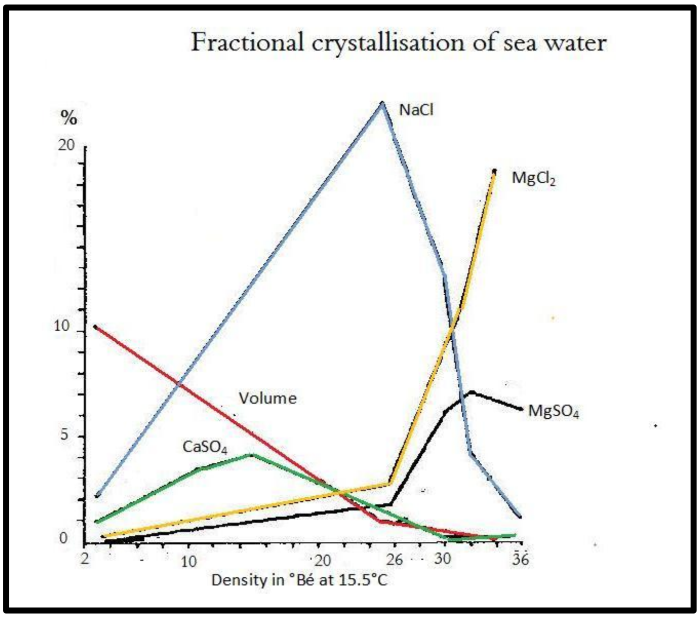


Composition of seawater

Sea water contains 3.5% evaporites of which salt (sodium chloride) comprises 77.8%. The remainder is known as bittern as it includes the bitter tasting, aperient and deliquescent sulphates of magnesium (Epsom salt) and sodium (Glauber's salt) as well as about 11% magnesium chloride.



Successful commercial salt making depends on the fractional crystallisation of seawater producing the maximum amount of salt without contamination by bittern salts. As seawater is evaporated, very small amounts of calcium carbonate are precipitated followed by some calcium sulphate. This is followed by the crystallisation of sodium chloride but before this is complete, bitter Epsom salt appears; something that needs to be avoided.[1]

In Continental Europe, evaporation of sea water is achieved solely by the energy of the wind and sun but this is not possible in the English climate so other techniques were developed.

[1] http://www.solarsaltharvesters.com/notes.htm SOLAR SALT ENGINEERING

Briquetage

Evaporation vessel

The earliest known English method of coastal saltmaking has been found in the late Bronze Age. This involved boiling seawater in crude clay dishes supported by clay firebars (briquetage) and was widespread in Europe. This technique continued into the Iron Age and into the Roman period with variations inevitably occurring in the industry, although the dating of saltworks is very problematical.[2] Detailed interpretation continues to be a matter of dispute.

Sandwashing site Crosscanonby

[2] www.crt.state.la.us/archaeology/SALT/product.htm Primitive techniques of salt production: http://www.eng-h.gov.uk/mpp/mcd/salt.htm: the literature on the subject is vast.

A major change in salt production technology occurred from late Roman times (or later) when a new process was introduced in which brine was used instead of sea water. The brine was made by sand washing (also known as sleeching). Between successive maximum (spring) high tides, there is a period of about three weeks during which the salt water impregnated ground, near the high water mark, may dry out by natural evaporation so that its surface contains dried salt. The surface sand was scraped off the beach (or other littoral site) and stored in primitive roofed enclosures. This salt-impregnated material was then washed with fresh water to produce brine and then filtered into sunken receptacles or 'sumps'. [3]

Roman lead pan from Cheshire

The brine was evaporated in lead pans over hearths using whatever fuel was available; usually wood or peat. Before complete crystallisation of the solution had occurred, the solid contents of the pan were removed into conical wicker baskets allowing the bittern to drain out of the salt. Only in the inland saltworks of Cheshire have Roman lead saltpans been found and there is nothing similar for the South coast until the Anglo-Saxon period. How and why the new technology was introduced remains a mystery though it appears the technique possibly spread from southwest France.[4]

The chronology of this change and its geographical spread is unknown although its dissemination is likely to have taken centuries rather than decades. Although of limited productivity, the technique enabled a flexible approach to saltmaking by the

[3] Brownrigg. 136
[4] E.L. Morris. 'Salt Production and distribution' in T. Lane and E.L. Morris (eds.) *A Millennium of saltmaking: prehistoric and Romano-British salt Production in the Fenland.* 2001, 389-404. Sleaford: V. Ridgeway. 'A medieval saltern mound at Bramber'. *Sx. Archaeol. Coll.* 138. 2000, 135 – 52: S. Penney, 'Lead Salt pans'. *Lucerna*. 22, 2001, 11: Lemonnier, P. *Les salines de l'Ouest. Logique technique et logique sociale*. Lille 1980: Productions and applications www.salines.com/index.php?page=3&fiche=44:

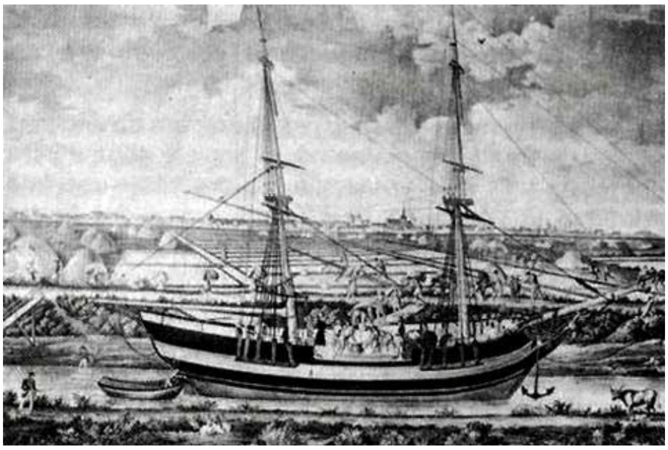
makers who were predominantly small farmers.[5] Before 1600, no person has been found who was exclusively engaged in commercial salt production The salt ‘crust’ (or crast) could be more easily stored and transported (short distances) than brine and the salt could be extracted at any time; as necessary. No large capital investment was required; inventories in Hampshire typically value saltern leads at about 20 shillings and utensils at around 15 shillings.[6] The technique could be used in areas of reduced salinity without increasing costs although the major disadvantage was the limited productivity. The system prevailed in Morecambe Bay and Normandy until the nineteenth century; these were areas with large tidal ranges and low beach profiles better suited to the technique.

Sand washing as practised in Normandy and Northwest England. Diderot Encyclopedia

[5] based on analysis of inventories for Lymington.
[6] For example HRO 1590B/17 Thomas Fox of Milford, Husbandman. ‘saltern lead 13s 4d: sand and wood at saltern, tools 26s 8d’

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.[7]

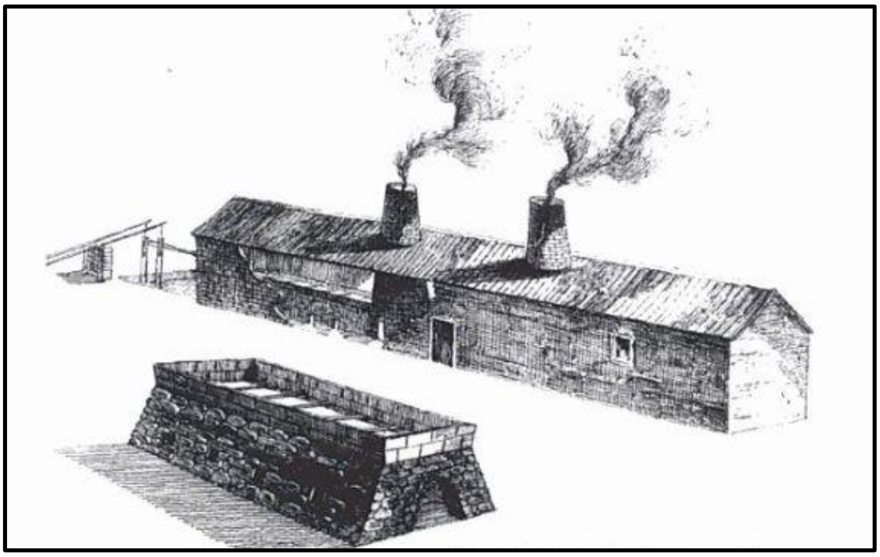


Loading salt at Bourgneuf

English commercial salt production had declined rapidly during the 14th century, for a number of different reasons; two of the major ones being the Black Death and the

[7] University of Glasgow Special collections, MS Hunter D155 Thomas Wilkins' description of saltmaking in Hampshire c 1700, hereafter 'Wilkins'.

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.[8] 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.[9] This stimulated the setting up of many new coastal salt works in England with Crown patents of monopoly from the 1560s onwards, particularly on the East Coast. [10] 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. [11]



Saltwater evaporation at South Shields c 1750

Changes in the early decades of the 16th century were promoted by the rapid expansion of coal mining in the northeast. The unsaleable small coal from coastal mines was used to evaporate seawater in large iron pans. No attempt at fractional crystallisation was made so a poor quality bitter deliquescent product ensued. This was refined in East Anglia and the United Provinces for fisheries use.[12]

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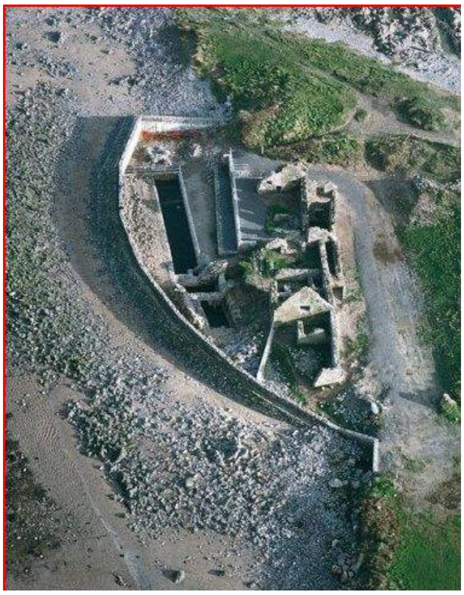
[8] Pelham 1930 184; Bridbury 1955 105
[9] Hughes 1934 45
[10] Hughes 1925, 334-51: BL Lansd. MS 59 no 66-70, 73 no 48-51; Lewis 1953
[11] TNA SP 78/82
[12] VCH Durham II 292: Ellis, J. 'Decline & fall of the Tyneside salt industry 1660-1790'. *Econ. Hist. Rev.* (2nd ser) 33. 1980, 45: Ellis, J.M. *A Study of the Business Fortunes of William Cotesworth, 1668-1726.* 1981. New York.



Remains of C16 saltworks at Port Eynon

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.[13] 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.[14] This is the only plan to survive but makes little sense.[15] The project never came to fruition except for a short lived venture in Aberdovey, Wales which simply boiled seawater in iron pans.[16]

The reign of James I saw an explosion in the granting of patents of monopolies before restrictions were imposed by the Statute of Monopolies in 1623.[17] 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

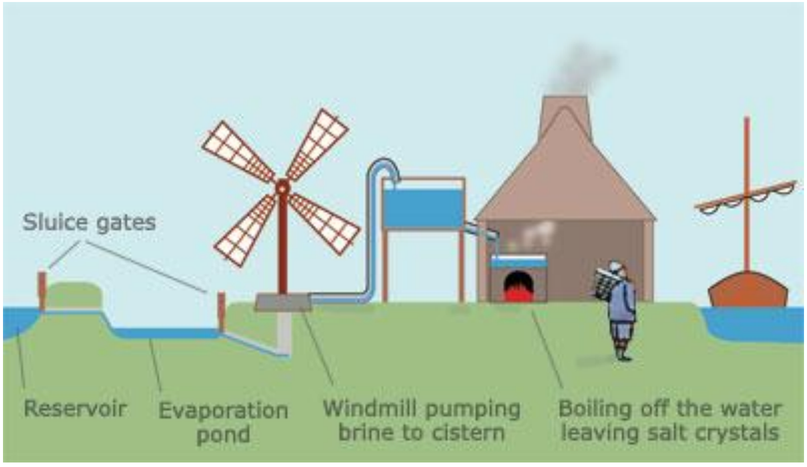
[13] TNA SP 12/36 f. 201-225
[14] *CSPD* 1547-80 238, 255, 274
[15] TNA SP 12/40 f30
[16] Lewis, W J. 1953, ‘A Welsh saltmaking venture of the 16th century’. *J Nat Lib Wales* **8** 419-32.
[17] 21 Jas.1 c.3

details are not recorded. A dispute ensued 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. [18] Disputes over conflicting patents continued with that of John More (MP for Lymington) being declared a 'grievance' 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'.[19]

Post medieval technique

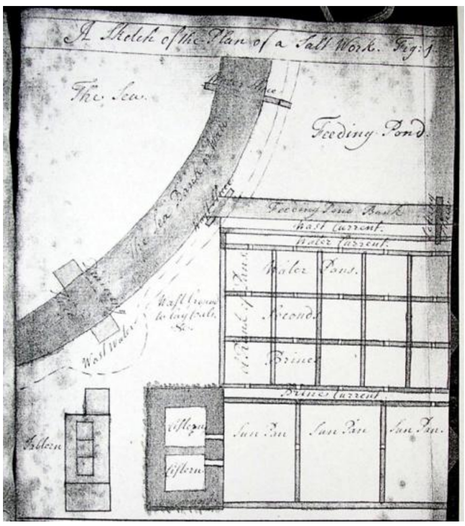
An almost totally new process developed, after about 1580, using coal-fired iron evaporation pans with brine obtained from the partial evaporation of seawater, by wind and sun, in large, shallow ponds. These changes were not coordinated or even concurrent; taking place gradually during the 17th century but were the result of conscious attempts to find an effective, efficient and economic method of salt making. It became known as the Lymington. Detailed first-hand descriptions exist by Robert Hooke FRS in c 1675[20], Thomas Wilkins c 1700,[21] Brown 1732[22], Brooks c 1735 [23] and Charles St Barbe 1805[24] as well as a number of less fulsome contributions from Fiennes, Collins and Davies.[25] The use of this technique was effectively limited to Hampshire.

[18] APC 1613-4, 567, 636; APC 1615-6, 67: TNA C 66/1704: CSPD 1603-1610, 319-27
[19] University of Kansas Kenneth Spencer Research Library MS P522: (Journal of the House of Commons 1547-1629 842-43 28 March 1626)
[20] Royal Society Cl.P 20/40 hereafter 'Hooke'
[21] Wilkins
[22] Brown 1732a, 1732b: Royal Society RBO/11/12 'Observations and Experiments on the 'Sal catharticum amarum' commonly called Epsom Salt' by John Brown, chemist 1723.
[23] West Glamorgan Archive Service RISW Gn 3/260 Mr Brooks account of making salt at Limington.(Hereafter 'Brooks')
[24] Red House Museum, Christchurch. Charles St. Barbe notebook 1805, hereafter 'St Barbe 1805'.
[25] Morris 1947: Collins 1682: Davis 1641



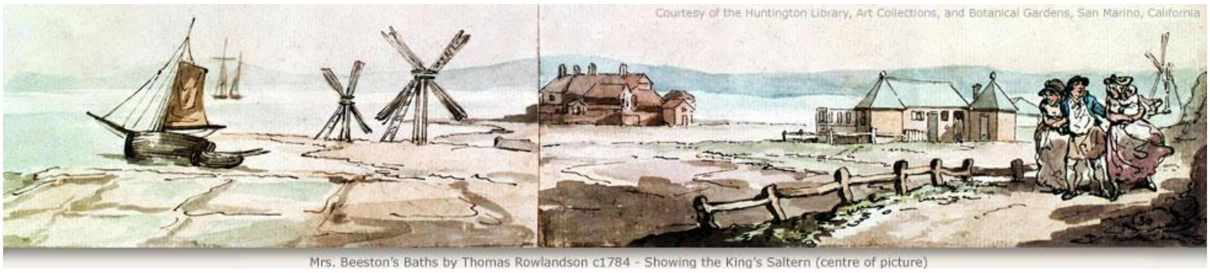
Schematic of salt production process in Hampshire

The greatest change required by the new process was the necessity of building of feeding (storage) and evaporation ponds; the siting of which demanded 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.



Diagrammatic plan of evaporation ponds at Lymington, c 1700

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 such as that granted to Robert Tipper, 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. A successful application was made, in 1628, by Robert Pamplyn of Lymington for a very similar grant of lands ‘being places overflown by the sea encompassing some 5000 acres of the foreshore over large stretches of the Hampshire (and Isle of Wight) coastline.[26]



Saltworks at Lymington 1796. Thomas Rowlandson

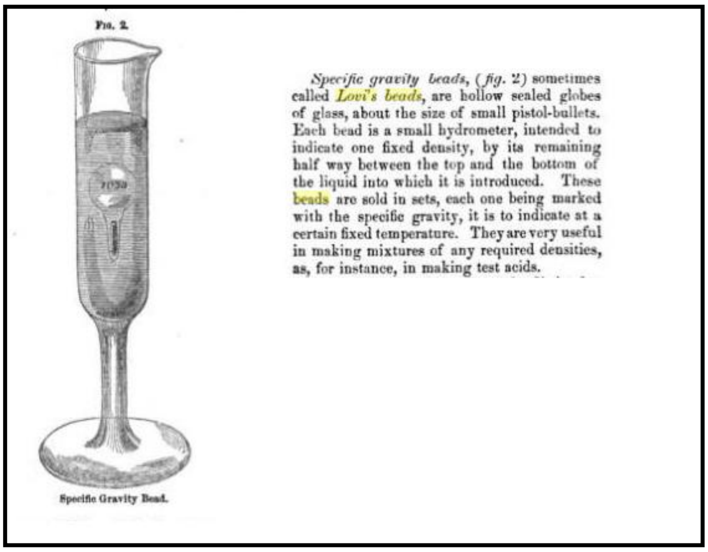
From the feeding pond, sea water passed into ranks (tiers) of evaporation ponds. These had a bewildering array of names; none of which were consistently used. As the water evaporated, it was fed - by gravity – into smaller ponds. The dimensions of these varied widely as did the number of ranks. Over 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.

[26] CSPD 1625-6, 41

Remains of feeding and evaporation 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. [27]



Specific gravity beads, (*fig.* 2) sometimes called *Lovi's beads*, are hollow sealed globes of glass, about the size of small pistol-bullets. Each bead is a small hydrometer, intended to indicate one fixed density, by its remaining half way between the top and the bottom of the liquid into which it is introduced. These beads are sold in sets, each one being marked with the specific gravity, it is to indicate at a certain fixed temperature. They are very useful in making mixtures of any required densities, as, for instance, in making test acids.

Lovi's beads

[27] Wilkins

The brinemakers used 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.[28]

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.

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.

Brine cistern excavated 2010

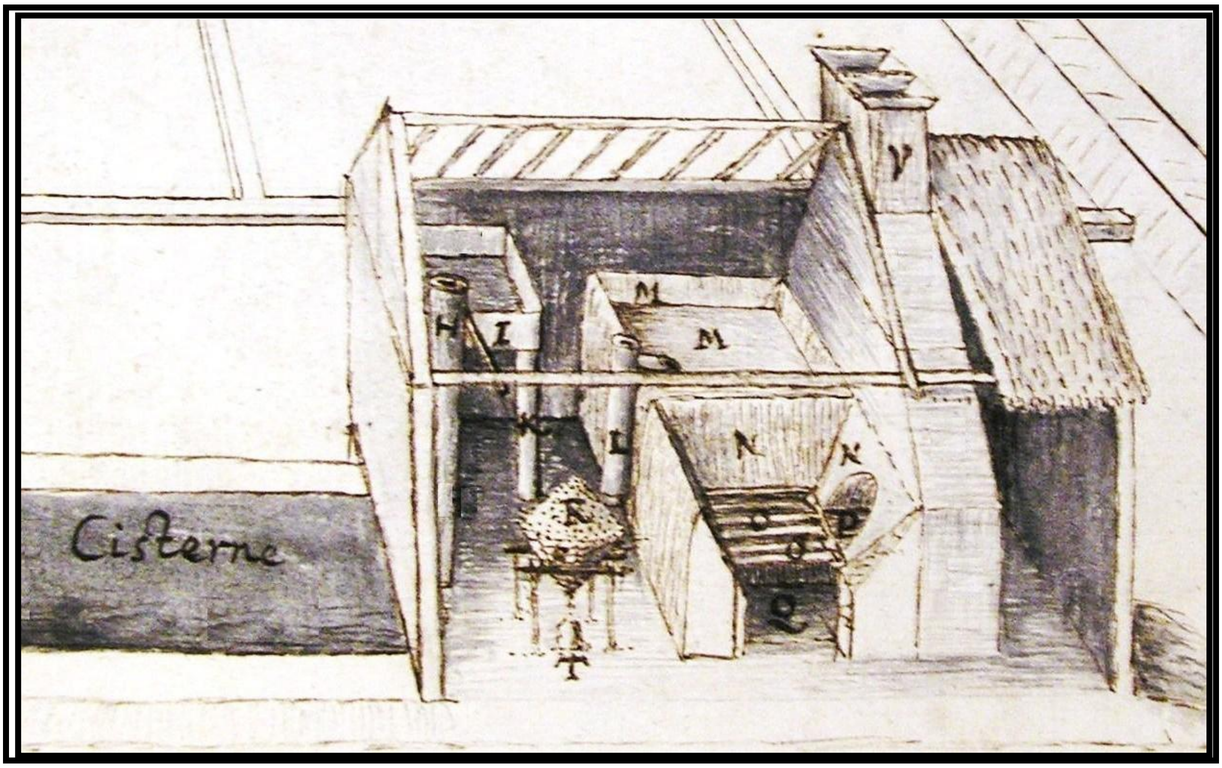
[28] Smith no.62: Hooke

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. Both lead and iron pans were in use in the early 17th century until the use of coal firing caused the lead ones to be discarded. Initially floor pans were used ‘in the new way’;[29] these were flat iron pans on the ground on which the coal was burnt as described by Brereton in the northeast, but were soon replaced by grates with firebars.[30] Evaporation (boiling) pans used in Hampshire were of a uniform size; about 8 feet 6 inches 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.[31] 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.[32] 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.

The use of Swedish iron was atypical but it was claimed that they lasted about 25 years, compared with about ten for ordinary bar iron’.[33]

[29] TNA SP 16/3 f 80; APC 1625-6, 62
[30] Hawkins 1844
[31] Wilkins: St. Barbe 1805
[32] Gerhold 2009; Greenwood 2005
[33] HRO TD/685/1



Detail of a plan of a Hampshire saltworks by Robert Hooke, c 1675. Royal Society Cl.P 20/40. © Royal Society

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

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.[34] As this contained about 60% salt it was sometimes redissolved in the brine. 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

[34] Wilkins

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;

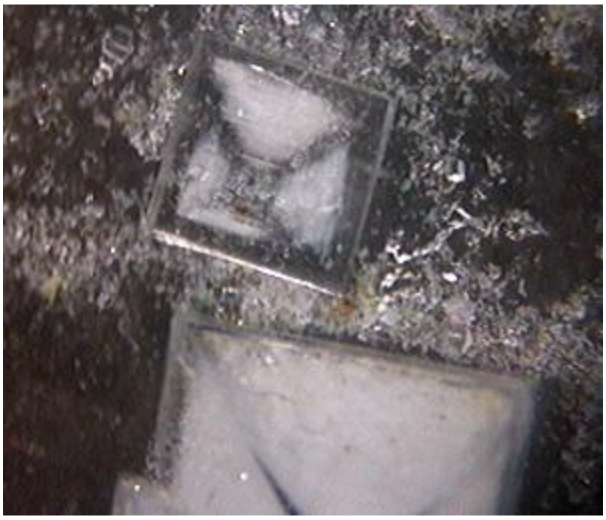
> It required the nicest Skill and Attendance of the Operator to determine the Time when to take out the Sea Salt from the Pans, before the Bittern incorporated with it, which would otherwise spoil the whole Making.

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.

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. [35]

[35] 1693 5 & 6 William & Mary c 7

 Salt crystals

Salt crystals occur in two different sizes, between which there is an important commercial difference, with distinct roles for each. 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. 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.[36] However, much Hampshire salt was made for both the English herring fishery as well as the northwest Atlantic cod fishery.

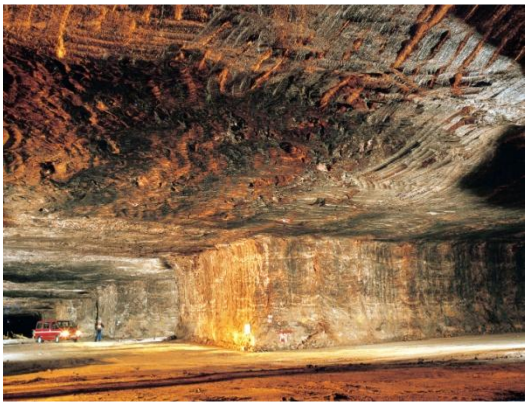
Only one complete account of building a saltworks has survived; for a four pan work at Exbury in 1722. William Mitford engaged John Dore to;

> 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 (note 13 ⅓ rank is one acre)
>
> 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

[36] Hockey 1975 188

> 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.[37]



Cheshire salt mine

Later developments

The discovery of rocksalt in Cheshire in 1670 brought about a revolution in salt production with most coastal saltworks being replaced within a surprisingly short time by rocksalt refineries close to supplies of coal so that they sprung up in such unlikely places as Yeovil. In 1702, an Act restricted rock salt being refined 'except within 10 miles of [salt] pits or at such places used before 1702 for such purposes' and most were around the fishing ports of Devon, Cornwall although later exemptions were made for some places in East Anglia.[38]

There were two very significant exceptions to this pattern. In the northeast, salt had been made, from the 15th century, simply by evaporating sea water in large iron pans heated by 'small coal' - the waste coal from the pits for which there was no other economic use. No attempt was made at fractional crystallisation until the mid 18th century so that a poor quality salt was produced which had to be refined near its main markets in Yarmouth and London.

[37] HRO TD 685/20-21
[38] BL 816 m 13(96) re bill to restrain more salt refineries. 1 Anne c 21

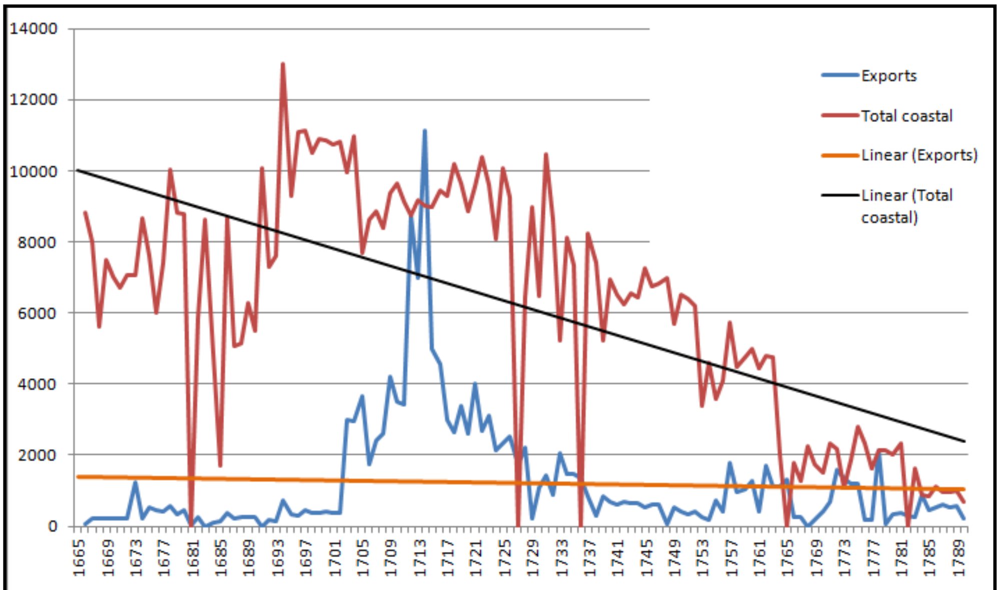
The process described remained in use fundamentally unchanged throughout the 18th century although a number of developments occurred. Saltworks were necessarily in exposed positions and the feeding pans were especially subject to damage by storms and tidal surges so (in west Hampshire particularly) the 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 single cost and it was thus 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.[39] More advanced 19th century techniques – particularly vacuum evaporation – 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. [40]

The very dry decades of the early 18th century prompted various attempts – some successful – at the production of Bay salt i.e. produced entirely by climatic evaporation. A return to normal weather patterns halted this.[41]

advert for Epsom and Glauber’s salts emphasising their aperient effect

[39] Tyne & Wear Archives Service Cotesworth MSS CM/2/405. 1911 1723: Carr Ellison MSS ZCE 10/2
[40] *Hampshire Advertiser* January 1846, July 1847: Jump & Court Patent no. 4967 1824
[41] Collins *Salt and* Fishery: Wilkins



Salt shipments fron Newcastle on Tyne 1665-1800 in bushels of 56 lbs

During this century also, the bittern was processed to recover magnesium sulphate (Epsom salt) and – later – sodium sulphate (Glauber’s salt) but even these commercial improvements could not halt the decline of South coast salt production. The Newcastle industry peaked around 1750 as did that on the South Coast and whilst the former was extinct by 1800 the latter was not finally extinct until 1870. The reasons for this were not just the increased availability and price competitiveness of Cheshire salt but also the loss of overseas markets and the disruption of trade by war.

The remains of the Lymington saltworks today

Abbreviations

HRO Hampshire Record Office

PCRO Portsmouth City Record Office

BL British Library

TNA The National Archives

Printed primary sources

Place of publication is London unless otherwise stated

APC Acts of the Privy Council

Collins, J 1682 *Salt and Fishery, a discourse thereof, etc*.

CSPD Calendar of State Papers, Domestic

Davies, J 1641 *An Answer to those Printed Papers published in March last, 1640, by the late Patentees of Salt, in their pretended defence, and against free trade*.

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