Salty Matters

John Warren - Wednesday May 13, 2015

Salt’s uses across human history

Introduction

Until the 19th Century and the advent of refrigeration, salt’s main uses was as a preservative and as a much sought after flavouring for foodstuffs. Even today, most people think of salt in terms of sprinkling it on their food, or in colder climates they may also think in terms of road de-icing. These are in fact lesser modern usages of halite; its main use is as a feedstock in the chemical industry, a topic we shall discuss in a later blog. This essay focuses on salt’s importance to humanity prior to the chemical age.

Sodium chloride (halite), the most common industrial evaporite salt and is used in some form by virtually every person in the world. The human body contains about 110 gm of salt. Salt is essential to all living creatures and even many plants. Since the body cannot manufacture it, salt is an “essential” nutrients, and as an electrolyte, we lose it every time we sweat. Without enough salt, muscles won’t contract, blood doesn’t circulate, food goes undigested, and ultimately the heart ceases to beat.

Halite, along with other salts, has long played a very important role in human affairs. Early hominids lived on the edge of the saline Lake Olduvai (Hay and Kyser, 2001) and salt was part of their diet. In ancient Greece it was so valuable that the slave trade involved an exchange of salt for a slave and gave rise to the expression, “not worth his salt.” Some 4,700 years ago the Peng-Tzao-Kan-Mu was published in China. It is probably the earliest known treatise on pharmacology, with detailed discussions of the palliative and curative powers of more than 40 kinds

Figure 1. Some of the methods described for the manufacture of salt as illustrated Georgius Agricola’s De Re Metallica of 1556. A) Brine concentration of seawater in a “salt garden”. B) Seawater boiled in iron salinators. C) Concentrating waters escaping from natural thermal brine springs. D) Wood-fired salt factories using seawater or other brine feeds.
of salts, including descriptions of two methods of recovering usable salts from brine. There are more than 14,000 reported usages of halite and more than 30 references to salt in the Bible. Some 3,200 years ago, near Hallstatt in Austria, Bronze-Age miners were extracting salt, from a network of several kilometres of galleries up to 300 metres below the surface. Two thousand seven hundred years later, some ten pages deal with salt in the “De Re Metallica” by Georgius Agricola (Georg Bauer), both mining it and producing it from seawater or brine springs. Published in 1556, Agricola’s was the first book on mining to be based on field research and observation (Figure 1).

Salt as a preservative

Historically, whether food was hunted, gathered, or grown and harvested, food supply was rarely available year-round to all members of a society. Yet, effective, year-round, reliable food storage was vital, especially for non-nomadic agricultural societies. Today, to maintain reliable food supplies to our ever-expanding urban populations, we refrigerate, freeze-dry or can our food. Food preservation problems seem trivial to most consumers in the developed world, outside of the world’s war zones. But, prior to the 19th century, effective food storage often made the difference between life and death to large segments of the world’s human population.

In arid climates, food can be effectively stored by drying. But in more humid temperate climates, fungus and bacteria rapidly destroy stored and cellared food. Even where food can be stored in winter ice, it quickly rots when spring thaws set in. Documents from northern Europe, give some clues about the severity of the problem, and its solution. In medieval societies, with relatively poor transportation systems, villages and counties had to be close to self-sufficient in food. If a bad harvest occurred, to mitigate a potential disaster there had to be enough food stored to tide over until the next harvest. Medieval Europe offers an example of the way in which agricultural societies dealt with food security. Good-quality arable land was scarce, and had to be used for crops. That meant that grazing and foraging animals, mainly cattle and pigs, were turned out into the local woodlands for the summer to forage for grass, roots, and nuts. Any relative shortage of winter fodder in turn meant that surplus animals would best be butchered before cold weather drove them indoors. In medieval England the annual slaughter was traditionally around Martinmas, St Martin’s Day (10 November), but it was earlier in the colder climes of Sweden. In turn, that meant that fresh meat was readily available only at that time, and that fresh protein in the form of milk and butter was only available in winter from cows kept in shelter. In addition, taxes were often paid in kind rather than money, and that meant that the landlord had to be given foodstuffs that could be stored.

The response of the Swedes and most northern Europeans, was to store almost all their food, and they used salt to do so. Beef and pork were salted and dried as joints, hams, and sausages. Butter was salted. Typically it took a pound of salt to preserve 10 pounds of butter (salt was sufficiently costly that housewives removed salt before they used stored butter). Fish, whether freshwater or from the sea, were salted and dried, and bread was salted and hung to dry. Surviving records from 1573 show the servants of King Gustavus Vasa of Sweden ate some 102 kg (224 pounds) of beef and pork, but 99 kg of it (218 pounds) was salted and dried. They almost never had fresh meat. The King issued an order to release 3-year-old butter from the tax stores for some men hired to work at the castle, and ordered the sale of 4-year-old (barley) malt because it was starting to get weevils in it. He ordered the peasants to store their butter and meat in the fall, after the annual slaughter, but he also ordered them not to eat any of it for 12 months (as they should be eating the previous year’s food during that time).

Outside of salted food storage, the ancient Egyptians are famous for their perfection of the art of mumification. A key ingredient in the process was natrun, which is a natural mixture of halite, trona and sodium sulphate (Edwards et al., 2007). The ancients knew its preservative properties as it readily absorbs water, making it an excellent desiccant/preservative of organic material. Natrun is found in large quantities in the beds of several Egyptian playa lakes (e.g. Wadi Natrun and El Kab, as well as Behiera in the nearby Libyan desert and in Lake Natron in the African Rift valley; Figure 2). It has been mined and traded from such localities for thousands of years. Writings as old as the reign of Rameses III (1198–1166 B.C.) refer to natrun deposits. Its preservative qualities must have been immediately apparent to the ancient Egyptians from its effects on any wild life, which...
Mummification has its origins in mundane processes, like salting fish for later consumption.

had died in these lakes (Figure 2). There is some evidence that the ancient Egyptians artificially precipitated natrun by isolating shallow basins of salt lake waters for faster evaporation, as is still done in parts of the Fayyum depression today. For purification and preservation, natrun was preferred over pure halite as it chemically attacks and destroys grease and fat, and so is a superior drying agent (as is sodium borate). Its residues are found not only in tombs and in pits, along with other discarded embalming materials, but also forms nodules and residues in the mummies themselves.

There is some popular debate over the method in which the natrun was used for mummification by the ancient Egyptians. Some argue it was used in a way similar to the contemporary method for “salting” fish. Dry natrun would be sprinkled over the body, perhaps with sawdust, or spread with linen cloth wraps. Others with a more starry-eyed bent, believe the body was immersed in vats containing a natrun solution. Such a wet method would have been odiferous and accelerated putrefaction, thus counterproductive to the preservation of the body, although it makes for good Hollywood images. A dry body is also more readily bandaged as well as being more amenable to the attachment of amulets and other jewellery. Although mummification has supernatural trappings in popular culture and ancient religions, its basis is rooted in simple chemistry and processes as mundane as salting fish.

The mummies of some Buddhist monks (Sokushinbutsu sect) in Japan resulted from the practise of nyūjō, which ultimately aimed to cause their own death and mummification by encasement in salt (Figure 3). This ritual took years to complete and involved starvation and dehydration. During the first three years, an ascetic monk significantly decreased his body fat by eating only nuts, seeds, and berries, while he increased his physical activity. Towards the end of the ritual the monk reduced his food intake even further by only consuming bark, roots, and sometimes stones. Post-mortem preservation was further aided by consumption of toxic herbs and tea that eliminated bodily fluids and killed bacteria that aid in decomposition. Japanese Sokushinbutsu monks were known to drink a tea made from the urushi tree, also known as the Chinese lacquer tree because its sap is used to lacquer tableware, instruments, and jewellery.

After years of starvation and dehydration, when the monk felt like he was close to death, his fellow monks arranged his body in the lotus position inside a coffin or a tomb. Then they surround-ed the dying man with salt, wood, paper, or lime to pull more moisture away from the body and further prevent post-mortem decay. Only a small opening for air was allowed when the tomb was closed. The monk then chanted, meditated and occasionally rang a bell until he died.

Once his fellow monks heard silence they completely sealed the tomb. After several years, the monks exhumed the body to see if the self-mummification ritual was successful. Like some Eastern Orthodox religions, these Buddhists believed that an incorrupt body, a body having delayed decomposition, indicated a monk’s holiness. If the body was incorrupt after exhumation then the corpse was placed in a temple, adorned, and tended to by followers. However, if a tomb was opened and the body had decayed,
then the corpse was left behind and the tomb was resealed. That monk’s efforts were respected, but his body was not given the deference of a religious relic. Japan banned unburying in 1879 and assisted suicide, including religious suicide is now illegal. In a similar vein, in 1933, the Dalai Lama was buried sitting up in a bed of salt.

Mummification can occur naturally if a body is encased in halite, and natrun is not necessary, although it improves preservation. In 1593 AD, and again in 1616 AD, several tombs encased in salt were exposed by natural salt weathering and collapse in the Hazel Mountains. When the coffins were opened by the local people of Hallein and Hallstatt, there was astonishment that the bodies inside had very well preserved soft tissues. It was the result of the hyperarid encasement in a Neolithic salt mine, but frightened religious locals, encouraged by the local clergy, insisted on prompt reburyal, along with additional religious efforts to lessen ambient sin levels (in part in the form of alms to mother church) and hence more prayer to create more effective seals. There was a similar popular response in 1734 AD when the salt preserved body of a man wearing mountain clothing (likely a salt miner) was discovered. Fearful locals, once again encouraged by the local clergy, insisted on immediate reburyal with no further scientific study or observations on the remains (Aufderheide, 2011).

In Iran, first in the winter of 1993 and later in 2004, in the modern Chehr Abad Salt Mine, near Hamzeholoo, Zanjan Province, a total five salt-preserved male bodies were found in a collapsed tunnel of a former salt mine, which was active around 400 BC. The first discovery in the winter of 1993 was a salt encased bearded head and some artefacts, the later discovery, beginning in November 2004, was of the remaining bodies. It is likely all five men died in earthquake induced collapses in the salt mine (Pollard et al., 2008). Encasement in the hyperarid atmosphere of the collapsed salt mine tunnel led to natural mummification of the bodies.

Salt and war
Salt’s historical use as a food preservative, along with its medicinal use, made it a valuable commodity with political and military significance. The earliest recorded war over access to a supply of salt was over a salt lake in China in 3000 BC. In 2200 BC the Chinese emperor Hsia Yua declared that Shandong Province must supply the Imperial Court with salt. An ancient Chinese philosopher once called salt “the sweetest thing on earth.” The words, “war” and “peace” originate from the words for salt and bread in ancient Hebrew and Arabic, while from the Latin “sal,” came words such as “sauce” and “sausage.”

As an example of salt’s military import let’s look at the significance of a reliable salt supply to the army of the Old South in the 1860s during the American Civil War. Each Confederate soldier was provided with starch (26 pounds of coarse meal, 7 pounds of flour or biscuit, 3 pounds of rice), protein (10 pounds of bacon), and salt (one and a half pounds). Bacon was the meat of the South, and every pound of it required salt. As well as military personnel, horses also need salt in their diet. The Confederacy also needed this precious mineral to treat wounds, tan leather and dye cloth for uniforms. Last century, the historian Ella Lonn (1933) devoted an entire book to the problem of reliable salt supply for the Confederacy during the Civil War. We know that the Confederate soldiers were hungrier than the Northerners throughout the war. We shall never know whether the hogs that were not slaughtered because there was no salt to preserve them took the edge off the Confederate troops, or whether the salt that was not available for the horses took the edge off the cavalry. “What hogs we have to make our meat, we can’t get salt to salt it,” wrote Mrs Sarah Brown to Governor Pettus of Mississippi in December 1861. In 1862, Governor Brown of Georgia wrote that only half of the meat of the State could be saved for the 1862-1863 season.

That most intelligent and brutally efficient of the Northern Generals, Sherman, had no doubt about salt’s importance to any army and its morale, he considered it as important as gunpowder, he declared. “Without salt they cannot make bacon and salt beef,” and, “Salt is eminently contraband, because [of] its use in curing meats, without which armies cannot be subsisted.” Sherman sent a captain for trial on a charge of aiding the enemy, because he had allowed salt through the lines to the Confederates. The Union forces were sent orders to destroy salt stores and salt works wherever they were found (Figure 4). Throughout the American Civil War the South’s salt production facilities in Saltville, Va., Virginia’s Kanawha Valley and Avery Island, Louisiana, were targets of the Union Army. The North fought for 36 hours to capture Saltville, Va., where the salt works were considered so crucial that Confederate President Jefferson Davis offered to waive military service to anyone willing to tend coastal salt kettles and so supply the South’s war effort.

In November 1863, General Burnside noted in a despatch to Grant that Lee had placed a strong defensive force in front of Saltville [Virginia]. Grant understood the significance of the deployment. In December 1863 he wrote to General Foster, “If your troops can get as far as Saltville and destroy the works there, it will be an immense loss to the enemy.” In the event, the Confederates guarded the works so well that the Union Army did not take (and destroy) the salt works until December 1864. General Burbridge boasted that the loss of Saltville would be “more
afelt by the enemy than the loss of Richmond." Meanwhile the North, even with salt sources of its own, imported 86,208 tons of salt from England in 1864 alone.

Likewise, thousands of Napoleon’s troops died during his retreat from Moscow, because for lack of salt their wounds would not heal.

Ancient salt production and its taxable value

Around 6,000 BC on the margins of Lake Yun Cheng in Northern China’s we see the first evidence of an industry designed to harvest and produce salt, via the evaporation of lake brines in purpose-built salt pans. In Europe, the first recorded industrial production of pan salt took place in Italy some 2500 years ago when Ancus Martius, one of the early Roman kings, began letting sea water into an enclosed basin, then allowing the sun to evaporate the water to create a salt residue. The importance that Rome attached to the salt works and port at Ostia was such that the main highway along which the salt was carried to Rome was called the Via Salaria. Like Venice after it, the city of Rome based much of its early commerce on trading salt. Special salt rations paid to early Roman soldiers were known as “salarium argentum”, the forerunner of the English word “salary.” With a near monopoly on supply to Rome, the traders in the port of Ostia raised the salt price so high that the state was forced to take over the industry in 506 BC.

When Julius Caesar landed in Britain in 55 BC, he brought his salinators with him, but found that even the backward Britons were extracting salt by pouring brine on to hot stones. The Romans, however, used iron pans in which they boiled the brine, and Caesar established a brine-based salt works in Cheshire and subsequently in other localities where ancient salt occurred at shallow depths. The towns in Britain where salt was made from brines extracted from shallow buried ancient salt beds can be distinguished to this day by the termination “wich”, an Anglo-Saxon descriptor for a place where salt was made and includes towns like Greenwich, Ipswich, Northwich and Middlewich. Likewise, within regions of shallow salt and brines in Austria and Germany, names containing “salz” and “halle,” such as Salzburg (“salt city”), Salzkammergut, Reichenhall, Halle, Hallein, and Halls, as well as the old Austrian/Polish province of Galicia, identify some of the salt-bearing areas.

Merchants in 12th-Century Timbuktu in Africa, the gateway to the Sahara Desert was the seat of renowned scholars, who valued salt extracted from salt lakes to north in the vicinity of Taoudenni, Mali, as highly as books or gold. The Taoudenni mines are located on the bed of an ancient erg-edge salt lake and have been actively quarried for more than a 1,000 years. Today, the miners use crude axes to dig pits that usually measure 5 m by 5 m with a depth down to around 4 m. The miners first remove up to 1.5 m of red clay overburden, in contrast to the salt miners in the Danakil who work at the active pan surface (see Salty Matters, 19 April, 2015). Then several layers of poor quality salt are removed before reaching three layers of high quality salt. The salt is cut into slabs that are 110 cm x 45 cm by 5 cm in thickness and weigh around 30 kg. Two of the high quality layers are of sufficient thickness to be split in half, so that 5 slabs can be produced from the three layers. Having removed the salt from the base area of the pit, the

Figure 4. Confederate Salt Works- Moremead City, North Carolina, USA. Destroyed by Union forces in 1862 during the American Civil War era as part of the strategy to deprive the South of salt for its armies.
miners excavate horizontally to create galleries from which additional slabs can be obtained. As each pit is exhausted, another is dug so there are now thousands of pits spread over a wide area on the lake. Over the centuries salt has been extracted from three distinct areas of the lake depression, with each successive area located further to the southwest. The areas can be clearly seen on satellite photographs (22.606519°E, 4.030660°S). Until recently salt was transported south by huge camel trains, now more and more salt is carried out by 4-wheel drive trucks, south to Timbuktu, on to the river port of Mopti (Figure 5). Among the nomadic tribes of the Sahara and Ethiopia’s Danakil Plains, salt carried by camel trains is still used occasionally as money or bartered for cash equivalent. When the camel trains of Mali carried the salt, each animal typically carried 4 blocks of salt. On reaching the salt market, three blocks sold off the back of each animal went to the camel train owners, and the profit of the sale of the remaining block to the salt miner.

In Tibet, Marco Polo noted that tiny cakes of salt, manufactured from salt lakes in the high plains of Tibet were pressed with images of the Grand Khan and used as coins. The ancient Maya made salt at Salinas de los Nueve Cerros, Guatemala, an area where natural salt springs flowed into a river gully, giving easy trading access to downstream customers (Figure 6). This site was the only large-scale source of salt for the interior Lowland Maya. Maya technology included solar evaporation and firing of brine from salt springs in special large ceramic bowls that are the largest receptacles ever found in any Maya sites.

The highly organized salt trade of China was observed by Marco Polo, who recorded that the major item of trade on the Yangtze River was salt, shipped upstream from the coast (especially from the city of Hangzhou) to the interior cities. The Chinese produced salt by many methods: they evaporated it, boiled seawater, and pumped brine from wells drilled into salt beds. Modern oil-drilling traces its roots back to Chinese methods of bamboo-based drilling technology that originally evolved for salt production from ancient subsurface brine sources (this will be the subject of a later blog).

Salt production, politics and taxes

Salt’s economic value has meant it has been taxed by governments from the ancient Chinese and Romans to governments of late medieval Europe to those of France, even up to the late 1940s. In 2200 BC the Chinese Emperor Hsia Yu levied a salt tax, which was one of the world’s first documented state taxes.

The Mediterranean and the rise of Venice

The great trading ports of the Mediterranean dealt in salt as well as spices and textiles. Not surprisingly, the greater of them, Genoa and Venice not only traded in salt, but fought for supremacy over the trade. Because of the hot dry summers and mild wet winters, salt can be made in a saltern or pan in almost any suit-
The vast wealth & arts of the Venetian Empire were derived from the creation of a salt cartel.

In Europe, Church and State vied for control of salt supply throughout the Middle Ages

able seashore flat or plain in the Mediterranean. So although it is possible to envisage a trader’s cartel from a specific geological region of shallow buried salt in Austria or England, it is much more difficult to control the production of salt in coastal salt-pans. So, in hindsight, it is surprising how effectively Genoa and especially Venice, managed to take control of Mediterranean salt production, as well as trading, across the 13th to 16th centuries. Genoa was positioned in the Western Mediterranean and Venice at the head of the Adriatic. Each used all its political and military strength to consolidate its local salt trade, and to encroach as far as possible on that of its rival. However, Venice was more organised politically, which translated into more ruthless and effective use of state power. And Venice made a conscious decision to concentrate on the salt trade, whereas to the Genoese it was just one of a set of potentially profitable cargoes. Where the two came into conflict over salt, the Venetians tended to win.

Venice managed to make a business out of control of the Adriatic salt trade. Venice owed some of its early wealth to the salt trade from salt works in its lagoon, and had a number of contracts with inland Italian cities in the 13th century to supply them with salt. The more that Venice came to control the salt trade in the Adriatic, the more the resulting profits were used by the city to subsidise other trading activities. Venetian traders delivering salt to the city were given bank credits, for example, allowing them to buy goods quickly. As the historian S. A. Adshead has written, “For the Venetians, salt was not a commodity among commodities... it greased the wheels of all the working parts and fuelled its motor”. The salt trade allowed Venetian traders to compete very effectively with their rivals across the board. Salt was “il vero fondamento del nostro stato” (The true foundation of our state).

Always, from their beginnings in the 5th Century, the Venetians were willing to exercise raw power to foster their control of salt. Prior to the rise of the Venetian State, the Roman salt-making center in the Adriatic was at Comacchio, a little north of Ravenna. After the fall of Rome, records of the 8th-century Lombard King Lutipold show that Comacchian salt was being shipped to all the major inland cities of Lombardy, through Ferrara, at least as far inland as Parma, Lodi, and Brescia. By 523 AD Venice was producing salt and in 932 AD the Venetians destroyed Camacchio. They burned the citadel, massacred the inhabitants, and carried off the survivors to Venice, where they had to swear an oath of loyalty to the Doge before they were released. The Venetians began to construct salt works on their own lagoon, and around 1028, we find the Doge of Venice giving permission for Chioggia to build more salines on the Venetian lagoon. However, it turned out that it was not as easy to build salt works in the relatively exposed, storm-prone lagoon of Venice as it had been at Comacchio, and it took a long time before salt production became really successful at Chioggia. Meanwhile, the city of Cervia, south of Ravenna, filled the salt production vacuum left by the destruction of Comacchio and Cervia was in full production at least by 965- 975 AD.

Around 1180, it was clear that Cervia and Chioggia were rivals for salt production, under the protection of Ravenna and Venice respectively. The Archbishop of Ravenna and the Doge of Venice now began exerting political pressure on the Adriatic salt market. Venice declared it illegal for Chioggia salt to be sold or shipped without a Venetian certificate, and Ravenna did the same for Cervia. The salt market was now out of the hands of merchants and in the hands of the politicians and the Catholic church. By 1234, war between Venice and Ravenna ended with a ban on any Ravenna (Cervia) salt being shipped northward, and Venetian galleys enforced the treaty.

Then, the Venetians went one logical step further: for all practical purposes they gave up trying to be salt producers, and instead concentrated on being (monopoly) salt traders. Between 1250 and 1280, they came more and more to be the dominant buyers of salt, which they then warehoused, shipped and sold (Figure 7). By the 1350s, no salt could move on a ship in the Adriatic unless it was a Venetian ship bound to or from Venice.

![Salt warehouse, (Punta Della Doga), Venice, Italy. These were purpose built strongholds (saloni) for salt storage that allowed the Venetians to control the Adriatic salt trade.](image-url)
A golden rule of Venetian policy was that all trade goods under their control must pass through Venice. As late as 1590 they were making an 81% mark-up on salt sold inland. But that was not always the case, sometimes, if it would foster trade in higher-value goods that would yield more profit, Venice sold salt at less than normal rates. All this activity was planned and supervised by a special State body, the Collegio del Sal. The rewards were staggering, and help to justify the tenacity and ruthlessness with which the Venetians operated the salt business. Typically, Venetian merchants bought salt for 1 ducat a ton, and it cost them about 3 ducats a ton to ship it to Venice. There they received a State subsidy of 8 ducats a ton. The State collected a tax as the salt left Venice, and after shipping to the customer, the selling price was roughly 33 ducats a ton. That was a profit worth fighting for! And it was not only the merchants who profited. Some of the State profits went to the architecture, sculpture, and paintings that remain today and make Venice so magnificent (Figure 7).

The Venetians had different methods for maintaining their trading monopoly. On the island of Pag, they would buy up all the salt that was not needed locally. It would then be shipped to Venice, warehoused and sold (at very high prices) to customers. At Muggia and Capodistria, the Venetians were given a fraction (about 10%) of the salt produced (presumably as protection money), but the locals were allowed to sell the other 90% only as long as it was carried overland, effectively limiting its value and the sales area.

As late as 1578, the Venetians destroyed the salt works at Trieste, and in the following twenty years were making an 80% profit on salt sold inland on the Lombardy plain. But around 1600, paradoxically with the defeat of the Turks at sea, shipping intensity in the Adriatic became too great for the Venetians to be able to maintain their monopoly by force. Their source of riches in the spice trade had also been cut off as the trade routes to India now passed around Africa, and so their shipping power and wealth declined.

Salt and wealth in inland Europe and the UK

Much of the salt supply of inland central and northern Europe came from the mining of shallowly buried ancient salt (Permian) or associated brines. The great salt extraction centre at Reichenhall, in southern Bavaria, was first operated in Roman times, but was destroyed later, possibly by Attila the Hun, but more likely by the German Odoacer. It was rebuilt in the early 7th Century by Saint Rupert of Salzburg (Figure 8) and became the concession of the Bishop of Salzburg, who derived a great deal of power and money from the salt trade. So mother Church promoted the “salt bishops” to Archbishops. About 1190, however, a competing salt works had opened at nearby Berchtesgaden, without the Archbishop’s approval, and a major quarrel between Church and State erupted, with the Archbishop and the Emperor in conflict. The Church lost, and in 1198 the Bavarian saltworks passed into the control of the Duke of Bavaria. Reichenhall’s production peaked at about this time, and it later lost out in competition with a new salt works opened to the south by the persistent Archbishops of Salzburg.

During that time it remained an important salt centre for several hundred more years and, even today, derives income from geotourism and from the therapeutic salt baths of Heilbaden.

Thwarted in Bavaria, the Archbishop of Salzburg turned to salt springs closer by, and so a new salt industry sprang up at Hallein, first mentioned in documents in 1232. By 1300 its production had outstripped that of Reichenhall, and as it was situated closer to the Danube, it was able to ship salt as far as Bohemia, as well as into Austria and Bavaria. The Archbishop gradually bought up shares in Hallein, and by the early 16th century he held them all. However, the crown of Bohemia passed into the Habsburg family, and from the early 1600s, the great market of Bohemia was closed to the Archbishop. The other Austrian salt works were small at first. In the Salzkammergut, salt springs emerged from horizontal tunnels in the valley sides, which, although the locals did not know it, were the ancient galleries into the old flooded salt mines that had been worked in prehistoric times. The salt works at Hall, in the Tyrol, provided a power base for its owners, who were the local Hapsburg Dukes from 1363. The Dukes
would sell salt to the Swiss, then use the profits to pay for the Hapsburg campaigns against the Swiss!

Salt production was always limited in Austria by shortages of fuel needed to extract salt by boiling brines. As the boiling houses consumed the local timber, they had to be moved, and fuel was a problem in salt manufacture in this region until modern times and the advent of highly mechanised mining operations. In 1770 there were purpose-built flumes running down the mountain sides, used not for water supply but to float down billets of timber for the boiling houses. Since fuel ran out at Hallstatt very early, the Emperor built a wooden pipeline to take the brine from the ancient mines down the valley to Ischland, on the way it crossed the Gosau Valley via a purpose-built bridge. Salt continued to play a significant role in the politics of the region after 1600, when it was produced by three major players, Austria, Bavaria, and the Archbishop of Salzburg. The Austrian Empire grew to include Bohemia and Moravia, and this salt-less region became a captive market for the Austrian salt producers, with substantial tax revenue accruing to the Habsburg Emperor. Salt production was considered a state monopoly and Salzmonopol was considered "the brightest jewel in the possession of the Hofkammer." By 1700 it provided some 10% of the total revenue of the state.

In times of military emergency the Habsburgs would regularly use the salt income as collateral for raising money quickly. They did it first when Bohemia revolted in 1618 in the Defenestration of Prague, and Protestant forces besieged Vienna. Emperor Ferdinand II mortgaged his salt revenues to pay for the Catholic army that saved Vienna and won the decisive battle of the White Mountain in 1620. Salt revenue from the Wieliczka salt mine paid the Polish army under King John Sobieski when it rescued Vienna from the Turkish siege of 1683. Interestingly, the Wieliczka salt revenue had earlier passed to the Habsburgs in return for their assistance to the Poles in the Swedish invasion of 1657. Salt was also a state monopoly in Bavaria. Both Austria and Bavaria sought to promote their own salt exports and protect their domestic markets from salt imports, hence there was a flourishing trade in contraband salt.

In 1611 the Archbishop of Salzburg was forced to market his salt through Bavaria, so the rivalry now had only two players. Given that Austria and Bavaria between them controlled all the major salt sources in Central Europe, it is difficult to understand why they did not cooperate to form a cartel. A brief agreement, the Rosenheimer Salt Trade Agreement, was set up in 1649, but lasted for only 40 years. The centrepiece of Bavarian foreign policy became a campaign to sell salt effectively to her western neighbours, given that Austria could sell hers throughout the growing Austro-Hungarian Empire. It is not a coincidence that Bavaria consistently fought on the French side against the Austrians in the War of the Spanish Succession in the early 1700s and during the Napoleonic Wars in the early 1800s.

On the British mainland, Mary Queen of Scots was perhaps the first head of state to have the idea of making salt a taxable source of governmental revenue. She granted a patent to an Italian to make salt in Scotland and then placed a heavy tax on it, which she appropriated to herself. Elizabeth, Queen of England, and Mary’s lifelong “dear sister” and eventual executioner, thought this an excellent idea and likewise taxed English salt making. Salt tax was a source of great resentment to everyone, English and Scots alike, and smuggling grew to alarming proportions. In 1775, the Earl of Duneldon wrote that every year in England, 10,000 people were arrested for salt smuggling. During Queen Anne’s reign, the salt tax rose to £30 a ton, an enormous amount of money in those days. The whole of England arose in rioting protest, with the result that the salt tax was finally abolished.

In Burgundy in the 1700s, salt was taxed at more than 100% as it came from the salt-works. This tax was extended to the whole of France when Burgundy was absorbed and the notorious salt tax “la gabelle” became a necessary input to the government’s finances. Cardinal Richelieu said that salt was as vital to France as American silver was to Spain. The repeal of the salt tax was a major goal of the revolutionaries of 1789. A few years later, as soon as he became Emperor, Napoleon restored the salt tax to pay for his foreign wars. The salt tax continued until 1945 to fund French government coffers.

It is said that income from a salt pan in southern Spain largely financed Columbus’ voyages. The Erie Canal, an engineering marvel that connected the Great Lakes to New York’s Hudson River in 1825, was called “the ditch that salt built” as salt taxes paid for half of the cost of construction. The “Great Hedge of India,” the mid-18th century colonial equivalent of the Great Wall of China, stretched 3,700 km from the western border of Punjab down to the Bay of Bengal. It was manned by 12,000 men and planted by the British to minimise salt smuggling into Bengal and so enforce the collection of the Indian salt tax. As late as the 1940s the people of India under the leadership of Mahatma Gandhi protested British taxes on salt supply. In 1930 Gandhi led a 200-mile march to the Arabian Ocean to symbolically collect untaxed salt for India’s poor.

Artisanal salt and culinary expectation

Today, halite is a cheaply-produced commodity extracted from the subsurface in mines, or salt solution plants, or produced at the surface in salt pans. In the production of table salt, processing, packaging and marketing are the major costs for most salt manufacturers. An interesting exception to the low sale price of modern table salt is the artisanal “Fleur de Sel de Geurande” a delicate gourmet form of white seashalt that is still hand-produced on fens along the coast of Brittany (Figure 9). It costs ≈US$40/kg and is produced by “paludiers” only on suitable summer days when halite rafts can be raked from the brine surface of specially maintained coastal salt pans, which are floored with grey clay. According to the local legend, salt flowers only form on hot days when the wind blows from the east (from the sea). It and the cheaper grey salt (sel gris), which is scraped from the pan floors and also prized by gourmands, has been produced this way in French coastal fens since Pre–Roman times. The flowers of salt is marketed as a “natural” product that contains all 84 trace elements and micronutrients found in the sea, and as being a natural source of potassium, calcium, copper, zinc and magnesium.
This halite product has an intense white color, with rigid crunchy crystalline structure and high moisture content giving it a distinct “feel on the tongue.” This is because “Fleur de Sel” is composed of clusters of halite rafts. These rafts formed on the brine surface, as a thin layer of floating salt crystals, which are harvested daily via raking and then placed on plastic sheets to dry in the sun, making it a highly labor intensive product (Figure 9). The flower of salt product is packed with no other processing, unlike what happens to industrially-produced sea salt that undergoes a process that typically consists of varying combinations of washing, centrifugation and drying by the heat of combustion, grinding and sieving. While large saltwork companies need several square kilometres for salt pan installations, a flower of salt product can be obtained in ponds with total areas smaller than 0.1 hectare.

There is a definite economic upside to the artisanal production of “flowers of salt.” Since it is a handmade product, small salterns can be constructed/operated by family groups, so offering a new or supplemental income source for low-income populations living in or near hypersaline strand line areas.

Impurities like clay are called grey spot or black spot in highly efficient mechanised salt production plants across the world and are considered undesirable in the processed end-product. To the cynical it says something about French marketing skills, and perhaps the gullibility of middle-class gourmands with too much money and time on their hands, that each year the gourmet industry successfully markets un-processed dirt-polluted salt (sel-gris) scraped from pan floors for top prices. We shall look deeper into the geological characteristics of various gourmet salt styles in a later essay.

The various untreated salt products from France, the Himalayas and elsewhere are typically marketed as a “natural organic” product, “completed untreated” so it retains all its “essential nutrients.” Such blanket claims from marketers targeting a moneyed, health-conscious and “new-age” mostly middle-class demographic, should at times be taken with a grain of salt. For example, some types of Himalayan “natural” salt produced from high altitude continental lakes in Tibet is iodine deficient. Its local use has led to high levels of cretinism and other thyroid problems in the local peasant population. Introduction of a “processed” iodised salt by the Chinese authorities is still met with resistance, yet such use of iodised salt in China has reduced goiter to 10% of previous levels in the Chinese population. For the similar reasons, “back to nature” and “organic” foods are increasingly popular in middle-class consumers of Australia. The associated resistance to the use of “iodised” salt and other processed products with iodine additives by urban new-age parents has lead to unhealthy levels of iodine depletion in preschool-age urban children, when tested in Melbourne and Sydney (Li et al., 2001; McDonnell et al., 2003). Likewise the use of natural “untreated” salt from Lake Magadi and Natron as a food additive has led to significant health problems (fluorosis) in the local population due to “naturally” high levels of fluorine in the harvested salt (Vuhahula et al., 2009).

Salt, social standing, religious superstition

Salt, because of its high value in the ancient world, has maintained both cultural and religious significance over more than three millennia. For example, in Medieval and Renaissance European kingdoms, easy access to salt during meals assigned social status. Intricately carved salt cellars would be placed on select tables within easy reach of those deemed worthy. Accordingly at any noble table, to be seated “below the salt” was to be seen as unworthy of access to such luxury (Figure 10).
From its value in its use as a preservative and food additive in the ancient pre-rationalist world, salt became a religious symbol, representing immutability and incorruptible purity. In many religions, salt is still included on the altar to represent purity, and it is mixed into holy water of various sects for the same reason. Ancient Greek worshippers consecrated salt in their rituals, for example the Vestal Virgins sprinkled all sacrificial animals with salt and flour. Salt was a token of permanence to both Jews of the Old Testament and Christians of the New Testament. To the Jews it came to signify the eternal covenant between Jews and Israel. Jewish temple offerings still include salt on the Sabbath and orthodox Jews still dip their bread in salt as a remembrance of those sacrifices. Covenants in both the Old and New Testaments were often sealed with salt, explaining the origin of the word “salvation.” In the Catholic Church, salt is used in a variety of purifying rituals. Jesus called his disciples “the Salt of the Earth”, a statement that was commemorated by the Catholic Church until Vatican II, by placing a small taste of salt on a baby’s lip at his or her baptism.

So to religious Christians, salt is a supernatural symbol of the permanent sanctity of Jesus and offers supposed protection for the superstitious. For example, salt is still used to make holy water and also the more powerful exercised water of the Roman Catholic Church. Salt is also used to make protective circles during exorcisms of demons. In the middle of the last millennia in Europe, salt was believed to provide defence against witches, witchcraft, demons, sprites, and the evil eye. It was a common belief that witches, and the animals they bewitched, could not eat anything salted. Inquisitors were advised by demonologists to protect themselves by wearing an amulet of salt, consecrated on Palm Sunday, along with other blessed herbs, pressed into a disk of blessed wax. Carrying a concealed packet of salt was said to ward off the evil eye as well. Another known talisman to ward off evil spirits was a jar of salt and a knife. Some people put salt and pepper in their left boot for good fortune. To ward off an evil witch, a peasant might throw salt outside the front door and lean a broom next to it. A passing witch would have to count the grains of salt and the blades of straw on the broom before she could do any harm.

Similarly, any waste of salt can be a portent of evil. In Leonardo Da Vinci’s famous painting, “The Last Supper,” Judas Escariot has just spilled a bowl of salt - a portent of evil and bad luck. In Buddhist tradition, salt repels evil spirits. It is also why in many Asian cultures it’s customary to throw salt over your shoulder before entering your house after a funeral: it scares off any evil spirits that may be clinging to your back. In the Christian tradition you should throw spilt salt over you left shoulder as, according to the Medieval Church, the devil or his demons reside behind or on your left shoulder, with your guardian angels on the right. In Hawaii and Samoa, sea salt is used for protection, both by placing salt in each of the four corners of the house and by poring salt on the door threshold to prevent any spirits from crossing into one’s home. Shinto religion also uses salt to purify an area. Before sumo wrestlers enter the ring for a match - which is actually an elaborate Shinto rite - a handful of salt is thrown into the centre to drive off malevolent spirits (Figure 11). In the American Southwest, the Pueblo worship the Salt Mother. Other native American tribes had significant restrictions on who was permitted to eat salt. Hopi legend holds that the angry Warrior Twins punished mankind by placing valuable salt deposits far from civilization, requiring hard work and bravery to harvest the precious mineral.

Chinese folklore credits the Phoenix with the discovery of salt. In Norse mythology the gods first came from a salty ice-block over the course of four days as the sacred cow, Auðumbla brought Búri the first god in Norse mythology, and grandfather of Odin, out of the salty ice block. In another creation myth, Tiamat is the symbol of the chaos of primordial creation in Mesopotamian religion (Sumerian, Assyrian, Akkadian and Babylonian). She is a primordial salty goddess of the ocean, mating with Apsu (the god of fresh water) to produce the younger gods. Her husband, Apsu, later makes war upon their children and is killed. When she, too, wars upon her husband’s murderers, she is then slain by Enki’s son, the storm-god Marduk. and the arch of the heavens and the earth were formed from her divided body. Records from the Middle Euphrates Hittite kingdom of Mari attest to the veneration of Hatta, the god of salt, through the erection of a statue to him by the city’s ruler, Zimri-Lim (Stackert, 2010). Among Hittite rituals, perhaps the best-known use of salt is one that parallels its use in various Mesopotamian curses: the First Hittite Soldier’s Oath employs salt within an analogical curse ritual against that soldier who would commit sedition. Ancient Greek worshippers also consecrated salt in their rituals.

Outcrops of diapiric salt masses can also have superstitious significance (Genesis 19:26); Lot’s wife was noted in the journals of Fulcher of Chartres (Chaplain to King Baldwin) who accompanied the crusader Baldwin I across the Dead Sea valley in December 1100 AD. In reality, the apophenic feature described as Lot’s wife is a 12m-high column of diapiric salt lying at the foot of the much larger Mt Sedom (Usdum) on the edge of the Dead Sea (Figure 12). It is one of a number of dissolitional remnants along the gypsum-capped cavernous edge of an outcropping diapir composed of Miocene salt, which makes up to core of Mount Sedom.
References


Figure 12. Lot’s wife is a pillar of salt. A) As a diapiric salt erosional remnant on the edge of Mt Sedom, given supernatural significance. B) As a Christian myth depicted in the Sodom and Gomorrah motif from the Nuremberg Chronicle by Hartmann Schedel, 1493. Note Lot’s wife, already transformed into a salt pillar, in the center.