

The salt production sites at Shuangwangcheng in Shouguang City, Shandong

Shandong Provincial Institute of Cultural Relics and Archaeology, Peking University Center for Chinese Archaeology, Shouguang City Cultural Relics Bureau, Shandong

Abstract

In 2008, the joint archaeological fieldwork team conducted excavations to three salt-making workshop remains (numbered 07, 014 and SS8) at Shuangwangcheng Site, Shouguang City. The excavations recovered intact salt-producing workshop units of the late Yinxu Period to the early Western Zhou Dynasty with clear structures and layouts: the brine wells, the salt furnaces, furnace shelters and the operating rooms attached to the salt furnaces and the brine ponds were arranged on the central axis which was the highest part of the site; the groups of settling ponds, evaporating ponds were arranged flanking them symmetrically. In addition, brine wells, salt furnaces, brine channels and filtering ditches of the Song and Yuan Dynasties were also recovered.

Keywords: salt industry and trade—history—Shang and Western Zhou Dynasties; salt-producing workshops; Shuangwangcheng Site (Shouguang City, Shandong).

Introduction

The salt production site cluster of Shuangwangcheng is located to the north of Koujiawu Village, south of Liugulu Village, and southwest of Linhai Park, in Yangkou Township, Shouguang City, Shandong. The sea coast is 27km to the northeast. After the discovery of a salt production site here in the summer of 2003, we undertook seven successive seasons of large-scale fieldwork, including survey, coring and excavation. The site cluster covers more than 30sq km and includes 83 loci, three of which date to the Middle Longshan, 76 date

to the Shang and Western Zhou period, four date to the Eastern Zhou, and six date to the Song to Yuan Dynasties. Shuangwangcheng is the largest known cluster of Shang-Zhou period salt-production debris along the southern coast of the Bohai Bay (Figure 1).

In 2008, we excavated 5000sq m concentrated at four loci where salt production workshop remains were known: Loci 07, 014A, 014B, and SS8. In what follows, we discuss the excavation results from 014A and 014B (Figure 2).

Shang-Zhou salt-production remains

1. Locus 014A

This locus is 70m long from north to south and 60m wide from east to west covering an area of approximately

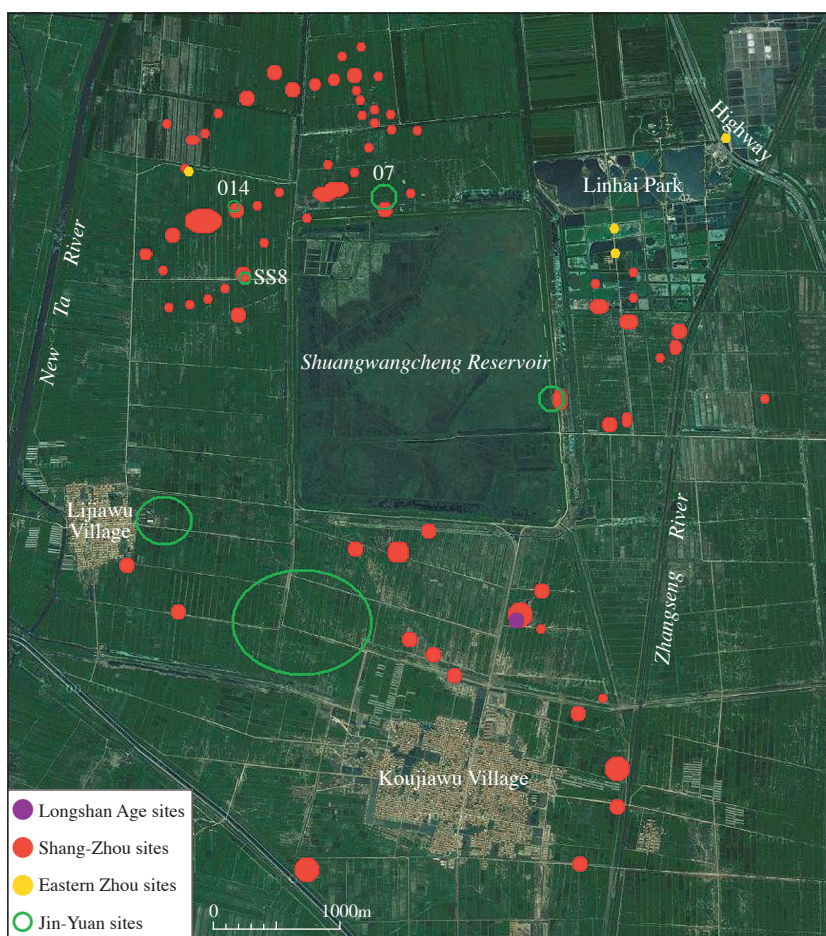


Figure 1 The distribution of the salt production sites at Shuangwangcheng (based on Google Earth picture).

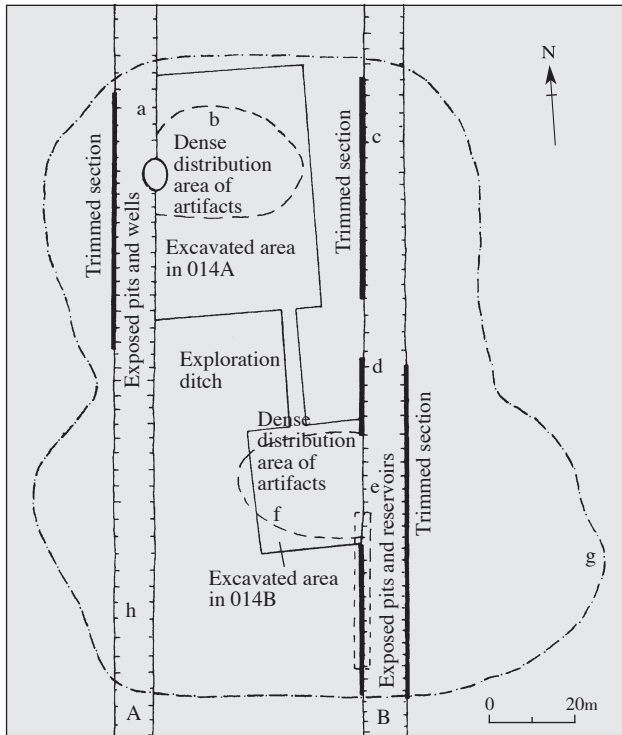


Figure 2 The plan of the excavation areas of Loci 014A and 014B in Shuangwangcheng Site.
A and B. modern ditches a-h. artifact concentration areas



Figure 4 The lower portion of brine well KJ1 (W-E, Shang-Zhou Period).

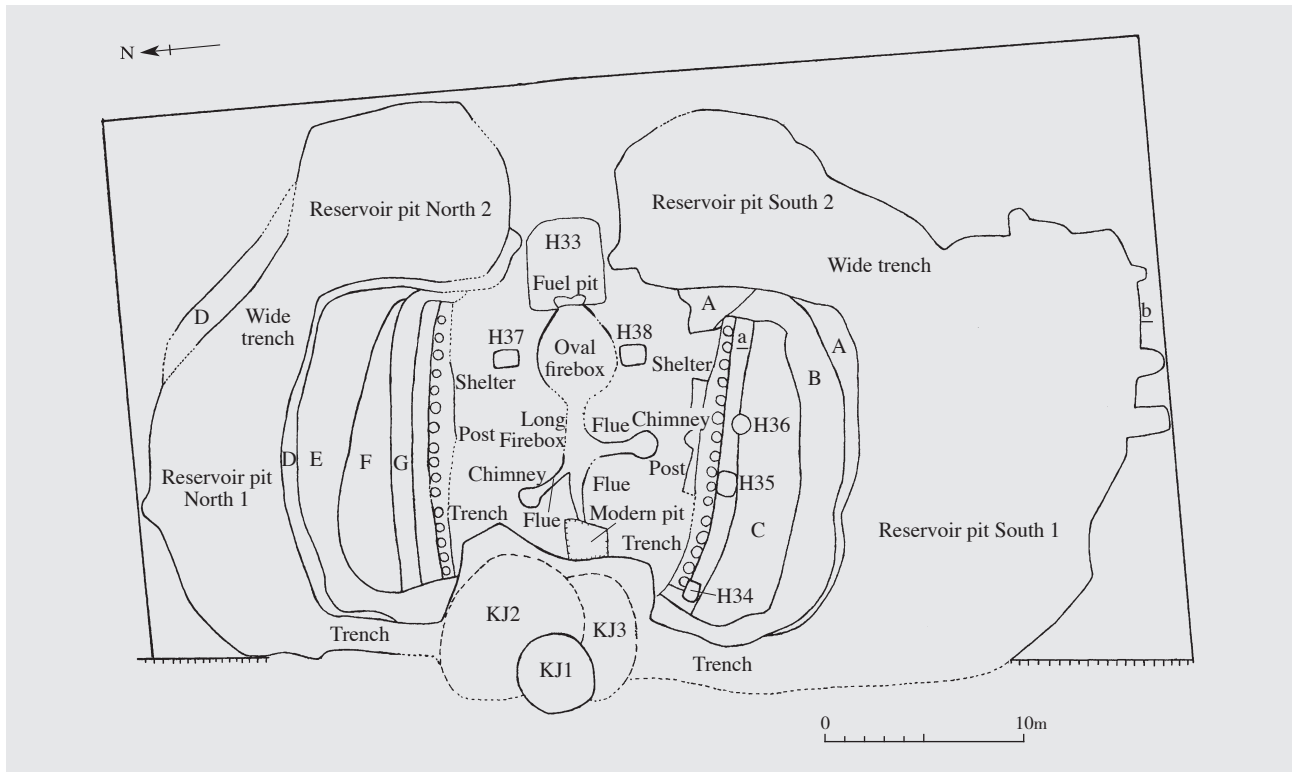


Figure 3 The plan of the Shang-Zhou salt production workshop remains at Locus 014A.
A, B and C. the reservoir pits South 3 to South 5 D, E, F and G. the reservoir pits North 3 to North 6

4000sq m. Here a relatively complete set of facilities for salt producing dating to the Shang-Zhou period was recovered. The various installations include: brine pits and wells, trenches, various reservoirs, large-scale firing facilities, brine storage pits, furnace shelter, operating room, and debris related to production and everyday life, as well as other building floors related to the production areas, cellars (ash pits), and water tanks for the use of the site occupants (Figure 3).

Brine pits and wells: These are found to the west of the central part of the salt production area and include three pits or wells (salt wells) of different periods (KJ1 to KJ3). The best preserved among them is the late period KJ1 well, which has a circular mouth 4.2 to 4.5m in diameter and is 3.5m deep. The lower part of the well is a cylinder lined with wood slats and reeds and the bottom has a reed matting to facilitate the seeping-in of salt water while preventing the collapse of the well walls (Figure 4).

Irregular shallow pits surrounded the pits and wells and each had trenches extending out of the north and south ends of the pit to the reservoirs to the north and south respectively.

Reservoirs: To the north and south groups of reservoir pits came to light. One group includes a large rectangular pit with curved sides, a mid-sized square pit with curved sides, and two associated wide trenches. Because these pits were continuously repaired and maintained, their distribution expanded outward. The earliest ones are intruded in by the later ones. To the north there are four partial groups (D, E, F and G), and to the south there are three groups (A, B and C), each from a slightly different period. The earliest examples are relatively deeper, while later ones are shallower. The larger reservoir pits located in both the north and the south (North 1 and South 1) are 130–350sq m in size and contains sandwiched fine white silt and dark brown clay strata. The mid-sized pits (North 2 and South 2) are located to the east of the larger pits and approximated 110sq m in size. They contain horizontal strata of grey-green silt sand, and each stratum has a thin, hard surface. These were probably the results of different episodes of activity. The silt and sand inside the north and south reservoir pits were each linked together which indicates that they were all part of the same facility. These pits were all constructed on top of a sand layer with a high proportion of clay and the pit bottoms were typically pounded firm, occasionally with an extra layer of clay added. The bottom was smooth, very hard and prevents seepage of liquid in or out.

Mapped by the total station, the features, from the trenches to the large reservoirs, the mid-sized pits, the terrain reveals a progressive decrease in elevation of more than 10cm between each of them. Based on the characteristics of the contents of the various components we can suggest that the large pits were used to settle the briny water and the mid-sized pits were used as evaporation basins as well as having the function of storing the brine. As for the hard surfaces found within the areas where salt water was left to precipitate and

evaporate, these were the result of calcium carbonate and magnesium coming out of solution as the salinity of the brine increased. The grey-green sand found in the evaporation basin may be also the result of increasing brine salinity causing the concentration and precipitation of some impurities.

Salt furnace and sheltered furnace areas: This was found on the central axis, east of the salt wells (Figure 2). Before construction, a large pit 20m long from east to west, 16m from north to south and 0.5m deep was dug first and clean grayish-brown clay was paved in this pit and processed hard layer by layer. On top of this paved ground, a hearth and brine storage pits were dug out in the central area, and foundation trenches for rows of posts were dug on each side for a shelter over the furnace (Figures 5 and 6).

The salt furnace consisted of an operating room (H33), fuel pit, a furnace entrance, a large oval firebox, long narrow firebox, three flues, and a circular area that acted as a chimney as well as two brine storage pits (H37 and H38). The furnace was 17.2m long in total, and 8.3m wide.

A small living area covering 30sq m is located in the southwestern part of the furnace shelter. The living floors can be divided into four strata. To the south of the shelter two cellars (H35 and H36) and a fresh-water tank (H34) are recovered.

2. Locus 014B

This locus is 6000sq m in size and located to the south of area 014A. We conducted investigations of the central portions of the site and uncovered a salt furnace, the furnace shelter, brine storage pits and related remains (Figures 7 and 8).

Other than the fact that a modern drainage ditch destroyed the operating room, the salt furnace is fairly well preserved. It has a furnace entrance, oval firebox, long firebox, long flues, and a circular chimney as well as two brine storage pits, one on either side. The remaining part of this furnace is 13m long and 9m wide (Figure 9).

The salt furnace and brine storage pits are built on a large 𠃑-shaped pit that is 13.2m long, 10m wide in the southeast, and 3.3m wide in the northwest. The pit that paved to create this foundation was 0.56m deep and was filled with yellow-brown sandy clay that was pounded firm layer by layer until it was quite hard.

The furnace entrance is dustpan-shaped with a wider west side and narrower eastern part. The western part gradually widens and links to the oval firebox and the area gets increasingly high from east to west. The base and the sides of the furnace entrance have been baked hard.

The oval firebox (A) is 4.5m long and 3.6m wide and somewhat bag-shaped, with a depth ranging from 50 to 70cm. In addition, a half crescent-shaped earthen terrace is found in the middle of the firebox. Within the firebox, most of the contents are red burnt earth and yellow-white chunky objects. Near the furnace entrance and the northern and southern walls the floor has been baked very hard whereas elsewhere it is softer. Also on both the

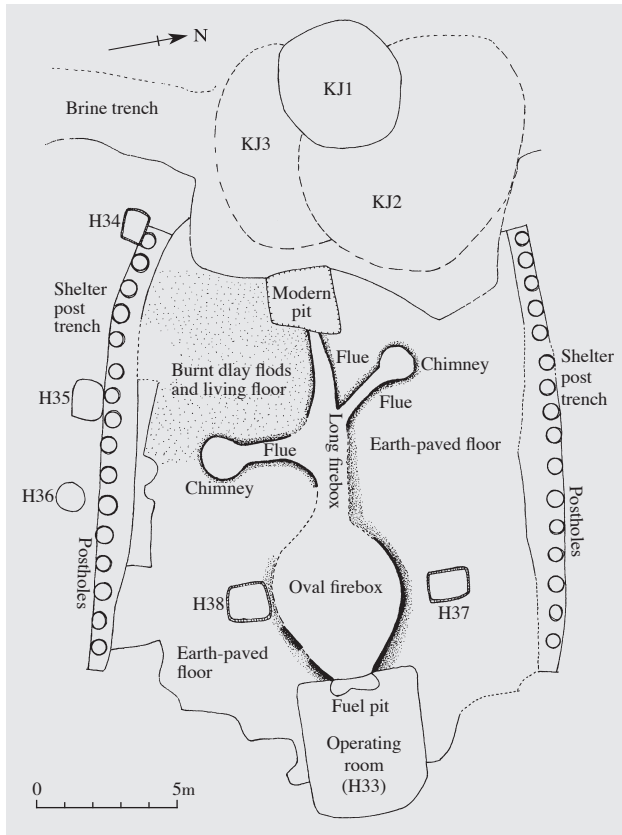


Figure 5 The plan of the salt furnace shelter and the related remains at 014A.

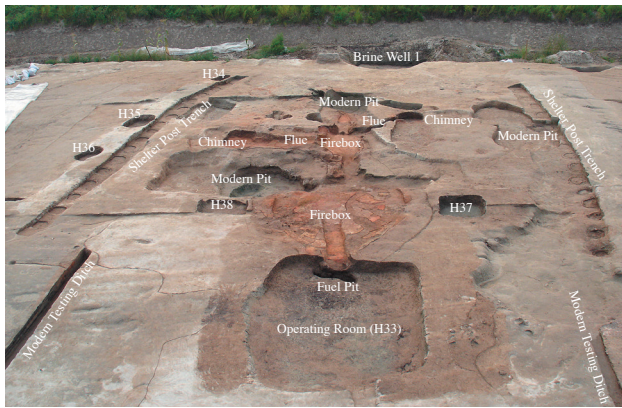


Figure 6 The salt furnace shelter and the related remains at 014A (E-W).

northern and southern sides near the walls there are faint remnants of ash and lenses of plant ash, which are clear evidence of past fires.

The long firebox (B) is connected to the chimney by a flue on the west and southwest respectively. The flues each are sloped upward to the chimney. The mouth of the chimney is circular, 1.1 to 1.2m in diameter and 60cm deep. The base of the chimney has a layer of ash that can be subdivided into eight separate lenses, which demonstrates that the flues and chimney were used

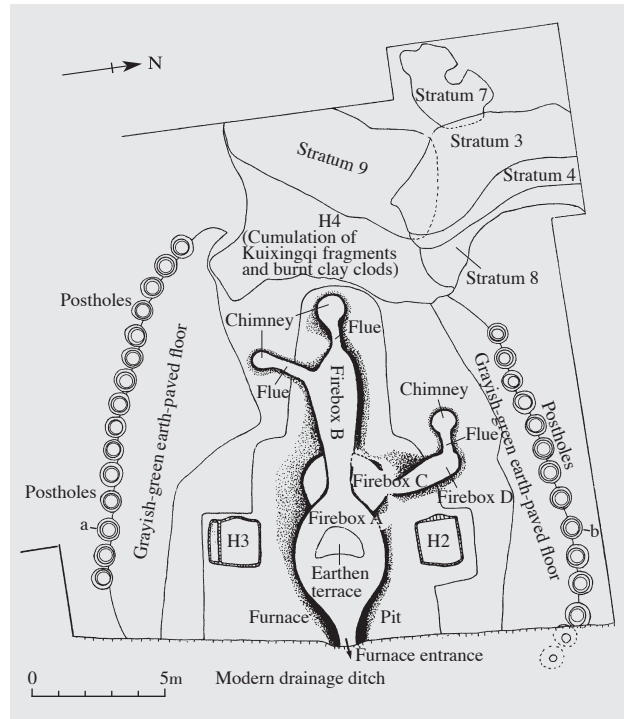


Figure 7 The plan of the salt furnace shelter and the related remains at 014B.



Figure 8 The salt furnace shelter and the related remains at 014B (N-S).



Figure 9 Salt furnace YZ1 at Locus 014B (E-W).

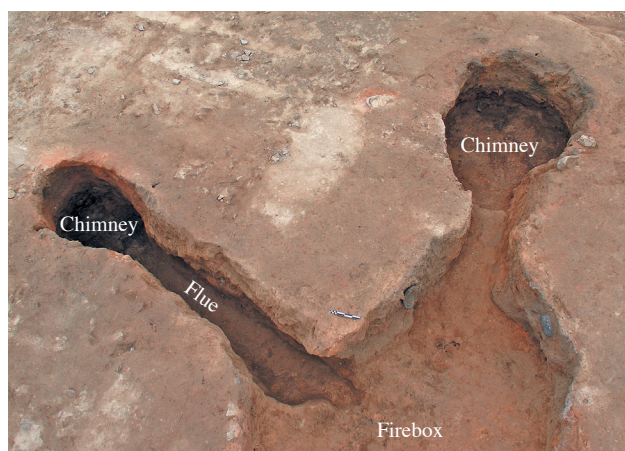


Figure 10 The flue and chimney of salt furnace YZ1 at Locus 014B (E-W).



Figure 11 The southwest chimney of YZ1 at Locus 014B and the ash on its bottom (NE-SW).

multiple times (Figures 10 and 11).

To the north and the south of the oval firebox there is a brine storage pit respectively (H2 and H3). These pits are rectangular with straight walls and flat bottoms. The walls and base are applied with a 5cm-thick layer of dark brown clay and grayish-green sandy soil. In several places, fragments of helmet-shaped pottery vessels (*kuixingqi*) were discovered adhering to the pit walls. These were evidence of attempts to make the walls hard and impermeable. At the base of the pits was a 5 to 10cm-thick layer of grayish-green silty sand on top of the brown clay which had been pounded firm. In the northern pit (H2), about 10 nearly complete helmet-shaped pottery vessels were found resting on top of the silty sand level, four of which were still adjacent to one another (Figure 12).

Furnace shelter: To the left and right of the salt furnace, two rows of postholes were found in arc-shaped wall foundation trenches which surround the area of the fireboxes, flues, chimney and brine storage pits. On both the northwest and southeast there would have been entrance and exit to the shelter. The shelter was in a



Figure 12 Brine storage pit H2 at Locus 014B (E-W).

trapezoid plan covering 200sq m in area.

Inside abandoned reservoir pits to the west of the furnace shelter and the salt furnace a concentrated level of fragmentary helmet-shaped pottery vessels and burnt earth chunks were found, probably debris from the production process. The abandoned reservoir pit to the south of the firebox came in contact with a thick layer of plant ash covering an area over 15m long and 10m wide which contained hard, conglomerated grayish-white chunky objects.

3. Important artifacts and their dates

Many salt production sites contain large numbers of tools like helmet-shaped pottery vessels (*kuixingqi*) used to boil brine (Figure 13), and small numbers of objects used for daily life such as other pottery vessels, grinding stones, shell-knives, etc. In addition, large amounts of plant ash, burnt earth, white or pale yellow chunks that result from the production process are also found at such sites as are small numbers of animal and plant remains related to the lives of those involved in the salt production process. Moreover, at the bottom of the salt wells found here, well preserved wood slats and reeds have been discovered. The white and pale yellow chunks have been analyzed and shown to be primarily composed of precipitation such as calcium carbonate and magnesium during the salt producing.

The helmet-shaped vessels (*kuixingqi*) at Shuangwangcheng comprise more than 95% of the pottery assemblage. Most are made of fine clay, although a few have a sand temper added. Nearly 90% of the helmet-shaped pottery vessels have white residue on the interior surface of the vessel. Furthermore, a considerable



Figure 13 The helmet-shaped pottery vessels (*kuixingqi*) unearthed from the Shang-Zhou salt production sites at Shuangwangcheng.

number of the helmet-shaped pottery vessels had red burnt daub made into the shape of round bottom stuck to their bottoms. Very few daily life vessels have been found. These include *li*-cauldrons, *yan*-steamers, *gui*-tureens, jars, urns, basins and *dou*-stemmed bowls. Among these, the *yan*-steamers were the most common.

Based on the helmet-shaped pottery vessels and the associated vessels, areas 014A and 014B should date to the period from Yinxu Phases III and IV to the early Western Zhou.

Salt-production remains of the Song and Yuan dynasties

Of this period, numerous salt production facilities including a total of six salt-wells, 30 salt furnaces, three brine trenches, four filter trenches, two pits for storing potassium nitrate, three semi-subterranean structures, and rectangular and circular pits have been excavated (Figures

14–17).

The wells and trenches for transporting and filtering brine are connected to one another. The wells are circular with diameters ranging around 4–5m. For 2m below the well mouth the walls of the wells are lined. The brine trenches are long and straight with flat bottoms 0.5 to 1m wide and 0.40 to 0.8m deep; their lengths are all more than 10m and the longest one is more than 30m (the recovered section). The filtering trenches for the brine are longer than 25m and are around 1m wide and deeper than 0.5m. The plan views of these trenches form arcs. On the bottoms of the trenches are distributed small rectangular pits in similar distance; they are filled with silt and silty sand. The brine transport trenches and the filtering trenches are connected in one direction and flow inclined away from each other in the opposing direction. Based on these aforementioned characteristics, these probably served a function of filtering the brine by allowing sand, silt and other precipitates to fall out of solution into the

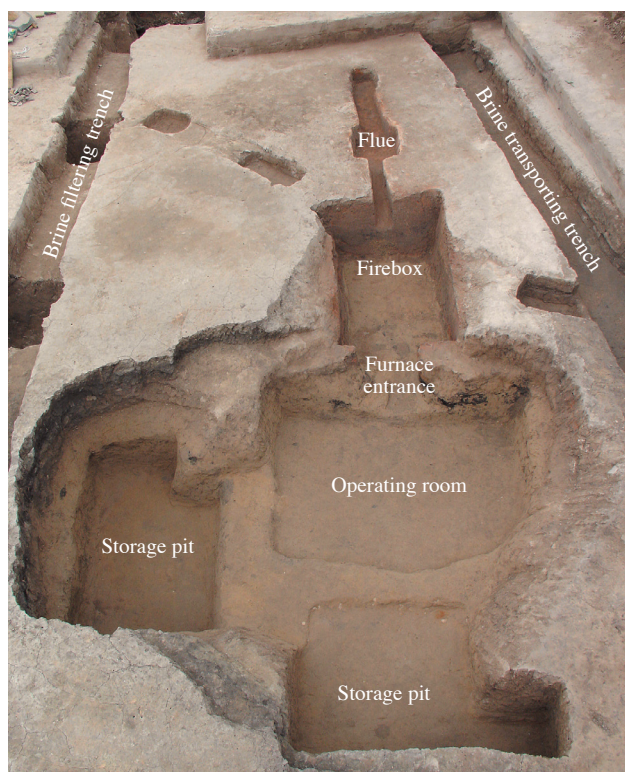


Figure 14 The salt furnace and the brine transporting and filtering trenches at Locus 014A (S–N, Song–Yuan Period).

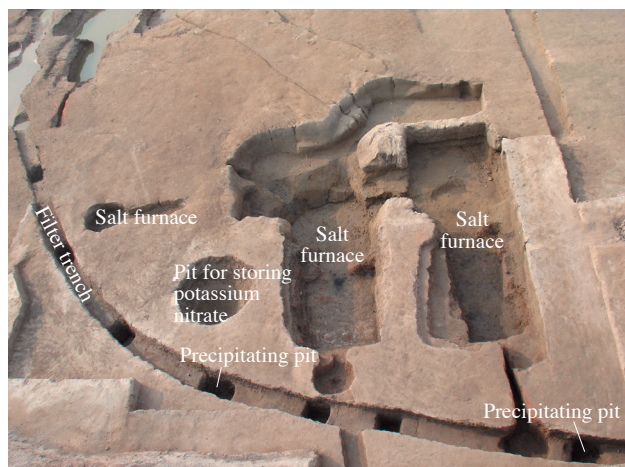


Figure 15 The salt furnaces, pits for storing potassium nitrate and filter trenches of the Song and Yuan Dynasties at Locus 014A (N–S).

small pits as the brine slowly flowed past.

The salt furnaces were mostly found on either side of the filtering channels. Typically two were lined up together in a group. They are all subterranean, constructed by first digging an operating room, firebox, store room, refuse pit and flue. Most are longer than 10m, although a few are shorter than 3m. The operating rooms are mostly square in shape, although a couple are

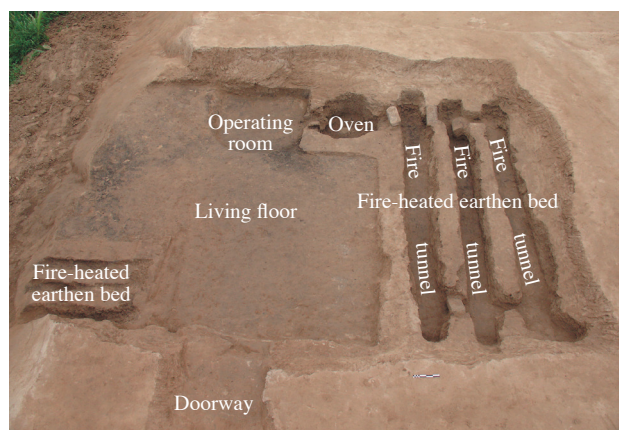


Figure 16 House foundation F1 at Locus 014B (S–N).

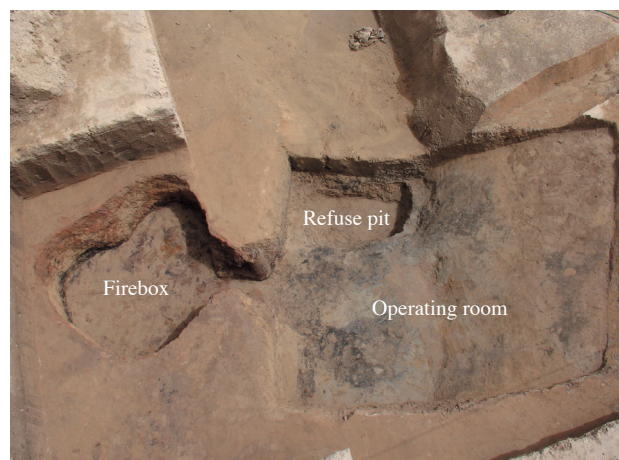


Figure 17 Salt furnace YZ10 at Locus 07 (S–N).

circular. Typically, near the firebox on one side a large vat was found in which brine would have been stored. The fireboxes can be divided into the rectangular and circular ones, the former being larger than the latter.

Conclusions

1. These excavations have first of all succeeded in exposing a Late Shang and Early Western Zhou salt production site. The basic structure of this site is as follows: brine wells, salt furnace, furnace shelter with an appended operating room and brine storage pits. These are located in the highest part of the surrounding terrain and formed the central axis of the site. The brine transporting trenches and reservoirs are symmetrically distributed on the north and south. The associated production debris includes fragmented helmet-shaped pottery vessels (*kuixingqi*), burnt earth, and plant ash dumped in empty areas around the production zone or in abandoned storage pits. A complete production area covers an area of about 2000sq m (not including the living area for workers and the area discarding life garbage). These features, including the brine wells, precipitation ponds, evaporation ponds,



large-scale salt furnaces, and furnace shelters are all the first such discoveries from the Shang-Zhou period.

We have a basic understanding to the Late Shang and Early Western Zhou salt production process of the southern Bohai Bay region. The source of the salt was highly saline underground saltwater. The saltwater obtained through wells was fed into transporting trenches and then into pits for precipitation and filtration. The brine underwent evaporation and purification, and was then transported into evaporation pits where wind and solar radiation increased the salinity of the brine even further. During this process, precipitates such as calcium carbonate and magnesium came out of solution and the salt water became purer. This pretreated brine was placed into storage pits on either side of the salt furnaces, and the salt workers built a framework above the oval and rectangular fireboxes on which they constructed a nest of grass and clay that was used to support helmet-shaped pottery vessels (*kuixingqi*). A fire was stoked in the firebox and brine was added to the helmet-shaped pottery vessels. As the brine in the vessels underwent evaporation, more was continually added. During this process, they would also have to have continuously skimmed impurities such as calcium carbonate of the top as they precipitated out of solution. Once the salt filled the helmet-shaped pottery vessels to the brim, the vessels would be broken, and the salt block was removed. According to our calculations, each salt furnace was approximately 30-40sq m in area of firing surface, which could hold 150 to 200 helmet-shaped pottery vessels densely packed. If each helmet-shaped pottery vessel could make a salt block of 2.5

to 3.5kg, every furnace would be able to produce more than 500kg per lighting.

2. The Song-Yuan period salt production at Shuangwangcheng is the first example of a salt production site from the Jin to Yuan period in coastal North China that has been excavated.

The Song-Yuan procedure for producing salt at the site is as follows: the salt workers obtained highly saline saltwater from wells and moved it into channels for transportation and filtration. During the movement in the channels, silt and sand would settle into small rectangular pits in the channels and the brine became increasingly pure. The purified brine was placed in vats near the salt furnaces and then moved into large iron basins or woks that were placed on top of the furnaces which were heated to evaporate the salt out of solution. During the boiling process, impurities that came out of solution would be skimmed off the top of the boiling solution. According to the size of the furnace, each basin might have produced more than 50kg of salt, and each wok might have produced between 10 to 15kg or so.

Postscript

The original report published in *Kaogu* 考古 2010. 3: 18-36 with 16 illustrations and seven plates was written by Yan Shengdong 燕生东, Dang Hao 党浩 and Wang Shougong 王守功. This abridged version is prepared by Yan Shengdong and translated into English by Rowan Flad 傅罗文.

