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Excavations at Harmony Borax Works

Historical Archeology at Death Valley National Monument

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Harmony Borax Works



Harmony Borax Works About 1885

Photo Courtesy
U.S. Borax &
Chemical Co.

Excavations at Harmony Borax Works

Historical Archeology at Death Valley National Monument

By
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and
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Contributions by
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PREFACE AND ACKNOWLEDGEMENTS

During the late summer of 1976 planning was begun for excavations at Harmony Borax Works in Death Valley National Monument. Excavation was needed to precede stabilization work programmed for 1977. A field party directed by George Teague, with assistance from Lynette Shenk and Boyd Dixon, took to the field on the first of October, 1976. Field work continued through the middle of November. Analysis and report writing were done from November, 1976, through April, 1977.

It is a pleasure to thank the many people who made this job easier than it might have been.

Ivan Phillips, of the California Division of Forestry, provided, under contract, a splendid excavation crew. Members of this crew were Rick Glover, Robert Caplinger, Will Crljenko, Terence Oviatt, and Guy Van Ness. Their interest and hard work was much appreciated.

Support from Donald Spalding, superintendent of the monument, and his staff, was outstanding. Many courtesies and kindnesses were extended us, but we would like especially to thank Karen Donaldson, Earl Polda, and Dick Raynor for their helpfulness.

Early in the project we were visited by Dean Lemon, of U.S. Borax and Chemical Corporation, and Vincent Morgan, a retired U.S. Borax chemist. Their many perceptive comments pertaining to borax production helped steer us in the right directions. Morgan's interest was sufficient that he went on to write an appendix and a portion of Chapter 7 of this report. The U.S. Borax plant at Boron, California, kindly provided analysis of soil samples from Harmony, for which we are grateful.

Other visitors to our project were William and Edith Wallace, who had done preliminary excavation at Harmony during the 1971-1972 winter season. They graciously provided us with their original field notes and maps, and allowed us access to artifacts they had recovered.

A considerable debt is owed to the work of Robert Herskovitz and Charles Sternberg, who recorded and mapped features at Harmony during 1975. Herskovitz produced a descriptive manuscript of their work, accompanied by 19 large-scale Sternberg maps and drawings. We used these in the field and found them extraordinarily accurate. Sternberg has redrafted eight of these (Figs. 8, 10, 11, 16, 17, 19, 29, and 34), with additions from our work. In addition, he has drawn five new plans and elevations (Figs. 4, 9, 18, 28, and 39).

Other drawings in this report are by Bridgid Sullivan, who drafted the area location map, the flow diagram, and the striking line drawings of artifacts and plant reconstructions (Figs. 1, 6, 7, 35, 36, 37, 38, and 40).

The frontispiece was provided by U.S. Borax & Chemical Corporation and the photo of the Harmony plant before stabilization was found in the monument files. The latter, attributed to E. C. Menning, gives a better perspective of the plant than the photos we took.

The proximity of University of Arizona to the Western Archeological Center enabled us to avail ourselves of the knowledge of specialists such as Sharon Urban, on shell, Lynn Teague, on textiles, and Jim Hewitt, on animal bones. Jeffrey Zauderer did the botanical identifications.

Tracy Andrews and Susan Brew are gratefully acknowledged for archival research. We are equally grateful to Sally Tobola for doing quickly a demanding job of typing. Carolyn Neithammer is to be commended for her professional and unruffled approach to editing. Additional editing and proofreading were provided by John Bancroft.

Special thanks are due to Keith Anderson for his guidance of this project through all phases.

Tucson, Arizona
May, 1977

GAT and LOS

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Chapter 1 INTRODUCTION

How to Use This Report

Archeological work carried out at Harmony Borax Works in Death Valley during the fall of 1976 was prompted by proposed management activities which include stabilization of ruins and replacement of fencing.

In order to satisfy a variety of reader interests, this report of our investigations and conclusions is constructed so that each section can stand alone. For example, a management summary in the last chapter will save planners the inconvenience of plodding through an entire report to extract recommendations. Those interested in anthropological or historical accounts will find them along with substantiating documentation. Finally, those whose interests lie in buttons or borax processing can have their curiosity satisfied by reference to appropriate chapters.

The project summary, given in the last chapter, attempts to be a genuine summary, rather than a catch-all for bits and pieces that wouldn't fit elsewhere. By referring to this chapter, and to illustrations in the text, the substance of the project can be quickly understood.

Background in Brief

Harmony Borax Works was the central feature in the opening of Death Valley and the subsequent popularity of the Furnace Creek area. The plant and associated townsite played an important role in Death Valley history. A map of Death Valley and environs appears as Figure 1.

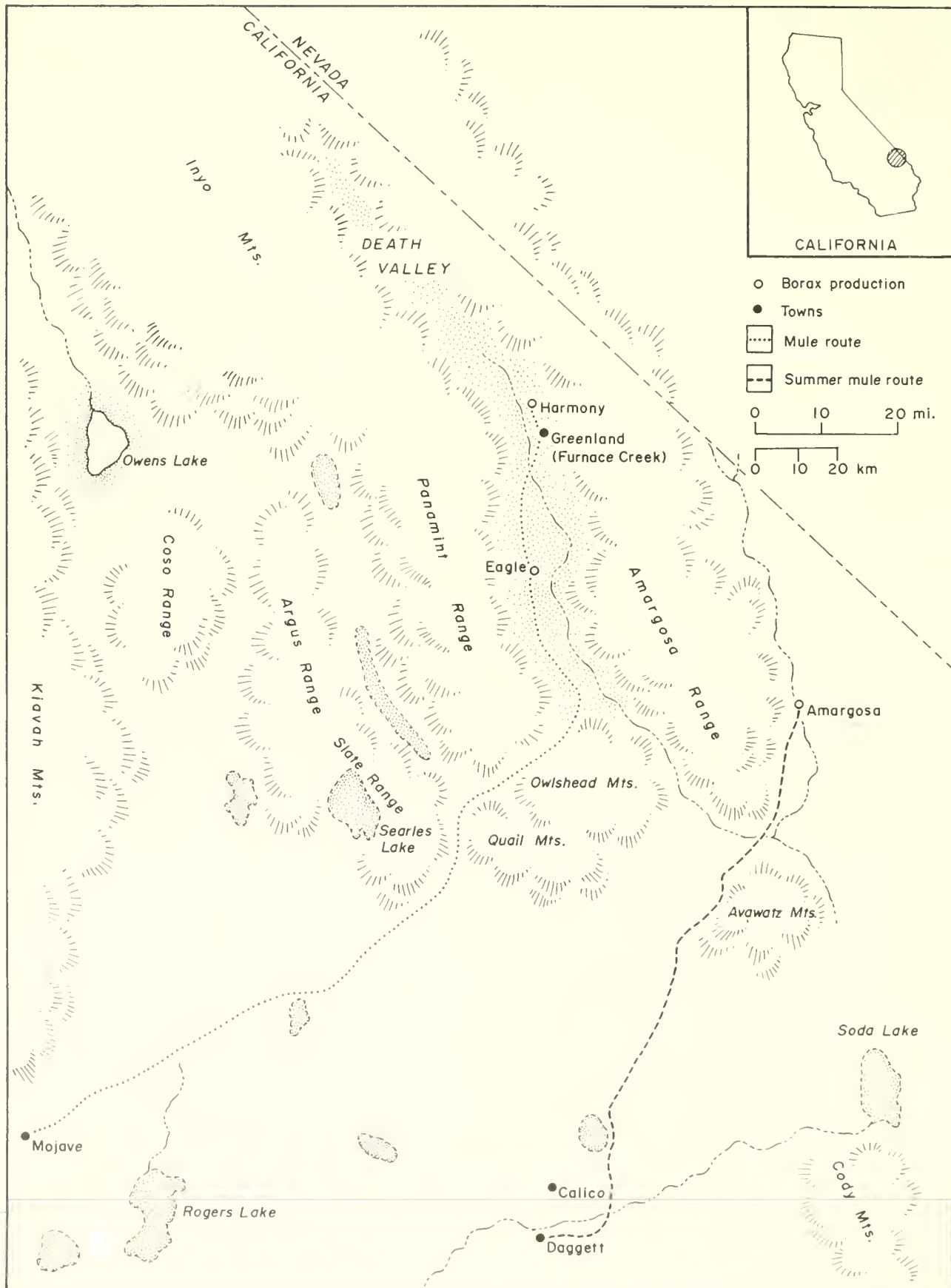


Figure 1. Location of Harmony and related area.

After borax was found near Furnace Creek Ranch (then called Greenland) in 1881, W. T. Coleman built the Harmony plant and began to process ore in late 1883 or early 1884. When in full operation, the Harmony Borax Works employed 40 men who produced three tons of borax daily. During the summer months, when the weather was so hot that processing water would not cool enough to permit the suspended borax to crystallize, Coleman moved his work force to the Amargosa Borax Plant near present day Tecopa, California (Holland and Simmonds 1971: 25).

Getting the finished product to market from the heart of Death Valley was a difficult task, and an efficient method had to be devised. The Harmony operation became famous through the use of large mule teams and double wagons which hauled borax the long overland route to Mojave. The romantic image of the "20-mule team" persists to this day and has become the symbol of the borax industry in this country.

The Harmony plant went out of operation in 1888, after only five years of production, when Coleman's financial empire collapsed. Acquired by Frank M. Smith, the works never resumed the boiling of cottonball borate ore, and in time became part of the borax reserves of the Pacific Coast Borax Company and its successors. On December 31, 1974, the site was placed on the National Register of Historic Places.

At present the Borax Works plant consists of a four-level ruin situated against a hillside. There are remains of buildings, machinery, tanks, piping, and waste tailings. In addition to the plant proper, a nearby townsite contains remnants of buildings and trash dumps relating to the company settlement. The entire complex is referred to as "Harmony Borax Works," or simply as "Harmony."

Justification of the Research

The Harmony excavations can be seen as a kind of "applied archeology" (Keller 1970). The foremost aim of this project was to satisfy Federal requirements regarding preservation of historic

structures by recovering information endangered by proposed stabilization and alteration of the Harmony ruins.

The excavations were unusual, or at least non-traditional, in other ways. Only lately have archeologists concerned themselves with the very recent past and only lately have the remains of industrial operations been of interest to archeologists. Nonetheless, such investigations can produce valuable results, as we hope is demonstrated in our findings here.

The Importance of Preservation Archeology

Preservation archeology, at least in the restricted use of the term here, refers to research done to lessen the harmful effects of ruins preservation. Another term for this is "prestabilization archeology."

A major management requirement within parks is that of ruins maintenance and preservation (National Park Service 1973). This frequently entails ruins stabilization procedures to prevent further deterioration of decaying structures. It is important to realize that along with all the benefits that accrue through stabilization there are disadvantages. When sites are stabilized, architectural and structural features often are disassembled, disturbed, or otherwise altered. Many times undisturbed archeological deposits have to be removed in order to provide access to wall bases. Unfortunately, information contained in these deposits may be, and often has been, lost.

Because of these hazards, current management policy requires that appropriate research precede all stabilization (National Park Service 1975). Research of this kind is frequently done by the Western Archeological Center (see Gilman 1976; Gregory 1975). By digging, collecting, or recording cultural resources, the archeologist provides a valuable service in the preservation of information about the past.

The Importance of Historical Archeology

As Deetz (1971: 208) has pointed out, archeology until very recently has been thought of as having to do with the old, the buried, and the exotic. In the past few decades, however, archeological investigations of historical remains have been much more frequent. In the United States, historical archeology has fallen under the parent disciplines of both history and anthropology, and as a result, reflects the interests of both of those fields (McKay 1975: 129).

Historical archeology allows the anthropologist to refine his techniques and to do primary research simultaneously. As Willey and others (1956: 25) have stated, the excavation of historical sites can provide a sound basis for interpreting prehistoric sites. At the same time, research in such significant matters as rates of culture change can be accomplished (see Deetz 1962; White 1975).

For the historian, historical archeology has the obvious potential for supplementing historical records and aiding historical reconstructions. In addition, the value of historical archeology may go far beyond this. In an engaging and persuasive article, Ascher (1974) argues that archeologists have developed a peculiar way of seeing things. This newly found perspective will, he believes, allow us to uncover the history of the ordinary man as well as the history of the technological world.

Little is known about the ordinary American of the past. As Jesse Lemisch has pointed out, "The history of the powerless, the inarticulate, the poor has not yet begun to be written because they have been treated no more fairly by historians than they have been treated by their contemporaries" (1970: 29, quoted in Ascher 1974: 11). The prospect of learning this history is intriguing.

To sum up, historical archeology offers insights into both the past and the present. Anthropological models of culture change, relevant to understanding prehistory as well as current social situations, can be devised through historical archeology. At the same time, the historical record can be augmented and refined.

The Importance of Industrial Archeology

In a sense, all archeology of the very recent past is industrial, in that most artifacts and other remains reflect the procedures of mass-manufacturing. However, the term "industrial archeology" has provoked a certain amount of discomfort and debate (Foley 1968, 1969; Vogel 1969). A good definition has been offered by Kenneth Hudson, who says simply that industrial archeology is the "organized, disciplined study of the remains of yesterday's industries . . ." (1966: 21).

While all industrial archeologists would probably like to be organized and disciplined, there are differences in study procedures. One approach, which we will call the historical, involves composing records of industrial works. These records apparently are made with no other goal in mind than to procure data which would otherwise be lost. Examples of this approach can be found in articles by Abrash (1974) and Todd (1970).

While protecting data from loss is certainly praiseworthy, we suggest that accumulation of data is insufficient in itself. Lewis Mumford has argued against ". . . the belief that technological history can be adequately described without reference to its social context . . ." (1961: 232). Harking back to the hoary dictum that "American archeology is anthropology or it is nothing" (Willey and Phillips 1958: 2), we must conclude that thus far American industrial archeology has fallen short of its promise.

The alternate, anthropological, approach holds considerable promise for integrating the social with the technological. Recently, archeologists have been nibbling at the fringes of such reconstructions by correlating industrial archeology, archival documentation, photography, and oral history. An excellent example of this kind of work can be found in an article by Schuyler and Mills (1976). With further studies of this sort, we may in time come to a better understanding of man's place in a man-made world.

Another, and more concrete, application of industrial archeology is to the reconstruction of past technological processes.

Reconstructions of this sort may prove to be of more than academic interest. Much of the world cannot afford the high technology of Western industry and would profit by knowledge of low and intermediate technologies of the past (see Schumacher 1973 for a discussion of intermediate technology). Reports such as this one should prove of value to people who want to develop industry depending largely on human labor and local resources.

Chapter 2

RESEARCH PROGRAM

Introduction

Excavations at Harmony were challenging for several reasons. Paradoxically, the site is archeologically complex because it was occupied so recently and for such a short period of time. Many cultural remnants are above ground and the remainder are near the present ground surface. Artifacts and features have been disturbed time and again by natural and man-related activities such as erosion and road grading.

We are also dealing with an occupation of less than five years and, even at that, the site was uninhabited during the hot summer months. Consequently, cultural remains are sparse and do not reflect the seasonal range of human activities. Further, the townsite represents a company settlement which was, for the most part, male-oriented, so that the full range of social interaction is not represented.

A constraint to research at Harmony was the need to keep site disturbances to a minimum (National Park Service 1963). As we understand it, prestabilization activities which require digging should be confined to those places which will be disturbed by stabilization. Other small-scale excavations and collections can, however, be made for comparative purposes.

Given all of these restrictions, it was even more critical than usual that an explicit program of research be designed before the start of excavations.

Designing the Research: Management Concerns

Recommendations made by Holland and Simmonds in their 1971 report were the first in a series of proposals for altering Harmony. Recommendations included stabilization of standing ruins, reestablishment of historic grades, obliteration of non-historic features, and reconstruction of the barn-like structure which once stood in front of the plant.

Proposals changed through the following five years according to changes in policy and staff. Emergency stabilization of the plant and of Adobes A and B took place in 1976. Later that year, a new parking lot was built and the old one directly in front of the plant was closed to all but foot traffic.

Our project was designed to mitigate the adverse effects of basic stabilization programmed for 1977, and to provide information about the effects of other proposed work, which included restoration of the old parking lot to historic grade and removal of the cobble-based chainlink fence around the plant. In addition, we were asked about the feasibility of locating and restoring the wooden barn.

We, therefore, selected a number of excavation and collection units which would do the least damage and still allow us to salvage information and answer questions. The four terraced levels of the plant have been numbered from hill top to bottom as Tiers 1 through 4. Excavation and collection unit designations refer to location--whether within the area of the plant (P), Chinese quarters (C), or townsite (T)--followed by a sequential number and letter (subunit). Provenience designations and recording controls are defined later in this chapter.

According to Ruins Stabilization Unit personnel, stabilization needs centered around rebuilding the retaining wall by Dissolving Tank 1. This wall was badly deteriorated and it was possible that the tank would come tumbling down the hill if something was not done. The deterioration was caused by drainage from the tank, which, when filled by rain, emptied directly into the supporting

terrace and retaining wall. Several excavation units (P7A-D in Fig. 19) were planned to expose the retaining wall to its footings so it could be rebuilt. During excavation we discovered a board wall on the north edge of the P7 units and exposed it by digging Units P9A-D. This exposure was necessary so the board wall could be reconstructed, adding needed support to the upper terrace. Units P6A-B, to the rear of Dissolving Tank 1, were selected to check the extent of below-tank erosion. Unit P8 was planned to clear an area where pipe could be laid. This pipe was designed to provide drainage from the dissolving tank, across Units P7A and P9A, along the Tier 2 retaining wall, and then through the P8 trench to the gully west of the plant.

Units P11A-B and P17 on Tier 3 were selected to expose sections of the upper tier retaining wall. These sections were badly eroded and required rebuilding. The same requirements dictated the placement of Units P17A-E along the base of the boiler terrace cobble retaining wall. Wall bases had to be exposed by Units P4A and P5A-C to determine the extent of basal erosion in the adobe machine room. P4A was expanded by Unit P3.

On Tier 4, the P12, P13, and P18 units were selected to check stability of the suspected E-W cobble retaining wall. Five units (P1, P2, P10, P14 and P15) were placed adjacent to the chainlink fence to find out the extent of intact deposits which might be disturbed by fence removal.

The stabilization team planned to obliterate paths in the skimmings pile (P20) and wood storage area (P19) to the west and east of the plant. Soil and botanical samples were collected every 2 m along the central axes of these features.

In the old parking lot, two trenches, comprising Units P21A-C, P22A-E, and P24A-F, were dug to determine the historic grade line and to ascertain the integrity of deposits.

Three other plant-related features were investigated. A 1 square meter test pit (P23B1) was sunk into the center of the tailings pond to obtain comparative soil samples. Units P25 and

P26 are mapping units out in the salt marsh. These units encompass two wood and iron features which may relate to the plant occupation. While recording these features was not in aid of stabilization, the information gained was useful, time expenditure was insignificant, and disturbance was nil.

In the townsite, small portions of Adobes A and B had eroded and required rebuilding. The bases of two walls in Adobe A and one wall in Adobe B were exposed by excavation. Units T4A and T4B were dug in Adobe A. Unit T5A was dug in Adobe B (Figs. 29 and 34). In addition to excavation, intensive surface collections were made around the adobes in order to clear the immediate areas so that trucks and mixing equipment could work near the structures without destroying information contained in surface trash scatters. Unit T2 is located around Adobe A and comprises 900 square meters. Unit T3 encompasses Adobe B and includes 400 square meters.

Three other collection units were laid out. These units were not directly in support of stabilization, but were needed to provide comparative data for use in evaluating the samples we were required to collect. These other units are C1 and C2, in the area that Wallace (1972) called the Chinese quarters, and Unit T1, a refuse dump near Adobe A. In collection units, plan view maps were made and all artifacts were recovered systematically. The collection subunit was the 2 m square.

We have detailed above why each excavation or collection unit was placed where it was to show that work was done only 1) to lessen data loss due to stabilization, 2) to provide information needed for management, or 3) to provide data for comparative purposes.

Designing the Research: Matters of Significance

Archeologists commonly begin by asking questions about the past and then selecting the method and procedures which will most efficiently allow a site to yield up its information. At Harmony, however, we were restricted largely to digging in places that were

to be affected by stabilization and site alteration, rather than those which were most likely to answer a broad range of questions.

The simple collection of data for its own sake is not an adequate reason for doing archeology. Archeologists have for some time seen the need for framing questions which go beyond the mere cataloguing of data. Important statements of this position were formulated some time ago (see, for example, Taylor 1948; Steward 1949).

To determine a set of productive research questions, we asked first, "What is the significance of the Harmony remains?", and then, "What questions can be fruitfully addressed by archeological work at Harmony?"

The significance of cultural resources, such as the Harmony ruins, may be assessed by reference to a variety of standards. To archeologists, the importance of archeological resources lies in their potential for yielding information relevant to the problems with which the profession is currently concerned. One of the criteria for inclusion in the National Register of Historic Places corresponds to this archeological conception of significance; any resources that have yielded, or are likely to yield, information important in prehistory or history are eligible for the register. Virtually any intact cultural resource fulfills this requirement and, indeed, the Harmony Borax Works has been included in the National Register.

There are basically two categories of significance attached to the Harmony ruins: historical and scientific. Historical significance is the potential for a resource to yield information pertinent to the identification of individual cultural groups, periods, or behavior patterns. Scovill, Gordon, and Anderson (1972: 13) interpret this as including resources which provide data useful in the identification and reconstruction of specific cultures, periods, lifeways, and events; those which provide a typical or well-preserved example of a prehistoric culture, historic tribe,

period of time or category of human activity; and those which can be associated with a specific event or aspect of history.

Scientific significance is the potential for information which is capable of contributing to the understanding and explanation of cultural phenomena. In contrast to historical significance, this involves the formulation of generalizations which can be tested. Within the archeological profession there are a broad range of research approaches. Major changes have occurred, and can be expected to continue to occur, in the ways in which archeological problems are defined and therefore in the variety of scientific contexts within which cultural resources may be considered significant.

Having satisfied ourselves that the Harmony ruins had significant potential for yielding historical and scientific information, we set about devising questions which could be answered by excavating the areas to be affected by stabilization and alteration. The distinction between historical and scientific (for which read "anthropological") significance will not be acceptable to some scholars. Nonetheless, we intend to adhere to this distinction as a matter of convenience. Historical and scientific concerns, as they apply to Harmony, will be detailed below.

Research Design

Goals and Systematics

The goals of any research are, first, to observe, measure, and describe, and then to order the data so they are comprehensible.

An efficient way to assure comprehension in the end is to ask specific questions at the outset. Never can all pertinent questions be addressed, but designed research assures that data appropriate to at least some concerns will be collected.

Questions can be formed in two ways. First, we may ask simply, "What was Building X used for?", with the expectation that digging up the remains will reveal artifacts and features pointing to function.

Another way to ask the same question is to put it hypothetically, with test implications:

If Building A was used as a kitchen, then the following will be the case:

- a. Kitchen-related artifacts will be found in primary association.
- b. Other artifacts will be few, unless the room had multiple functions.
- c. Architectural features will resemble those of known kitchens, and will include ovens and food preparation space.

This latter way of asking questions, known as the hypothetico-deductive (H-D) method, was seized upon with great fervor by archeologists in the past decade. A great many abuses of this method occurred, mainly because of misapprehension about what it could do. As Merrilee Salmon recently pointed out, the H-D method has no particular usefulness in either confirmation of archeological speculations or in explanation of cultural process; as used by archeologists it isn't even truly deductive (Salmon 1975; 1976).

Another source of abuse was in the confusion of the H-D method with another, and more powerful, method, the deductive-nomological (D-N) (see Morgan 1973; Watson and others 1971). D-N methodology, as described by Hempel (1965), requires the use of non-probabilistic covering laws in explanation of particular events, and has been of great utility in other disciplines. Unfortunately, its application to archeology thus far has been hampered by failure to identify non-trivial laws of this kind. There is, in fact, reason for skepticism about the applicability of such laws to human behavior.

Our concern here, however, was not so much with method as it was with rendering an accurate account of the archeological record at Harmony, and extracting from this record useful information. If our approach must be put in a pigeon-hole, then the model of inductive inference proposed by Platt (1964) will do as well as any. Questions asked were couched in hypothetical form when rigor was needed, and in narrative form when plain language would do.

Research Questions

Questions may be conveniently examined by first proposing a very general central hypothesis and then developing more specific corollary hypotheses. Our central hypothesis is that technology and resource utilization at Harmony are directly related to networks of communication and transportation and to patterns of social interaction between cultural groups. This hypothesis represents what is probably an undeniable, and fairly uninteresting, truth. Its virtue lies in allowing the field of inquiry to be narrowed to general problems regarding technology, environmental adaptation, and group interaction.

Fontana (1968b) has remarked, "as interesting as the problem of the biological emergence of man . . . is the relationship between man and his tools in this era of interchangeable parts." While much has been written in the past concerning the history of borax mining in California, most of this literature has been in terms of production rates, profit and loss, and labor statistics. Little has been noted about engineering problems, machinery, or variations in processing methods.

Only a few descriptions exist which attempt to explain the actual operational procedures followed at early borax mining facilities. Therefore, the first questions asked with regard to the Harmony operation were concerned with the technological basis of producing borax. We were particularly interested in interpreting the data in terms of two important conditions which affected the Harmony enterprise: its remoteness and the market value of the end product.

These two factors both played a role in the efficiency and thus the economic success of the operation. Besides the fact that the distance of the Death Valley mines from the railroad was detrimental to their profitable working, an 1885 report indicates that the price of borax was very low at this time, and steadily declining. We hoped to be able to comprehend the engineering and technological problems that contributed to making the site a going concern in the world borax market.

In addition, there has been, to date, no comprehensive assessment of how far and in what direction changes in mining technology progressed during the latter half of the 19th century. It is possible that the present study will be able to add information about this and about the technical processes which accounted for the rise or decline of such industrial undertakings. Of wider consequence is what this research may have to offer to those interested in the way man has changed his environment and in the machines by which he has accomplished the change.

We addressed technological problems by seeking specific data in the plant operations. Excavation units on the boiler terrace (Fig. 19) were monitored for answers to the following questions:

1. Are there indications of water sources other than the Texas Spring source?
2. Are there indications of structures other than those remaining above ground?
3. What was the function of the adobe structure? Was it used as a machine shed, for storage, or for other purposes?
4. Is the boiler terrace an artificial feature?
5. Is the north cobble wall an original or reconstructed feature?

From Tier 1 units we wanted to know the original grade line and the methods of tank and terrace construction.

From Tier 2 we wanted to know the construction methods and original grade line. Here we asked the following questions:

1. Is there evidence of settling tanks?
2. Was there a wooden platform in front of Dissolving Tank 1?
3. Are there remnants of drive line and winch footings?
4. Is there evidence of an ore cart track?

From the lower tiers, we sought answers to other questions:

1. What was the flow system?
2. Were solutions recycled?
3. Was machinery as well as gravity used to move solutions?

4. What was the extent of the ore cart track?
5. Where were the vats located?

In the old parking lot area we asked:

1. What was the original grade line?
2. Are there *in situ* features such as drain and vat bottoms?
3. Are there remnants of the old barn?

We hoped these specific questions, when answered, would allow reconstructions of plant operation, building and alteration sequences. Other questions were addressed by sampling the skimmings pile, wood storage area, and tailings pond. These questions relate to both technology and environmental adaptation.

The skimmings pile is a linear feature formed of grass skimmed from the dissolving tanks. This grass was inadvertently scooped up with borax ore when ore was mined in the salt marsh. With the grass are borates and other chemicals which were incidentally included when grass was taken from the dissolving tanks. The pile is stabilized by natural sand deposits.

From photographic and archeological evidence, it would seem that skimmings were trucked by ore cart from the tanks out along the pile and then dumped. We assume that those deposits furthest from the tanks are the most recent.

By collecting soil and botanical samples, we intended to ask questions regarding environmental adaptation and plant efficiency:

1. Is there a change through time in discarded grass species? If so, does this indicate a disruption in the natural environment due to borax mining?

2. Assuming that the more borax included in the discard, the less efficient the process, was there a change in efficiency through time?

Old photographs show substantial amounts of wood stored to the east of the plant. Historical records indicate that local wood, especially mesquite, was used to fire the boiler. We asked of our botanical samples from this area:

1. Is there indication of non-local tree species, and does this mean that the local wood supply had been depleted by the borax operation?

The tailings pond was used to catch foul solutions from the plant. We reasoned that samples taken stratigraphically would allow us to ask more about refining process efficiency. We assumed that upper deposits are younger, and that the more borax in the discard, the less efficient the operation. The questions were:

1. Did the plant process become more or less efficient through time?

2. Was the tailings pond harvested for residual borates?

In addition, soil samples were taken routinely from excavation units within the plant. We wanted to know what chemicals were used in the process, what the strengths of the solutions were, and whether concentrated or refined borax was produced.

The project also involved work in the townsite. An 1892 photograph shows a group of at least seven buildings in the area, only two of which are standing today. We collected artifacts from around these two, excavated three small pits in the buildings, and collected artifacts from two other areas. These are a trash dump (Unit T1) near Adobe A, and the area designated by Wallace (1972) as the Chinese quarters (our Unit C1). From these collections we asked the following questions:

1. Do the adobes date from the Harmony occupation?

2. Is C1 the site of an isolated Chinese occupation, or is it a general purpose area?

3. What is the nature of a Chinese laborer camp? How is it arranged spatially? Were tents or wooden buildings employed? What special facilities were required?

4. Does T1 relate to the Anglo or to the Chinese sector? Is this a formal refuse dump which can be differentiated from informal refuse scatters? We hypothesized that, if this is a formal refuse dump, the contents will reflect items which in present terminology

would be called garbage, as opposed to trash. This has important ramifications for interpretations of site function.

5. What was the function of the townsite? Were the buildings used as houses for workers, or were they used for storage and office space? Put hypothetically,

a. If buildings were used as habitations, we expect to find in and around them a varying artifact assemblage consisting mostly of domestic and food-related items, such as broken crockery, eating utensils, bottles, bone, and personal items.

b. If the buildings were used for storage or office space, we expect to find a repetitious and functionally restricted artifact assemblage. There will be few domestic artifacts.

A basic question which can be asked is, "In what way did the inhabitants interact with their natural environment?" This may be characterized as a problem in adaptation. According to historical accounts, Coleman purchased the ranch at Furnace Creek so that the plant could be provided with at least some crops for both men and livestock. Other supplies either had to be procured from the nearest major town, 165 miles away, or obtained or manufactured locally from the available resources. It is not known how close the ties were between this Death Valley outpost and civilization.

We may approach this problem by reference to subsistence economy and trade and communication, as revealed in the archeological record.

We can ask the following:

1. To what extent did the inhabitants depend on local resources? Of interest here is evidence of hunting and other local procurement.
2. What is the range and variety of imported goods?
3. What is the evidence for communication and trade with the outside world?

If Harmony was in extreme isolation, as romantic tradition insists, then we would expect the following:

1. Makeshift structures and features (Burlingame 1961).
2. Expedient repairs to facilities.

3. A lack of amenities such as comfortable housing, medicines, liquor, exotic food, and so forth.

4. Many improvised artifacts such as smoking pipes made of bone, and tool handles made of local wood.

5. Many artifacts recycled and used in different functional context--for example, tin cans wired with handles for use as drinking cups, or worn horseshoes used for building hardware (Herskovitz 1975a: 136, Fig. 36e).

An interesting set of conditions allows us to ask about processes of social interaction at Harmony. We know from documentation that Chinese laborers lived near the Harmony plant, as did non-Chinese workers. Examining the artifacts left by these people should offer some insight into ethnic differences and processes of acculturation.

First, we wanted to determine to what extent the Chinese laborers had become acculturated into the dominant non-Chinese culture of California. Our expectation was that acculturation had not proceeded to any extent. This relative lack of assimilation is to be observed even today in Chinese communities throughout the world.

Establishing the extent of acculturation is very difficult. Tests for acculturation have always relied on the assumption that acculturation is most readily evidenced through comparison of change in male-related and female-related artifacts (see Deagan 1973; Deetz 1962). This complicates matters at Harmony because we are dealing with an essentially all-male population. To approach the question from another way, we proposed that, within the Chinese quarters, only tools and building materials would be of Anglo-American origin, while personal accessories and food consumption items would remain Chinese. This proposition should be compared with the artifact patterning found in sites known to have been occupied by similar groups.

A related question has to do with ethnic differences as they are revealed in the archeological record. We hoped to refine or reject a hypothesis proposed elsewhere (Shenk and Teague 1975: 173) that:

Given strong caste and class differences, there will be status and economic differentiation, and this differentiation will be reflected by rigidly defined spatial units, differential patterns of waste disposal, and differential access to goods and food.

Among the expectations of this proposition are that refuse deposits will differ in quality and content, with exotic and expensive items, and potentially useful items, being found in some deposits, but not in others. We expected to find these differences when comparing the Chinese and non-Chinese quarters.

Method and Technique

Recording Controls

Controls at Harmony consisted of both an arbitrary grid for surface collection, and feature-specific units for excavation.

The grid was established by laying a base line, oriented magnetic north-south, from behind the plant to well beyond Adobes A and B. The south end point, located in the water-tank area on the bluff above the plant, consists of a piece of 3/8 in. iron reinforcing bar set in concrete. The north end point is a wooden stake to the north-northeast of Adobe A. Another reinforcing bar was set in concrete in the old parking lot. The location of this bar was assumed to be 500 m east and 500 m north of a grid zero point. All subsequent points were taken from this location by transit and tape. Two-meter grid squares within collection units were designated by the intersections at northeast corners.

Vertical measurements, in meters, were taken from the baseline south end point, which was assigned an arbitrary elevation of zero. Actual elevation is about 200 ft below sea level.

Excavation units were not placed within the grid, but rather were placed where needed. These units are square or rectangular and range from one to five square meters.

Provenience Designation

We used a four-part system for designing provenience units. A typical excavation unit might be called P13F2L1. The "P" stands for plant, and includes the borax refinery and associated features. Other units at this hierarchical level are Units C and T. Unit C includes the area between the plant and the townsite. Wallace (1972) calls a feature within this area the "Chinese quarters," hence the abbreviation. Unit T comprises Adobes A and B and associated features. This area was called the "Townsite" by Holland and Simmonds (1971). These units are somewhat arbitrary. Clearly, there is a real Harmony plant, but where the area of the plant meets the area of the Chinese quarters is subject to interpretation.

The next level in our system was designated by a sequential number standing for a smaller unit of investigation. In the example given, the number 13 might apply to a collection unit, a small test square, or a large trench. This unit may be divided into smaller sub-units such as 13A, 13B, 13C, and so on.

The next level refers only to real units of observation, and is concerned with archeological features. Feature 2 (F2), for example, might be a wooden drain, or a vat bottom. Feature numbers were assigned sequentially within excavation units.

The last recording designation is that of vertical relationship. In the example above, Level 1 (L1) is used. This would refer to the first stratigraphic (or arbitrary) level of a feature or an excavation unit.

A provenience designation may have only three parts, as in P13L1. The vertical unit refers, then, to levels within either whole units or within features.

Sampling Procedure

As detailed earlier, the number and placement of excavation units was dictated by management needs. The size of these units was determined by the questions asked and by the need to keep disturbance to a minimum.

Surface collection units around the adobes (Units T2 and T3) were placed on a common-sense basis. We asked ourselves how large an area would likely be disturbed by trucks and machinery, and systematically collected all the artifacts within this space. Collection units C1, C2, and T1 were placed to provide comparative quantitative and distributional data. Their limits were defined by the features centered within them.

Had the areas to be collected been much more extensive, we would have had to resort to probability sampling. As it was, the expenditure of time and money seemed commensurate with the information gained.

Collection Procedures

A grid of stakes was superimposed on the surface collection units. Units were divided into 2 m by 2 m squares and all artifacts were collected except sherds of glass or ceramics less than fingernail size. Plan view maps were made of features within the units. On the same maps were marked the location of culturally sterile squares.

Soil and botanical samples were collected along the terraces to the east and west of the plant (Units P19 and P20). Lines were staked along the central long axes of these units, and samples were taken every two meters. The procedure was to dig small pits about 20 cm deep to eliminate surface contamination. From the underlying strata in each pit we collected one-half liter of soil, wood, or charcoal.

Excavation Procedures

After establishing horizontal excavation unit boundaries, deposits were removed by natural stratigraphic level. Digging stopped at occupation grade levels. Fill was removed with shovels, and features were defined with trowels and other small tools. Tier 4 units were the first to be excavated, and all fill was put through 1/4 in. mesh hardware cloth. Experimentation at this stage showed that

artifact recovery was the same with or without screening. Consequently, upper tier units were not screened, with the exception of Units 1 and 2, where we hoped to recover wood specimens.

Soil samples were taken from deposits which showed chemical alteration. Examples are vat-bottom surfaces and spill-over areas around the dissolving tanks and on the settling tank tier.

All portable artifacts, such as nails and broken glass, were recovered and subsequently analyzed. Other artifacts, such as boards and pipes, were recorded and left *in situ*. Units were backfilled at the close of excavation, with the exception of the P7 and P9 units, which were left exposed for the convenience of the stabilization crew.

All units were photographed, and profile and plan view maps were made. In addition, surface features were recorded. Artifacts, field notes, and laboratory notes are stored at the Western Archeological Center.

Chapter 3
SUMMARY OF PRIOR KNOWLEDGE

Introduction

The first Anglos to enter Death Valley were travelers seeking a shortcut from Utah to the California goldfields during the winter of 1849. Eventually, rumors of possible mineral riches in the area spread throughout the West. Many groups then began to probe at Death Valley's recesses during the 1850s and 1860s in search of this wealth, with little success.

Lack of documented information on the Death Valley region prompted a number of government surveys and explorations after 1860. Mining booms in the vicinity soon followed. Perhaps the most significant and best known historical activity that occurred in Death Valley was the mining and processing of borax. Eagle Borax Works was the first borate processing plant established, operating from 1882 to 1884. It was quickly followed by Harmony Borax Works.

Borax was first discovered in the vicinity of the Harmony site in 1881, and W. T. Coleman, a prominent San Francisco businessman, set up a processing plant and began producing in late 1883 or early 1884. Harmony enjoyed initial success and spurred interest in working the region's vast borate deposits (Wallace 1972: 1). Today it is the best preserved example of the beginnings of the borax industry in the United States.

Location and Resources

Societies function within an environment to which they have adapted their culture, and which they exploit to the limits of their day-to-day requirements and technological competence. Thus, studying

man's history is, to a considerable degree, the examination of ecosystems within which human culture operates, and of the increasing control exercised by man over his environment (Fagen 1972: 142).

Questions posed at Harmony regarding the extent to which this late 19th century populace depended on local resources in such a remote area presupposes a knowledge of the flora and ecological relationships present during occupation. We want to determine here 1) what natural resources were available for subsistence and industrial exploitation, and 2) what the environmental picture was like so that the borax operation's impact on this ecosystem can be measured. In considering the relationship between past human behavior and environmental conditions, it is first necessary to determine if the environment has changed to any degree. Judging from historical accounts by Death Valley travelers (Spears 1892), we conclude that the climate of 100 years ago in the area could not have differed greatly from today's.

The Mojave Desert, in which the Harmony area is found, forms a part of the Great Basin section of the Basin and Range physiographic province (Thornbury 1965). The climate here is extremely arid--rainfall approaches only two inches per year--and the area has no well-determined drainage lines. The few small streams that do drain the snowcapped mountains on the border of the desert flow toward the interior, and are soon lost in the arid plains.

The ground surface in this region is considerably diversified. In the western end it is generally regular and nearly level, but in the remaining parts it is composed of isolated knobs and short ranges of mountains having no noticeable system of arrangement. These ranges serve to separate stretches of desert composed of vast alluvial fans and playas (Campbell 1902: 8).

The most noted surface feature of the region is Death Valley, which lies 50 miles east of the Sierra Nevada, near the Nevada state line (Fig. 1). This 156-mile trough is walled by major block-faulted mountains; the Grapevine, Funeral, and Black Mountains of the Amargosa Range appear on the east and the Panamint Range on the west.

The valley has a length of about 50 miles and an average width of from 5 to 10 miles. Only 15 miles from the highest peak in the area, rising to over 11,000 feet above sea level, is the lowest point in the United States, the Badwater Basin salt pan, at 282 feet below sea level (Death Valley National Monument 1976: 10). It is this great relief of the region that has allowed relatively wide ecological diversity.

Harmony Borax Works is located within the boundaries of Death Valley National Monument, and is a short distance north of the National Park Service Visitor Center at Furnace Creek. By far the greatest exposure of lake beds and also the largest deposits of borax known in the region occur in the Furnace Creek area (Campbell 1902: 16). Harmony is situated just a few miles from the point where Furnace Creek emerges from the hills into the Valley, on the margin of an alkaline marsh. The site itself sits on the north slope of an alluvial fan extending westward into the floor of Death Valley, at an elevation approximately 200 feet below sea level. The fan is composed of clay and fine to coarse gravel, while the salt marsh is made up, from top to bottom, of a thin alkali crust, evaporates such as gypsum and carbonate, silt, and gravel (Death Valley National Monument n.d.: 1).

Climatic Conditions

The climate of Death Valley, recognized as the hottest and driest area of the United States, played an important part in the operation of the Harmony works. Temperatures on the valley floor vary from a recorded high of 134 degrees to a low of only 15 degrees (Death Valley National Monument n.d.: 2). As already indicated, during the hot summer months work at Harmony had to be suspended since the solutions would not cool sufficiently for the borax to crystallize.

The low humidity is another important climatic factor in Death Valley. The mean annual rainfall of two inches usually occurs during

the months of September, November, and January. Summer thunderstorms do take place occasionally, bringing intense rains and flash flood danger.

Vegetation

The diversification and distribution of Death Valley's plant communities are in part the result of the region's geographic location and great physical relief. As in any desert region, plant species in Death Valley's arid environment have developed special features enabling them to survive. The life zones found here are representative of four basic associations: salt flat, desertscrub, pinyon-juniper, and forest (Death Valley National Monument 1976: 22).

Within the lower elevations of the valley, distinct boundaries of plant forms are apparent up to an elevation of approximately 3000 feet. Harmony and Greenland (its associated ranch at Furnace Creek) are situated in this first zone. Plants within the salt flat association are generally influenced by the availability of soil moisture and salinity.

Both the alluvial fan and the salt marsh north of Harmony are almost barren of any plant life. Around the perimeter of this salt pan, and at canyon springs or springs on alluvial fans, are found plants that put roots down into the water table. Included are species such as desert baccharis, willows, mesquite, reed grass, arrow weed, saltgrass, rush, saltbush, and pickle weed. Between the salt pan and about 3000 feet above sea level are found desert holly, honeysweet, and cattle spinach (for scientific names see Death Valley National Monument 1976: 22-24).

The surrounding area of Death Valley has scattered vegetation of great variety. Desertscrub such as creosotebush, shadscale, and sagebush dominate almost three-fourths of the valley landscape; mesquite thickets mark the area as a whole. There are also many shrubs, several types of cactus, herbaceous plants, and annuals

during wet seasons (Federal Writers' Project of California 1939: 7-8). In the higher parts of the mountains are pinyon-juniper woodlands; higher yet are subalpine and bristlecone pine forest communities.

Important sources of desert fuel during the 19th century in Death Valley were brush, nut-pine, and mesquite (Spears 1892: 110-118). Spears (1892: 145) noted that all along Furnace Creek occurred an "abundant growth of mesquite, the Indian arrow-reed, and other plants." As for plant-food sources, Hanks (1883: 32) reports that at the borax settlement of Greenland (near Furnace Creek) garden vegetables, melons, alfalfa, and other plants had been successfully cultivated "by dint of constant irrigation."

Animal Life

Death Valley and the adjacent desert support an interesting and varied array of wildlife. Many animals have also had to adapt themselves for survival in this arid environment. With few exceptions, all mammals and reptiles range throughout the Great Basin and Mojave Deserts and nearby mountain ranges.

Over 200 species of animal life have been observed within Death Valley National Monument, including desert bighorn sheep, mountain lion, mule deer, coyote, kit fox, antelope, ground squirrel, pack rat, grey fox, bobcat, and wild burro. Seventeen species of lizards and 18 species of snakes are also found within the area, as are numerous birds, amphibians, and fishes. Insects are abundant, and scorpions, tarantulas, and centipedes are occasionally seen throughout the valley.

Water Sources

One way a desert can be defined is in terms of its dryness. Death Valley is a hot desert where about 90 percent of the precipitation evaporates (Death Valley National Monument 1976: 16). Both surface and groundwater hydrology, therefore, are very important to the understanding of life in this arid region.

The origin of groundwater in Death Valley includes local precipitation and underflow from drainage basins to the northwest, northeast, and southeast (Death Valley National Monument 1976: 17). Potholes, seeps, wells, springs, and ponds are the only known surface water sources. The majority of the water sources are in the form of springs, which tend to be brackish or salty on the valley floor.

Two major streams within Death Valley, the Amargosa River and Salt Creek, also offer a water supply. The Amargosa River enters the Monument from the south and reappears intermittently in the south-central valley. Salt Creek flows from Stovepipe Wells sporadically as far south as Badwater.

Two developed water resources in the vicinity of Harmony are Texas Spring and Travertine Spring; it is believed that the former was the source of water for the borax works. These springs, and others, supplied water to Furnace Creek and thus to the ranching settlement at Greenland. According to Hanks (1883: 31), water flowed here all year round, the average quantity being "one hundred miners' inches," which is equivalent to about 9 U.S. gallons per minute. He reports that while this water was good for drinking, it was always warm.

Another important source of water at Harmony may have been artesian wells. In such wells, water rises to the surface and flows out under its own pressure, without pumping, after being tapped by a vertical shaft (Gabler and others 1975: 530). As early as 1860, Spears (1892: 22) noted that emigrants could obtain excellent water in Death Valley by digging wells. In an 1883 publication of the California State Mining Bureau, Hanks (1883: 33, 36) reported the existence of artesian wells at both Harmony and Greenland.

Borax Deposits

The borate marsh deposits are efflorescent crusts in the desert basins, the typical location being at the edge of a salt flat where water percolating down an alluvial fan emerges as a spring or seep

(Smith 1960: 107). In some, the borate mineral is borax, such as at Teels Marsh, Nevada, and Searles Lake, California. In others, it is ulexite, for example at Fish Lake Valley, Nevada, and Death Valley, California.

The Harmony borate deposits have an obvious source, having been derived from large Tertiary deposits of borate minerals along Furnace Creek (Smith 1960: 107). Surface water played an important role in the resulting formations. It gathered boron from these sources, and transported the minerals to sites where borates could accumulate, such as spring aprons, salt flats, pools, and lakes.

Historical Background

A preliminary orientation report on the Harmony Borax Works was prepared in 1971 by F. Ross Holland, Jr. and Robert V. Simmonds. One of the main purposes of the project was to study the history of the borax industry in Death Valley. The report, drawing on published sources, also presents available reference data on borax-producing operations similar to that found at Harmony. Since this research was as exhaustive as available material would permit, we will present here only a concise synthesis of the pertinent information.

The Borax Industry

The business of producing and processing boron compounds is called the borax industry, because the chief product is borax, the decahydrate of disodium tetraborate. As Spears (1892: 190) tells us in somewhat simpler terms, "borax, in the language of the chemist, is the bi-borate of soda--it is a compound of boracic acid and a small proportion of soda." Boracic acid is formed naturally in some volcanic regions, and usually combines with other elements, such as lime and soda, to create compounds.

References to borax "mining" is common, and while appropriate where it emphasizes the diversity of borate minerals that are exploited in various countries (Smith 1960: 103), it is rather unsatisfactory where used in a general sense. For example, it tends to

exclude the important early years of borax production when "cottonball" borax, so called for its appearance, was harvested. Near Harmony, the presence of borate minerals on the alkali flats or dry lake beds of the valley floor called for no mining equipment more complex than a shovel (Death Valley 49ers 1960: 15).

In the late 19th century, borax was produced in the United States only in Nevada and California, its occurrence being chiefly in the region of the Great Basin (Engineering and Mining Journal Vol. 53: 8). Borax deposits throughout the world were characterized by the same essential surface exposures, and the minerals were easy to recognize and recover. These were all marsh operations, utilizing tincal and cottonball, a type of ulexite which was found on the surface of the ground where lakes had once been.

Ulexite, a borax of high purity, generally forms clusters of silky fibers rather than large individual crystals. A transparent mineral, it usually appears white. Rounded, loosely packed aggregates of ulexite fibers in weathered zones and playa muds are appropriately referred to as "cotton balls." These range from very small clusters showing an open radiate arrangement to rather compact masses several inches in diameter (Smith 1960: 104).

In 1882, a new form of borate was discovered in the Funeral Mountains bordering Death Valley on the east. This borate, named colemanite after Harmony's owner, W. T. Coleman, did have to be mined, and required more complicated processing than cottonball. But colemanite, a quartz-like ore, was potentially richer and would eventually spell the end for marsh operations.

Before 1864 the existence of borax in the United States was unknown, and the whole of our supplies came from abroad. In those days its application for commercial purposes was comparatively limited, and borax was chiefly known as a drug and a blacksmith's flux (Engineering and Mining Journal Vol. 54: 247). But its uses expanded widely in following years, with the product becoming a highly important factor in everyday life (Spears 1892, Chalfant 1933, Glasscock 1940, Levy 1969).

The major uses of borax today still include some that were discovered many centuries ago (Connel 1949). The ability of fused borax to dissolve many otherwise resistant oxides accounts for many of its older applications, among them metal-working and brazing (Smith 1960: 116). Borax and boric acid also have detergent and mildly disinfectant qualities, known for many years and utilized today in a wide variety of products. Industrial materials are prepared with borax, for example glue and paint, and the manufacture of leather and textiles also consumes large quantities (Smith 1960: 116).

According to the Engineering and Mining Journal (Vol. 53) of January 2, 1892, New York and England were the chief markets for the 11 million pounds of borax produced in 1887. The borax industry still is faced with rising demand for its products, and consequently is increasing its productive capacity and appraising its borate resources (Dinsmoor and Weishaupl 1958). Thus Levy (1969: 117) has perhaps accurately termed borax the "white gold" of Death Valley, and its story is one of the major chapters in the history of the National Monument.

Early History. Modern research has shown that boron minerals exist in nature in a worldwide belt of arid lands, including Iran, Tibet, Turkey, the Central Andes region, and California (Multhauf 1972: 4). For nearly 4000 years, however, the world's only productive source of borax was the Gobi Desert marshes of Tibet (Levy 1969: 117).

The history of the modern borax industry starts with the introduction into Europe of borax from Tibet in the 13th century. The discovery that borax had unique value as a flux in metal working and ceramic glazing must have been made much earlier (Smith 1960: 103). In any case, borax turned out to be a precious commodity, for it was the only substance metal workers found that permitted them to solder gold (Effelinck 1937: 5).

As a rule, any mineral that has been used so long that its early history is lost, must occur in deposits that are easily recognized and worked, and this is undoubtedly true of borax in Tibet (Hanks 1883: 7; Smith 1960: 103). Yet for a long time, the Venetian alchemists were the only ones who knew how to refine the crude borax, and they kept their processes secret. Eventually, the confidence was broken and the technique spread first to Holland and France, and then throughout the world (Levy 1969: 117).

Other deposits were discovered in northern Italy around 1850 (Woodman 1951: 3-5), and by the early 19th century the boracic boiling springs of Tuscany were beginning to produce. In 1836, the largest deposit then discovered was opened at Iquiqui, Chile. But despite these findings, borax remained a scarce item that brought a fairly high price (Holland and Simmonds 1971: 12).

The source that would surpass them all still lay unsuspected in California. The United States at this time had to import what borax it used. However, American business interests would soon begin to consider the possibility that deposits existed in this country.

U.S. Discovery. Dr. John A. Veatch is credited with making the first observation of borax in California (Hanks 1883: 15). On January 8, 1856, Veatch noticed that some water he was examining contained borax (Spears 1892: 15). After careful prospecting, he discovered that the waters of a small lake (Borax Lake) in Lake County, California, were high in borax content and, with drilling, he found pure borax crystals (Engineering and Mining Journal Vol. 54: 247). Determining the deposit to be worthy of development, Veatch and a group of San Francisco businessmen formed the Borax Company of California, which began commercial operations in 1864 (Holland and Simmonds 1971: 12; Campbell 1902: 7).

From 1864 to 1868, this area was the principal supplier of borax for the U.S. market (Day 1892: 495). Production in California had an immediate effect on the importation of borax, which dropped

from a value of \$200,000 to a mere \$9,000 per year. In the meantime, the price of borax in this country dropped from 50 cents to 30 cents a pound, but that was still \$600 a ton (Weight 1955: 3). Unfortunately, the drilling struck water and the resulting artesian well flooded the lake and halted development.

The subsequent discovery of borax at Lake Hachinhama (now Little Borax Lake) nearby allowed Veatch and company to continue supplying domestic needs for the next three years. But by 1871, the scene had definitely shifted to Nevada, with the discovery of cottonball borax on the alkaline marshes at Salt Wells and Columbus Marsh. William Troup, a prospector from Virginia, began commercial operations which by 1872 served to cut imports of borax by half of the figure the year before (Levy 1969: 118).

Not to be outdone, the Borax Company of California moved into the Nevada desert and began to ship borax to their plant at Little Borax Lake, thus raising production in California for 1872 to 280,000 pounds. The following year, F. M. Smith--to become an important figure of the borax trade--discovered the Teels Marsh borate field in Nevada, which contained the richest specimens of cottonball borate found so far (Woodman 1951: 10-11). At about the same time (April, 1874), John W. Searles and E. M. Skellings began setting up borax operations at Searles Lake, California (Bailey 1902: 37; O'Donnell n.d.: 5). Their firm, the San Bernardino Borax Mining Company, became the giant in California, while Smith dominated the Nevada fields.

The effect of this competition almost proved disastrous for the borax industry. There just was not the demand for the quantity being produced. Overproduction resulted in rapid price declines, car-load values dropping to only 10 cents a pound. Costs of transportation were eroding profits and margins were consequently narrowing. Pressure was building on the small ventures, and by 1875 only five companies remained on the active lists (Levy 1969: 120).

At the same time that the Smith and Searles ventures were being established, the presence of borax was first noted in Death Valley. But this mineral resource was not to be exploited for

another 10 years. As Levy (1969: 121) explains, the reason for this was simple:

Entrepreneurs were preoccupied with other major deposits. They were struggling with the problems of overproduction and falling prices. The fields of Death Valley were remote and distant from lines of transportation and could not be developed economically if freighting expenses were added to the basic cost of production.

Events would soon take place in Death Valley, however, that would ultimately attract the interest of corporate producers.

Death Valley Borax. It appears that borate minerals were noted on the alkali flats and dry lake beds of the valley floor as early as 1873 (Chalfant 1933: 116; Ver Planck 1956: 278). But no real interest was shown in the deposits at this time. According to the Inyo Independent of May 10, 1873, development possibilities in Death Valley were doubtful because of the impure state of the borate, the distance from transportation, and the inhospitable land and climate (Holland and Simmonds 1971: 14).

One of the first people to notice the presence of borate minerals in Death Valley was Isadore Daunet. In 1875, while Daunet and several companions were crossing Death Valley, he collected some crystallized minerals out of curiosity. At the time, no one was interested in his find. Later, in 1881, Daunet heard news of Aaron Winters' discovery and sale of similar cottonball borax from Death Valley (Death Valley 49ers 1962: 4).

Aaron Winters, a prospector living at Ash Meadows, learned of borax activities in Nevada and decided to search out this mineral in the Death Valley marshes. In 1881, he found ulexite borates at the mouth of Furnace Creek. Within a few weeks, Winters had sold his claim to a San Francisco businessman, W. T. Coleman, for \$20,000 (Wallace 1974: 1).

After hearing of Winters' success, Isadore Daunet, along with three partners, established title to 270 acres of land in Death Valley with the purpose of working the borate fields (Levy 1969: 123). The claims were situated near Bennett's Well, just 22 miles

south of Furnace Creek. The Eagle Borax Company was thus formed, and the works were set up and producing by late 1882. The end product was hauled to Calico Station near Daggett.

The first shipment of borax from the Eagle plant was fairly crude, selling for only eight cents per pound (Holland and Simmonds 1971: 15). Techniques improved and by the end of 1883 the works had produced about 130 tons (Wallace 1972: 3). Losses were still high, however, because of competition from operators elsewhere. The Eagle operation finally had to be abandoned in 1884 (Levy 1969: 124).

Borax Production at Harmony

As already noted, Aaron Winters sold his borax claims near Furnace Creek to W. T. Coleman, along with the water rights to Texas Springs (Putnam 1946: 44). By late 1881, the Death Valley Salt and Borax Mining District was formed. Surveyors were sent to the area to stake out the numerous claims being filed by interested parties (Spears 1893: 26). F. M. Smith's name also appears on claims in the Furnace Creek area, indicating that he and Coleman were business partners during this early stage of borax development in Death Valley (Copp 1882: 52; Spears 1893: 26; Stiles 1939: 8).

In late 1882, Coleman established a plant just north of Furnace Creek, near the marsh in which Aaron Winters had gathered his cotton-ball borax. The refinery was named the Harmony Borax Works. The same problems of high temperatures that had affected the Daunet plant near Bennett Well also afflicted Coleman's operation at Harmony.

To compensate for this condition, Coleman purchased a borax claim near Resting Springs, just east of Death Valley. He was thus able to maintain production throughout the year by shifting his operation in the summer months to these Amargosa deposits. The two areas were evidently developed by separate Coleman companies--Harmony Borax Mining Company and Meridian Borax Company--both incorporated in 1884 (Levy 1969: 125).

Establishment. There is some question as to exactly when borax production began at the Harmony works. In 1883, Henry Hanks, the California State Mineralogist at the time, reported that the mining company had already located their grounds and settlement at the mouth of Furnace Creek (Hanks 1883: 36). The actual processing facility was being established on a nearby ridge, along with artesian wells. Evidently Coleman had set up the Amargosa works first, since Hanks (1883: 37) reported the presence of 80 crystallizing vats there, which were about to commence production.

It is likely, then, that Harmony went into operation shortly after the summer of 1883 (Holland and Simmonds 1971: 25). By May 1884, according to the San Francisco Mining and Scientific Press (Vol. 48: 324), the plant was producing "three tons of refined borax per day, besides shipping a great quantity in a crude state." The company holdings consisted of the land and works at Harmony, a supporting ranch at Greenland, and included the borate fields surrounding Furnace Creek (Figs. 2 and 3).

Harmony was established as a larger and more complex operation than the previous Death Valley venture at Eagle. Only fragments of documentary evidence remain on the physical plan of the site. Most of our information comes from photographs taken both during occupation of the plant and shortly afterwards. The majority of these photographs have been published in the Holland and Simmonds (1971) report.

Coleman, or his field representatives, set up the manufacturing facility on a hillside near Furnace Creek. This positioning allowed for gravity flow, whenever possible, of water and solutions during processing. Overland piping connected water storage tanks on the top of the hill to Texas Spring, some three or more miles away. A graded service road climbed up the hill from the salt marsh on the west and down to the wash on the east, thus allowing for a continuous flow of wagons carrying the unprocessed borax ore to the plant.



Figure 2. Aerial view of plant (against hill)
and townsite forming Harmony Borax Works.



Figure 3. Harvesting grids and windrows
in borate fields near Furnace Creek.

The plant itself was constructed on a series of four terraces, or levels of varying heights, each supported by cut sandstone, cobble rubble, or wood plank retaining walls. Adjacent to the service road, on the uppermost tier of the plant, were placed two large rectangular dissolving tanks of iron. Fronting the end-to-end tanks on the north were wooden platforms.

East of the dissolving tanks, on a slightly lower level, an adobe structure was built to house the boiler and to act as a machine room. An opening between the two sections allowed for natural air ventilation. At least two different roofing systems covered this structure and the dissolving tanks at various times, as seen in photographs of the site. This problem will be discussed later in this chapter.

Wood to fuel the boiler was stored in the area east of the adobe structure. The west side of the plant was reserved as a skimmings pile. Here, grass and other debris mixed in with the raw ores was disposed of.

The next two levels down the hill contained square metal tanks housed in wood. Near these tanks and the dissolving tanks above were rail tracks for ore cars. The bottom level of the plant contained several long rows of crystallizing vats, with truncated cone shapes, and a wooden barn-like structure for storage. According to the San Francisco Mining and Scientific Press (Vol. 56: 220), Harmony had 57 crystallizing vats, each holding 1800 gallons, and eight "receiving" tanks, with a capacity of 2000 gallons each. Three large earthen reservoirs were formed just across the wash to the north, to hold waste solutions.

A small town was established just to the north of the plant. Here the company supposedly housed employees and support facilities in adobe and wood structures, of which two adobe walled ruins remain today. Only a single photograph, dated 1892, shows what the settlement looked like, but even this is unclear.

A cluster of seven buildings can be seen, which probably consisted of an office, living quarters, and cooking and dining

facilities for the men who worked at Harmony. Evidently only two of these buildings were constructed of adobe bricks. Two other structures are partially visible in an 1885 photograph. Both are constructed of wood planking, and possibly represent the blacksmith shop and a cooking and dining facility.

As Spears (1892: 27) tells us, the Coleman company followed the example of other Death Valley settlers, and established a ranch at the mouth of Furnace Creek to support the borax operation. The name "Greenland" was given to the agricultural community. Eventually, with extensive irrigation, an oasis of sorts was formed in this otherwise barren region.

A half-acre pond was created by conducting the creek, with ditches and pipes, to a level stretch of ground. Irrigation ditches watered some 30 acres of land on which alfalfa, vegetables, melons, fruit trees, and natural grasses were cultivated (Hanks 1883: 32). Spears (1892: 27) also noted the presence of an adobe house with a wide veranda.

The next problem to be faced was getting the end product to Mojave and the railroad station. A road more than 160 miles long had to be constructed, using sledge-hammers as grading tools (Scherer 1939: 303). Water, naturally, was scarce on this long haul and, in some instances, watering places such as wells, springs, and water-tank wagons were more than 50 miles apart.

Operation. After the facilities at Harmony and Greenland had been established, it was necessary for production to get underway. While the boracic acid content of ulexite was slightly lower than that of some other borates, certain operational advantages were present. The process of extracting commercial borax from such borate ore was not complex, but it was time consuming.

Basically, the cottonball borate was scooped and shoveled off the ground, allowed to dry, and hauled to the plant by wagon or cart. Here it was crushed and dumped into large open water-filled tanks. As the water was heated by steam coils from a boiler, the mixture

stirred by hand, the borax dissolved. According to an 1892 account, carbonate of soda was mixed with the cottonball borax at this first step, apparently as a flux to get rid of such impurities as lime (Engineering and Mining Journal Vol. 54: 247). Fuel for this operation was obtained in the neighborhood, while water usually came from springs or artesian wells.

The borax solution then, in some similar operations, went through various settling and receiving (mixing) stages. The solution, now of proper strength, was poured off into vats, commonly made of galvanized iron, where the water cooled and the borax crystallized either on the sides of the vats, or on plates or rods suspended in these containers. In May, the vats were covered with layers of thick felt for insulation against the heat. Workers played a hose of water on the felt to lower the temperature by evaporation (Death Valley 49ers 1962: 6).

The borax remained in the crystallizing vats for from 10 to 14 days (San Francisco Mining and Scientific Press Vol. 56: 220). The Engineering and Mining Journal (Vol. 53: 8) for 1892 indicates that "if the crystals are dirty or impure, resolution and recrystallization may be necessary." The residue water was generally recycled through the process. The crystallized borax was removed from the vats, broken into chunks, and sacked immediately or stored in a building where it was later bagged for shipment to the railhead. Waste solutions were piped into earthen reservoirs where they could evaporate and be re-harvested.

To reach the railhead at Mojave, Coleman hitched 20-mule teams to huge borax wagons with a payload, in tandem, of over 20 tons. The teams usually consisted of two "wheeler" horses and 18 mules, and were handled by two men. Each of the five rigs pulled two large high-wheeled borax wagons and a water tank wagon, and could average about 15 to 20 miles a day (San Francisco Mining and Scientific Press Vol. 56: 220). The round trip usually took a little more than three weeks. Supposedly, 2.5 million pounds of borax were hauled from Death Valley each year by this method (Levy 1969: 128).

On the average, 40 men were employed at Harmony. Teams were coming and going all the time, and the settlers in Death Valley made the works a center of operations. Spears (1892: 28) reported that the men at Harmony had the best food obtainable, and were housed "as men are in all mining camps."

Workers with a variety of skills were employed by borax processing plants. Included were engineers, blacksmiths, teamsters, coopers, boilermen, watchmen, and common laborers (Holland and Simmonds 1971: 26). Pay ranged from \$5.00 per day for blacksmiths to \$1.25 per day for laborers, and included room and board, except for Chinese workers (California State Mining Bureau 1884: 93). At Harmony a number of ethnic groups participated in the operation. Chinese workmen were responsible for gathering the raw ores from the ground surface and transporting them to the plant. Some sources state that local Paiute Indians supplied the mesquite and brush to fuel the boiler (Levy 1969: 125; Holland and Simmonds 1971: 27). Anglos made up the remainder of the work and managerial force.

Decline. In 1888, after only five years of activity, the Harmony Borax Works permanently closed down operations. This failure may be attributed to a fall in the market price of borax, along with the financial collapse of Coleman's complex business interests, which led to his entire corporate holdings going into receivership.

In 1887, such quantities of borax were being imported from Italy that a drastic drop occurred in the value of borax. At the time, Coleman was extending his borax holdings in Death Valley and elsewhere. To finance his increasingly large and diversified interests, he had borrowed heavily. Coleman could not cover his loans when several banks unexpectedly called in his notes.

Coleman's organization was sold in 1889 to Francis M. Smith, who consolidated his holdings into the Pacific Coast Borax Company. No effort was made to resume borax processing at Harmony, since Smith preferred to concentrate his attention on richer borate

deposits in the Calico Mountains. Harmony and Amargosa were only to be held as reserves. The site was subsequently abandoned.

Contemporary Borax Plants

Since so little documentary evidence exists about the Harmony Borax Works, only a fragmentary picture of the plant and its operation could be discussed above. Perhaps a better understanding of Harmony can be attained if we look at descriptions of how borax was produced at similar plants elsewhere. Accounts of four such borax works will be offered here, all of which were in operation during the 1870s and 1880s in California and Nevada.

Searles Marsh. The Searles borax marsh is situated in the northwestern corner of San Bernardino County, California, only a short distance from Harmony. The San Bernardino Mining Company, J. S. Searles' operation, was established in 1874, near the center of an extensive alkali flat or dry lake bed (Day 1892: 498). One method of obtaining borax at this locality was by working quite extensive deposits of tincal (California State Mining Bureau 1883: 26).

This crude borax was found on the ground surface, as were the ulexite deposits at Harmony. The surface crust was scraped into windrows, shoveled into carts, and then carried to the factory. Supposedly, 13 tons of crude material was required to produce one ton of borax (California State Mining Bureau 1883: 27).

The borax was obtained from the natural ore in the following manner:

The impure, natural borax is shoveled into the boiling tanks, and the soluble matter dissolved by heat communicated through a wet steam coil, of one and a quarter inch iron pipe... When the solutions are brought to the proper strength...they are drawn off, while still hot, into crystallizing vats lined with galvanized iron. The borax taken from the crystallizers, after the first operation, is called "concentrated", and is not wholly pure. While the solutions are cooling, the mud is sluiced out of the boiling tanks, after which they are again filled, and the operation goes on continuously.

The crystals were then taken from the vats, redissolved, and the solution run into square crystallizers to cool. The result was "refined borax" of a very superior quality. The remaining solutions (mother liquors) were returned to the boiling tanks and reused until foul:

All liquors are returned to the boiling tanks by a steam syphon pump. Water is brought seven and a half miles in inch and a quarter iron pipes for the steam boilers and for drinking; but water for the solutions is derived from fourteen (artesian) wells... The entire steam power is derived from one steam boiler, 42 inches in diameter, with 32 flues... The solutions are drawn off by means of an iron pipe, which passes up through the bottom of the tank, and is connected with a shorter length, to which it is joined by a common elbow....

The only building in the plant was constructed of wood and covered the boiling tanks. A large evaporating trough of wood, lined with galvanized iron, was used in connection with open cuts or trenches in the ground to crystallize the foul waste solutions. Fifty men and 35 animals were employed at the Searles Marsh works (California State Mining Bureau 1883: 27-28).

Teel's Marsh. Teel's Marsh, a very productive borax field, was located in Esmeralda County, Nevada. After its discovery in the 1870s, boilers, tanks and crystallizers were obtained from Chicago and operations begun. An immense establishment was created which produced a great quantity of chemically pure borax.

A further understanding of borax manufacture can be gained from a description of the Teel's Marsh operation:

The method employed by Smith Brothers for the production of borax from the crude material is by solution, separation of mechanical impurities by settling, and crystallization. The result is concentrated borax. When this is recrystallized, it is known as refined borax. The deposit is known as crude borax... This is raked into windrows, shoveled into wagons, and hauled to the borax works, situated on a small hill near by.

Two 24-inch Cameron & Douglas steam boilers provided the heat necessary for solution. It was conducted to the boiling tanks through two-inch iron pipes to a wet coil. The ore was processed as follows:

The operation is commenced by filling the boiling tanks one-third to one-half full of water... When the water is boiling hot, the crude borax is shoveled in... The hot solution is allowed to stand over night, the steam being turned off. In the morning the solution, now free from sand and other mechanical impurity, is run off into (square) crystallizers of No. 14 galvanized sheet iron... As the solution cools, crystals of borax form... As soon as the boiling tanks are discharged, the mud is sluiced out... When crystals cease to form in the crystallizers the mother liquor is drawn off, and the crystals removed from the sides and bottom, and returned to the clean boiling tanks in which they are redissolved and allowed to stand for a time undisturbed, as in the first operation, when the solutions are drawn again into the crystallizers.

The mother liquors were run off into shallow evaporative pans of wood, covering half an acre, for crystallization of any remaining borax (Hanks 1883: 46-48).

Rhodes' Marsh. Rhodes' Marsh, also situated in Esmeralda County, Nevada, began operations during the 1880s under the ownership of the Nevada Salt and Borax Company. Borates existed in this so-called marsh in the form of ulexite and tincal. Certain aspects of borax manufacture not mentioned in the previous descriptions are found in a brief discussion of this plant:

The work of producing borax out of such excellent material is very simple... At the railroad station, on the western portion of the marsh, the company has its works, consisting of a warehouse, an engine and boiler-house, four boiler tanks (7x8), twenty-four crystallizing tanks, waste tanks, etc.

The process followed in the manufacture of native borate is as follows:

To do this, the top crust to the depth of six inches is shoveled into cars, taken to the works, and dumped into the boiling tanks, which are partly filled with water from a well strongly impregnated with borax. The tanks

are then boiled by steam from the boilers until the borate of soda is all dissolved, when it is allowed to settle. The water containing the solution is then decanted into the crystallizing tanks, which are of galvanized iron, with sheets of the same material suspended in them. Here the borax crystals form on the sides and on the plates... The borax crystals are knocked off and shoveled up. This constitutes the "crude borax" of commerce, really worth more than the "refined", because it contains an excess of boracic acid.

The crude borax was then redissolved and mixed with carbonate of soda, to reduce it to the standard of a refined product. Waste solutions were run into a reservoir and saved for later harvesting (Hanks 1883: 48-49).

Fish Lake Valley. The Fish Lake Valley plant, called the Pacific Borax Works, was situated near Candelaria, Nevada. Its owners, F. M. and J. P. Smith, set up operations here in the 1880s. The processing operation of the Pacific Borax Works at Fish Lake Valley was probably quite similar to that at Harmony. Exceptions may include the water supply and the sequence by which solutions and settlings were cycled through the system. Photographic evidence indicates that both plants were also alike in their physical layout. The description of Fish Lake which appeared in the San Francisco Mining and Scientific Press (September 2, 1882) will therefore be quoted in some detail.

The Pacific Borax Works contained several large buildings, sheds, and platforms along with steam engines and other machinery. The process of manufacture was as follows:

The site selected for the works is on the western marsh and under the side of the hill, high enough to allow a grade sufficient for the handling of the solution from the time the crude borax is first landed on the dump. The crude is shoveled up into windrows on the marsh and allowed to remain for a time, that the moisture might leave it, decreasing the weight in the matter of hauling. It is then loaded into a wagon and taken to the dump. The side of the hill has been excavated for the building of a stone wall, done in mason work... The dump has an easy approach from two sides, and is level enough on the

top for the easy handling of all the material taken there. A new building covers the boiler and pumping room, in which is a tubular boiler 16 feet in length and 54 inches in diameter.

Two steam pumps were used at Fish Lake. One pumped water from the well for washing the tanks, sprinkling, and for containing fires. The other pump fed water to the boiler and crystallizers. An immense network of steam pipes, varying from 1/2 in. to 4 in. in diameter, ran about the pumps and boiler to the dissolving tanks, of which there were six:

The tops of these are covered with a platform made of two-inch plank, in which openings are made for filling the tanks. A system of steam pipe extends all over the bottom of each tank, and about every four inches the pipe is perforated for the escape of steam. A quantity of the crude borax is dumped into one or more of the tanks, and about three feet of water added.

The steam was then turned on and the mixture boiled. After settling for 10 to 12 hours, the solution was drawn off from the top by a syphon into one of 45 crystallizers on a platform 30 ft below:

Each of these is lined with galvanized iron, upon the surface of which the borax precipitates itself and is easily removed. The solution remaining in the dissolving tanks is then given a second boiling and drawn off again as above described. The mud and remainder of the borax is then turned into a system of mud tanks, which occupy a position immediately below the first line of tanks, and if found to contain a large enough percentage of borax it is shoveled into a car and run along a track to a Hinckley elevator, which lands it on the top again, whence it goes into the dissolving tanks. After the crude borax has been worked over and over, until but little remains, the tailings are removed to a reservoir made in the ground, just below the last line of crystallizers.

Car tracks ran between the lines of mud and crystallizing tanks, and into a drying and storage building. The second floor of the structure was used as a superintendent's office and a sleeping room for the 20 or so employees. Other structures present included a boarding house and blacksmith shop, a corral 100 feet square, and a large barn (San Francisco Mining and Scientific Press Vol. 45: 150; Williams 1885: 861-862).

The Coleman Ledger

On display at the Furnace Creek Borax Museum in Death Valley is a ledger which is entitled "Coleman Daybook." If indeed this account book does belong to the borax operation, it is the only company record that exists from Harmony. The ledger was apparently kept by whomever was ordering provisions for the Harmony/Greenland complex. It seems likely from the wide array of supplies and equipment received over the years, that Coleman ran a company store type arrangement in Death Valley.

The ledger lists shipments of goods from various companies in San Francisco, including the W. T. Coleman Company. The first 79 pages of the book deal with purchases made during the Harmony occupation. Evidently the store, which may have been situated at Furnace Creek, remained open after the plant closed down in 1888, as entries continued to be made in a different handwriting.

The account book reads like a hardware and grocery store inventory. It lists the name of the company being dealt with, date of the transaction, quantity and items purchased, and cost. For example, one entry reads as follows:

<u>R. J. Trumbell & Co.</u>		
10	Sweet Corn	1.00
10	Top Onions	8.00
1	Onion Seed	1.50
2 doz	Tomato Sets	.50
	Lettuce Seeds	.40
	Parsley	.25
1	Turnip Seed	.75
		<u>12.40</u>

After perusing the Coleman Ledger, one gets the feeling that frontier conditions in the late 19th century were not totally spartan. Food products listed include vegetables by the pound and case; garden seeds; dried and canned fruits; seafood such as oysters, salmon, and clams; bacon and hams; beef; Eagle milk, tea, and coffee; honey; butter and cheese; relishes and spices; and staples such as rice, crackers, flour, sugar, lard, and baking powder. Don Pedro brandy and Milwaukee beer were also ordered.

Other categories of supplies may be termed personal gear (tobacco, pipes, pocket knives), pharmaceutical products, and household items (pots, candles, matches, brooms, soap, can openers, lanterns, lamp shades). Lumber was ordered to specification, along with office supplies, and textile and rubber products (rope, hoses, clothing and bags). Horsegear, wagon parts, and blacksmith's stock are frequent entries. Livestock feed and leather tack were among other purchases made.

Machine and industrial parts listed included pumps, tanks, hangers, ore car frames and track, fire bricks, and a boiler. Hardware comprised fasteners, steam gauges, thermometers, and padlocks. The tool inventory consisted of rasps, shovels, picks, planes, plows, files, and hay forks.

We can say with some confidence that this ledger was associated with the Harmony operation in Death Valley. For example, specifications given for the boiler purchased from Hinkley Spears & Co. in 1886 exactly match those of the boiler which remains at the site. The other machinery purchases listed also suggest that Harmony was the likely depot for most of the entries.

The equipment, supplies, and provisions shipped to Death Valley from San Francisco probably ended up in a company store near the Greenland ranch on Furnace Creek. We know from historical records that Harmony was a center of operations for prospectors in Death Valley, one of the few links to civilization in the area. This store provided needed items not only for the Harmony/Greenland work force, but also sold goods to local residents. The Chinese laborers, who did not usually receive room and board, may also have had to buy supplies from this country store.

Chinese Laborers

The discovery of gold in California in 1849, along with unsettled conditions in China due to the Taiping Rebellion (1851-1864), led large numbers of Chinese men to emigrate from Kwangtung province in southwestern China to the Pacific Coast (Bean 1968). These men

entered the country, as entrepreneurs and as employees of others, through the Port of San Francisco. From this point, they spread out and established numerous communities adjacent to the California and Nevada gold towns. The Chinese were then subjected to both persecution and discrimination (Paul 1947: 322).

Chinese were also imported by the thousands to work on the first transcontinental railroad (Rush 1958). At one time, the labor force of 14,000 included 11,000 Chinese (Spier 1958b: 99). After 1875, when the gold gave out and the railroad no longer employed them, they deserted their old communities and settled wherever work was to be found. However, the Chinese were then considered to be too much competition for the general population, and again became a target for abuse and violence (Quellmalz 1972: 148).

No matter where the Chinese settled, they brought their civilization with them from Kwangtung Province (Quellmalz 1972: 148). Chinese merchants in San Francisco imported a wide variety of goods which were shipped to the various communities. In their domestic life, the Chinese evidently continued to follow the same diet and to use the same cooking utensils that they had used at home. Yet, in most instances, the tools and machinery used were out of necessity of American origin (Spier 1958b: 108, 110).

At Harmony, the bulk of the labor force was apparently composed of Chinese laborers. Chinese worked in a number of other borax-producing areas as well, collecting the minerals from the ground surface (Chinn 1969: 36). Unfortunately, little is known about the lifestyle these people followed in the borax towns. Most accounts tend to be impressionistic. Supposedly the 1,000 Chinese employed near Columbus, Nevada, lived in adobe huts, setting up opium dens in cellars. Opium use was ignored by the white employers whose main policy was to "keep John Chinaman at work" (Carter 1967: 490).

Perhaps a description of how the Chinese worked and lived in railroad camps will be useful for comparative purposes (see Chinn 1969: 44-45). First of all, each work group had a common cook who prepared meals and took care of domestic chores. A foreman was

responsible for time keeping and for buying all provisions used by his gang. Work hours were usually from sunrise to sunset, six days per week.

Possibly on the advice of Chinese merchants, mainly a Chinese diet was offered. The inventory included dried oysters, dried cuttle fish, dried fish, sweet rice, crackers, dried bamboo, salted cabbage, Chinese sugar, dried fruits and vegetables, vermicelli, dried mushrooms, peanut oil, tea, rice, pork, and poultry. Well balanced and varied meals were evidently the rule for such work camps. The company provided the Chinese with low cloth tents for shelter but many preferred to live in dugouts or to burrow into the earth.

History of Previous Work

As already noted, a preliminary orientation report on the Harmony Borax Works was prepared in 1971 by F. Ross Holland, Jr. and Robert V. Simmonds, both of the Office of History and Historic Architecture of the National Park Service. The purpose of this project was to study the history of the borax industry in Death Valley, along with the remains and extent of preservation of the Eagle and Harmony works, so as to form a basis for the interpretation of borax mining in the area.

The report, drawing on published sources and an architectural study of the ruins, also presents available reference data on borax-producing operations similar to that found at Harmony. Apparently, almost no company records of the operation have survived. Holland and Simmonds recommended that restoration of Harmony be implemented after completion of (1) emergency stabilization; (2) comprehensive archeological investigations and (3) technical research on the process of borax manufacture (Holland and Simmonds 1971).

Archeological Research

Archeological research at the Harmony Borax Works has been stimulated primarily by preservation and stabilization needs. To date,

such work at Harmony has been almost non-existent. It was not until after 1970 that any planned excavations were conducted in the area of the site.

An initial archeological study of Harmony was undertaken in 1971-72 under the direction of William J. Wallace. The project was implemented prior to proposed stabilization of the plant, its immediate aim being to provide facts useful for determining the full extent of the needed work. The excavations, of three weeks total duration, were carried out in search of the remains of buildings and other installations at the borax works and at the nearby company town.

As the excavations were exploratory in nature, testing was restricted to spots likely to yield information on vital aspects of the plant and townsite. Old photographs guided the placement of excavation units. Two well-preserved wooden troughs, part of the plant's drainage system, were discovered; a possible crystallizing vat bottom was exposed; location of the blacksmith shop was established; and, from surface finds, an area called the Chinese quarters was partially delimited.

A brief reconnaissance by Wallace revealed traces of wagon roads, as well as a privy and two wooden features, to the west of Harmony. All features were collected, sketched, and backfilled. A report was prepared (Wallace 1972), but no formal artifactual analysis was attempted.

The only other archeological undertaking at Harmony was done by Robert Herskovitz during the period February to March, 1975. The project, which consisted of mapping and archeological clearance activities, was accomplished in conjunction with emergency stabilization (Herskovitz 1975b). The objectives of this archeological study were essentially three-fold.

First, a detailed base map of the site was prepared, which included overall plan views, a series of profiles through the site, and architectural elevations of all structures and features. The next phase of work involved profiling behind several sections of

wall removed for stabilization purposes. The final segment consisted of the excavation of trenches at the base of several walls to provide archeological clearance. A major contribution of the project was the drafting by Charles Sternberg of a series of excellent line drawings depicting virtually every aspect of surface features remaining at the site.

Perhaps the most important information gained by these brief excavations was a more complete understanding of the quantity and quality of artifactual material and information still present at Harmony. These projects made it clear that all future stabilization work at Harmony must be preceded by thorough and careful research and planning.

Stabilization

The first attention the Harmony ruins were to receive came during the 1930s. At this time, the Civilian Conservation Corps began work in the area, but the scope of their activities is not entirely known. Roads were established around the site and a protective chainlink fence was set into a low cobble wall around the perimeter of the plant proper. Stabilization work supposedly included only minor wall patching, but it is suspected that the actual endeavor was on a somewhat larger scale.

Recent emergency stabilization, beginning in February 1975, has, first of all, reset cobble and sandstone retaining wall sections within the enclosing chainlink fence. In addition, erosional cuts were filled in on the east terrace slope; basal erosion was checked in adobe structures A and B; and proper preservative treatment was established for the adobe construction materials (Adams 1975). However, the walls, terraces, tailings, dumps, bulkheads, and other principal features of the works continue to weather and erode.

It is this increasing state of deterioration that resulted in the proposal of further stabilization activities at Harmony. Thus, in accordance with the Advisory Council on Historic Preservation,

necessary archeological mitigation was required, initiating the present study. Both actions were of importance in the prevention of any further destruction of this valuable resource and to provide for its continuing interpretation.

Modern Alterations

Modern alterations in the terrain are a hindering factor to any research-oriented undertakings at Harmony. A graded dirt road taking off from California State Highway 190 a few miles north of the monument visitor center leads to what, until recently, was a parking lot directly north of the fenced-in portion of the borax works. This graded lot covers an area where many of the plant's installations formerly stood. A protective chainlink fence, set in a low cobble wall, and crude stonework laid to stabilize the east and west slopes, hide other parts of the works. Due to previous uncontrolled visitor use, several conspicuous trails have been worn into the tailings and the ash dump, located respectively west and east of the main plant.

Because a major portion of the Harmony Borax Works has been fenced since the 1930s, the present state of deterioration has been caused primarily by natural erosional processes. Stabilization of this site will be a continuing necessity if further accelerated decay of the ruins is to be prevented.

Chapter 4

ARCHEOLOGICAL CONTEXT

Introduction

Harmony Borax Works consists of the ruins of the refinery and an associated townsite (Fig. 4). The refinery, or plant, was built against a hillside which was terraced to provide four tiers so that gravity might aid in moving solutions from stage to stage. At present there are remains of adobe structures, tanks, piping, and settling ponds. These features are fenced off, and form an interpretive exhibit (Fig. 5).

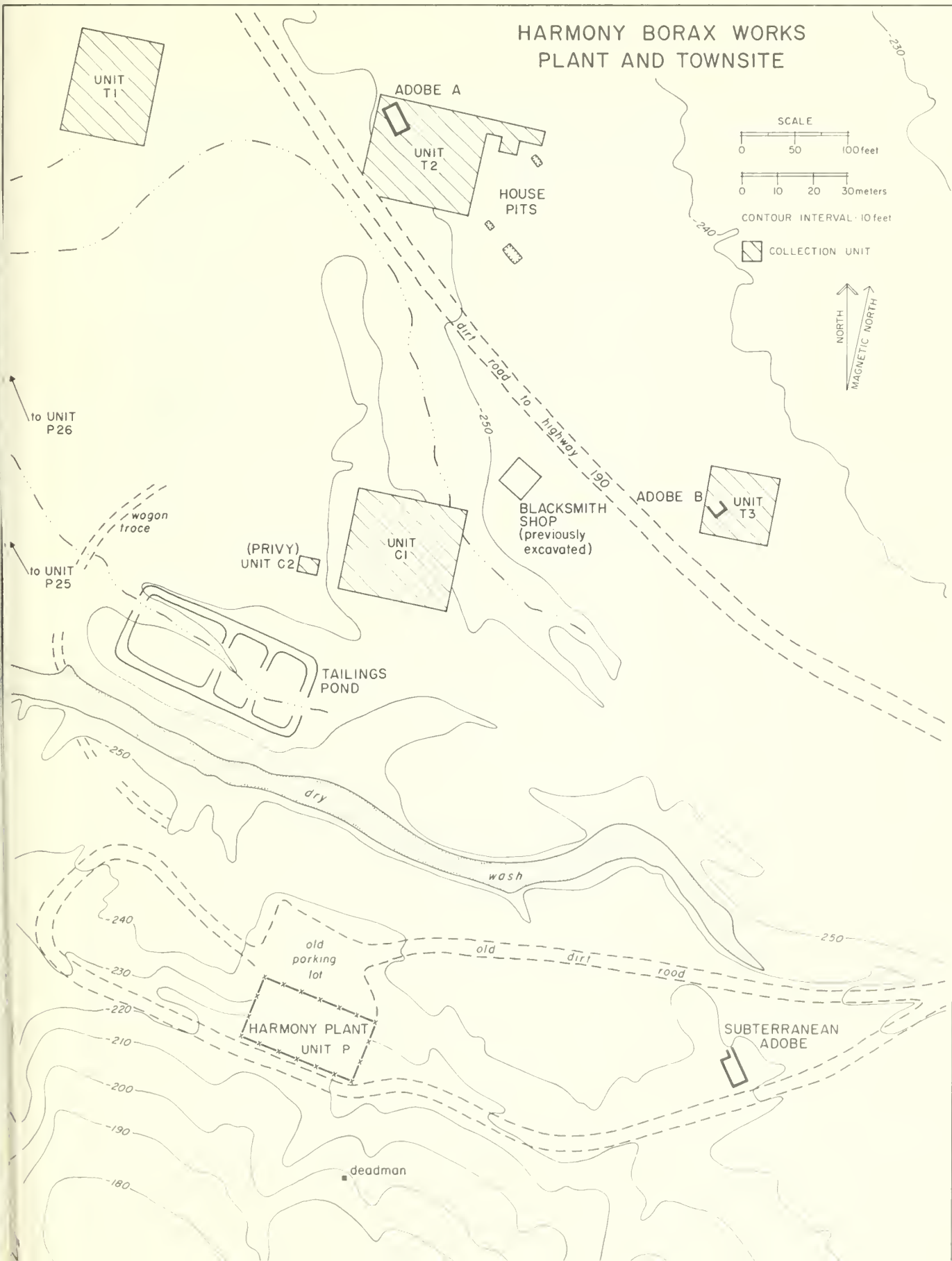
In front of the plant, to the north, is a relatively flat expanse of ground on which was built the townsite. Only two ruined structures, Adobes A and B, remain above ground. Between the townsite and plant is an area which Wallace (1972) called the Chinese quarters.

As detailed earlier, we chose to order our recording units into three major classes, Units P, C, and T. These designations serve as shorthand for plant, Chinese quarters, and townsite. Under these rubrics were subsumed the various excavation and collecting units. For more information on this scheme, see the section on method.

In this chapter will be given descriptions of surface and sub-surface features recorded. Line drawings will be used for most illustration, as opposed to photographs, for two reasons. Drawings are more economically reproduced, and almost all pertinent historical photos have already been published by Holland and Simmonds (1971).

Less detail in measurement will be presented than usual because major surface features have already been described elsewhere (see Herskovitz 1975b; Holland and Simmonds 1971; Wallace 1972).

HARMONY BORAX WORKS PLANT AND TOWNSITE



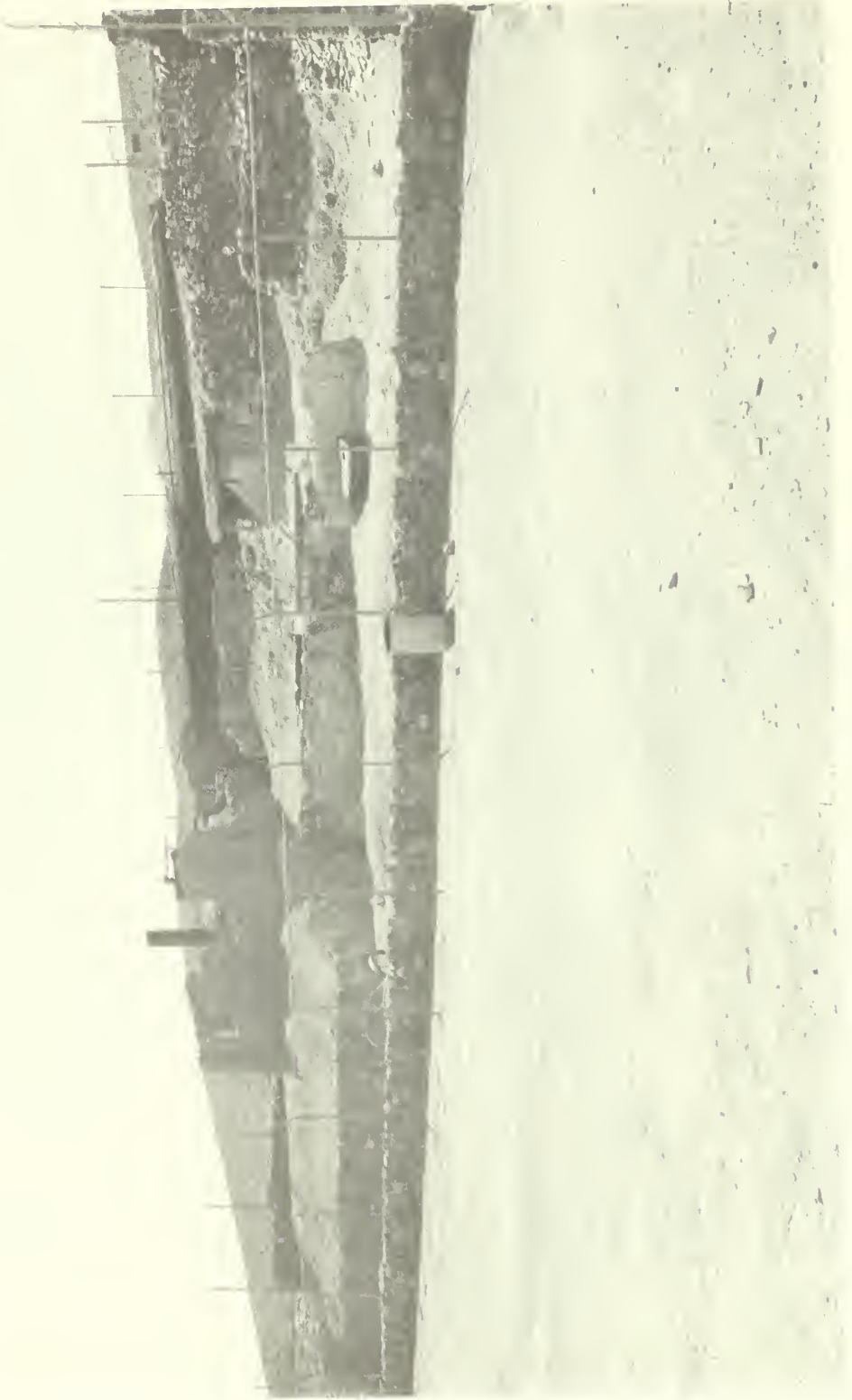


Figure 5. Harmony plant before stabilization.

Stratigraphy

Initial units were excavated microstratigraphically by natural level, but this strategy was soon abandoned. Deposits proved to be shallow (5-25 cm deep) with multiple strata. In a 20 cm level it was not unusual to note a half-dozen laminae resulting from colluvial action on deposits at a higher elevation. However, we recognized that little, if any, information was to be gained by excavating laminae separately. What could be learned from such excavation was what we already knew--that Harmony lay exposed for some 90 years while erosion reduced deposits to a lower elevation. Stratigraphic units of interest, then, were original surfaces, artificial grades established by plant construction, and post-abandonment fill.

The townsite and Chinese quarters are essentially without stratigraphy. The northeastern sector of the study area (Fig. 4) has been deflated to desert pavement and artifacts are on, and imbedded within, this surface. The remainder of the area has shallow deposits of presumably alluvial sand of unknown age. This area is in the process of deflation to desert pavement. Artifacts are found on the surface of the sand but seemingly not within it.

To sum up, Harmony will have to be understood largely without recourse to stratigraphic interpretation, except in architectural reconstructions. Deposits are shallow, time span is short, and superposition of features was seldom seen.

Architecture and Features

Plant

Surface Features. Before beginning the description, a good bit of orientation will be needed. The plant is compact and hard to understand because of its vertical arrangement. Perhaps the best way to begin is by reference to Figures 6 and 7, artist's reconstructions of the plant after abandonment. While looking at these, bear in mind that they were drawn from photographs taken after plant abandonment, perhaps about 1900. The photos, on file

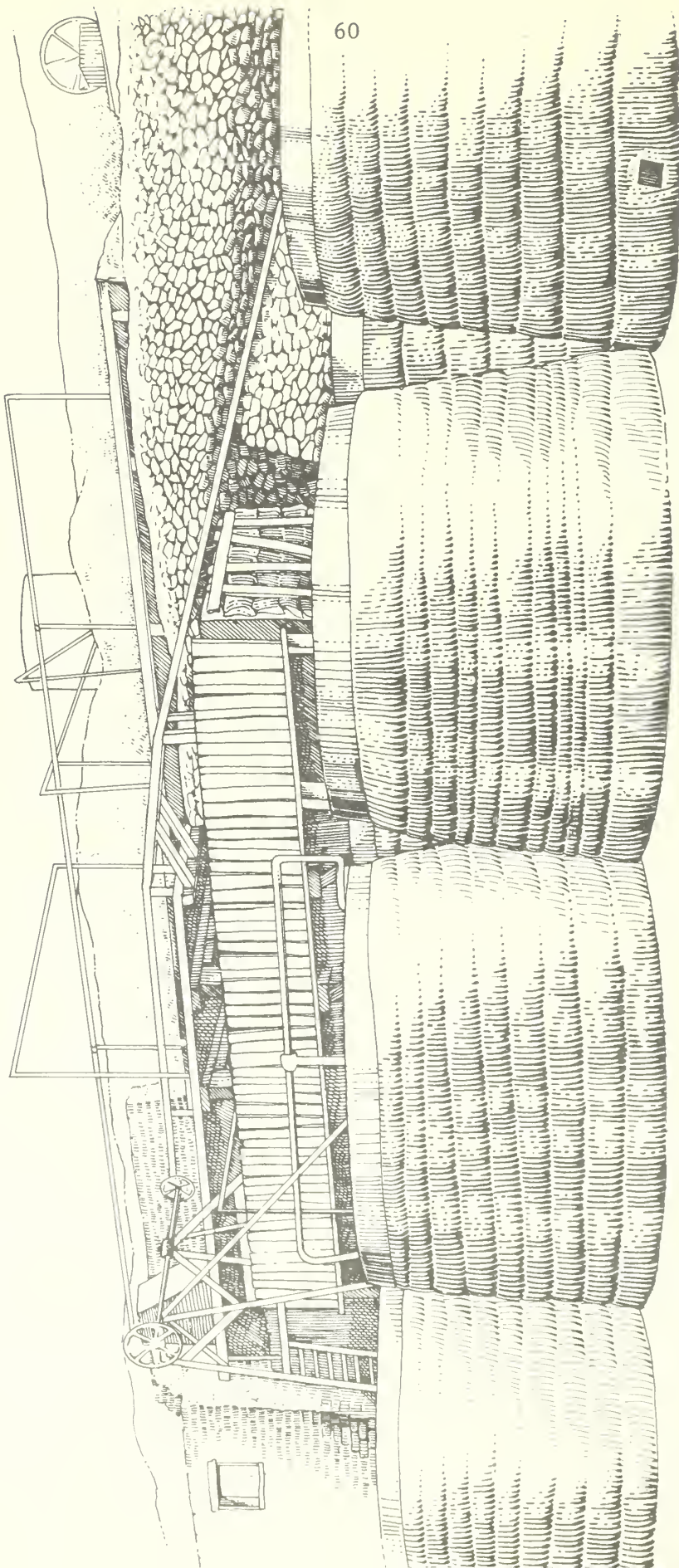


Figure 6. Harmony plant shortly after abandonment, looking south from area of the crystallizing vats. Artist's reconstruction from a photograph in Death Valley National Monument files.

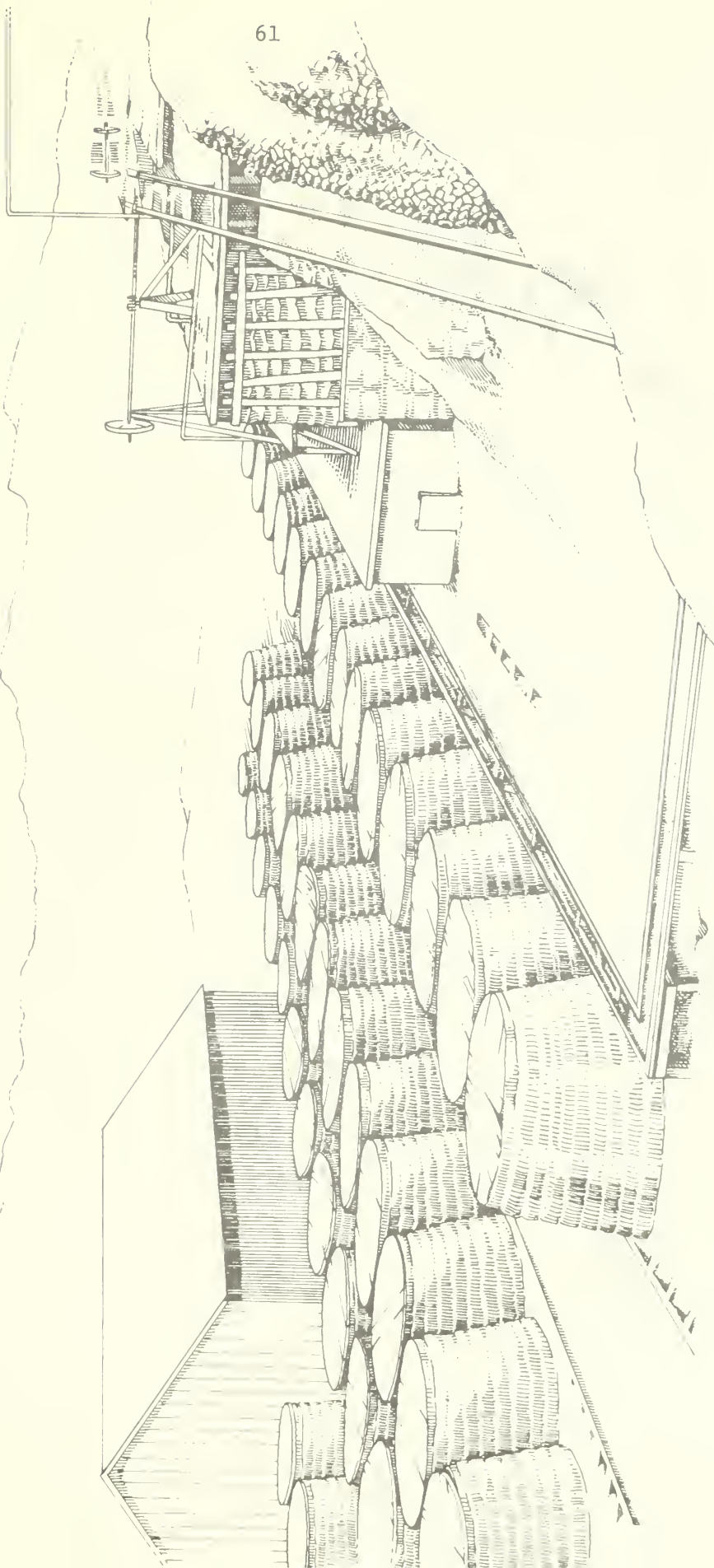


Figure 7. Post-abandonment view of plant, looking east.
Artist's reconstruction from a photograph in
Death Valley National Monument files.

at Death Valley National Monument, are old and somewhat blurred. Also, the plant was littered with junk at the time, and features which remained were obscured.

Figure 6 is a view to the south. In the foreground are some of the large felt-covered iron crystallizing vats. Above them are square settling tanks, sheathed with boards. On the westernmost tank (right of drawing) is a framework of boards and sacks stuffed with straw. Above this tank is an inclined ramp with an ore-cart track leading to a wooden platform. Long tanks, running east-west, are barely visible beneath the pipe grid. A lone water tank remains on the hillside above. West of the tanks is a wheel-and-box contraption which may be an ore crusher. On the east end is an adobe machine shed. Just to its west is a drive line assembly with pulleys mounted on A-frames. Between drive line and building is some sort of wooden construction. This may be a housing for a drive belt from inside the machine shed.

Figure 7 is a view to the east. The vertical extent of the plant becomes clearer. To the north (left of drawing) is a large wooden shed, which, for convenience, will be called a barn. Between barn and plant, on what we have called Tier 4, are three lines of felt-covered vats with wooden tops. The number of vats is hard to determine, but there appear to be about 15 to the line. Alongside the vats can be seen vestiges of wooden drains with 2x4 spreaders. A slightly elevated track on the north forms the boundary between Tiers 4 and 3. The track turns south, then east up a ramp to the wooden platform. You can see that there are square settling tanks on both Tier 3 and on an upper level, Tier 2. Tier 2 was formed by grading the hillside and installing sandstone block retaining walls. On Tier 1, the highest, can be seen an end of the platform. Another view in Holland and Simmonds (1971: Illus. 10) shows an ore cart and track, leading to the skimmings pile. Above the ore cart is the circular steam drum from the boiler. Other features in the drawing are the driveline, pipes, and what may be a winch for hauling carts up the incline.

Having gotten this far, consider the elevation drawings in Figure 8. These were made before excavation and are keyed to the central plan map, Figure 11. Along line B-B' can be seen the western dissolving tank, retaining walls, and the ramp. The CCC cobble walls which bound the drawings were placed during this century as base for a protective fence. The drawing along line D-D' shows tank, walls and a remaining section of platform. Along line E-E' there appears the eastern dissolving tank, walls and wooden posts. Building remains and boiler are shown in section along line H-H'.

Through excavation we were able to produce another cross-section of the plant (Fig. 9). This one shows the probable arrangement of the hillside before alteration, the grade lines established for the plant, and the extent of deposits formed after plant abandonment. Note that Tiers 3 and 4 were graded, Tier 1 was leveled with fill dirt, and Tier 2 was both graded and filled.

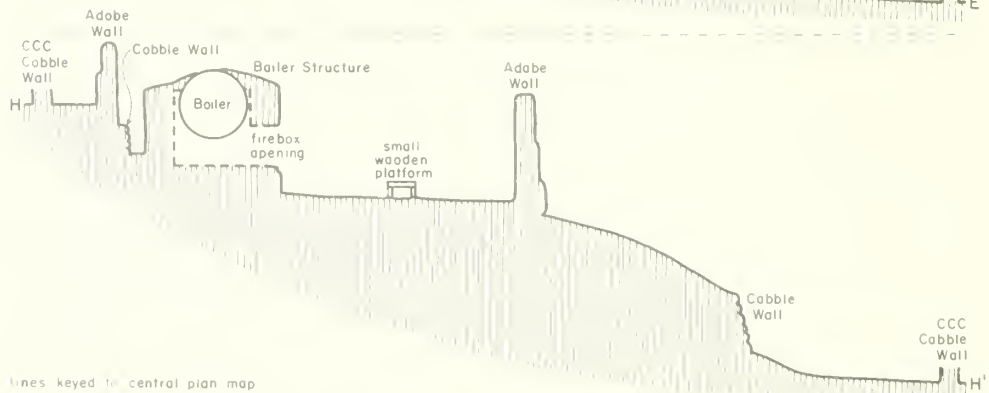
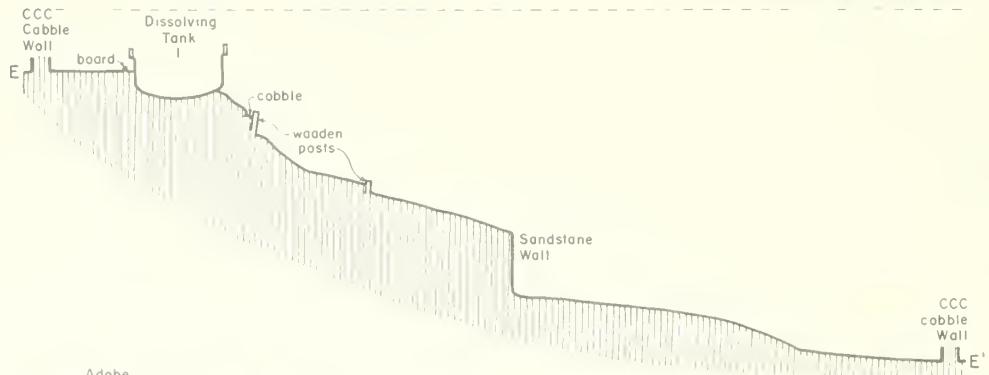
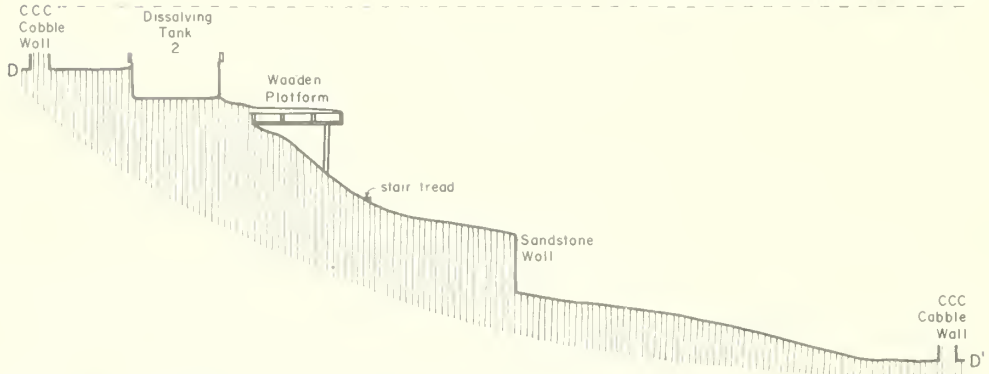
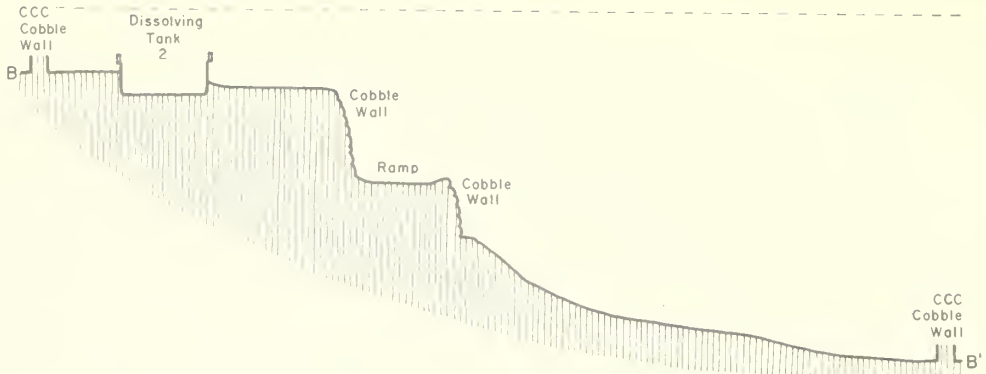
The original surface and grade lines are, of course, projections made by extending trench profiles. Information from lower tiers is good. From Tier 1 it is not so good; only one small trench was dug to the south of the dissolving tank. We still feel this is a good reconstruction of the leveling procedures.

As for the plant in plan view, let us first consider Figure 10, which shows the fenced-in plant as well as associated features. To west and east of the fenced section are natural terraces that were used, judging by inspection and contemporary photos, as a dump for skimmings in the one case, and for wood storage in the other. The skimmings pile, called Unit P20, is composed of grass, sand, and borates and other chemicals. Grass was skimmed from the dissolving tanks and discarded in this area. Posts set in the pile indicate a probable ore cart track once ran along this pile. The wood storage area (Unit P19) is largely unmodified, except by erosion. Large quantities of decayed wood and charcoal can be seen in eroded areas.

South of the plant, and at a higher elevation, are artificially leveled spaces used as platforms for water tanks. To the north is

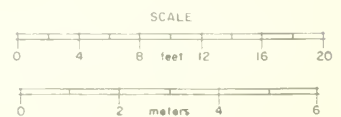
SOUTH

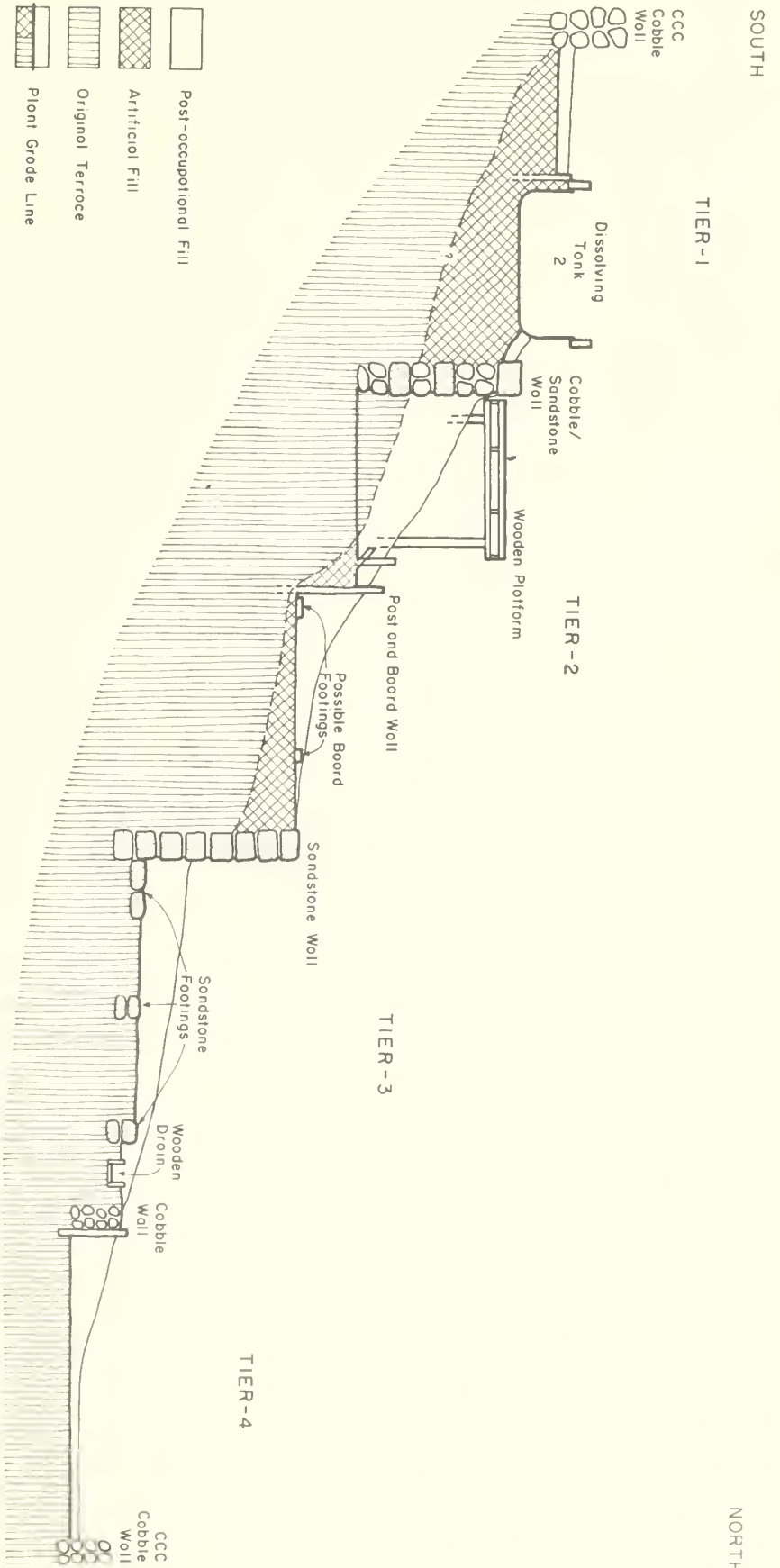
NORTH



lines keyed to central plan map

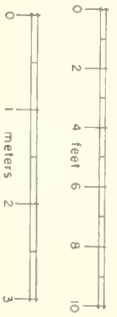
CROSS-SECTIONS OF PLANT HARMONY BORAX WORKS

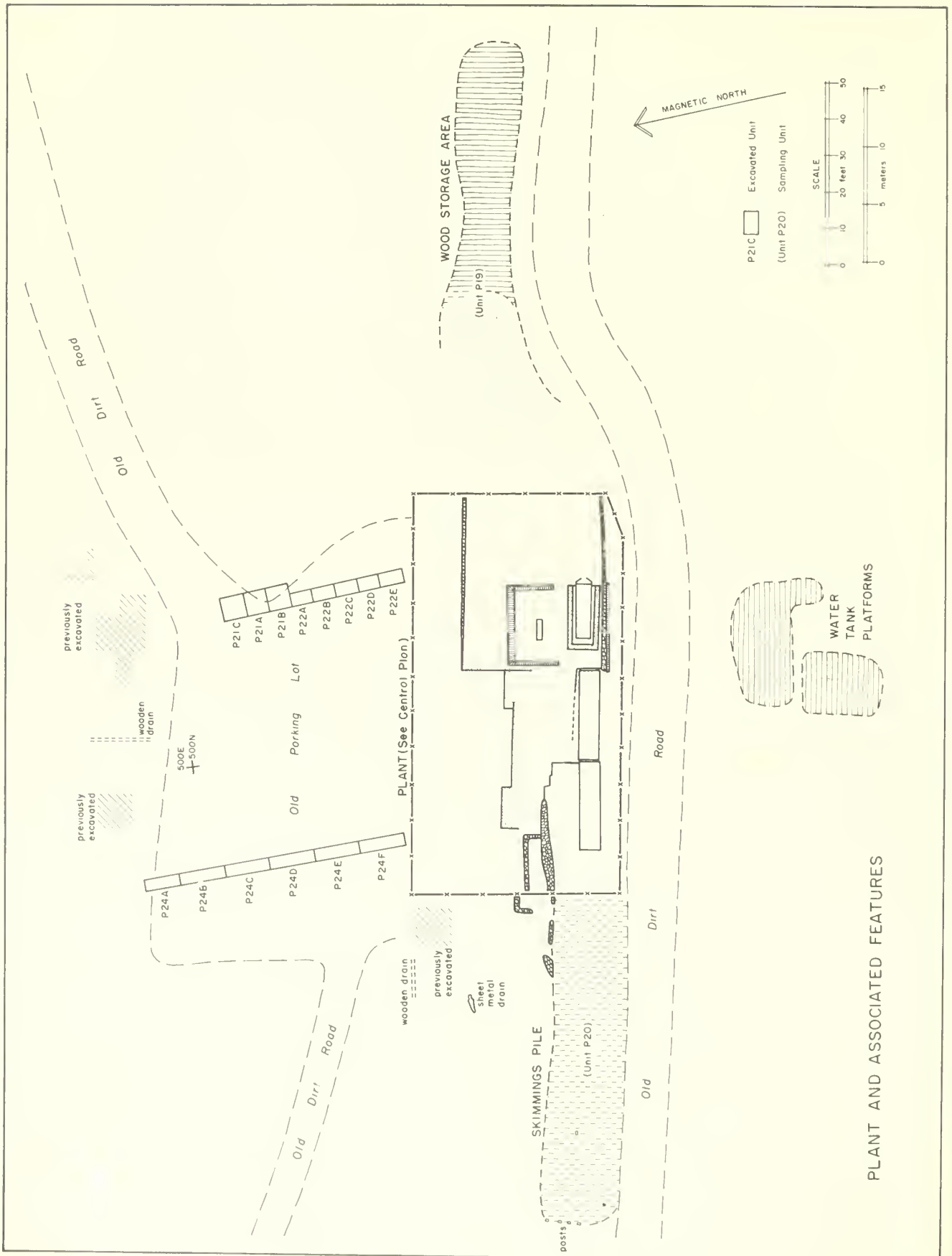




CROSS-SECTION VIEW OF PLANT ALONG LINE D-D'
 SHOWING PROBABLE ORIGINAL GRADE

SCALE





PLANT AND ASSOCIATED FEATURES

the old parking lot. Shown here are our parking lot trenches and the areas excavated by Wallace in 1971-1972.

To tighten up focus, refer to Figure 11, a drawing of the fenced-in plant made before excavation. Note that little was revealed on the surfaces of Tiers 3 and 4. Prominent were a couple of 4x4 posts, a cobble alignment, a reciprocal steam-driven pump, and walls separating Tiers 3 and 4 from upper tiers.

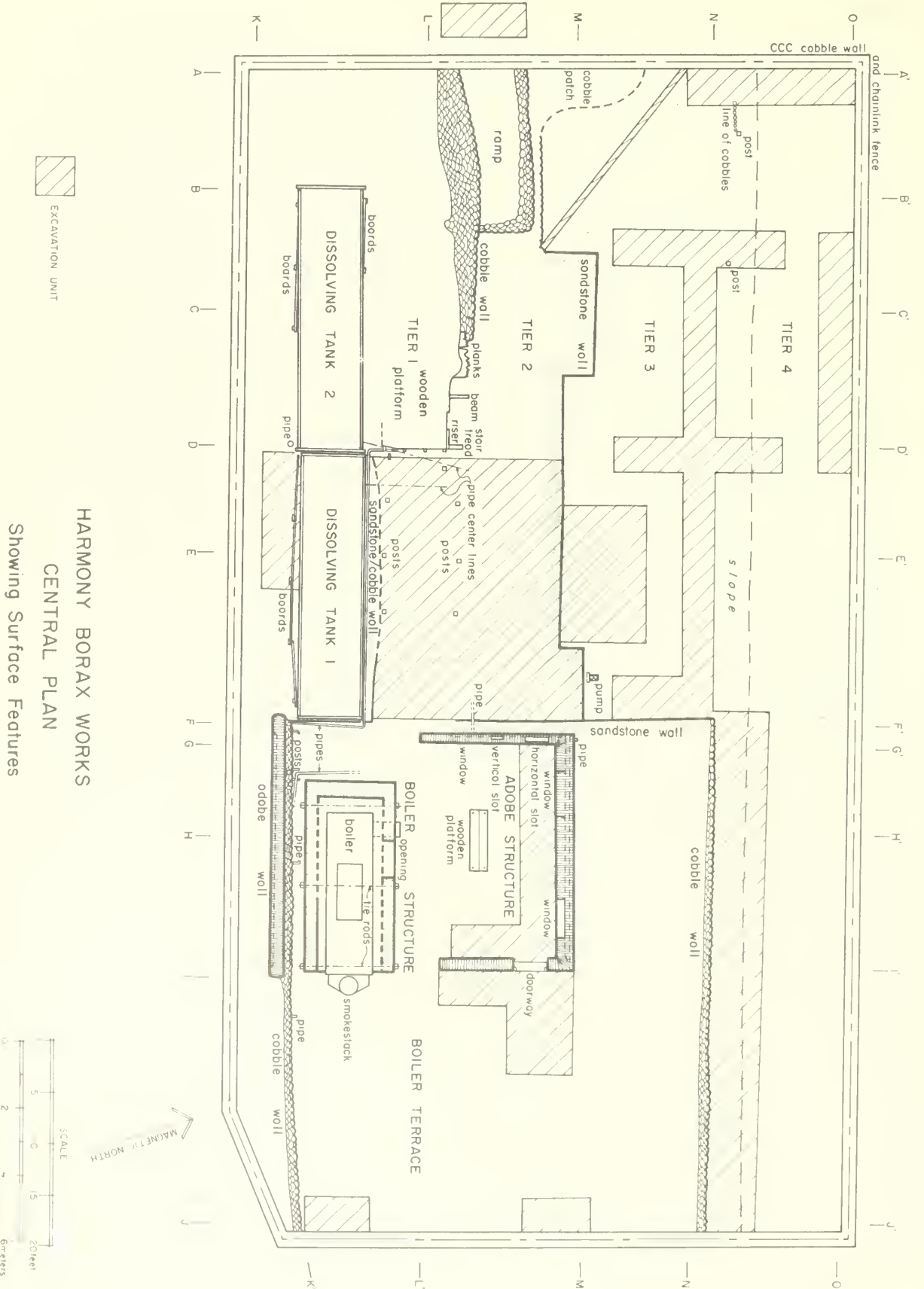
The pump is fastened with bolts to a vertical 2 in. by 10-1/2 in. board. It consists of a 4 in. inside diameter cylinder connected to a four-section valve box. Valve chambers are 4 in. by 4 in. by 1-1/2 in. Intake and exhaust ports with 2-1/4 in. diameters are at either end of the valve box. Two 5-3/4 in. diameter flanges served for pipe installation. Height of the valve box is 18 in. (Fig. 12).

The northern cobble wall is about 4 ft high and is slanted slightly to the south. Materials used were granite, quartzite and basalt cobbles averaging 8 in. in maximum dimensions. The original mortar was mud, but the wall has been capped with sandstone slabs and portland cement, presumably by the Civilian Conservation Corps in the 1930s.

The sandstone retaining wall is made of dressed block set with mud mortar. Average size of the blocks is about 12 in. by 12 in. by 8 in. Part of the 4 ft high wall has been stabilized (Adams 1975) and part is deteriorated.

In addition to features shown on the map, there is a good bit of junk lying about on the lower tiers. Included are pieces of pipe, a galvanized vat hanger rod, a pulley flange with set screw, a sheet iron box, two possible well-bailers, a wagon spring, and a set of wagon wheels. These objects may or may not relate to the plant occupation, although nothing militates against this time assignment.

The wagon wheels are joined by a square axle-and-spring arrangement about 4 ft long. Wheels, spokes, hubs, and tires are iron. Lubricating ports are built into the hubs. Tires are 40 in. in diameter. Hubs are fastened to axle with 2-1/4 in. hex nuts.



HARMONY BORAX WORKS
CENTRAL PLAN
Showing Surface Features

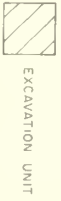
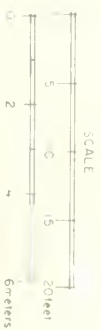




Figure 12. Reciprocal, steam-driven pump on tier 3.



Figure 13. Platform support posts in front of east dissolving tank.



Figure 14. Dissolving tanks with lumber bolted around rim.

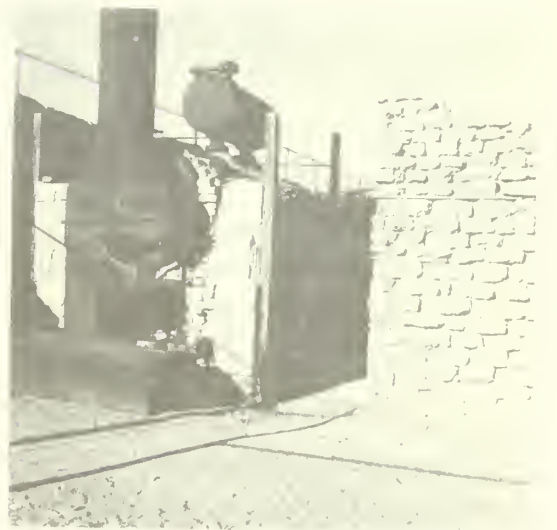


Figure 15. Boiler and machine room.

Cast around the hubs is the following legend: "2 IN. PAT'D MAR 19 72 MAR 25 79 & JULY 1 79."

One of the two presumed well-bailers is built into the north cobble wall, possibly as reinforcement. The other was found on the surface and was available for inspection. Sheet iron was joined by rivets into a cylinder 8-1/2 in. in diameter and 74 in. long. A heavy yoke of bar iron is fastened to one end and is threaded to take a coupling. The end opposite the yoke is reinforced with steel and has provision for a hinged flap-valve. Similar tools, called "sand augers" or "dry buckets" are pictured in a manual put together by Volunteers in Technical Assistance (1973). Apparent function of these tools is to dig or clean out uncased wells.

The iron box found on the surface of Tier 4 is open on top and on one end. Dimensions are 49 in. by 29 in. by 16 in. This may have served as an auxilliary fire box for the boiler. Construction is of sheet iron with a strap iron frame, joined together with bolts.

On Tier 2 (Fig. 11) several features can be seen. To the west is a cobble and earth ramp resting on a cobble footing which extends out 12 in. from the ramp base. The footing is retained by two indistinct, low cobble walls. The ramp has been much modified post-abandonment and is now from 4 to 5 ft high. Original mortar was mud, but a soil cement overgrout has been applied. At about the mid-point on the north side is a partially buried pipe, 2-1/4 in. in outside diameter. The pipe may have been functional or may have been included fortuitously in the wall matrix.

A substantial cobble retaining wall supports the wooden platform of Tier 1. Materials used were cobbles with some sandstone block and broken firebrick. Mortar is mud, and there are two kinds. The darker of the two seems to be soil cement overgrout. The wall probably predates the ramp. It runs east to the end of the existing wooden platform when it turns south. The situation is obscured by erosion, but this wall probably once abutted the upper tier retaining wall.

This upper wall runs east-west along the north side of the dissolving tanks. Badly eroded at the time of our work, it was originally of cobbles with random sandstone scrap. Original height was about 6 ft. This wall appears to run the length of both dissolving tanks, but under the platform eroded fill dirt prevents inspection.

The platform itself, the top of which is at the Tier 1 level, is 74 in. high. At present it extends 11 ft 4 in. on an east-west axis. Tests on the Tier 2 level, as well as contemporary photos, suggest that the platform once ran the length of both dissolving tanks (Fig. 13). Apparently, the eastern extension was salvaged for lumber. Very rough cuts, as if made by a bow saw, were observed on the Tier 2 post stubs.

Posts made of 4x4 lumber support the platform remains. To these uprights were attached beams either 11-3/4 in. by 2-1/2 in. or 6 in. by 2-1/2 in. Upon these, 2x6 stringers were set on edge. On the stringers was laid a deck of random width 1 in. and 2 in. planks.

A stairway once led from Tier 2 up to the platform, as indicated by a fragment of stair below. The fragment has a wood footing to which is fastened a fragment of riser. Judging from saw cuts on the riser fragment, there would have been about 8 in. of run for each 9-1/2 in. of rise, forming a fairly steep stairway.

Other major features of Tier 1 are the dissolving tanks, pipes, and the south cobble-adobe wall. The tanks have been described in some detail by Holland and Simmonds (1971). Briefly, they are made of heavy sheet iron and are about 25 ft long, 6 ft wide, and 2-3/4 ft deep at their deepest. Each tank was assembled, probably on the spot, out of six sections 53 in. wide. Joints are lapped and riveted. Angle iron forms a lip, and 3 in. by 7-1/4 in. lumber is bolted to the rim (Fig. 14).

Tank 1 has been patched twice on the bottom with sheet iron and rivets. There is a 5-1/4 in. diameter drain on the west end. Six bolt holes would have served a drain pipe flange.

Tank 2 is in all ways like Tank 1, except there is no apparent bottom drain hole. However, a hole 2-1/4 in. in diameter has been

made near the rim on the west end. This may have been for an elbow-jointed siphon. It is of note that Tank 2 is 8 in. lower than the other, and a lip has been bent into the west end of Tank 1. It may be that solutions were siphoned from Tank 1 to Tank 2, and then to lower tanks.

Two pipes extend north from underneath the dissolving tanks. Their center-lines are shown on Figure 11. One is of 2 in. pipe and the other is of 3 in. The larger may have been a sludge drain, although it disappears under the tanks and connections cannot be seen. The 2 in. pipe winds its way up to the rim of Tank 1, along its length, and then goes underneath the south cobble wall. This pipe probably ran to the water tanks above.

Another pipe, at the southeast corner of Tank 2, extends vertically 45 in. It has an inside diameter of 2-1/2 in. Purpose is unknown.

A long 2 in. pipe, not *in situ*, lies along the dissolving tanks and runs nearly their combined length. The pipe is joined with a collar and Tee and double-Tee fittings. It probably serviced the steam injection grid.

What may be part of the grid itself is represented by two large pipe assemblies, also lying atop the tanks. The assemblies are made of 1-1/2 in. or 2 in. pipes joined to central pipe spines with double-Tee connections. Ancillary pipes are arranged as opposing pairs and are capped at ends and drilled with 1/8 in. holes at irregular intervals. The assemblies are 88 in. wide, and are therefore too wide to have been submerged in the tanks. But we can't imagine what else would have been done with them. It may be that steam was injected from above the solution level, as unlikely as this may seem.

One other convoluted piece of pipe joinery was seen in Tank 1. The pipe takes four bends with the aid of elbow joints. Purpose is unknown. The assembly is not *in situ*.

The south cobble wall is from 2 ft to 4 ft high. The eastern extent may have been reset by CCC labor, but mud mortar is consistent throughout. A five-foot adobe wall was built on top of the cobbles to the south of the boiler. Set into the base of this wall are the remnants of two wooden uprights. One is a 4x4; the other is a 6x6. Both have been burned. Apparently the adobe wall served as the south wall of a boiler/machine shed room, and the uprights supported a common roof which burned.

Five pipes emerge from the south cobble wall between the wall and the boiler. Four go back underground and probably served to take water from the elevated water tanks to various tanks or vats in the plant.

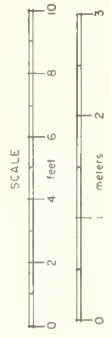
Major features on the boiler terrace are the adobe structure (which we will call the machine room) and the boiler with its housing (Fig. 15).

To turn first to the machine room, refer to Figure 16 for elevation drawings. The end walls stand about 10 ft high on their south end, and about 8 ft high on the north. Apparently, a shed roof with a slope to the north once covered the structure, and probably ran to the cobble-adobe wall behind the boiler. The structure apparently had no adjoining east wall, this space being left open for a breezeway.

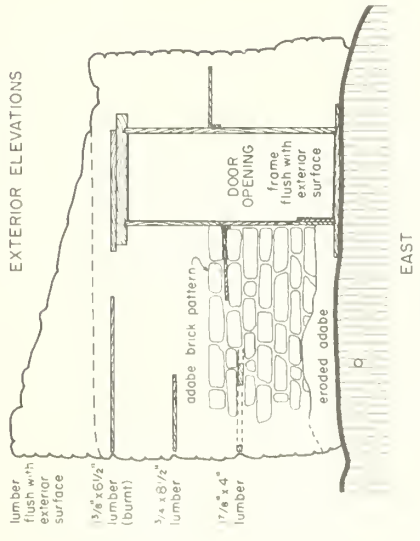
Construction was of random-sized adobe bricks with heavy gravel temper. Construction is a bit haphazard. Wall thickness ranges from 12 to 14 in. because of offsets at varying heights, as shown in the drawings. Lumber was set horizontally within the courses, probably for greater stability. Mortar is of mud. No wall plaster was noted.

Wall openings include a door to the east, windows to the north, and slots to the west. The slots are presumed to have been made to pass belts from machinery to outside pumps or drive lines. Numerous fragments of flat glass on the slope to the north suggest glass windows may have been installed.

ADOBE MACHINE ROOM
HARMONY BORAX WORKS
Wall Features and Elevations

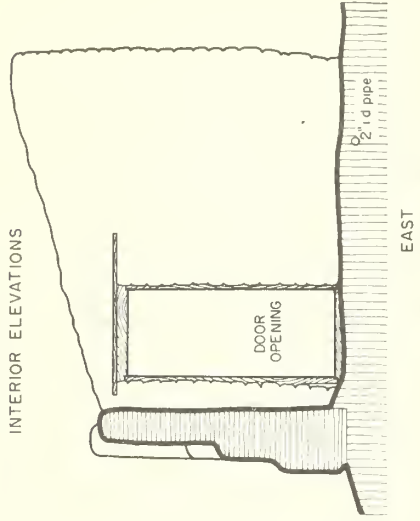


EXTERIOR ELEVATIONS

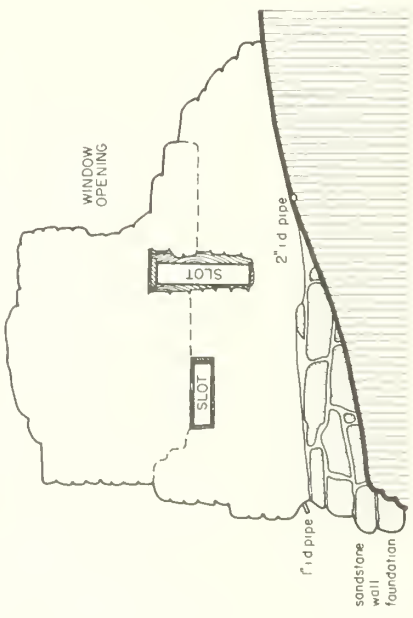


EAST

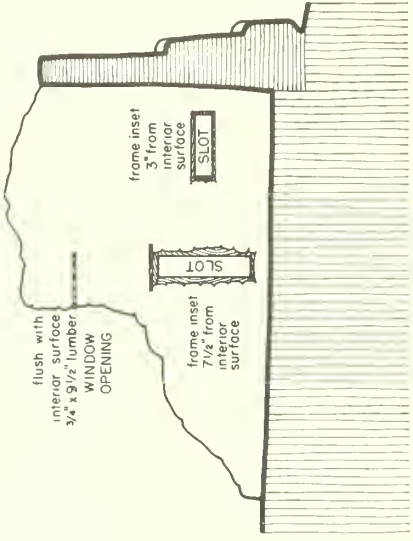
INTERIOR ELEVATIONS



EAST

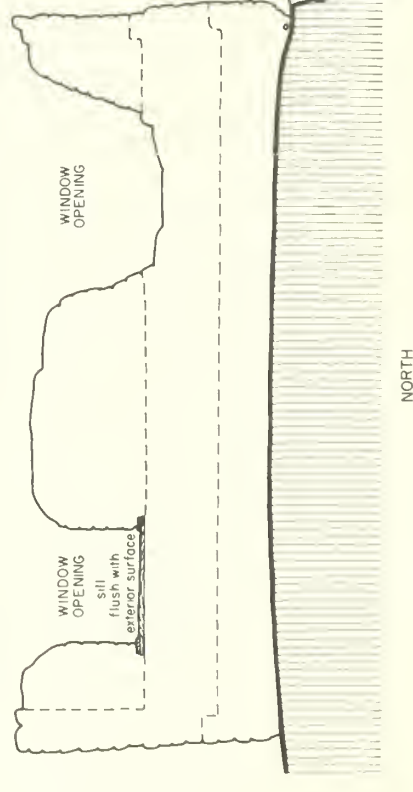


WEST

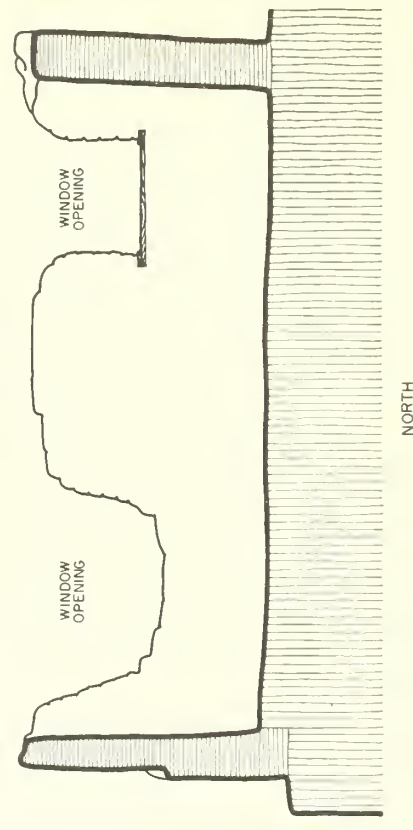


WEST

dashed lines indicate change in width of wall



NORTH



NORTH

In the room center is a platform of massive lumber, bolted together. This served to raise a large engine off the floor. A photo, taken in 1947, shows such an engine in place, but it has since disappeared. Building measurements can be scaled off Figures 11 and 16.

The boiler consists of a firebox, grate, boiler chamber, steam chamber, mud drum, and housing (see Fig. 17). The firebox is no longer in place, but now lies to the east of the front firebox opening into which it fits. It is made of riveted sheet iron and served to confine the fire to the heavy iron grate area. Presumably it was removable to facilitate cleaning.

A mud drum, used for cleaning the boiler chamber, is located on the south wall. It is 6 ft long and 18 in. in diameter. The north end is capped and had a port secured by a dogged-down cover. The drum joins the boiler above it through a pipe stanchion 6-1/2 in. in diameter.






The main boiler chamber is 54 in. in diameter and is 17 ft long. Forty-four 3-1/4 in. diameter flues run from end-to-end within the chamber. On the east end is a draft box with a door and an 18 in. stack. A short length of pipe extends vertically from the chamber and was used presumably as a water inlet. On the front of the draft box is a plate stamped: "Fulton Iron Works., Hinckley, Spiers & Hayes., San Francisco."

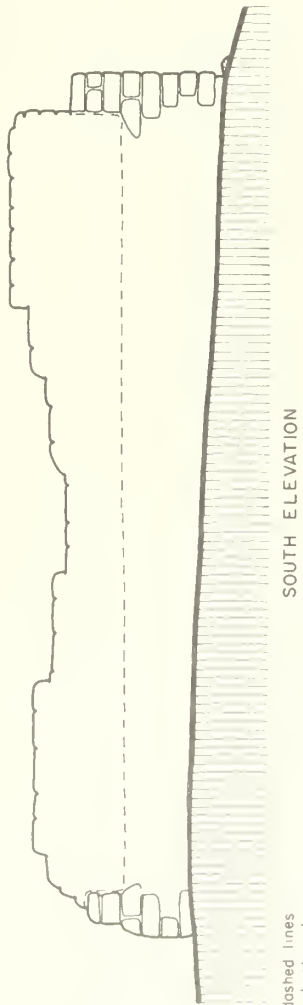
A steam chamber is joined to the boiler chamber with 6-1/2 in. stanchion pipes. Joints are sealed with rubber gaskets. The steam chamber is 65 in. long and 29 in. in diameter. On one end can be read:

"...RAL IRON WORKS
C. H. No 1
...000"

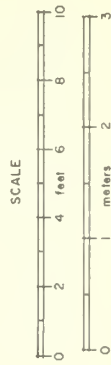
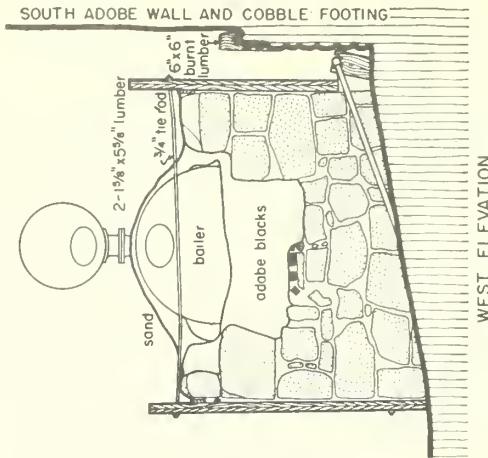
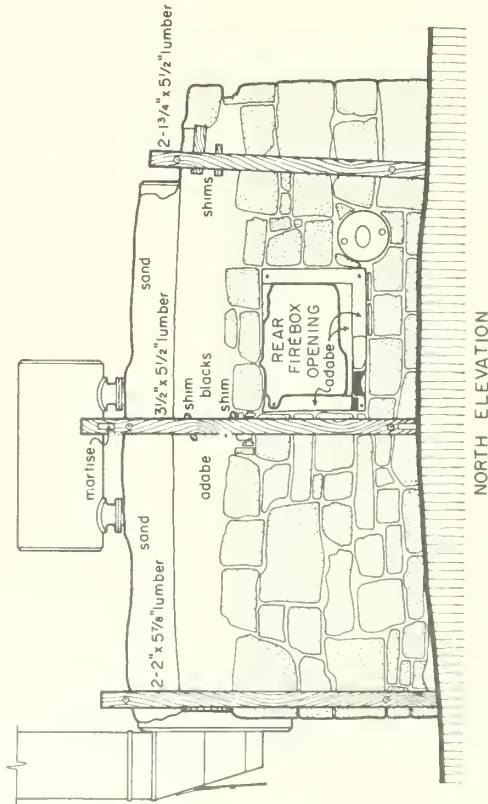
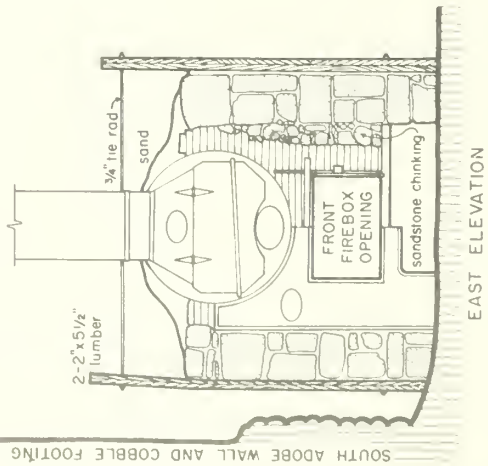
On the south side appears:

"... ROLL...
O. No 1
... ON ROLLING ...
45000"

-  sandstone
-  adobe blocks
-  cobble
-  firebricks
-  lumber



dashed lines
indicates change
in width of wall



BOILER STRUCTURE AND SOUTH ADOBE WALL
HARMONY BORAX WORKS

Steam pipes on the chamber are joined with hex nut fittings, as opposed to the simple screw collars or unions found on water pipes.

The boiler housing is of sandstone blocks with some adobes on the sides and west end. On the east end a boiler cradle was built up with iron plate and firebrick. Bricks measure 9 in. by 4-1/2 in. by 2-1/2 in. and are stamped with the legend "T CARR."

An opening on the north side, labeled "rear fire box" in our drawing, may have served that purpose, or may have been merely a cleanout space. The opening is reinforced with scrap wagon spring pieces, and two iron bars probably supported an iron door.

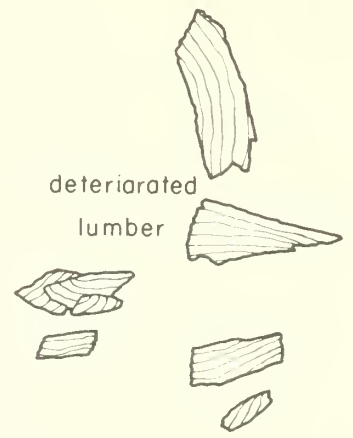
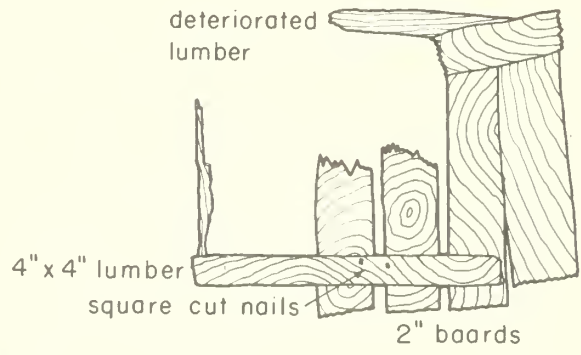
The structure is braced with upright beams and 3/4 in. rod tensioned with nuts. Measurements may be taken from our drawing.

Apparently, the structure was sealed on top with sand and mud. Hot gases from the fire were taken to the west end, back through the flues, and up the chimney through draft action. These gases heated the flues, or tubes, which in turn boiled water in the boiler chamber, producing steam. This steam would have been held under pressure in the upper steam chamber. Boilers operating like this are called fire tube boilers (Anonymous 1967: 40).

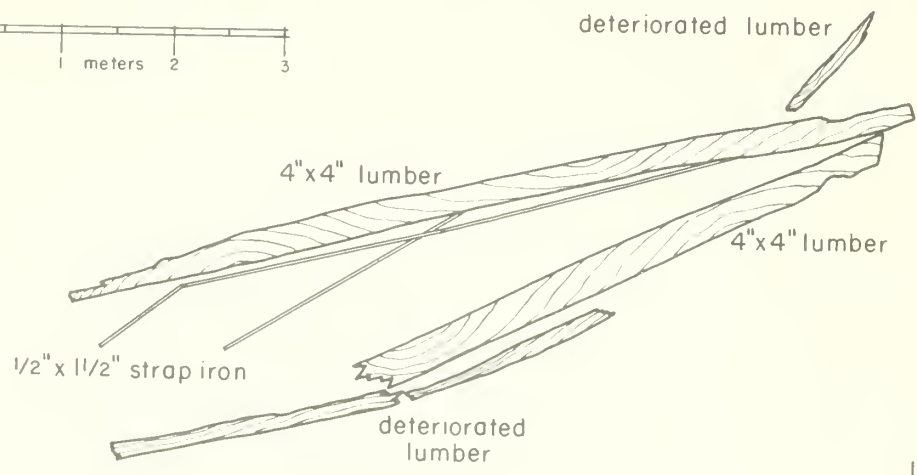
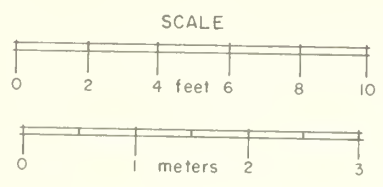
Outside the plant proper, but probably associated with it, are five other surface features: two wooden features out on the salt marsh, the tailings pond, a subterranean adobe near the plant, and a wood-post deadman.

The wooden features shown in Figure 18 may be remains of abandoned carts or sleds once used for hauling ulexite ore from salt marsh to plant. Both are about 1000 ft from the plant on headings as indicated in Figure 4.

In mapping-unit P25 was an assembly of badly deteriorated lumber held together with square cut nails. One fairly intact piece of lumber measured 4 in. by 4 in. in section. Unit P26 included long sections of 4x4s to which were fastened 1-1/2 in. by 1/2 in. strap iron. The iron was nailed on with square cut nails. The feature may represent the remains of heavy sled runners.



UNIT P25



UNIT P26

PLAN VIEW AT SURFACE OF UNITS P25 ,P26
HARMONY VICINITY

An earthen reservoir with three chambers is located across the wash from the plant (Fig. 4). Overall dimensions are approximately 180 ft by 90 ft. Chambers are labeled, from west to east, P23A, P23B, and P23C. We have called this feature the tailings pond, after its presumed function.

One last plant feature appeared on the surface. This was a subterranean adobe east of the plant. According to Herskovitz (1975b: 10), this was built by digging a hole, laying adobe walls up about 6 ft or higher, then backfilling behind the walls. The room produced measured about 30 ft by 18 ft. This structure was not available for inspection during our recent work, since it has been backfilled to protect it from further deterioration (Adams 1975). Function is unknown.

The deadman is a three-foot-high 6x6 post set in the hillside above the plant. Apparently something in the plant was anchored to this post with cable or rope.

Subsurface Features. Features revealed through excavation were few on the boiler terrace (see Fig. 17). Unit P1 reached grade line at 45 cm below present surface. On this grade rested a 6 in. by 6 in. beam, 44 in. of which was exposed. In the middle was cut a 10-inch-wide notch. We could not tell whether the beam was in its original place. Function is unknown.

Also found was a 3 in. pipe trending east-west. This is doubtless the same pipe revealed in Units P3, 4, and 5C. Fill above the pipe is formed by waste from the boiler. The pipe was buried by the occupants of Harmony.

No features were found in Unit P2, but the upper matrix was of tan sand with large quantities of twigs and branches, presumably of the sort used to fire the boiler. At the bottom is the original grade composed of pebbly, dark brown sand with about 15 percent clay.

The only feature found in Unit P3 was a section of the east-west three-inch pipe. However, stratigraphy indicates a great deal of boiler waste dumping, which substantially altered the terrace profile.

The three-inch pipe is seen again in Unit P4, where it runs about 15 cm below the adobe machine shed wall. The pipe is supported by a piece of 2x4, and is separated by cloth insulation. This may indicate that hot liquids were run through the pipe. No footings for the wall were noted. A burned earth lens runs beneath the wall, indicating use of the terrace before construction of the adobe.

No interior footings were seen in any of the P5 Units. About 20 cm of post-occupational sand deposits were removed, revealing an uneven, hard-packed floor. No plastering or formal packing was done by the occupants. The three-inch pipe appears again in P5C.

The P6 Units, to the rear of Dissolving Tank 1, revealed no features save a board retaining wall made of 1-1/2 in. by 4-1/2 in. boards set edge-to-edge and nailed to uprights. Deposits consist of about a meter of sand heavily laden with borax. These rest on the original hill surface. We interpret the upper level as artificial fill, piled behind the board wall to form a convenient level for dumping ore into the tanks. Sand in this level became impregnated with borax, presumably through spillage of solutions.

The P7 and P9 Units are best described together. Posts seen in P7 are 4x4s set vertically on squared one-inch board underpinnings. Two-by-fours were nailed at angles to keep them upright. These posts have been rudely cut at their uppermost limits, and may have been salvaged for the lumber. We suggest these once supported an eastern extension of the wooden platform.

A low post-and-board wall divided Tier 2 into upper and lower levels (Fig. 20). On the upper, P7 level were found three boards, one of them burnt, and a length of half-inch rope.

On the lower, P9 level was found a quantity of scrap lumber, pipe, and burlap, as well as four 2x12s and 4x4s arranged as if for a footing. Another possible footing is formed by half-a-dozen sandstone blocks set into the artificial grade surface. Surfaces are covered with traces of hardened borax spill.



Figure 20. P7 and P9 units.



Figure 21. Wooden troughs in P13.



Figure 22. P14 with wooden drain, tier 3 retaining wall, and iron vat bottom.



Figure 23. P17 in process of being excavated.

Also found was a length of two-inch pipe which emerges from underneath the adobe and falls to Tier 2 grade. It is joined by a union and an elbow and has a three-way coupling on the north end. A section of one-inch pipe comes from the south wall and is welded to the larger pipe. This assembly was probably for water, and the smaller pipe may have been used for pressurizing the system.

A remnant of low sandstone and cobble wall runs east-west in P9D. The wall is 45 cm high and 35 cm wide. It has been partially knocked down, either by nature or by design. Function is unknown, though it could have been a footing for machinery or tanks.

The board wall dividing Tier 2 was made of 4x4s five feet on center, three of which remain. Planks 1-1/2 in. by 12 in. were nailed to the uprights. The bottom course remains, but nail holes show that the wall was at least 24 in. high. Boards are rough-cut pine, and were fastened with 16d square cut nails. A large diameter thin-wall pipe was let through the wall at one point, and was fitted with a wooden collar. This pipe may have been for tank drainage.

Slots were chiseled across the width of the boards for some unknown purpose, and cloth, now gone, was once nailed to the wall using one-inch sheet metal battens and small square nails. It is interesting to note that planks were nailed to the wrong side of posts to get the best effect. They may have been nailed up, as an afterthought, to existing platform posts to prevent unforeseen slumping of the upper levels.

Little needs to be said about Unit P8. This was a 20 cm wide, 20 cm deep trench dug through loosely consolidated colluvium. The purpose was to clear a trench for use by the stabilization crew in their drainage work. No artifacts or features were found.

Unit P10, outside the west fence, revealed a jumble of wall fall from the ramp, and a subsurface sandstone ramp retaining wall. Also found are probable remnants of the ore cart track--two lengths of 4x4 and a drilled piece of quarter-inch track iron.

In Unit P11 was revealed a dressed sandstone block footing which may have served both the sandstone wall and a series of tanks.

Blocks are two courses high and two stones wide and were set with mud mortar. Exposed on top of the footing was an eight-foot 1-1/2 x12 and two scraps of tongue-and-groove lumber.

The P12, P13, and P18 units should be described together. Revealed by excavation was a substantial east-west wooden drain made of 2x12s. The side planks are nailed to the edges of the bottom planks, and 2x4 spreaders with half-lap joints at the ends were nailed to the top, as shown in Figure 19.

In P13 can be seen a wooden trough 6 ft long made of 2x12s. It was apparently designed to be movable, but at present is held to the main drain by three nails. It must have drained one of the settling tanks into the main drain (Fig. 21).

Two lines of dressed sandstone footings were discovered on Tier 3. These were probably for the settling tanks. A quantity of debris was scattered at plant grade line, including scrap lumber, pipe, strap iron, and burlap fragments.

There are many cobbles north of the east-west drain, but no patterning could be seen. However, a very good section of low, cobble masonry wall was found in Unit P14. The wall is 45 cm high, 30 cm wide and has a 4x4 post as part of it. We suggest this served both as the Tier 3 retaining wall and as footing for an ore cart track (Fig. 22).

The east-west main drain is present in Unit P14. Construction is the same as in other units, except that triangular molding 1-1/4 in. to the side has been nailed along bottom joints to help seal the drain.

A largely intact sheet iron vat bottom was found in P14B. A fragment of the vat side has been forced down against the bottom. This feature has been disturbed by the CCC cobble wall footing trench. The metal is quite deteriorated, but seems to have been more than 1/8 in. thick. Side and bottom are joined with a lap joint and iron rivets.

Little was found in Unit P15. A roughly circular feature of rusted sheet iron fragments represents the site of a vat bottom.

Unit P16 extends nearly a meter deep. It is clear in profile that a hole was dug (during occupation) about 75 cm deeper than plant grade line. From this hole were recovered scrap lumber, pipe, felt insulation, and four intact burlap sacks filled with hay. A piece of sheet iron had been installed as a floor.

Interpretation of this feature is difficult. The only thing we can suggest is that it may have been used as a storage pit.

The P17 Units revealed an east-west alignment of jumbled cobbles at the base of the north cobble wall (Fig. 23). No clear arrangement of cobbles was seen until we excavated the east end (P17E). In this unit was a fairly distinct section of masonry ending at a 4x4 post. We suggest this is a section of the low retaining wall-ore cart footing as described for Unit P14B.

Also found were three sections of *in situ* sheet iron vat bottoms. The sides are gone but the flared lip is drilled every inch or so for rivets (Fig. 24). Large amounts of scrap lumber, felt, and nails were found, along with a piece of track iron and two curved pieces of wood. These latter, found in P17C, are well made and have rabbet slots along the undersides. We believe these are segments of wooden vat-cover rims.

Deposits are very shallow in P17, being only 10 to 20 cm deep. They are composed of wind-borne sand, adobe melt, and borax spill.

Units P19 and P20 are surface collection areas and have been described in Chapter 2.

The P21 and P22 Units form a north-south trench in the parking lot. Contrary to our expectations, the recent fill dirt is very shallow, only about 10-15 cm deep, and features are relatively undisturbed. In P21A are two posts, one a 4x4, which may have been part of the barn. An old arroyo cut with modern artifacts in its fill intrudes into the east side of this unit, as it does into P21B. In P21C there is another upright post, a 1x1.

There are no features in P22 except a badly deteriorated vat bottom in P22C and D. On the original grade line were scattered some 16 pieces of scrap lumber and some felt and sheet iron from vats.



Figure 24. Lip of vat bottom and wooden cover rims of P17.



Figure 25. Iron vat hanger rods in P24A.



Figure 26. Tailings ponds north of plant.

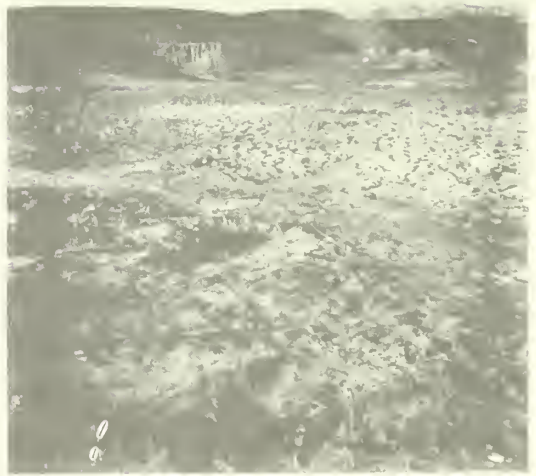


Figure 27. Collection unit C1 in area of Chinese quarters.

The other parking lot trench is made up of the P24 Units. It is very similar to P21-P22 with two exceptions. First, only a few pieces of scrap lumber were found on the original grade line. Second, modern grading operations were deeper on the northwest corner than elsewhere; still, features seem relatively intact. The original grade is from 10 cm below present surface near the fence to 50 cm below surface at the northwest embankment.

In the northernmost unit, P24A, was found the only significant feature. A bundle of eight vat hanger rods were found stacked three-deep on the original surface (Fig. 25). They are aligned east-west and each is made of 1-1/4 in. inside diameter galvanized iron pipe with 3/8 in. rod welded to one end to form a hook. One rod was rusted through and was retrieved for analysis. The others were left in place. Total lengths are unknown.

Unit P23B1 is a one-square-meter test pit put into the northeast corner of the middle chamber of the tailings pond (Fig. 26). We dug it to check stratigraphy and to get comparative soil samples. Depth of deposits was 40 cm. On top was a thin crust of alkaline sand. Ten centimeters below was a 15 cm thick layer of tailings mixed with silt and sand. Below this was a 10 cm thick layer of silt, underlain by a 5 cm layer of tailings similar to the upper tailings unit. This was formed on the original pond bottom grade.

Units P25 and P26 were mapping units, as described elsewhere, and no subsurface studies were made.

In addition to our excavations, subsurface work by Wallace (1972) revealed three other plant features, a vat bottom site and a wooden drain west of the fence, and a wooden drain north of the old parking lot. Drains are identical to the main drain seen in units P12, 13, 14 and 18. The northern drain found by Wallace probably served to channel foul solution to the tailings pond.

Chinese Quarters

Wallace, in his exploratory excavations (1972), observed an area in which artifacts of Chinese origin were exposed. One low,

rectangular heap of stone, thought to be a dwelling site, was excavated. No structural remains were found. In our recent work, we collected from and recorded this same area, which we have called Unit C1 (Fig. 4 and 27). Artifacts were collected in 2 m by 2 m units. A number of features were noted and mapped, as shown in Figure 28. All features rest on, or within, desert pavement.

Feature 1 is a paired-board alignment set on edge to form a kind of trough. The feature is about 2 m long and 30 cm wide. A vertical stake supports one of the boards. Only the edges are visible, and function is unknown. We suggest this may be the remains of a board-lined drainage ditch.

Feature 2 is a sand and cobble mound about 30 cm high and 3.3 m by 2.8 m in plan. The rocks make no particular pattern, but do not seem naturally deposited. The feature may be the remains of a structure footing. Three planks stick out of the pile on the east side.

Feature 3 is a 1.3 m long cobble alignment. This may have been used as a structure footing.

Feature 4 is a pebble-and-sand mound about 6 m by 5 m. Function is unknown. Disturbance may have been done by previous excavation.

Feature 5 is similar to Feature 4, except that its constituents are cobbles rather than pebbles.

Feature 6 is a cobble arrangement resembling a hearth. No deposits remain within.

Feature 7 is a circular burned spot. With it were found fragments of metal, charcoal, and melted glass. Burning of refuse may have taken place here.

In addition to these features, there are several notable deposits, including a concentration of bone scraps, two barrel hoops, and one wooden stake.

Roughly divided along a north-south line, the eastern half of the collection area is desert pavement of angular and rounded pebbles. The western half has a sandy soil about 20-30 cm above the elevation

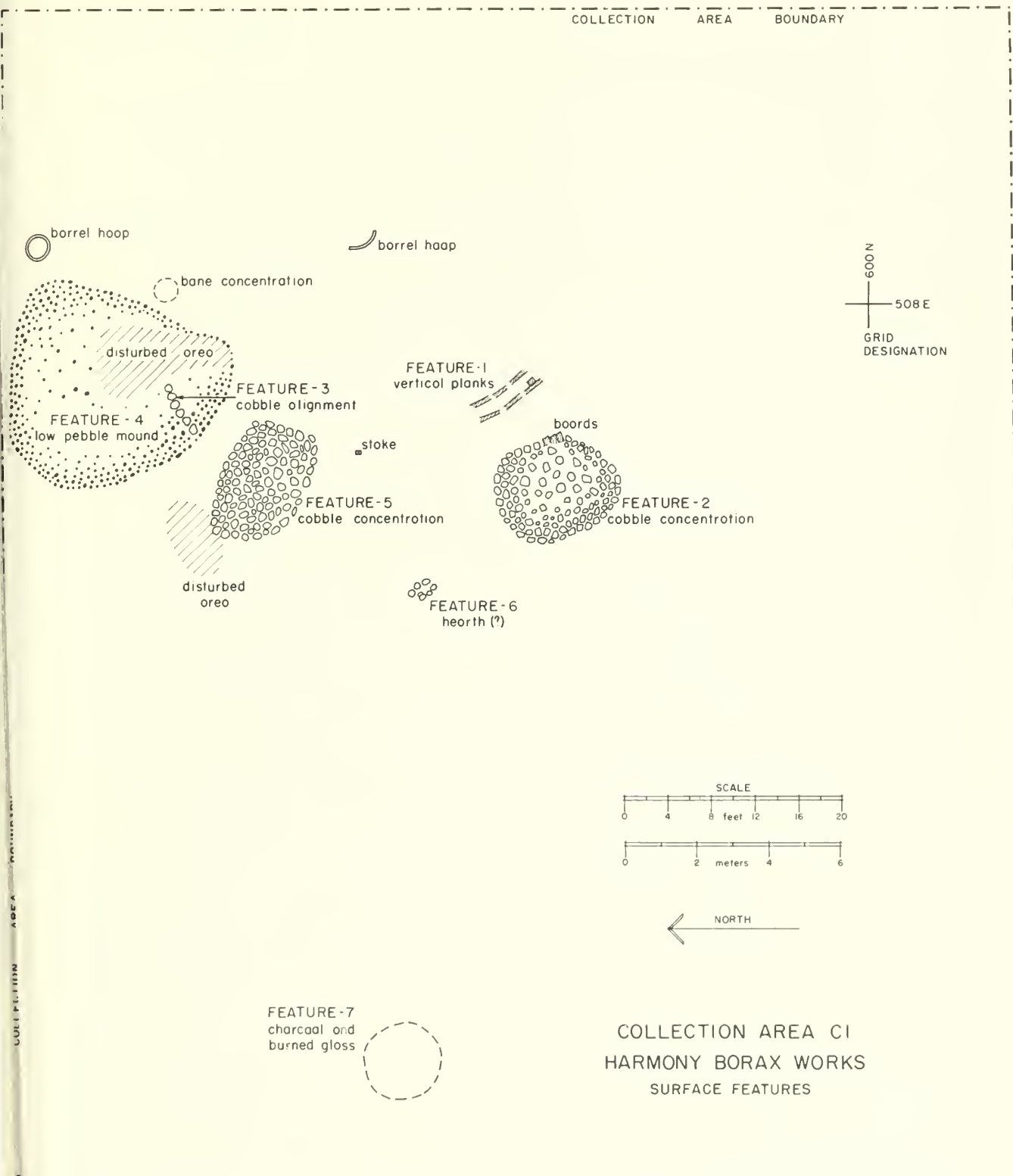


Figure 28.

of the desert pavement. Soil is light, friable and loosely consolidated, with an alkaline crust formed at the surface. Evidently, all artifacts come from within and on top of this crust, although no formal testing was done to demonstrate this. It looks like the soil creeps and shifts considerably, and is in the process of deflation.

Nearby is Unit C2, which encompasses a feature Wallace (1972) called the privy (Fig. 4). We mapped and searched this unit, but found no artifacts.

Wallace reported finding a rectangular depression some 5 ft square and 2 ft deep. Upon excavation, he noted several boards, including two parallel 4x4s. The latter were presumed to have been sleepers for some sort of superstructure, such as a privy. At present the feature is eroded and function is difficult to determine. Wallace's original conjecture seems sound.

Townsite

The townsite north of the plant has several surface features. Included are the site of a blacksmith shop; two ruined adobes, A and B; and three rectangular house pits. We collected surface artifacts from three areas of the townsite, Units T1, T2, and T3. Location of features and collection units may be seen in Figure 4.

Surface Features. The blacksmith shop was excavated by Wallace (1972). An area of about 400 square feet was examined. Just below the surface were found short post stubs and other more ephemeral structural remains such as pits and postmolds. From excavations was recovered a wealth of scrap metal, charcoal, dross, and iron artifacts. Wallace suggests that the shop must have been of framed wood, built directly on the ground without footings. No mapping or collecting was done in the blacksmith shop area during our recent work.

Plan view and elevation drawings of Adobe A may be seen in Figure 29. Walls remain standing to a height of 4 m or so. The

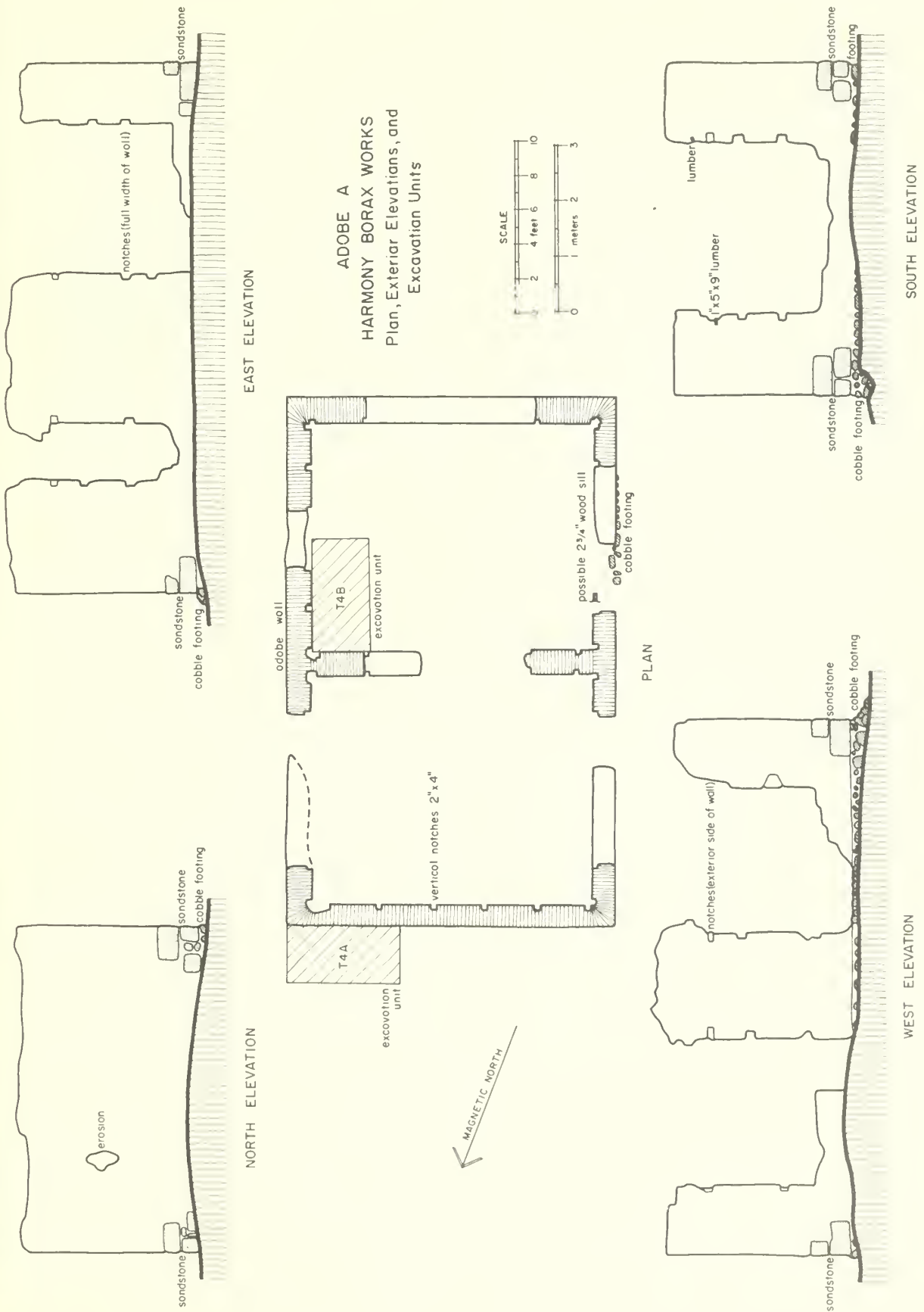


Figure 29.

building is believed contemporary with the Harmony plant operation, though no documentation exists to support this.

It is doubtful that much pre-construction preparation of ground surface occurred. A footing of cobbles was set the width of the wall, and adobes were laid. Corners are reinforced with dressed sandstone block (Fig. 30).

Adobes were mixed from mud and gravel and seem to have been made in wood molds. Sizes vary greatly, with lengths ranging from 9 to 54 cm and widths ranging from 7 to 22 cm. Bricks are laid, with mud mortar, in no apparent pattern. A veneer of narrow bricks was noted at places in the interior, but these may have been placed during subsequent remodeling, or even during recent stabilization work (Fig. 31).

A striking feature is the vertical notches, 2 in. by 4 in. in section, which run vertically on the interior walls (Fig. 32). We suggest these notches held 2x4 furring strips and that the interiors were finished with paneling, plaster, or the like. No directly applied wall plaster was noted.

Due to erosion, little can be said about wall openings except that they existed. Most likely, there were two doors to the west side, a door connecting rooms, and windows on east and south walls.

No sign remains of roof or floor construction techniques, although excavation indicated the floor was an unprepared dirt surface.

To the east is Adobe B, the ruins of a similar, but smaller, structure (Fig. 33). Only sections of the east, south, and west walls stand, as shown in Figure 34. As with Adobe A, it is assumed that construction was at the same time as plant operation.

Site preparation is the same as for Adobe A, but footings are of sandstone block and rubble, rather than cobbles. Wall construction is also similar, with adobe blocks found in a multitude of sizes. Wall thickness is about 40 cm. Again, a veneering technique was noted in places, but this time on wall exteriors. No interior grooves were seen.



Figure 30. Adobe A.



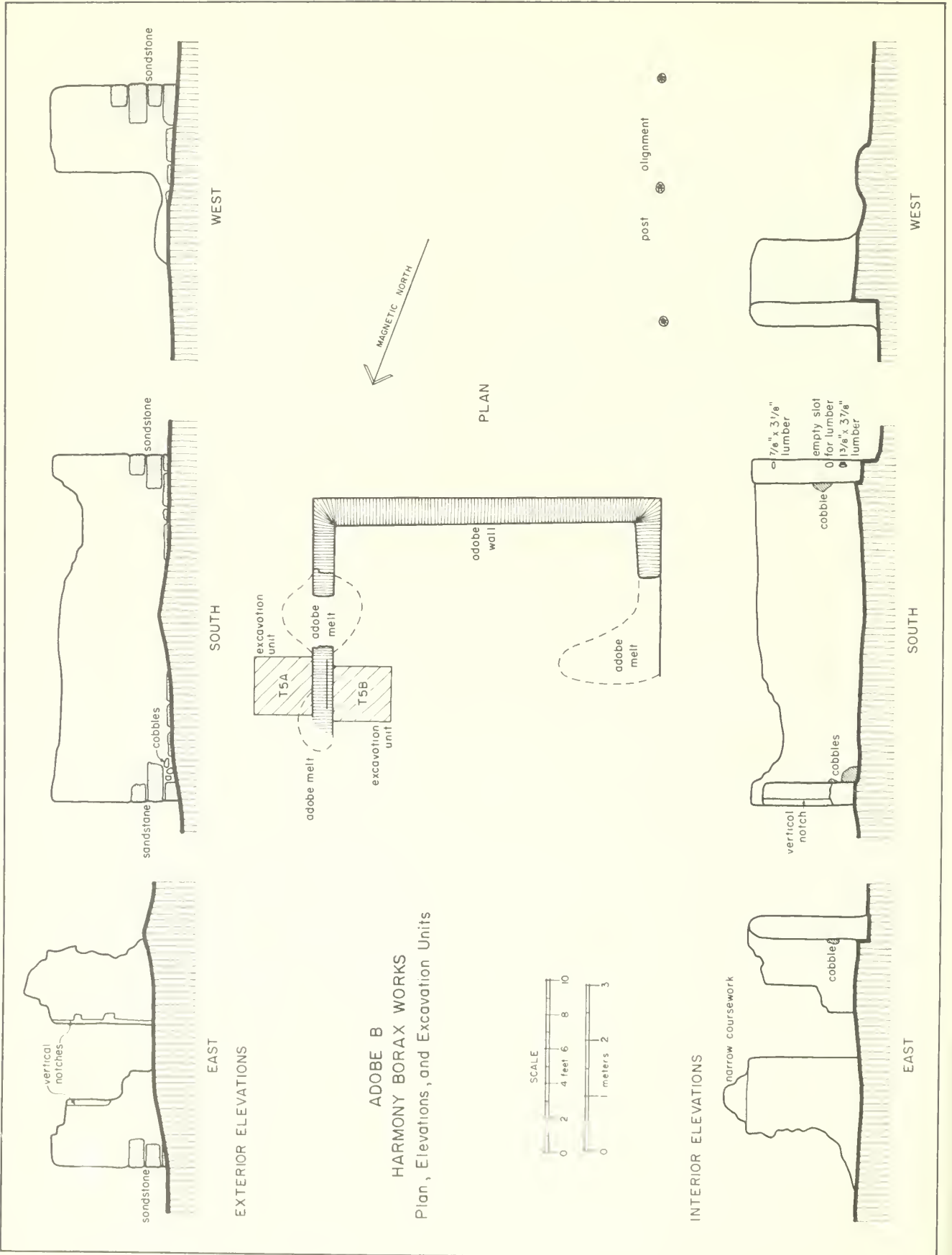
Figure 31. Brick pattern and interior veneer of adobe A.



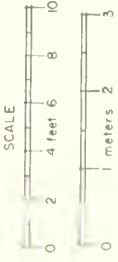
Figure 32. Interior vertical notches in adobe A.



Figure 33. Adobe B.



ADOBE B
HARMONY BORAX WORKS
Plan, Elevations, and Excavation Units



EXTERIOR ELEVATIONS

INTERIOR ELEVATIONS

PLAN

Wall openings are hard to determine, but we suggest that windows were present in the east and west walls. Horizontal slots 2 in. by 4 in. in section at these openings suggest the use of wooden blocks to hang window frames.

Roof and floor construction details are unknown.

An alignment of three post stubs to the south suggests there was once a ramada or corral attached to the building.

Between the adobes are three eroded, rectangular pits. These may have been the sites of underground or semi-subterranean structures (Fig. 4). The largest is 6 m by 4.5 m by 1 m deep. The one to the west is 3 m by 2.5 m by .75 m deep. The northern pit is 3.5 m by 2 m by .75 m deep. No excavation or collecting was done.

Subsurface Features. Only four small pits were excavated in the townsite, all at Adobes A and B (Figs. 29 and 34).

Unit T4A was placed against the north wall of Adobe A. Deposits consisted of 10 cm of undifferentiated sand overlying desert pavement. No features were seen.

Unit T4B is in the northeast corner of the Adobe A south room. Deposits noted were 20 cm of sand and adobe melt resting on an unprepared, but packed, dirt surface. This underlying surface was the same level at which footings were set, and may have served as a dirt floor to the structure. No feature save those of the wall were encountered.

Units T5A and T5B were dug to either side of the Adobe B east wall. Exterior deposits comprised 15 cm of sand and gravel deposited by slope wash action. Interior deposits consisted of 10 cm of sand and adobe melt, with some gravel. Both pits were stopped at the gravel fan surface upon which wall footings were set. No features were found. No architectural floor was seen.

Collection Units. The location of the collection units can be found in Figure 4. Unit T1, west of Adobe A, bounds a large refuse

exposure. All artifacts from this exposure were systematically collected by 2 m grid square.

The collection area has a sandy soil which is light, poorly consolidated, and friable. On the surface is an alkaline crust. Ground surface is uneven and tends to mound around clumps of salt grass, the only vegetation found.

An arroyo, very shallow and about 4 m wide, cuts the unit on a north-south line. It is in this exposure that most artifacts are found. We don't know the extent of subsurface refuse, or whether the arroyo has redistributed artifacts.

No features were mapped, but a circular mound 1 m in diameter was seen at the north edge of T1. This may or may not be natural.

Units T2 and T3 were placed, respectively, around Adobes A and B. The areas are very similar. Ground surface is desert pavement composed of angular and rounded pebbles, and some cobbles, cemented into a sand matrix. Extremely shallow, and recent, arroyos meander over the surface.

Artifacts were found as light surface scatters. No particular clustering was noted on inspection, with the exception of a small area to the east of T2. Unit T2 was expanded to include this concentration, as shown in Figure 4.

Chapter 5

ARTIFACTS

Introduction

More than 6000 artifacts were recovered during our recent Harmony project. Most are fragments of metal and broken glass; all are of 19th century manufacture except for a few modern beer cans and bottles. Modern artifacts were retained, but were not analyzed. There is no doubt some mixing of old and new glass fragments from surface collection areas.

No aboriginal artifacts were found, although Paiute and Shoshone were reported historically in the Death Valley region.

Artifacts described in this section are portable, as opposed to the pipes, boards, tanks, and so forth described in the architecture chapter. Artifacts are organized by material type or by function.

There are few illustrations in this chapter. It has become redundant for historical archeologists to illustrate the same classes of artifacts time and again. If the industrial revolution had a purpose, it was to produce nails which were just like other nails. The only items illustrated here are those which could be more economically shown than described.

As to conventions of measurement, we used the English system instead of the metric, which has become standard in archeological research. An early miner was not in the least concerned with the liter capacity of a beer bottle; he was, however, very interested in knowing that it held a full pint. He bought beans by the pound, boards by the foot, and land by the acre. Historical archeologists might do well, when dealing with Anglo-American sites, to stick with English measures.

Analysis results follow.

Ceramics

Introduction

In many instances, ceramics have proven a valuable archeological tool for assigning dates to sites and interpreting the economic level of the occupants. Since the dates for the Harmony Borax Works are well established, the discussion presented here is geared to a description of the ceramics and an interpretation of the vessel forms represented in the collection. The classification of ceramics into basic types is generally based on the paste of the vessels, which is a product of the types of clays used in making the objects and the temperature at which they were fired (Ramsay 1939, Spargo 1938).

Ceramics recovered from the various occupational areas of Harmony can be divided into four major categories based on the body or paste type, the kind of glaze applied to the surface and decorative techniques. The categories, and their distinguishing characteristics, are as follows: earthenware (relatively soft, porous paste); porcelain (vitreous paste which is hard, non-absorbent and translucent); whiteware (hard, vitreous, white-bodied paste); and stoneware (hard paste, only slightly absorbent). As no whole or reconstructable vessels were available in our collection, vessel form could not always be relied on for identification. However, ceramic shapes are fairly standard, and all types of paste were made into storage vessels and utilized as tableware in the form of plates, cups and saucers.

At Harmony, 605 pottery sherds were recovered. Of these sherds, over 99 percent are Chinese ceramic wares, including porcelain bowls, glazed pottery vessels used for foodstuffs and wine, and small round flat-faced saucers which may have served as jar lids or as pieces of paraphernalia associated with opium smoking. The remaining sherds are Anglo-American in origin, representing dishes and covered containers of white earthenware.

The analysis of historic Chinese ceramics uncovered in an archeological context is difficult. Few publications even mention the presence of these wares in excavated sites, let alone attempt to

discuss their origin, manufacture and use. While many reference works deal exclusively with Chinese ceramics (Jenyns 1951, Beurdeley 1962, DuBoulay 1963, Valenstein 1975), these sources are primarily concerned with very fine and unusual collector's pieces. Chinese ceramics recovered in many archeological contexts, on the other hand, tend to be of an everyday, durable variety, such as would be found in many middle class households (for example, see Grimm 1970, Quellmalz 1972 and Olsen 1976). The majority of ceramic references neglect the coarser utilitarian items, like cooking and food-storage containers.

It is important, therefore, that studies such as this one attempt to present as much information as possible on the total range of ceramics recovered from an historical occupation. An effort has been made here, for instance, to identify and count the minimum number of vessels of each type. This method of sorting provides an entirely different perspective to the ceramic inventory and allows discussion of not only the economic status of the occupants, but also of possible spatial function. Vessel dimensions were taken whenever possible. Because vessels were fragmentary, it was necessary to measure the component parts, such as rim and base diameters, and express size in terms of ranges. All measurements were taken in the English system, since this was the way they generally had been measured in the literature (Noel Hume 1972, Berge 1968, Herskovitz 1975a). Line drawings will be used where feasible to illustrate decorative styles and extrapolated vessel forms.

Description: Porcelain

As Quellmalz (1972: 148) has noted, wherever the Chinese settled they brought their civilization with them. Chinese merchants in San Francisco imported all types of items, and shipped them to the various communities, thus reinforcing the customs of the inhabitants. Assemblages of Chinese porcelain from various sites have revealed the early (16th century) exportation of such ceramics to the United

States, and the common features which these trade wares shared. It appears that once introduced into this country, Chinese porcelain became an integral part of the domestic household (Olsen 1976: 10).

A wide range of clays and tempers were used in the construction of Chinese ceramic vessels. Hard paste porcelain, with which we are now concerned, was made from a combination of kaolin clay and petuntse (a variety of feldspar rock) fired at a temperature of about 1400 degrees centigrade (Hanson and Hsu 1975: 116). The final appearance of the vessel was largely dependent upon the quality of the material that went into its construction. Coarse, off-color pastes of varying textures are usually associated with utilitarian items, while quality porcelains are composed of finely textured pure white clays.

Of the total pottery sample recovered from our investigations at Harmony, Chinese porcelain comprises 7 percent with 42 sherds. Of these sherds, 71.4 percent, almost three-fourths, are definitely from the rims and bodies of what was apparently a common type of bowl. Many fragments, as well as some whole specimens of similar vessels, have been recovered from sites around San Francisco (Quellmalz 1972: 149), which was the supply center for the Harmony operation.

In general, porcelain bowls range in thickness from 0.11 to 0.13 in. at the rim. Rim diameters are consistent at 5.5 in., while foot-ring diameters range from 2 to 3 in. Rim forms will be discussed under the individual variety headings.

Blue-on-White. A total of 17 sherds of porcelain decorated in underglaze blue paint appeared at Harmony, comprising 40.5 percent of the Chinese porcelain assemblage. There was a minimum of six vessels in this variety, all of which were probably small bowls. These so-called rice bowls are round and are characterized by foot rings, a diameter greater than their height, and a rim which is rounded outwards (Fig. 35: c).

The body of the porcelain varies from gray to gray-white and white; the glaze is blue-green with many small bubbles in it, along with other flaws of varying size. Decorations, in underglaze blue,

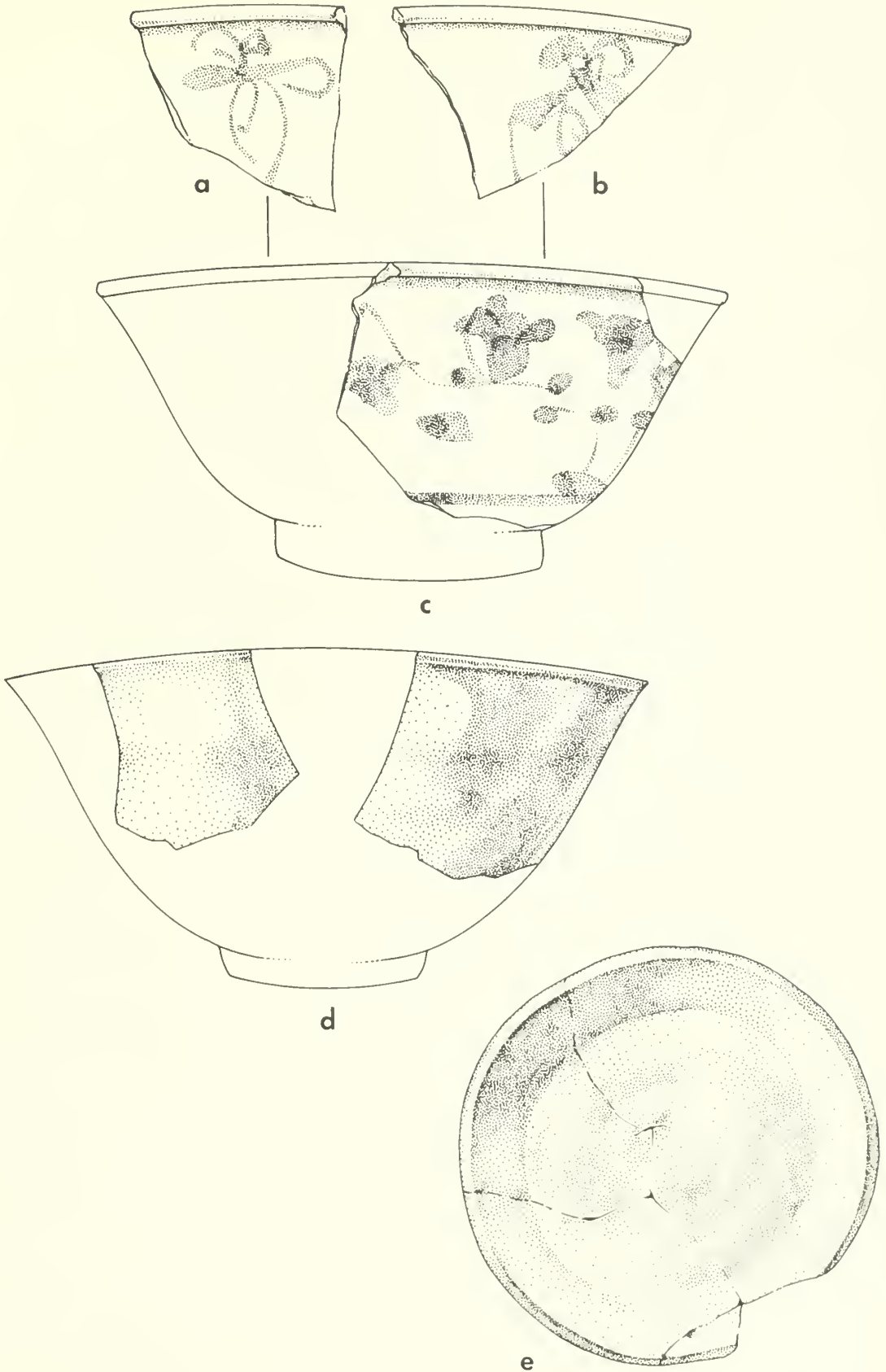


Figure 35. Chinese porcelain bowls and earthenware saucer.
Height of c is 2.5 in.; diameter of e is 3.5 in.

consist mostly of floral and abstract designs on the body, and interior and exterior rim bands. Most decoration was done in light blue with well-defined lines (Fig. 35: a, b). However, a few specimens exhibit darker smudged blue floral designs which, according to Noel Hume (1972: 262), are typically found on early 19th century "Canton" Chinese export porcelain (Fig. 35: c).

Many attributes of the Harmony sherds are very similar to those associated with "Swatow Ware", a ceramic type with a history dating as far back as the Ming Dynasty, with very little stylistic change occurring through time (Olsen 1976: 33). Shared traits include a greyish-blue overall appearance, double rings circling the bottom of the vessel's interior, and a small potter's mark, usually indecipherable (in the case of the Harmony bowls, the mark resembles a heavy C), on the bottom of the bowl's interior. This mark was apparently a personal inscription made by individual potters or kilns to differentiate their products (Olsen 1976: 33).

It seems evident from the literature that this type of porcelain may have been made from the 16th century onward. For example, Quellmalz (1972: 153) reports that on a number of occasions he has seen similar pieces dated Ming Dynasty by antique dealers. He goes on to note that "while the style appears to be that of provincial Ming Dynasty ware, the fact that it was brought to California for common use in the latter part of the 19th century puts some doubt on the earlier dating."

Blue and Green-on-White. This ceramic style is identical to the Blue-on-White wares, except that painted designs appear underglaze in both blue and green. The 14 sherds of this variety comprise 33.3 percent of the total Chinese porcelain sample, with at least three vessels being represented. Again, the form is restricted to small bowls.

Designs on the body consist mostly of floral patterns in light blue and a deep jade green. Rims are decorated with blue (exterior)

and green (interior) bands. On some small sherds, only the rim bands could be seen.

In Olsen's (1976: 34) discussion of the Tucson Urban Renewal ceramics, he indicates that the Swatow-type bowls were occasionally found in a green variety. Except for their deep jade green underglaze floral designs, the bowls were identical to their blue counterparts, measuring about 5.75 in. in diameter and 4.75 in. high. No mention, however, is made of a bichrome blue and green combination.

Celadon-type White. A total of nine sherds with a transparent light green glaze were found at Harmony, comprising 21.4 percent of the Chinese porcelain collection. There were a minimum number of three vessels present in this variety, all of which were probably small rice bowls. According to Olsen (1976: 38), green celadon rice bowls have an average diameter of 5.5 in. across the mouth and stand about 2.5 in. high. Our specimens are also characterized by foot rings, and rims which are slightly recurved (Fig. 35: d).

The body of the porcelain is composed of a fine-grained white clay, covered by a fairly thick (about .045 in.) overall glaze that is a pale green celadon on the exterior and a milky white on the interior. On a few sherds, the celadon glaze appears to have covered the entire bowl, being present on both interior and exterior surfaces.

In his discussion of Chinese porcelain excavated from older (16th century plus) Pacific Coast sites, Quellmalz (1972: 154) states that white porcelain with a celadon appearance was a very common type. Besides rice bowls it was also made into dishes, spoons, and small tea and winecups. This ceramic style is still a common ware in Chinese households today, "indicating...its pervasiveness within Chinese culture" (Olsen 1976: 39).

Unclassified White. Only two sherds of plain, white porcelain were recovered, comprising 4.8 percent of the total porcelain sample. These sherds were both very small, and probably represent undecorated portions of stylized bowls such as those described above. An overall

glaze was present, but it is difficult to say if it was of the grayish-blue Swatow-type.

Description: Earthenware and Stoneware

Other items which could be included in the Chinese ceramic inventory are glazed pottery vessels used for foodstuffs and wine, and small bisque earthenware saucers, possibly for opium smoking. The glazed utilitarian containers appeared in both earthenware and stoneware paste types. Earthenwares are made from low grade clays and fired at a relatively low temperature, creating a non-vitreous and porous body. Stoneware, made from fine, dense clays, is fired at high temperatures. The body of stoneware, therefore, is not porous and generally does not require a glaze to make it suitable for domestic use.

Construction of the vessels falling within these categories was accomplished by the wheel technique. The evidence of this production method is clearly indicated on many pieces by circular ridges on the body of vessels. Vessel form is more difficult to discern. Again, references describing these everyday Chinese ceramics are almost non-existent. Only general comments as to the types of storage containers present in the Harmony inventory will be possible. After a discussion of the Harmony sherd traits, we will rely on Olson's (1976) study of the Tucson Urban Renewal collection to suggest comparative forms and their usage.

Brown-Glazed Pottery. Brownware ceramics were found in considerable numbers at Harmony, comprising 86 percent of the total pottery sample with 521 sherds. Of these sherds, 2.3 percent are definitely from the rims and bodies of bowls, 12.3 percent are from small jars, and 2.3 percent are from ceramic bottles. There were a minimum number of 15 vessels in this variety, all of which apparently differed little except for neck form.

Brownware containers range in thickness from .095 to .225 in. at the rim. Rim diameters range from 1.25 in. to 5.5 in., and average

3.25 in. Rim shapes for the three basic vessel shapes include straight, outward flanged (from angles of 90 to 180 degrees), and flat-lipped forms. It is likely that some vessels, such as jars, had distinctly flanged lips so that a lid could be securely tied in place around the rim. Basal diameters range from 4.75 to 5.5 in., and average 5.25 in.

The brownware is found in two different paste types. Some containers were made of a buff-colored, refined and porous earthenware, while others had a tan to gray, coarse textured (with granules of grit and sand), less porous paste resembling a stoneware. Both pastes are represented in our sample in more or less equal numbers, with perhaps the earthenware body being more attributable to bowls and the stoneware to jars and bottles.

Brownware sherds in our collection are characterized by three distinct types of glazes--a thick, dark brown glaze; a thin glaze resulting in a honey-brown appearance; and a glossy, smooth olive-brown glaze. Almost any combination of these glazes could be found. Following is a brief description of the numerous brown glazed ceramic variants that appeared at Harmony:

1. A total of 353 sherds exhibited a dark brown interior-exterior glaze. This thick, coarse glaze, filled with imperfections and flaws, occurred on jars, bottles, and shallow bowls. Bowls of this kind were sometimes glazed only down to the level of a double ridge running around the vessel's circumference near its center point. This flange may have facilitated nesting for storage, or could have held a lid in place (Olsen 1976: 75). Jars were apparently squat with rounded bodies and flat bases, the mouth of the container being smaller than the maximum body diameter. In most cases, the glazing is incomplete to the extent that a band of unglazed paste appears around the bottom of these jars. Another 54 sherds had unglazed exteriors, and probably represent jar lids. The circular covers were embossed to form a spiral ring look, peaking near the center.
2. At least 67 sherds had a dark brown exterior glaze and a honey-brown interior glaze. Again, the color difference may only reflect the overall thickness of the glaze. The glazing is coarse, and some sherds show only partial interior glazing. Containers such as the shallow bowls and small jars described above are present.

3. A honey-brown interior and exterior glaze was found on only seven sherds. No distinctions were noted from the varieties already described. Three other sherds were unglazed on the interior, but had a honey-brown exterior.
4. A total of 19 sherds had a smooth, glossy olive-brown glaze on the interior and exterior surfaces. In reality, the color of these vessels grades from dark brown to a light olive-brown. Olsen (1976: 60-61) noted a similar glaze technique on round, globular wine bottles. Also recovered was one sherd with an unglazed interior.
5. Only 10 sherds were found with an olive-brown exterior glaze and a honey brown interior glaze.
6. Six sherds recovered were plain and of brownware paste, probably body sherds of the above vessels.

It is apparent from the foregoing descriptions that at least three basic vessel forms are represented by our sample of brown-glazed pottery--wine bottles, small storage jars, and food preparation and storage containers in the form of shallow earthenware bowls (Fig. 36).

In order to facilitate a better understanding of these wares and the role they played in the Chinese household, let us consider similar, intact vessel types in the Tucson Urban Renewal (TUR) collection (see Olsen 1976). First of all, it should be remembered that while these containers were inexpensively mass-produced to hold certain products for shipping and storage, they could be employed for many other purposes after being emptied. This characteristic of recycling containers was common to the frontier, where material goods were not always easily obtained.

Brownware wine bottles, still available today, are characterized by their distinctive shape--a round, globular body with a short neck and a flared mouth. The TUR bottles stand about 6.5 in. high, have a maximum diameter of 5.25 in., and were sealed with a cork, held in place by gluing a paper label over the top. Also among the TUR collection are several small containers, some of which exhibit a flanged, wide mouth. Vessel sizes vary, but one example is 5.5 in. high with a mouth opening of 3.25 in., while another is 4 in. high with a rim diameter of 2.5 in. These jars probably contained

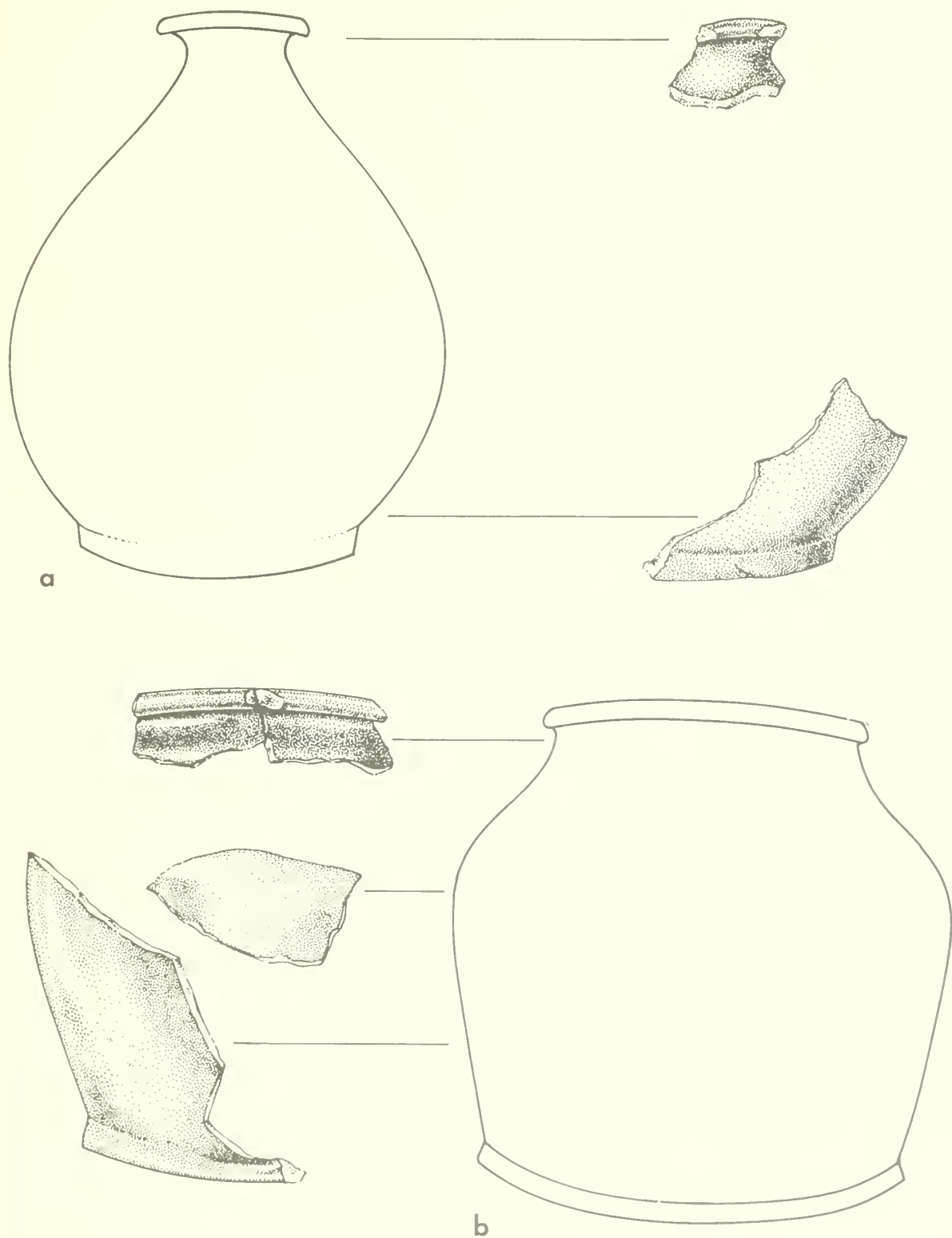


Figure 36. Brown-glazed pottery vessel forms.
Height of b is 5.25 in.

such products as preserved vegetables, sweet gerkins, soy bean cheese, preserved fish and shrimp paste. A wooden or ceramic plug was used to close the mouth, which could then be sealed in place with hot wax paper. Another container present in the Harmony and TUR collections is a low, steep-sided earthenware bowl, measuring about 2 in. high and almost 5.75 in. in diameter. It was evidently an important vessel for food preparation and storage.

On the basis of the TUR collection, we can postulate that the 15 or so vessels represented by the brown-glazed ceramic sample could serve a variety of functions--from utilitarian cooking and food preparation to specialized, single product food storage, to whatever other culturally-determined uses they may have had after recycling.

Clear-Glazed Pottery. One sherd of pottery, only 0.2 percent of the total ceramic sample recovered at Harmony, had a clear over-all glaze. The sherd is probably from the base of a jar of unknown size or shape.

The body of this ware is a coarse-textured, buff colored stoneware. Over the paste is a thin, clear glaze containing many imperfections. On the flat bottom is an indecipherable potter's mark. The embossed mark probably contains four Chinese characters indicating a reign-title designation. The interior surface is slightly peaked with ridges radiating from a center point.

This ceramic ware was probably made into food storage containers similar to the brownware types previously described.

Bisque Earthenware. There were 38 sherds of plain earthenware at Harmony which had been fired, but not glazed. This ware comprised 6.3 percent of the total ceramic assemblage. Of these sherds, 76.3 percent were from the rims of saucers or very shallow bowls. It is unusual to find such a large percentage of rim sherds. There were a minimum number of eight vessels in this variety.

The bisque ceramics range in thickness from .105 to .150 in. at the rim. Rim diameter as extrapolated from the small sherds is about 4 in. Rims are straight and rounded.

The paste of this thin ware is fine and dense, but contains many impurities. Body color ranges from buff to orange. No glaze or other surface decoration was applied and the ware is slightly porous. These vessels could probably be described as small, round, ceramic flat-faced saucers (Fig. 35: e).

There are several possibilities as to how this crockery was used. First of all, besides being unglazed, the ware was really too thin for utilitarian use. Based on the Tucson Urban Renewal collections, it has been hypothesized that small, very shallow saucers served as lids for brownware jars (Bill Liesenbein 1977: personal communication); such a lid evidently was found in place covering the mouth of a storage vessel. Quellmalz (1972: 149), on the other hand, notes that the Chinese ceramic wares of Pacific Coast sites included similar items for opium pipe smoking. A discussion of appliances necessary to smoke opium, including earthenware flat-faced bowls, can be found in McLeod (1948: 157).

The bisque earthenware vessels, whether domestic or personal-related, were still a part of the Chinese cultural inventory.

Description: Whiteware

The criteria generally used in distinguishing this category of Anglo ceramics include white body paste and decoration. The names assigned to types and varieties reflect the styles of surface decoration. White earthenware, being vitreous, is a thin, very hard pottery with a body ranging from cream-colored to pure white. At Harmony, only two varieties of this type were found--white ware and ironstone. More elaborate discussion of these wares can be found in a number of sources, including Bemrose (n.d.), Fontana and Greenleaf (1962), and Gooden (1971).

Only four sherds of whiteware were found at Harmony, comprising 0.7 percent of the total pottery sample. These were the only Anglo-

related ceramics that we collected at the site and this small number is rather amazing. The other 99+ percent was Chinese. A minimum number of three vessels are of this type.

White Ware. A total of one sherd of undecorated white ware was recovered. According to Noel Hume (1972: 130-131), by 1820 earlier English ceramic types were being replaced by various forms of hard white wares and semiporcelain that are extremely difficult to date with accuracy. These wares were developed concurrently with Mason's Ironstone China.

The body of the white ware has a slight blue tint to it. Over this paste a clear glaze has been applied. There are no surface decorations. The sherd is a partial lid from an oval bowl or tureen. It has a footed ring for setting within the vessel mouth.

Ironstone. The remaining three sherds in this category may be classified as ironstone. Of these sherds, one is from a jar rim, and the other two are from the body of a plate. England did not begin to export ironstone in large quantities until sometime around the middle of the 19th century, even though it was first manufactured in 1813 (South 1972).

Ironstone is slightly heavier, denser and thicker than white ware, and has a white body with a clear glaze. It is basically a utilitarian product, and was used extensively by the U.S. military throughout the West, because it was inexpensive and durable. In fact, ironstone is by far the most abundant ceramic type found in 19th century sites of the American Southwest (Berge 1968: 203). One would have expected to find a greater number of these sherds at Harmony.

The two plate sherds can definitely be labeled as household. The jar could have held either culinary or patent medicine products. Just below the rim is a groove running around the circumference of the vessel, probably for holding a wire attaching a lid.

Additional Ceramic Materials

During archeological investigations conducted in 1971-72, William Wallace recovered a large number of ceramic materials. Included in his sample were wares very similar to those already described.

At least 50 sherds of porcelain were found by Wallace in Area C1. No new varieties were noted. A whole porcelain bowl, of the Swatow style, measured 2.5 in. high and 5.25 in. in diameter. In addition, a bowl from a porcelain soup spoon was noted. It is decorated overglaze in a green, gold and pink floral pattern. The form of the bowl is angular, with an unglazed foot on the bottom.

Wallace also collected more than 800 sherds of brownware near C1. Bowl, jar and bottle forms were present, along with spouts from wine or soy pots. Rim diameters of these vessels ranged from 1.25 in. to 4.75 in. Basal diameters ranged from 3.25 in. to 5.5 in. Additionally, Wallace found a total of four brownware sherds in the blacksmith shop.

A total of 24 sherds of bisque earthenware came from C1, with only one sherd being present in the blacksmith shop area. Eight sherds of ironstone (two from C1 and six from the shop) included fragments of a bowl and of a preserve jar.

Spatial Distribution

The distribution of pottery types found at Harmony appears in Table 1. Materials collected by Wallace in 1971-72 are not shown in these totals. Problems of comparability, both in sampling procedures and area designations, necessitate this exclusion.

As can be seen in this table, over 90 percent of the ceramic artifacts at Harmony were discarded or abandoned in the area of C1. A total of 565 pottery sherds occurred here, as compared to only 30 sherds found in the next most dense area, T3. Ceramics from other sections of the site are almost negligible.

Table 1
Distribution of Pottery Types

	Plant	C1	T1	T2	T3	Totals	Percent
Porcelain	1	41				42	7.0
Glazed Pottery	2	486	2	1	30	521	86.0
Bisque		38				38	6.3
Whiteware	2		2			4	0.7
Area Totals	5	565	4	1	30	605	
Percent	0.8	93.3	0.7	0.2	5.0		

A distinct pattern of spatial use is apparent as regards the ceramic inventory. From just this artifactual category, it can be tentatively suggested that storage and preparation of food was centered in Unit C1. It is in this small area that almost the entire stock of utilitarian tablewares, cooking, and storage vessels was found. A functional interpretation of patterns of artifact discard and abandonment in general will be found in the section of this report devoted to spatial organization.

Conclusions

To reiterate, a total of 605 sherds of pottery was found at Harmony. Over 99 percent of these sherds are of Chinese origin, including porcelain bowls, glazed pottery vessels used for food preparation and the storage of foodstuffs and wine, and small round bowls which may have served as jar lids or possibly for opium pipe smoking. Only 0.7 percent of the sample could be classified as Anglo-American, representing dishes and covered containers of whiteware.

This entire collection can be considered as utilitarian in nature. These everyday common wares, out of necessity, tend to be durable and in general poorly made. Even the items of porcelain were full of imperfections. A ceramic inventory can be a good guide to the cultural level of the inhabitants of any household. For example, it is known from historical records that more than 40 people resided at Harmony. Yet, our ceramic inventory included only 39 (minimum number) vessels. Of this total, 14 containers can be included under the

the activity set of food preparation and consumption (Shenk and Teague 1975: 147), 17 under food storage, and eight under a category of articles related to personal activities. These figures are surprisingly small and perhaps reflect the short occupational time span of the site or a difficulty in shipping fragile containers from Mohave.

As already noted, wherever the Chinese settled, they carried their culture with them. Chinese merchants in San Francisco imported a wide variety of goods which were then shipped to the various communities. Area C1 contained 93.3 percent of the ceramic inventory, all of which was Chinese. A wide range of domestic items are included--from utilitarian cooking and table wares to specialized, single-product food containers to opium smoking paraphernalia--all of which emphasize a Chinese cultural background.

It seems very likely from this assemblage that only the Chinese laborers were residing at the Harmony townsite. While the Chinese ceramics were inexpensive, the absence of more traditional historically common wares, such as ironstone, suggest that culturally-determined preferences were involved here. The number and types of these ceramics from C1 indicate that food preparation and storage were centered in this area. An early photograph of Harmony does show a wooden structure in this locality which may have been a general cook shed and dining facility. We also find that opium smoking, usually a group activity, may have occurred in or around the C1 structure as well.

Glass

Fragments of glass are one of the most abundant artifactual materials found in western U.S. historical sites. As a category, the 3280 whole and fragmentary glass artifacts at Harmony form the largest group of materials recovered. Bottle glass was by far the most evident; other glass products included household items such as tableware, window panes, eyeglass lenses, chemical glassware, homeo-

pathic vials, and gaming pieces. Almost the entire sample of glass artifacts from Harmony was in a very fragmentary condition.

Description: Bottles

As previously noted, the remains of bottles at Harmony were numerous, comprising 83.1 percent of the total glass sample with 2725 sherds. Represented in this collection is a minimum number of 90 vessels, a figure derived by reporting whole and partial bottles, as well as other discernible fragments. Bases were primarily used, although in some instances distinctive body parts and finishes were included.

The bottle glass has been divided into six categories based on color. Recent classification systems have attempted to make divisions on the basis of the intended use of the contents. It is indeed true that it was the contents which were the original criteria used by the consumer in making his selection (Herskovitz 1975a: 8), but it is also true that once drained of their original contents, bottles in frontier households were often used for other purposes (Fontana 1968a: 53). The color classification method was dictated in this study since so few whole or partial specimens were available to determine usage. Analysis will therefore have to remain primarily descriptive.

The terminology used for bottle shapes and finishes has been derived from several sources. Illustrations of the various forms are available in the Fort Bowie manuscript by Hershovitz (1975a). The catalog for Whitall, Tatum and Co. 1880 and the bottle identification guide compiled by Putnam (1965) were also principal resources. Detailed information on the construction of bottles can be found in Berge (1968).

Production Technology. As there are a number of sources dealing with the history of bottles and their manufacture, this subject will only be touched on briefly here. End dates given for a certain mold or finish should not be taken as absolute. For example, some shops

continued to produce bottles using old techniques even after new methods had been introduced. Also, bottling companies would use up their old bottle stocks before ordering more. Virtually all of the major techniques used to produce glass bottles and tableware were in existence by the beginning of the 19th century. What occurred during this period were improvements and innovations in glass working and production.

Early in the 19th century, the most common method of producing bottles was by free blowing. The use of molds was still rare at this time. Hand blown bottles are usually globular and asymmetrical, with pontil scars or rough spots present in the center of most bases. These scars were caused by a rod, or pontil, which was attached to the base with a glob of molten glass to hold the object while the finish was applied (Lorrain 1968: 36). Finishes were completed by laying a narrow band of glass around the top of the neck.

Bottles were also produced by forming them in molds. Shortly after 1800, mold-blown bottles were being made in full-size contact molds and dip molds of various sizes. A dip mold was composed of one piece, open at the top, leaving no mold seams. After the lower portion of the bottle was released from the mold, the neck was finished by hand. Such molds were used primarily in the production of wine bottles. Bottles blown in contact molds may or may not exhibit mold lines which resulted from molten glass seeping into seams where the mold sections joined (Switzer 1974: 6).

Hinged molds did not make their first appearance in this country until after 1810 when the three-piece mold was introduced (McKearin and McKearin 1971: 427-428). Three piece molds leave seams around the shoulders, and lines from the shoulder to the neck, disappearing below the hand finished lip. Newman (1970: 72) indicates a 1900 cut-off date for the manufacture of this mold type, but it was most widely used after 1870 for utility wares such as wine bottles (Toulouse 1969: 578). A two-piece hinged mold began to replace the three-piece mold between 1840 and 1850, continuing in use until about 1913 (Newman 1970: 72). These molds left a seam which ran from the base of the

bottle up to the neck before fading out. The disappearance of the mold lines on the upper neck is due to the reheating of the neck when additional glass was added to the finish.

At about this same time (1850), an applied glob of glass formed by a lipping tool had almost entirely replaced the simple laid-on-ring of molten glass (Lorrain 1968: 40). The rotation of the tool obliterated some of the seam lines and the glass was left with a swirled appearance. In 1857, the snap case, another tool important to the bottle-making industry, was invented. This simple device completely replaced the pontil for holding a bottle while the lip finish was being applied, and left no rod scars.

Mason, on November 23, 1858, was the first to patent the post bottom mold for use in his wide-mouthed jars. The name of this popular construction technique comes from the design of the bottom plate, which has a raised platform in the center (Toulouse 1969: 582). Seams on these bottles circle the center of the base, with two side seams extending from this ring to the neck.

Sometime in this decade, the first bottles with raised lettering were making their appearance. Around 1870, an improvement in bottle-manufacturing techniques made it possible to produce a smooth, shiny exterior surface on the bottle. Prior to the chilled-iron mold, bottles produced in contact molds had a pebbly appearance (Lorrain 1968: 41).

Another innovation which came into existence between 1880 and 1920 was the turn-paste mold (Newman 1970: 72). Bottles were turned in the mold after being blown, obliterating any seams and leaving horizontal striations on the vessel. Such bottles were used primarily for wine. Quite a few of the bottles recorded at Harmony were produced by this technique.

The first semi-automatic bottle machine was developed in 1881 (Meigh 1960: 3). Mold lines on these bottles run up to the lip, but few bottles were produced as the machine was not widely distributed (Lorrain 1968: 43). In 1903, Michael J. Owens patented a fully automatic bottle machine. On these bottles mold seams continue onto the

top of the lip, with cut-off and valve scars being common (Toulouse 1969: 582-583). Bottling machines generally use the cup bottom mold, which leaves a seam encircling the bottom of the body connecting the side seams. The changeover to automation by the commercial glass industry was completed by 1920, and large-scale production begun.

The above section is only a brief summary of dateable changes in 19th century manufacturing techniques. More pertinent information on production methods and possible vessel usage will be given where practicable. While it is traditional for certain shapes of bottles to be associated with their contents, in many cases one bottle type could be included in several categories.

Olive Green. Within this category are bottles that are either dark olive green or light olive green in color. A minimum number of 10 bottles are represented by the 241 fragments of dark olive green glass. This number comprises 8.8 percent of the total bottle glass sample. The 642 fragments of light olive green glass comprised 23.6 percent of the total sample; it is the largest category of bottle glass, with at least 18 specimens being present. Vessels represented in the collection are presumed to have once contained alcoholic beverages such as wine and champagne.

The dark olive green glass is opaque and black in appearance until viewed against a strong light. Sherds apparently are from heavy bottles with thick walled bodies and bases. Sherd thickness ranges from .195 in. to .350 in. All basal fragments have a kickup, an indented concave bottom, which strengthens the bottle and serves as a settling basin for sediments in the liquid. All specimens lack pontil scars.

Except that the lighter olive green glass is paler than those fragments described above, these specimens are virtually identical to the others. Sherd thickness ranges from .108 in. to .275 in. All finishes present are applied lips.

Basal fragments are believed to represent the following vessels:

1. One cylindrical wine bottle, turn-paste mold, high basal kickup with small protruding knob in center, basal wear. Base diameter: 2.25 in. Contents: champagne. Probable dating: 1880 to 1920. Area: T1.
- 2-17. Sixteen cylindrical wine bottles, turn-paste mold, chilled-iron type, high and shallow basal kickups, basal wear on four specimens. Base diameters: 3 in. (4), unknown (12). Contents: wine, champagne. Probable dating: 1880 to 1920. Areas: C1 (4), T1 (5), T2 (7). Discussion: One basal fragment has a ring groove on the bottom of the heel, while another has a similar groove at the insweep of the heel.

A total of 11 necks with finishes were found. Eight bottle necks had champagne or wine finishes, while three had brandy finishes. Only two interior neck diameters were present, .650 in. and .695 in.

One body fragment of light olive green glass contained embossed lettering, which unfortunately was not legible. This sherd was found in area C1. Its contents were presumably alcoholic.

Green. At least 16 bottles are represented by the 307 fragments of green glass recovered at Harmony. This category comprises 11.3 percent of the total bottle glass collection. Vessels are presumed to have contained culinary products such as olive oil, flavor extracts, such condiments as sauces and horseradish, and beer.

This glass is a light, transparent, pale green, and contains gas bubbles and other imperfections. Most of our sample has smooth exterior surfaces and slightly depressed bases. Sherd thickness ranges from .90 in. to .156 in.

Basal and body fragments are believed to represent the following vessels:

1. One whole 5-ounce club sauce bottle, two-piece mold, cylindrical neck, club sauce finish, recessed dish base. Dimensions: height, 8 in.; base diameter, 2 in.; neck diameter, .680 (inside). Contents: club sauce. Probable dating: 1870 to 1913, as mold was chilled-iron. Area: T1. Discussion: This bottle type is illustrated in Herskovitz (1975a: Fig. 3). The neck finish has a ledge around the inside to hold the glass stoppers used on

- these bottles. An embossed basemark consists of the numerical symbol "498", probably a production code.
- 2-3. Two cylindrical pickle and preserve bottles, post bottom mold, chilled-iron type, basal dish depressions. Base diameters: 3 in. Contents: condiment, probably horse-radish. Probable dating: post 1870. Area: T1. Discussion: Refer to Putnam (1965: 193) for an illustration of similar bottles.
 - 4-5. At least two cylindrical club sauce bottles represented by embossed body fragments. Dimensions: unknown. Contents: Worcestershire sauce. Probable dating: post 1877. Areas: C1, T1. Discussion: We believe these to be Lea and Perrins Worcestershire Sauce bottles. Bits and pieces of these words are embossed on a number of fragments. In 1877, Lea and Perrins sauce was finally produced in New York after being imported for many years (Switzer 1974: 79).
 6. One nearly cylindrical olive oil bottle, post bottom mold, slightly outward flaring heel with basal dish depression. Base diameter: unknown. Contents: olive oil. Probable dating: post 1860. Area: T1. Discussion: This bottle type is illustrated in Putnam (1965: 208).
 7. One rectangular (panel) extract bottle, represented by embossed body sherds. Dimensions: unknown. Contents: flavor extract. Probable dating: late 19th century. Area: T2. Discussion: Several embossed letters appear vertically on a front or side panel--"...PARILLA EXTR...". It is possible that this refers to sarsaparilla extract, a flavor offered by Sears in 1897 (Israel 1968: 10).
 - 8-9. Two cylindrical beer bottles, post bottom mold, dish shape basal depressions with ring groove around bottom of heel. Base diameters: 2.5 in. (1), unknown (1). Contents: beer. Probable dating: post 1873. Area: T1. Discussion: Beer was not bottled until the process of pasteurization had become a part of the brewing business in 1873 (Woodward 1959: 154). Both bases had the embossed mark "72", which is again probably a production code.

All lip treatments are applied. Two beer finishes are present (inside diameter of one is .70 in.), along with two double bead and two bead finishes. One of the bead finish necks is probably from a pickle and preserve ware bottle, and has an inside diameter of 1.36 in. Another neck possibly had a packer finish.

Aquamarine. A total of 416 fragments of aquamarine glass was found, comprising 15.3 percent of the entire bottle glass sample. A minimum number of 13 vessels are included. Bottles represented in this collection are presumed to have once contained patent medicines, perfume, and possibly other products as well.

This glass is transparent and pale bluish green in color. Bottles are thin walled with slightly recessed bases. Glass thickness ranges from .122 in. to .175 in.

The following bottles are represented by basal and body fragments:

1. One Florida Water type bottle, represented by an embossed body fragment, originally cylindrical with long neck and oil finish. Dimensions: unknown. Contents: Florida Water. Probable dating: late 19th century. Area: Tl. Discussion: Raised lettering vertical on bottle reads FLORIDA WATER, MURRAY & LANMAN, DRUGGISTS, NEW YORK (underlined letters are legible). This all purpose preparation was also noted at Fort Bowie (Herskovitz 1975a: 45) and Fort Union (Woodward 1959: 164). An 1892 newspaper account claims that it was a "... most refreshing lotion after exposure to the sun" (Herskovitz 1975a: 45).
2. One almost intact 4-ounce castor oil style bottle, post bottom mold, oval body with short cylindrical neck, oil finish, slightly depressed base. Dimensions: height 5.70 in.; base diameter 2.25 in.; neck diameter .442 in. (inside). Contents: patent medicine. Probable dating: about 1880. Area: Plant. Discussion: Embossed lettering vertically on front slug panel reads: "J.A. FOLGER & CO. ESSENCE OF JAMAICA GINGER SAN FRANCISCO". This is the same company of coffee fame today. Evidently the essence was a family healing remedy (Israel 1968). An illustration of this bottle can be found in Wilson and Wilson (1971: 35).
- 3-6. Four square panel bottles, represented by embossed body sherds. Dimensions: unknown. Contents: patent medicine. Probable dating: about 1880. Area: Tl. Discussion: Embossed on front panels are various parts of word "AYER'S", while "SARSAPARILLA" appears on side panel. Ayer's Sarsaparilla, a product of a Lowell, Massachusetts firm, was a medicinal cure-all, made up of several fluid extracts (Wilson and Wilson 1971: 19, 105).

Four applied neck finishes were identified: one oil finish with an inside diameter of .550 in.; one brandy finish; one double bead finish; and one packer finish. Four other glass fragments from

panel bottles had embossed lettering which could not be identified. These are likely from patent medicine bottles as well, and were recovered from C1.

Blue. Only 60 fragments of blue glass were found, comprising 2.2 percent of the total sample. A minimum of four vessels are present. Bottles represented are believed to have contained a patent medicine and some other unknown substance.

This thin glass is for the most part light blue and transparent, with a fluted or ridged exterior surface. Average sherd thickness is about .118 in. All fragments are very small, making identification almost impossible. Ridges on the fragments appear to radiate from some central point. One of these pieces of molded glass also has an embossed pendant dot arrangement. The original shape or contents of these vessels is not known.

The only recognizable fragment of blue glass was a recessed side panel from a cobalt blue rectangular panel bottle found in area T1. The original height of the bottle was about 7.5 in. In raised lettering down the side of the panel were the words "RADICAL CURE". According to Wilson and Wilson (1971: 81, 136), Samuel T. Sanford of New York first introduced his Radical Cure in 1871 as another popular cure-all remedy.

Amber. A minimum number of 15 bottles are represented by the 560 fragments of amber glass. This total comprises 20.5 percent of the total bottle glass sample. Vessels in this collection are presumed to have once contained alcoholic beverages such as beer and possibly liquor.

The majority of this glass is from beer bottles, being dark brown and transparent. Vessel walls are thin, with glass thickness ranging from .162 in. to .250 in. The exterior surface of these cylindrical bottles is smooth and shiny, indicating the mold was chilled. Again, beer was not bottled in the United States until after pasteurization had been refined in 1873.

The few diagnostic basal fragments are believed to represent the following bottles:

- 1-5. Five cylindrical beer bottles, post bottom mold, slightly dished basal depressions. Base diameters: unknown. Contents: beer. Probable dating: post 1873 (3), 1881 to 1885 (2). Areas: C1 (1), T1 (1), T2 (3). Discussion: The embossed basemarks "MIL. WIS G CO" and "MILW WIS G CO" appear on two bottles. These are the identifying marks of the Wisconsin Glass Company of Milwaukee, in production between 1881 and 1885.

Four necks with applied finishes were recovered, two brandy, one bead, and one champagne finish. No dimensions were available from these small fragments. Two body fragments contained raised lettering which was not discernible.

Clear. A minimum number of 14 bottles is represented by the 499 fragments of clear glass found at Harmony. This number comprises 18.3 percent of the total bottle glass sample. These vessels are presumed to have once contained culinary products, condiments, and patent medicines.

For the most part, this glass is clear and transparent. Several fragments had turned purple in the sun, because of the presence of manganese in the glass. Such specimens were manufactured between 1880 and 1925 (Newman 1970: 74). Glass thickness ranges from .077 in. to .147 in. A large amount of the dateable clear glass at Harmony was modern.

Basal fragments are believed to represent the following vessels:

1. One barrel-shaped mustard bottle, two-piece mold, small barrel with raised staves and bands, slightly concave base, purple glass. Base diameter: 2.24 in. Contents: French mustard. Probable dating: 1880 to 1913. Area: T1. Discussion: A number of these bottles were also found on the steamship Bertrand (Switzer 1974: 38-50). Putnam (1965: 198) indicates that they were available in 2-ounce to 8-ounce sizes. A body fragment, possibly from the same vessel, contained the raised letters "MOU...", which may be part of the word moutarde, the French spelling of mustard.

2. One rectangular panel bottle, two-piece mold, flat base, purple glass. Base diameter: 1.75 in. by 1.0 in. Contents: patent medicine. Probable dating: 1880 to 1913. Area: T1.
3. One hexagon ring style pepper sauce bottle, two-piece mold, flat base, purple glass. Base diameter: unknown. Contents: pepper sauce. Probable dating: 1880 to 1913. Area: T1. Discussion: According to Putnam (1965: 211), this bottle was produced in a 5-ounce size.

Five necks with finishes were found. These include two bead, one oil, and two patent/extract finishes, along with a neck from a ballneck panel bottle with an interior diameter of .455 in. All finishes are applied. Several body fragments from both cylindrical and panel bottles contained raised lettering, only one of which could be identified. The letters "H.P. WA..." probably indicate a product of the H. P. Wakelee drug company of San Francisco. Wakelee sold proprietary medicines such as camelline and citrate of magnesia (Wilson and Wilson 1971: 143).

Description: Household Glass

Few objects of glass at Harmony could be classified as household in nature. Only four fragments of tableware glass were identified.

A basal fragment from a clear drinking glass was found in area C1. It has a diameter of about 2.5 in. The glass itself was fairly thin (.117 in.), but the container had a slightly thickened bottom. Another embossed fragment of glass was also probably from a drinking vessel. The decorative pattern consisted of raised circles and dots within two parallel bands.

Two fragments of opaque white milk glass were also recovered. These were probably tablewares, anything from cups to bowls, but as nothing diagnostic was noted, this is hard to verify. The fragments are from the plant and T1.

Description: Miscellaneous Glass

A total of 10 fragments of glass can be placed under the heading of miscellaneous. Categories included here are medicinal glassware, gaming pieces, chemical glassware, and an eyeglass lens.

These items, along with the household glass, comprised only 0.4 percent of the total glass collection.

Eyeglass. A fragment of convex spectacle glass was found in Unit T1. The round lens was approximately one inch in diameter. Eyeglass lenses are nearly impossible to identify in a fragmentary state (Corson 1967: 122).

Medicinal Glassware. Two neck fragments from clear glass homeopathic vials have been identified. These have inside diameters of 5 mm. Glass thickness is .052 in. Similar vials were available for sale in the Whitall, Tatum & Co. catalog for 1880 (1971: 31) in sizes from 1/8 drachm to 8 drachms, and from 5 mm to 21 mm in diameter. Such vials were used for minute doses of medicine. Both specimens were found in Unit C1.

Gaming Pieces. Three glass gaming pieces, two of opaque white glass and one of black glass, are present in the Harmony collection. These markers are .455 in. in diameter and .210 in. high. The general shape is that of a round dome with a flat bottom, for sitting on the game board. Both pieces were found in Unit C1.

As Quellmalz (1972: 154) noted, some of the more interesting artifacts in 19th century sites are glass markers which were "commonly used in the Province of Kwantung for gambling and were brought to the Pacific Coast for the same purpose." These gambling markers could have been used in a number of different games. One possible example is the Chinese pebble game of Wei ch'i, which was also played in Korea and Japan (CuIin 1958: 91). This game is played by two on a special board with two sets of men of different colors. In Korea the men are small, polished black pebbles and pieces of polished white shell.

Chemical Glassware. Four pieces of light green (flint) glass tubing were found within the plant area. They have been tentatively

identified as sections of ignition tubes, used in the chemical assaying of minerals. According to the Whitall, Tatum & Co. 1880 catalog (1971: 41), these are 5/8 in. #1 heavy tubing, with an inside diameter of 3/8 in. Two of the fragments have flat cut edges on one end, and were probably similar to test tubes in appearance.

The Coleman Company ledger (1884-1887: 5, 29, 35) notes at least three purchases of ignition tubes for Harmony: two orders, each for one-half dozen four-inch tubes and another order for one dozen nine-inch tubes cut to 4 in. Today these items are commonly called combustion tubes. They are used in chemical assaying to determine the content of a specific component of a mixture, by the use of high temperatures (Hampel and Gessner 1976: 25).

For example, to test for the content or purity of borax, sulfuric acid is poured on the ore to dissolve away the salt. The borax left behind might then be placed in a combustion tube, along with a small quantity of alcohol, and ignited. The quality of the product would be determined by how green the flame burned (Holland and Simmonds 1971: 20-21).

Description: Window Glass

Recently, a study was undertaken to determine if a chronological scheme based on window glass thickness could be developed. Window pane sherds from 12 assemblages representing the Hudson's Bay Company and Army occupations at Vancouver (Chance and Chance 1976) were measured for thickness in thousandths of an inch. The plotted results, using modes, indicate a thickening of glass through time from .045 in. for the period 1830-1840 to .095 in. between 1870 and 1900.

Since Harmony fits into such a limited time span (1883 to 1888) and represents a single cultural unit, we felt that by applying our window glass data to this scheme, it could be further tested and perhaps refined. Chance and Chance (1976: 248) felt that in discussing individual structures or discrete stratigraphic deposits, the modes

are the most important measure, and that means and medians are only useful in looking at clusters of several buildings from one period or a discrete span of time. We question the use of modes in either case, especially if derived from actual values for a relatively small sample. Thickness data will be presented here using both modes and means so as to be more useful to future investigations on this matter.

A total of 541 fragments of window pane glass was collected at Harmony, comprising 16.5 percent of the total glass sample. As is usually the case in archeological sites, the size of these fragments of flat glass was very small. It is interesting that almost half of this glass came from Unit C1.

A sample size of 195 sherds was chosen for measurement, representing 36 percent of the total. The thickness range for the site as a whole is .060 in. to .125 in., a spread of .065 in. The mean for this sample is .085 in., while the mode is .095 in. This mode does agree with the Chance and Chance (1976: 252) suggested age ranges for modes of window glass thickness in use at Vancouver, Washington.

When this measured sample is arranged by functional units, we see that the reliability of using actual value modes begins to break down. So, here, modes are less valuable when discussing individual loci. As Table 2 indicates, the mean glass thickness by spatial area does deviate very little from the total sample mean. However, the mode seems to be skewed by quite a bit in some cases toward the lower end of the range.

Table 2
Measurements of Window Glass Thickness
at Harmony by Area
(.000 in.)

	Plant	C1	T1	T2	T3	Total
Sample	40	82	18	50	9	199
Mean	.086	.082	.089	.089	-	.085
Mode	.090	.065	.070	.095	-	.095
Range	.065-.108	.061-.125	.060-.110	.065-.110	-	.060-.125

It seems that as suspected, the mean is a more reliable indicator than the mode when actual values and a small sample are combined. In any case, overall window pane data for the five-year occupation at Harmony does fit well into the Chance and Chance (1976) chronological scheme. It is hoped that other statistics on window glass thickness will soon be applied to this time chart so that it might be refined.

Additional Materials

Approximately 220 sherds of glass were collected at Harmony by William Wallace from surface and subsurface proveniences--65 from the blacksmith shop and 155 from Unit C1. Wallace's sample was very similar to ours in its composition. The only objects worth mentioning are one black and three white gaming pieces found in C1; three fragments of window glass held in iron frames from the shop and Unit C1; and an ignition tube section, also from the blacksmith shop.

The collection Herskovitz made in 1975 within the plant contained about 42 fragments of bottle glass and 10 of window glass. He also found one whole champagne bottle of light olive green glass, cylindrical, with a high basal kickup and champagne finish. It was made in a turn-paste mold, about 1880 to 1920, with a base diameter of 2.75 in. and a height of 8.25 in.

Spatial Distribution

The distribution of glass fragments by category is shown in Table 3. As far as bottle glass is concerned, no one area stands out as a major cluster. Area T2 contained 35.4 percent of the bottle glass, while Units C1 and T1 followed close behind with 28.5 and 16.8 percent, respectively.

Table 3
Distribution of Glass Categories

	P	C1	T1	T2	T3	Totals
Bottle (Total)	136	777	459	965	388	2725
Olive Green	7	309	60	445	62	883
Green	22	62	114	81	28	307
Aquamarine	5	77	169	65	100	416
Blue	40	3	4	13	--	60
Amber	5	130	7	300	118	560
Clear	57	196	105	61	80	499
Household	1	1	1	1	--	4
Eyeglass	--	--	1	--	--	1
Vials	--	2	--	--	--	2
Gaming Pieces	--	3	--	--	--	3
Chemical	4	--	--	--	--	4
Window	140	244	40	104	13	541
Areal Totals	281	1027	501	1070	401	3280
Percent	8.6	31.3	15.3	32.6	12.2	

These numbers are not entirely reliable, however, as is evident when the minimum number of bottles is reported by area (Table 4). Area T1 is seen to contain the greatest number of bottles, in this instance, with 31 specimens, while at least 27 bottles are present in Unit C1. We believe this discrepancy (the greater number of glass fragments) is due mainly to the location of Unit T2 along an access road, and its use as a stopping place and picnic ground by visitors to the site. Some of this large sample (965 fragments) may be sherds from modern bottles. The difference may also be a function of sherd breakage in this area by human and vehicular traffic, creating a greater number of smaller fragments.

Table 4
Distribution of Identified Bottles by Contents

	P	C1	T1	T2	T3	Totals
Alcoholic Beverages		5	9	10		24
Culinary Products			1	1		2
Club Sauce		1	6			7
Patent Medicine	1		7			8
Overall Min. # Vessels	6	27	31	17	9	90

The fact that almost 67 percent of the blue fluted bottle glass came from the plant may indicate that it is a chemical ware, perhaps containing reagents. As Table 4 indicates, almost the entire stock of identifiable bottles related to personal needs such as food and medicine was found in Unit T1.

Conclusions

The 3280 whole and fragmentary glass artifacts collected at Harmony form the largest artifactual category studied. Of this total, 83.1 percent of the fragments are from a minimum number of 90 bottles. Window pane fragments comprise the next largest group, with 16.5 percent of the total. The remainder of the sample is almost negligible, being composed of tableware, an eyeglass lens, homeopathic vials, gaming pieces, and chemical ware.

The vast majority of identifiable bottles from Harmony are alcoholic beverage containers. Twenty-four wine, champagne, and beer bottles were noted. Considering the site was occupied for five years by upwards of 50 people, there is no suggestion from the archeological record of the frequent consumption of alcohol from glass containers.

This brings up an interesting point. We know from the historical record (Coleman Company Ledger 1884-1887) that at least nine dozen bottles of "Don Pedro" were shipped to Harmony by Porter Slessinger & Co., probably for use by the plant management. It is believed that this product is a brandy, or perhaps a wine. The majority, if not all, of this lot was apparently consumed away from

the Harmony townsite, which may again give credence to the theory that only Chinese laborers resided there.

A total of nine identified bottles contained culinary products, suggesting, as suspected, that most food products came in tin cans. Items included in the Harmony inventory are olive oil and sarsaparilla extract, along with a number of club sauces, such as horseradish, French mustard, Lea and Perrins Worcestershire Sauce, and pepper sauce. The Coleman Company ledger contains few products which necessarily had to come in glass containers, probably because of shipping difficulties. Two cases of Montserat sauce, four of Lusks catsup, and two of chow-chow were ordered over the years. Again, where did all of these bottles end up?

Harmony was operating at a time when family remedies and cure-all medicines were flourishing in this country. Unfortunately, only eight patent medicine bottles could be identified. These include Essence of Jamaica Ginger, Ayer's Sarsaparilla, Sanford's Radical Cure, and Florida Water. Only two items, the sarsaparilla and ginger, match up with the Coleman ledger. Other products ordered from the Langley & Michaels Company (in business after 1871) are as follows: family remedies such as castor oil, camphor, and glycerine; liniments; salves; "HHH Medicine"; Schenk's Pills; and a homeopathic remedy, Swifts-Specific.

Trends of glass discard alone are difficult to interpret, and so will be discussed only briefly here. As far as identifiable specimens are concerned, T1 is definitely the largest disposal area for beverage, food, and medicine bottles. In the case of overall minimum number of vessels, Unit T1 is again on top with 31 assorted bottles, but C1 and even T2 are close behind with 27 and 17 containers, respectively. Why these bottles are clustered in Unit T1 is difficult to say. Perhaps preservation has been better in this area because of its isolation. Another possibility is that Unit T1 represents a formal garbage dump for the townsite, where whole bottles were tossed after being emptied. Bottle glass present in the other areas may then be the result of accidental or non-formal

breakage, being walked and trampled into the ground by traffic around the possible cook shack (C1) and storeroom office building (T2 - Adobe A).

Other domestic glass artifacts such as the tableware are too few and scattered to interpret, as is the eyeglass in T1 and the vials in C1. It is the absence of these items that is significant. The occurrence of the gaming pieces in Unit C1 is not surprising. We can assume that just as the group activities of dining and opium smoking were centered around C1, so was the gambling. Industrial supplies of glass (the ignition tubes and possibly the blue reagent bottles) are centered where chemical analysis would be likely to take place, the plant.

The nature of this collection again seems to indicate the work camp atmosphere of the townsite. Evidently, a number of items among the vast array shipped to Harmony were contained in sturdier vessels than glass, such as cans and barrels, for the trip from San Francisco. It is questionable from the archeological record that all of these supplies ended up at the plant townsite--provisions may have been purchased by residents from a company store at Furnace Creek.

Metal

Introduction

More than 2000 metal artifacts were recovered from excavation and surface collection at Harmony. The bulk of the collection comprises tin can fragments and nails. Additional categories include tools, horsegear, blacksmith's stock, hardware, machine parts, wire, and a variety of miscellaneous objects. As a kind of shorthand, "iron" and "copper" will mean ferrous and cuprous metals.

Description: Storage Containers

Tin Cans and Can Fragments. Tinned-iron-can technology of the nineteenth century can be summarized briefly, following Fontana and Greenleaf (1962: 67-78). The hole-in-top can was patented in 1810

and continued in use throughout the century. A can was made by joining top and bottom to a cylinder. A hole an inch or two in diameter was left in the top so the can could be filled. After filling, a cap was soldered into place, and the can was heated to cook the contents. During processing, a small hole was left in the can top for venting steam. This hole was finally closed with a drop of solder.

After the Civil War, a series of open-top cans were developed. These cans are like the hole-in-top cans, except that cans were filled and then capped in one step. Solder-drop final closures were still used. At the turn of the century the familiar crimped-seam can was developed. These cans are still in use today.

Cans and can fragments found at Harmony fit into the late 19th century style. Both hole-in-top and open-top cans were found, all with simple lapped and soldered seams and solder-drop closures. Only three examples of crimped seams were found, but this may be accounted for by differential preservation. In many cases deterioration was so bad that all that remained were solder-joint skeletons of cans. Apparently lead holds up better than iron in alkaline soil.

Cans range in diameter from 2-3/8 in. to 5 in., and in height from 2 in. to 5 in. The most common round can size was about 4 in. high and 3 in. in diameter. Fragments of square cans also were found. Cans are similar in form to a variety of turn of the century cans which contained vegetables, fruit, fish, beef, evaporated milk, and tobacco (Israel 1968; Butler Brothers 1915).

Thirty of the can-ends showed evidence of the opening techniques in use. Although can openers were sent to Harmony (Wm. T. Coleman & Co. 1884-1887: 42), only four cans were opened this way. One can was opened with a strip opener, but the remainder were cut open with knives. Three techniques were used. On one can a simple flap was hacked into the end and turned up. Seven more can-ends were roughly haggled open, following the end perimeter. The other 17 cans were opened by cross-cutting the end in an "X" and turning back the flaps.

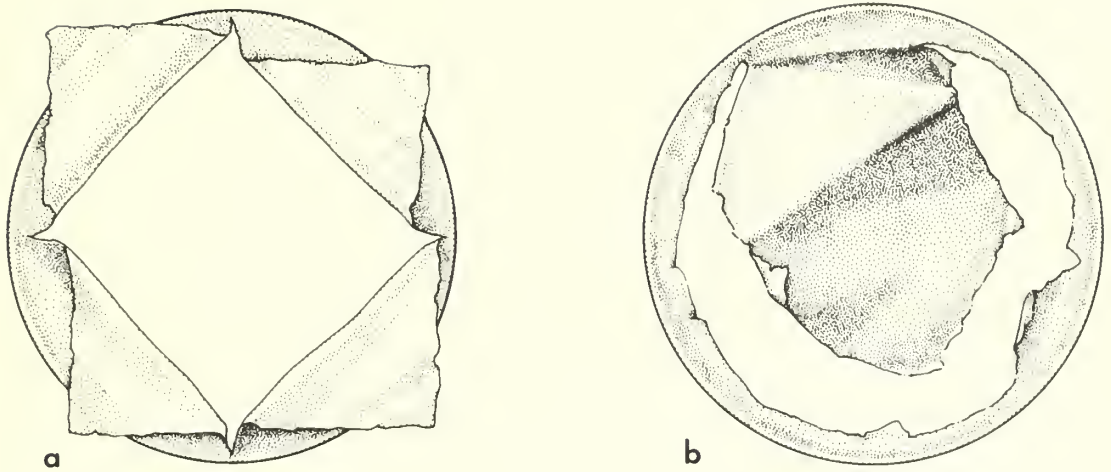


Figure 37. Tin can opening techniques. Diameter of b is 4 in.

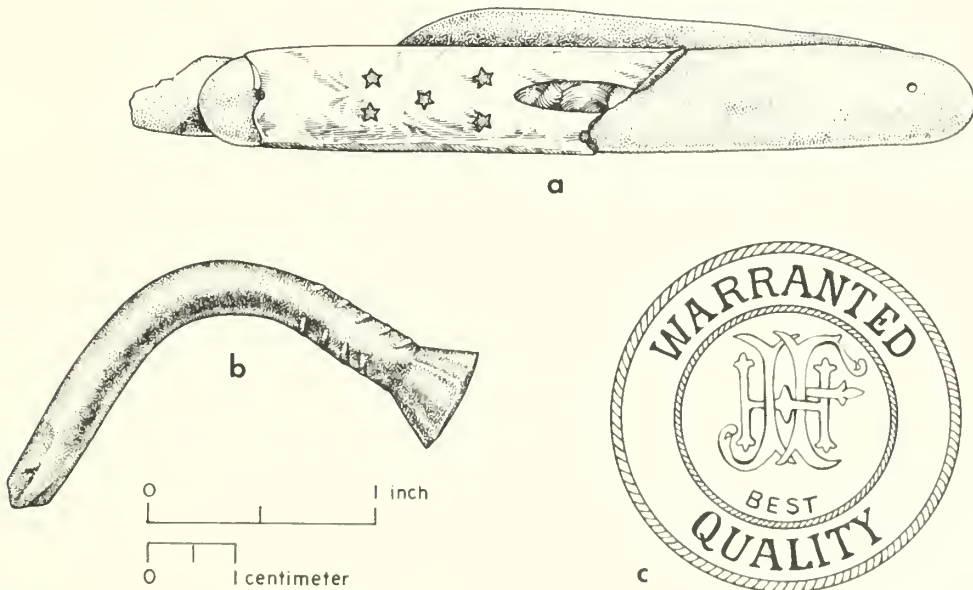


Figure 38. Metal artifacts: pocket knife, track nail, and lead foil seal.

Opening techniques are illustrated in Figure 37. All cans but two were opened on the bottom.

Cans and can fragments were found in virtually all provenience units. More than three-quarters came from the trash dump in Unit T1. Only a few pieces were found in the plant and in Unit T3. The rest were divided about equally between Units C1 and T2. In all, 474 specimens were recovered.

Openers and Closures. Three key-strip openers, two crown seal bottle caps, and one screw cap were recovered. All probably date after the abandonment of Harmony. Key-strip openers, like those that come with canned meat, weren't patented until 1895 (Fontana and Greenleaf 1962: 71). Crown seal bottle caps, the familiar pry-off kind, were patented in 1892 (Lief 1965: 17). The screw cap, like those on mayonnaise jars today, was patented in 1873 (Woodward 1959: 166).

Foil. Thirty-six pieces of lead foil were recovered. Pieces range from scraps to sheets as large as 60 square in. On the larger pieces, a turned edge can be seen. One piece bears embossed stamping, apparently a symbol of a manufacturing or packing company (Fig. 38: c).

The foil is about the same gauge as that found on wine and brandy bottles today. Indeed, some of the foil may have served to seal corked bottles. The other, larger, pieces would have served some other food packaging function. All but three of the foil fragments were found in Area C1.

Metal Tags. Two sheet iron tags, each about an inch long, were found in Unit T2. Embossed on both is the legend "J.B. PACE."

Sharp tabs stick out on the ends and, presumably, the tags were fastened to wooden boxes. Most likely, they bear the maker's name for some food product.

Cooking Vessel

A fragmentary coffee pot was found in Unit T1. The pot, made of tinned sheet iron, was originally about 12 in. high. Body seams were crimped and soldered. The spout was lapped and soldered. A bail attachment is riveted to the rim. The C. Sidney Shepard & Co. catalogue (1895: 157) shows coffee boilers sold in 8, 10, and 12 quart sizes. The Harmony example looks like one of these.

Fasteners

Square Cut and Wire Nails. In the 1880s two kinds of nails were sold: square cut and wire. Square cut flooring nails and common wire nails found in hardware stores today are virtually indistinguishable from nails of the late nineteenth century (Nelson 1968). Cut nails were the standard from about 1800 until 1890 or so, when wire nails became predominant (Fontana and Greenleaf 1962: 54-55; Nelson 1968). The dominance of cut nails is clear at Harmony, with over 90 percent of our collection being made up of that kind.

The numbers and distributions of Harmony nails are shown in Tables 5 and 6. The symbol "d" stands for "penny", which is a term for nail size. The larger the pennyweight, the longer the nail. A four-penny (4d) cut nail is 1-1/2 in. long; a 20d nail is 4 in. long (Fontana and Greenleaf 1962: 56).

Upon examining the nail tables, two facts caught our attention. First, most of the wire nails were collected in Unit T3, around Adobe B. Two explanations may be offered for this. Nails in Unit T3 may have been deposited after 1890, or nails in this area may have been put to a very different use than those found in the plant. For example, wire nails may have been accepted more readily for cabinet work and building trim.

The second thing we noticed was that wire nails, with two exceptions, are found only in 8d and smaller sizes. Perhaps the shift from cut nails to wire nails occurred first in the smaller sizes.

Table 5
Distribution of Cut Nails

Size	Collection Unit					
	P	C1	T2	T3	T4A	T4B
40d	2					
20d	12			1		1
16d	22	1	1			2
12d						
10d	19	5				
8d	40	10	5	2	2	1
6d	36	26	1	3	1	
4d	40	30	5	1	3	
3d		13	2	4		1
2d	2	14				
Fragments	332	154	17	15	2	90

Total: 918

Table 6
Distribution of Wire Nails

Size	Collection Unit		
	P	T2	T3
40d			
20d			
16d	1		
12d			
10d			1
8d			16
6d	10		16
4d	3		23
3d		1	25
2d			5
Fragments	1		

Total: 102

Countersunk Nails. A dozen heavy gauge countersunk nails were found, mostly in the plant. The nails come in 2-1/4 in. and 2-1/2 in. lengths, with a 1/4-5/16 in. diameter shaft. Tips are flat, and raised barbs extend 1/2 in. from the head. One specimen is illustrated in Figure 38: b. These nails are similar in some ways to wagon box nails (Sears Roebuck & Co. 1905: 25) and barbed rafter nails (Whitaker Manufacturing Co. 1905: 173), except for the countersunk head. The Harmony nails would have been ideal for securing track iron to wooden runners, using drilled pilot holes. In the company account there is reference to "25 lb. Track Nails 1/4 x 2-1/2" (Wm. T. Coleman & Co. 1884-1887: 49).

Spikes. Two five-inch iron spikes were found in the plant. Both have round heads and diameters of 1/4 in.

Tacks. Three square-cut iron tacks with large heads were found in Unit C1. Lengths are 3/4 in. or 1-1/4 in. One ornamental brass tack was recovered, also from C1. The head diameter is 1/2 in., as is the shaft length. The shaft is threaded and the head is machine turned. This is probably an upholstery tack.

Shoe Nails. In Unit C1, eleven brass nails were found within a few inches of each other. Nails are 5/8 in. long and have threaded shanks and wedge tips. These nails are all that remain of a decomposed shoe.

Horseshoe Nails. Only two horseshoe nails, both No. 5 nails, 1-7/8 in. long, were found. Both were in Unit C1.

Hand-Wrought Fasteners. Three nails were wrought from soft iron. Lengths are 1-1/2 in. or 2-1/4 in. Two have rose heads, the other is flat headed. Also found was what appears to be a two-headed wrought nail. This was doubtless a hand-forged rivet.

Staples. Five wire staples were found, ranging in size from 5/8 in. to 1 in. These are the same as modern fence staples. One additional staple, found in the plant, was forged from 1/4 in. stock and is 2-1/2 in. long. This may have served as a pipe bracket.

Corrugated Fasteners. Five corrugated fasteners from Unit T3 were probably used to join box corners.

Iron Rivets. Eight soft iron rivets were found, most of them in the plant. Head diameters range from 7/16 in. to 5/8 in. and shaft lengths are about 1/2 in. These rivets were used to join sheet iron, and are commercially made.

Screws. The 11 screws from Harmony are all flathead, counter-sunk wood screws. Lengths are 1 in., 1-1/4 in., 1-1/2 in., and 1-3/4 in.

Bolts, Nuts, and Washers. Fifty-eight nuts, bolts, and washers were recovered, 90 percent of these being found in the plant.

The 26 machine bolts are in sizes 3/8 in., 1/2 in., 5/8 in., and 3/4 in. Nuts were made to fit these sizes plus 1/4 in. bolts. Only two carriage bolts were seen. These were in 1/4 in. and 3/8 in. sizes. Bolt lengths ranged from 2 in. to 14 in. Bolts all appear machine made, but quite a few of the nuts look to be cut from bar iron stock and hand tapped.

Washers are in larger variety than nuts and bolts. Sizes included 1/4 in., 3/8 in., 5/8 in., 1/2 in., 9/16 in., 3/4 in., 7/8 in., and 1 in.

Hardware and Machine Parts

Springs. Two small brass springs were found. One is 1/4 in. by 1-1/4 in., the other is 1/8 in. by 1/2 in. long. Functions are unknown.

Valve Handle. One 4-1/2 in. diameter valve wheel handle was found. A 3/8 in. square hole is cast in the hub. There are six spokes leading from hub to rim. This may have been used to open and shut a water valve.

Chain Links. Two chain repair links were made of 1/2 in. stock. One link is 2-1/2 in. long, the other 4 in. long. These were made in an open spiral and were meant to be welded closed, joining lengths of chain. Neither has been used.

Bearing Case. One broken cast iron bearing case was found on Tier 3 of the plant. The bearing surface is lined with babbitt metal and a cloth-packed oiling reservoir feeds into the bearing interior. The bearing took a 1-3/4 in. shaft. We interpret this item as a part of the drive line fittings on Tier 2 (see Fig. 7).

Iron Hooks. Two iron hooks were found, both made of 1/4 in. bar stock. Functions are unknown.

Cotter Pin. A large cotter pin was found in the plant. Length is 3-1/4 in.

Pipe. Three pieces of pipe were recovered from excavations in the plant. The pipes have inside diameters of 1 in., 1-1/4 in., and 2 in. Also found was a brass pipe union with a hex head sized for a 5/8 in. wrench. The union would have been screwed into a 1/2 in. hole and, apparently, copper tubing was put into the top. The piece was probably used for steam fitting.

Iron Plate Assembly. A piece of half-inch plate 11 in. by 2 in. was drilled for 3/8 in. bolts or rivets. Function is unknown, but this may have been a tank part.

Hanger Bar. Eight pieces of galvanized iron pipe were lying in a bundle at the original grade line in the crystallizing vat area (surface of level 2a in pit P24A). One of these pipes was rusted through about two feet from the end. This broken specimen was retrieved for analysis. The pipe has an inside diameter of 1-1/4 in. Welded to the end was a short piece of 3/8 in. iron rod, bent to form a hook. This specimen is from one of the hanger rods which once were suspended in the crystalizing vats.

Tools

Soldering Copper. One large soldering copper was found behind the east dissolving tank. The copper has a wooden handle, a 5/8 in. diameter iron shaft, and a seven-inch long solid copper head. Total weight is 4-1/2 lbs. Such tools were heated in an open fire, or by blowtorch, and used for heavy soldering.

Melting Pot. One fragment of a cast iron pot rim was found. The rim has an exterior ridge and a cast bail attachment hole. Thickness is 3/4 in. The location of the fragment within the plant, and the heavy gauge, suggest use as a melting pot rather than as a cooking pot. The pot may have been used in melting lead for sealing pipe joints.

Pliers. One pair of lap joint, round nose pliers was found in the plant. The pliers are 7 in. long. Identical tools were available around the turn of the century (Sears Roebuck & Co. 1895: 108).

Pocket Knife. One pocket knife was found in Tier 2 of the plant. Overall length is 3-1/4 in. The knife had two blades, one of which is snapped off. The lining is brass and the handle is bone, inset with mother-of-pearl stars and an oblong shield (Fig. 38: a). Similar knives were made in the nineteenth century (Israel 1968: 110).

Screwdriver. In Unit C1 was found a 4-3/4 in. long screwdriver blade of very light gauge. It is badly rusted, and its original dimensions are undetermined.

Iron Awl. Also found in Unit C1 was a 3-1/2 in. long, pointed metal tool with a rounded butt. This could have been used hafted as an awl or unhafted as a splicing fid.

Tool Fragments. Three badly deteriorated iron objects were found in the plant. These may be parts of tools. One is a 3 in. by 2-1/4 in. piece of iron with a triangular cross section. It may have been used as a wedge. Another is a forged and pointed piece of heavy bar iron. It is 1-1/2 in. long and may be the broken end of a pry bar. The third fragment is a 2-1/2 in. by 1-3/4 in. by 1-1/2 in. block with a concavity across its width. This may have been a top swage for forming iron. All interpretations as to use are speculative.

Harness Fittings. One iron harness square and 30 copper rivets and burrs were found. Most came from Unit C1. The rivets have head diameters of 7/16 in., 1/2 in., or 9/16 in. Shanks range in length from 5/16 in. to 1-1/2 in. Burrs have diameters of 7/16 in., 1/2 in., 9/16 in., or 5/8 in. Rivets and burrs like these were commonly used to join leather harness, but other applications are possible. Two rivets had headstamps. One is a five-pointed star, the other is a fouled anchor.

Wire

Iron Wire. One hundred and seventy pieces of iron wire were found. Lengths ranged from 2 in. to 35 in. Wire is in gauges similar to modern stove pipe wire, baling wire, and heavy, galvanized, smooth fence wire. Only one piece of barbed wire, a double strand, reverse twist, four-barb wire, was found. This wire looks identical

to the Ross Four-Point style, patented in 1879 (McCallum and McCallum 1965: 256).

Smooth wire was joined in the usual way by twisting ends together or by interlocking end loops. Several specimens had been wrapped around posts or the like. Wrapped wire was secured by twisting free ends or by passing the running end through a loop.

Copper Wire. Sixteen pieces of copper tie-wire were recovered. No patterning in distribution could be seen.

Cable. Six pieces of steel cable were recovered. Represented are 6-strand, 12-strand and 20-strand specimens, all with right-hand twist. Diameters range from less than 1/8 in. to 1/4 in.

Screen Wire. In Collection Area T2, near Adobe A, were found two scraps of screen wire. Mesh is 1/16 in. Probable use was as window screen.

Blacksmith's Stock

Iron Stock. Eighty-one fragments of iron stock were found, the bulk in the plant. Stock is in the form of sheet iron and iron plates, bars, and straps. Pieces are small, fragmentary, and badly deteriorated. Bar iron was found in both square and round forms. Round stock recovered was 3/8 in. in diameter. Square bars were, in section, 1/4 in. by 1/2 in., 3/8 in. square, 3/8 in. by 1/2 in., and 1/2 in. by 1 in. Plate iron varied in thickness from 1/8 in. to 1/2 in. Strap iron was in several thicknesses and ranged from 3/4 in. to 1-1/2 in. in width.

The iron stock had been variously cut, drilled, and punched, but no interpretations of function could be derived for any but four specimens. These four pieces of sheet iron had been riveted to the bottoms or rims of crystallizing vats.

Copper Stock. One piece of strap copper of light gauge was found in Unit C1. The specimen is 3/8 in. wide and 3-1/4 in. long. Function is unknown.

Lead Stock. Three pieces of lead were found, all in the plant. One is a thin sheet of lead scrap from which pieces had been cut. Another is a 1/8 in. thick sheet of lead trimmed to a disc 4-1/4 in. in diameter. Function is unknown. The last is a piece of molded lead shaped like a fragment of pipe. Evidently this lead was used to seal a pipe joint.

Clothing Fasteners

Buckle. One iron buckle was found in Unit C1. It is the same as one identified for use with suspenders or vest straps by Fontana and Greenleaf (1962: 86).

Rivets and Snap. Twelve clothing rivets and one snap were found in Unit C1. They were made of iron, brass, or copper. One of the copper rivets has stamped on it "LS & CO. S.F. PAT. MAY 1873". There are three others which are still attached to scraps of blue denim.

Coins

One Chinese copper coin was found in Unit C1. The coin has raised edges on both sides and a square hole was cast in the center. One side has four characters in relief which indicate the coin was minted during the reign of K'ang Hsi, who ruled during the Ch'ing Dynasty from 1662-1723 (Coole 1965: 52, 54). The reverse is blank.

A local coin dealer showed no surprise when asked about the early date of the Harmony coin. Apparently, coins of this type were in circulation for long periods.

Coins of similar description were used as counters in the popular gambling game of fan-tan (McLeod 1948: 165). The Harmony coin may have served this purpose.

Previous Collections

Herskovitz (1975b) collected about 100 metal artifacts. Included were nails, nuts and bolts, washers, wire, and scrap. His collection is little different from ours.

Wallace, in his 1971-1972 excavations, recovered hundreds of metal artifacts from the site of the blacksmith's shop and the Chinese quarters (equivalent to our Unit C1).

In the Chinese quarters were found the usual nails, lead foil, scrap iron, and so forth. Also found were a double-pulley tackle block, a large cast brass barrel cock, a Chinese coin, and a thin brass box lid. The lid is 2-5/8 in. by 1-11/16 in. The coin is similar to the one we found, but bears a different description. Characters on the obverse indicate coinage during the reign of Ch'ien Lung, during the Ch'ing Dynasty, from 1736 to 1796. On the reverse are the Manchu characters yuan and pao (Coole 1965: 52, 54). The lid is identical in appearance and measurement with opium tin lids from Ft. Bowie (Herskovitz 1975a: 155, Fig. 29).

From the blacksmith's shop were recovered hundreds of nails, nuts, washers, and pieces of iron stock. Over 100 bar iron cut-off scraps were found. These scraps have sheared or wedge-shaped ends from being cut with hot chisels, or on the hardy. A number of blacksmith's and farrier's tools were found. Included are a top swage, a threading die, a rivet set for copper rivets, a pry bar, an iron pestle, a pritchell, and two drift punches. A hanger rod, cut 18 in. from the end, shows the use of a wheeled pipe cutter. Only two horseshoes and two mule shoes were recovered. Evidently fastener forging was going on. About 25 hand wrought specimens were found.

The Coleman Ledger

The Wm. T. Coleman Co. ledger (1884-1887) reads like a hardware store inventory when it comes to metal artifacts. Gears, cranks, and pawls, solder by the hundreds of pounds, and nails by the keg were ordered. It is not unusual that so many nails were found at Harmony.

At least nine kegs were shipped to the plant, amounting to tens of thousands of nails.

The shop initially established at the plant must have been fully equipped. Tools ordered from San Francisco during the operation's heyday were mostly items which were more or less expendable and subject to wearing out--spades, shovels, picks, files, rasps, pipe cutters, and a tuyer for the forge.

In addition, case after case of canned food, paint, and grease were shipped in, accounting for the large number of tin cans that remain.

Industrial supplies included a vast array of blacksmith's stock and nearly 400 hanger bars, ranging from 4 ft 8 in. long to 7 ft 6 in. long.

Summary and Interpretations

Over 2000 metal artifacts, mostly remains of tin cans, nails, and blacksmith's stock, were found in our excavations at Harmony. Taken together with the historical records and results from previous excavation, some interpretations of these artifacts can be made.

Metal containers are typical of the late 19th century, with solder seam/solder closure tin cans being predominant. An opening technique involving the cross-cutting of can bottoms was noted. With more information from other sites, this technique may prove to be indicative of time of can use. The records, and our collection, imply the importation of a great quantity and variety of canned food. Other food and drink was packed with lead foil, ample remains of which were found. Little remains of the cooking gear used at Harmony; only one pot, a coffee boiler, was recovered.

Fontana and Greenleaf (1962) have noted that square cut nails were predominant until 1890 or so. This was true of the Harmony collection. Some 90 percent of recovered nails were square cut. Wire nails may have gained more rapid acceptance for cabinet work and building trim than for heavy structural work such as is found

in the plant. Also, there may have been post-occupation modification of Adobe B.

A number of heavy, countersunk nails were used, apparently to secure track iron to wooden runners.

Smooth iron wire was in good supply, but the impression we get is of wire used for structural purposes rather than for fencing. Only five fence staples and one piece of barbed wire were found. Of course, wire fencing had by no means gained universal acceptance by the 1880s. Still, it seems likely it would have appealed to stockmen in the bottom of Death Valley. We like the interpretation that animals were kept down the road at Greenland rather than at Harmony.

Company records, and our collections, suggest to us that buildings had screened windows. Two scraps of window screen were found around Adobe A.

All indications are that the smithy, on arriving at Harmony, was well equipped, needing to be supplied only with expendable tools, stock, and coal. One can infer from artifacts a standard shop, with forge, anvil, and metal forming and cutting tools. A full range of blacksmith's stock was brought to Harmony in the form of iron bars, straps, and plate. Fasteners such as bolts, nuts, and rivets were bought as needed, but there is evidence that nuts and bolts were occasionally cut from stock and tapped or threaded at the smithy. The blacksmith was a busy man, fabricating and repairing plant equipment, making up fittings, and doing farrier work.

Only three items, the two coins and the opium tin lid, are of definite Chinese manufacture. The rest of the artifacts reflect the common procedures of late 19th century American industry.

Ammunition

Introduction

At Harmony we recovered 57 cartridge cases and five bullets. Before the descriptions are given, a few definitions are in order.

Metal cartridges have three basic parts: a case, a primer at the base of the case, and a bullet. In rim fire cartridges, the priming compound is placed around the inside rim of the cartridge base. In centerfire cartridges, the priming compound is, as you might expect, placed in the center of the base. Often the base is stamped with the caliber of the cartridge and the manufacturer. This is known as the headstamp.

Caliber is an expression of the bullet diameter in hundredths of an inch, as in .44 caliber. Keep in mind that caliber is a nominal figure; it is not uncommon for the measured diameter of a bullet to vary two or three hundredths from the stated caliber. Actual dimensions for most cartridges can be found in Barnes' (1965) excellent book.

When a weapon is fired, the hammer or firing pin strikes the base of the case, setting off the shock-sensitive primer. This, in turn, ignites the powder in the case, which explodes and propels the bullet toward its target. The cartridge case is ejected and discarded or saved for reloading.

Description

One of the bullets is a modern, copper jacketed .45 caliber similar to the .45 Automatic Colt Pistol bullet (Barnes 1965: 171). The other four are solid lead and have concave bases and grooves around the bodies. One specimen each was found in calibers .30, .38, .41, and .44. These latter four are similar in form to a variety of pistol and rifle bullets produced during the last quarter of the 19th century (Barnes 1965: 177; Bearnse 1966: 153-154; Datig 1958: 146; Logan 1959: 146).

Most of the cartridge cases, some 38, are .22 caliber rim fire. A number of cartridge manufacturing companies are represented by trademark. These include Federal, Remington-Union Metallic Cartridge, United States Cartridge, Western, and Winchester. While headstamps reveal that 12 cases were made after Harmony was abandoned, the dates of the other cases are uncertain. For example, cartridge cases with

the United States Cartridge Company stamp might have been made at any time from 1870 to 1936. Assigning dates to .22 cartridges is always difficult because these are the longest lived and least changed of any.

One other rim fire cartridge case, in caliber .32 Long, was found. An "H" headstamp is present, indicating manufacture by Winchester. Arms were chambered for this cartridge from 1861 to 1936 (Barnes 1965: 277).

Six of the center fire cases were manufactured after the abandonment of Harmony. These were found in calibers .32-20, .32 Automatic, .380 Automatic, .45 Automatic, and .45 Auto-Rim. The remaining center-fire cases may have been manufactured before or during the operation of Harmony. Recovered were three .38 Smith & Wesson cases, four .44 Webley cases, and five .44 Smith & Wesson Russian cases. These latter three cartridge types were introduced around 1875 for use in pistols (Barnes 1965: 163, 167, 173).

In addition to our collections, Wallace recovered seven cases in his 1971-1972 excavations. One is of modern manufacture, while the others were introduced as pistol cartridges around 1875. These are in calibers .32 Short (rimfire), .41 Long Colt, .44 Webley, and .44 Smith & Wesson Russian.

Interpretations

Interpretations about cartridges must be made with caution. There is first the obvious consideration that bullets often end up hundreds of yards from where they were fired. Second, rim fire cartridge cases cannot be practically reloaded, while center fire cases can (Barnes 1965: 271). Rimfire rifle and automatic pistol cases, then, are likely to be ejected and discarded at the place of use, while center fire cases are likely to be saved. To further complicate matters, revolvers do not eject spent cases, and the shooter may choose to wait until returning home to reload.

There are also problems with assigning time to cartridges. While it is relatively easy to find the date of earliest introduction

for a cartridge, the time of use is hard to determine. Ammunition for 19th century guns is still being made and used. Despite these problems, some interpretations can be made.

In the plant, 35 cartridge cases were found, but only one, in caliber .44, dates from the time of occupation. The remainder are recent .22 caliber rim fire cases, representing post-abandonment shooting. In Units T2 and T3, none of the cases could be assigned to the occupation period with any certainty. In Unit C1, 11 of the 12 cases could have been used in 19th century weapons. These are in calibers .38 and .44. Other cases, found by Wallace, include a .41 caliber case from the blacksmith shop.

In all likelihood, weapons used at Harmony included a variety of pistols in calibers .38 Short, .38 Smith & Wesson, .41 Long Colt, .44 Webley, and .44 Smith & Wesson Russian.

This speculation leads to another question. Why are only pistol cartridges found? Granted, a number of rifles were chambered for pistol rounds in the interest of economy, but we found no cases or bullets which were specifically designed for rifles (with the exception of one modern .32-20 case). This is surprising because a bewildering variety of sporting rifles, converted military rifles, and shotguns was available on the western frontier. Perhaps the lack of long guns can be interpreted as reflecting the part hunting played at Harmony. Rifles and shotguns are decidedly more efficient for hunting than are pistols. We offer the interpretation that hunting was of little importance to the economy at Harmony. Otherwise, rifle or shotgun cartridges would have been found along with the pistol cartridges.

Summary

Fifty-seven cartridge cases and five bullets were collected at Harmony during recent excavations. Wallace recovered an additional six cases during his 1971-1972 operation. Most of the ammunition post-dates the occupation of Harmony Borax Works. We speculate that a variety of pistols in calibers .38, .41, and .44 were in use at

Harmony. We interpret the lack of rifle or shotgun cartridges as indicating little emphasis on hunting.

Buttons

Buttons were not a common find at Harmony, particularly in areas other than Cl. A total of 25 garment buttons were collected. In order to more easily handle this small group, the buttons were divided into types based on the materials used, including metal (14), molded glass (10), and shell (1). Both whole and fragmentary buttons were found.

All of the Harmony buttons are civilian style, as would appear on everyday work apparel. Basically, these clothing fasteners fall into four general varieties based on use--trouser, vest, shirt, and sleeve. Because of the volume of literature available describing manufacturing processes, little time will be spent here on technique.

Metal

The 14 metal buttons recovered are mostly from ordinary work pants. As Olsen (1963: 552) has noted, trouser buttons changed little from the time of their introduction in the mid-1700s, except for the material used in their manufacture. Other specimens constructed of metal include ball vest types and a fabric covered button of unknown use.

Two buttons are of a kind described by Chance and Chance (1974: 120) as the Saunders type. R. Saunders of Birmingham, England, patented a three-part button in 1823 which remains in use today. It consists of a face, generally domed or convex, a shank plate, and a loop or eye which was inserted into a center hole in the plate and then brazed in place. The face was centered over the plate and its edge crimped over the plate edge, and then sealed through pressure.

The Harmony specimens are probably ball vest buttons, brass with a brass loop shank and a plain, undecorated face. Two sizes are present. The smaller button has a dome height with shank plate

and loop of 1/2 in; diameter is 5/16 in. The other button has an overall length of 9/16 in. and a diameter of 3/8 in. Three-part buttons such as these are a commonly used and sturdy variety.

Two iron trouser buttons recovered at Harmony are Type 21 buttons according to South's (1964: 121) classification system. These four-hole buttons were generally made in three pieces. The front, with a depressed center area, is crimped over a thin back disc. A center disc of wood or fiber is used to provide a tight fit between the two metal halves.

The Harmony buttons were found without the metal back, possibly indicating that materials other than iron may have sometimes been used as a base for the crimped over front. The size of these two specimens is 9/16 in. (14 mm) across. This type of button is said to have been introduced after 1870 (Olsen 1963: 553), although it has been found in an early 19th century context at Brunswick Town, Fort Fisher, and elsewhere (South 1964: 121).

Also included in our collection were a number of two-piece metal shank buttons of the type riveted to the waist of Levi Strauss blue jeans today. Nine specimens were analyzed, all of which had been used as trouser or workpants buttons. These fasteners are flat, stamped-steel types. The shank and front disc were cast in one piece, and the rivets, made of brass, are still in place. Diameters are 1/2 in. (3), 5/8 in. (4), and 3/4 in. (2). Button centers are recessed, and almost all have plain faces. One of the half-inch specimens contains engraved concentric lines on the flat rim which radiate from the sunken center panel. Three of the buttons still have small pieces of cloth, two of blue and one with white, attached to the rivet.

The remaining metal button is a two hole, sew-through type which was originally fabric covered. The button was made in two pieces. The plain front, of brass, is flat with a depressed center area, and is crimped over a thin back disc of lead. The hollow underside is still partially filled with a fiber cloth material, used to create a tight fit between the two metal halves. The two

holes in the center panel appear to have been hand punched, resulting in two irregular slashes. The button was originally covered with white cloth, and has a diameter of 1/2 in. Similar buttons were reported at a late 19th century ranch site in Arizona (Fontana and Greenleaf 1962: 87) and at Fort Bowie (Herskovitz 1975a: 88).

Milk Glass

Ten buttons constructed of molded glass were recovered at Harmony. All are white milk glass, either plain or very simply decorated. The addition of oxide of tin to the glass mixture gives it an opaque appearance. Milk glass buttons were being produced in England from the mid-18th century (Albert and Kent 1949: 50; Howard 1973: 10), and are still available today. Most of the specimens are plain white four-hole, sew-through shirt buttons, while one button contains a loop shank for attachment to the garment.

Eight common four hole shirt buttons were found, with slightly cupped centers and rounded rims. They range in diameter from 7/16 in. size 16s (5) to 1/2 in. size 20s (3). Size/diameter equivalents are available in the Butler Brothers Grocers Catalogue (1915: 487). Another common four hole type is decorated. This size 20 shirt button has a depressed panel center and a flat rim containing molded rays around the margin.

The last specimen is a cone-shaped button of plain white milk glass. It has a brass wire loop shank attached to a flat back. The diameter of this button is 3/8 in., and it is 1/4 in. high. This molded glass button is probably a shirt or sleeve fastener.

Shell

Only one shell button was found at the site. It is a common four-hole sew-through button of mother-of-pearl shell. The size 18 button is a polished white, flat type, with a chipped face and irregular thickness (.060 in.). Machine made "pearl" shell buttons have been produced since 1850 (Luscomb 1967: 177).

Spatial Distribution

There is a very definite spatial clustering observed when reviewing the distribution of buttons at Harmony. Of the 25 buttons recovered, 84 percent (or 21) of this total came from Unit C1. Metal and glass specimens were present.

Garment buttons are very scarce in other areas of the site. One of the common four-hole milk glass buttons was found in T1; the fabric covered button was from T2; and the decorated glass button and the shell button were collected in Unit T3. No buttons occurred within the plant.

Conclusions

Twenty-five garment buttons were recovered from Harmony, most of which were of a plain civilian type. Materials used in the construction of these buttons were limited to metal (14), milk glass (10), and shell (1). There was nothing special about this particular collection of buttons; they would fit into any inventory of everyday work clothing. Varieties present include ball vest buttons (2); iron sew-through trouser buttons (2), and metal shank buttons of a type riveted to the waist of Levi Strauss pants (9); a fabric covered button (1); and common milk glass and shell shirt, or possibly underwear (Howard 1973: 12), buttons, of which there were 11.

The Coleman Company ledger (1884-1887) was checked to see what types of clothing that had been ordered could be matched up with our button sample. The only supplier of clothing noted was the Levi Strauss Company of San Francisco. Items listed which would use buttons include 7-1/2 dozen blue and denim pants; 4 dozen overalls; 1 dozen "jumpers" (coats made to wear with overalls); and 10 dozen white and gray flannel "shirts and drawers" (long underwear). From this list we would expect to find buttons from ordinary work clothes and underwear at Harmony, but again we see a discrepancy between the sheer number of things shipped to Harmony and the assemblage evident from the archeological record.

Twenty-one of the 25 buttons that were recovered came from Cl. This is further evidence of the importance of this area as a center of activity in the townsite. Buttons from other sections of the site are almost negligible, perhaps playing down the domestic role of these areas at Harmony.

Smoking Pipes

Only four artifacts are included in this category, two white clay pipe stems, one pipe stem of hard rubber, and a brass pipe bowl cover. This small sample is unusual, since pipes, especially those of clay, were both inexpensive and fragile. Fragments of smoking pipes are generally very common finds in historical contexts.

The white clay pipes represented at Harmony are of the variety with non-detachable stems. As Herskovitz (1975a: 242) has noted, white clay pipes were made of ball-clay, and not the frequently mentioned kaolin. The first two items recovered are stem fragments of white clay and probably are from plain, undecorated pipes. Bore diameters are 2/64 in. and 3/64 in. It can be assumed that both pipes were produced by the same manufacturer using the same molds.

Tobacco pipes of molded clay were first introduced to Europe during the 16th century and had almost completely fallen from popularity by the 20th century (Humphrey 1969: 13). One of the most significant differences between the early and late pipes, revealed first by Harrington (1954) and then by others (Irwin 1959, Eaton 1962, Binford 1961), is that there was a consistent reduction of the size of the stem bore over time. Unfortunately, this bore-date relationship breaks down after about 1780. As Noel Hume (1972: 296) has stated, such pipes were generally "manufactured, imported, smoked, and thrown away, all within a matter of a year or two...". In addition, pipes were very cheap, thus making them available to all economic levels of society. This fact makes tobacco pipes a valuable tool in historical analyses.

One complete pipe stem of hard black rubber was found at Harmony. The specimen is a straight type, 3-1/4 in. long, and

contains no markings or other decoration. The pipe stem is broken where the fitting would be for attachment to the bowl. Herskovitz (1975a: 266) indicates that hard rubber stems were generally used on briar pipes, although they were evidently for sale with other wood bowl varieties as well (Israel 1968: 333).

The last item of smoking paraphernalia is a brass pipe bowl cover. The ornate cover and bezel is hinged and has a spring attachment. The bowl lid contains incised floral decoration and perforations. A very similar cover was found at Fort Bowie, Arizona, and is illustrated in the Herskovitz (1975a: Fig. 33h) manuscript. Later pipe bowl covers, such as those sold by Sears in 1897 (Israel 1968: 333), were evidently made of polished nickel.

The steady demand for English clay pipes is demonstrated by inventories at other frontier outposts, such as Fort Union, New Mexico (Woodward 1959), Fort Berthold, North Dakota (Smith 1972), and Fort Bowie, Arizona (Herskovitz 1975a). For example, at Fort Union in 1850 two gross of pipes were listed at a cost price of only 33-1/3 cents per gross. The Coleman Company ledger (1884-1887) indicates that a total of three dozen pipes were purchased from Son Brothers in San Francisco and shipped to Harmony. It is not known what types were included in this inventory. A determination of unit cost is difficult, therefore, since more than one kind of pipe could be present in any lot. In any case, at the most, only three of these reported 36 pipes were noted in the archeological record.

The pipe stem fragments and bowl cover, representing at least two white clay and one briar pipes, were all collected in Unit C1. Recently, Lyle Stone (1974: 150) noted that while pipe stems at Fort Michilimackinac were deposited more frequently in non-structural contexts, they were usually found in areas near and between buildings, such as gardens and streets. From this we might assume that pipes can be good indicators of non-formal trash deposit locations and peripheral activity centers.

Miscellaneous Artifacts

A number of miscellaneous artifactual materials were also recovered at the site. A total of 207 specimens in our sample do not fit into any of the six major categories of material discussed thus far. The division of objects presented here is based on the material from which they were made. Included in this section are textile, leather, rubber, paper, and wood artifacts.

Textiles

Preservation of textiles was excellent at Harmony. We recovered 132 textile fragments, including pieces of rubberized fabric, burlap bags, felt, cordage, and cloth.

Rubberized fabric was used to make gasket material, belting, and hose. The gasket material consists of rubberized, fine-woven cloth sandwiches, either two or three plies thick. The exterior is finished with a coating of rubber. Thirty-three pieces were found, most of which are trimming scraps. Diameters of gasket holes range from 3/4 in. to 3 in. Gaskets seem to have been used in joining flanged pipe fittings. One scrap has been used as a patch.

A different cloth was used to make rubber hose. Heavy canvas was made with a triple-twisted warp and double-twisted weft, forming a tough, dense cloth. The hose is four-ply with a thick rubber coating inside and out. Two of the recovered specimens have inside diameters of 2 in.; the other has a 1 in. inside diameter. Company records show the purchase of about 1000 feet of hose in diameters from one to two inches and in three and four-ply weights (Wm. T. Coleman & Co., 1884-1887). The one-inch hose probably was used in steam fitting.

The same rubberized fabric used for hose was used for belting. Eleven pieces of four-ply belt, in two-inch and four-inch widths, was found. These are probably fragments from drive belts, as shown in Figure 7.

Twenty-four burlap bag fragments were found. The most common weaving style is simple tabby, but several specimens were found with

paired warp ends and heavy single weft. These latter were woven in both tabby and twill weaves. Two whole bags were found, both measuring 24 in. by 12 in. Both were stuffed with hay and expanded to 8 in. thick. The bags have a rolled selvage and seams are whip-stitched with doubled jute cord. Warp and weft are set about ten to the inch. Another bag, measuring 15 in. by 25 in., was found by Wallace in his 1971-1972 excavations.

During a three year period the Borax Works received over 60,000 burlap bags from half a dozen manufacturers. These are listed variously as ore bags or borax sacks. One reference to size was made, noting the receipt of 2000 bags 17 in. by 28 in. (Wm. T. Coleman & Company 1884-1887). The bags from our excavations doubtless served as ore bags, and for other purposes as well. The two alfalfa-filled bags, found in lower tier excavations, were likely part of a makeshift insulation mat around the rectangular tanks on Tier 2 (see Holland and Simmonds 1971: Illustration 11).

Serving for insulation and for cooling were the thick felt pads placed around the crystallizing vats. We recovered 12 pieces of this felt, all in Tier 4 context. We do not know what the felt was made of, but it looks like very short hair or wool trimmings.

Eight fragments of cordage were found. Pieces include hard-finish cotton cord, sized twine, three-quarter inch braided cotton rope, and five-eighths inch braided hemp rope. Only one piece of ordinary, plied manila rope was found. This was half-inch, three-ply rope with a right hand twist. This rope was common at the plant, however, as records show about 1500 feet of it being ordered in diameters of 1 in., 1-1/4 in., 2-1/4 in. and 3 in. (Wm. T. Coleman & Company 1884-1887).

Forty-one scraps of cloth were found, including pieces of garments and canvas. Twelve fragments are of muslin or other plain weave fine cotton cloth. Two of these were dyed blue. Another has a machine-punched grid of small holes, the function of which is unknown.

Three pieces of canvas, in about 8 oz weights, were recovered. One of the pieces is a metal-tipped strap which could have been used in any of a dozen ways.

The remainder of the collection is made of garment fragments. Most of the specimens are of blue denim, with double seams of orange thread. The material is identical with modern blue jean cloth. Five scraps of slightly elastic cotton knit cloth and three pieces of cotton print are present. The knit pieces probably came from long johns, while the printed scraps are from bandanas. One last item, a curious garment fragment, is a bastard weave which changed in mid-stride from double-weft basket weave to a single weft twill. It is of blue-dyed heavy cotton.

Most of the garment fragments found in the excavations are represented in records of shipments to Harmony. Denim pants, flannel shirts, overalls, socks, handkerchiefs, and underwear were ordered in dozen-lots, usually from Levi Strauss & Company (Wm. T. Coleman & Company 1884-1887).

Textiles were found in virtually all provenience units, but there are centers of distribution. Garments were found largely at recent surface exposures in Unit C1, while all other textiles are from the plant. Within the plant, most are from Tiers 2 and 3, and are associated with machinery and piping. The exception to this is the felt which is found only on Tier 4, near the original location of the receiving vats.

Leather

Only three leather artifacts were collected at Harmony. It is likely that this leather was derived from cowhide and commercially prepared. All of the leather was badly dried and had lost its resilience.

The types of leather items recovered at the site are also limited. The sample includes only one fragment of footgear, one possible glove tab, and one piece of leather cordage.

The shoe leather was part of an outer sole. While the length of the shoe could not be determined, its maximum width was 2-1/2 in. The sole contained six brass nails, which were probably machine driven to attach the outer sole to the inner one. The headless shoe nails are 3/4 in. long, with miniscule circular grooves around the shafts, the result of angular pieces of brass wire having been twisted (Fontana and Greenleaf 1962: 103). These nails are spaced 1/2 in. apart. Nails in the heel section of the sole are made of iron. They were headed from the inside of the shoe, through the sole, and into the now missing heel. Similar shoe nails are illustrated in the 1897 Sears catalog (Israel 1968: 208).

The next item is a piece of machine-sewn leather, in the form of an irregular oval, with a border coil stitched around the outer edge. The leather tab is 2 in. long by 7/8 in. wide at its maximum dimensions, and is 1/8 in. thick. The material is again probably cowhide, while linen thread was used for the stitch work. Attached to one end of the tab is a brass button and rivet shank, 3/8 in. in diameter and 1/4 in. long. Around the rivet shank is a brass wire loop fastener, 1-1/8 in. long by 1/4 in. wide, with a small round ball on one end, 1/4 in. across. It is possible that this specimen is a reinforced leather tab from a pair of men's gloves. The brass loop fastener would have been hooked to an opposing catch, closing the glove at the wrist. Similar arrangements can be seen in the Sears catalog for 1897 (Israel 1968: 228-229).

One small piece of leather cord was also found. The cord is badly deteriorated, being 3-1/2 in. long, 1/4 in. wide, and 1/8 in. thick. Leather thong such as this could have served a multitude of functions.

No harness or other horse-related tack was noted, even though these animals were much used at the site, not only in the operation of the plant, but for basic transportation needs. The Coleman Company ledger (1884-1887) verifies the importance of these animals at Harmony by the amount of horsegear ordered. Included in the inventory are harness and hip straps by the dozen, team traces and

lines, lashes, saddles, buggy whips, buckskin, and sides of leather in various weights. This could be further indication that the animals were stabled nearby at the Greenland ranch, and not at Harmony.

As far as distribution is concerned, all three leather items came from within the area of the plant. Both the shoe and glove leather occurred in the adobe structure adjacent to the boiler, while the leather thong was nearby on Tier 2. No leather artifacts occurred in the townsite, a circumstance difficult to interpret.

Rubber

A total of 15 items can be included in this category, only one of which was made of soft or flexible rubber. The remainder are of hard vulcanized rubber, a process developed from Goodyear's discovery and patent in 1851. Vulcanized rubber is less susceptible to solvents and changes in temperature than other types.

One hard rubber shoe heel, possibly of a child's or woman's size, was recovered from the plant. The heel is 1-3/8 in. long, 1-3/4 in. wide, and 1/8 in. thick. It contained a total of five brass shoe nails for attaching the heel to the shoe sole. These nails are about 3/8 in. long and were headed from the outer surface. Spacing of the nails is irregular.

Hard rubber combs were widely used during the latter half of the 19th century. A portion of one such comb was found in Unit T1. It was probably a single-edged comb, with teeth of one size, in this case about 1/2 in. in length.

A fragment of a flexible rubber washer was also found. This circular piece of rubber is 1/4 in. thick, with an outside diameter of 1 in. and a 5/8 in. hole punched through its center. The washer came from Unit T3.

Other rubber artifacts recovered from T3 include 12 unidentified fragments of hard rubber. The specimens may have been part of some kind of rubber sheet with a ridged surface. Thickness of the fragments is 1/8 in.

Little can be said about an assortment of artifacts that includes one shoe heel (plant), one comb (T1), one washer (T3), and 12 pieces of ridged sheeting (T3). The rubberized hose and fabric utilized at Harmony are discussed under Textiles. The only other items of rubber noted in the Coleman Company ledger (besides the hose) are corks, none of which were found at the site.

Paper

Because of the nature of soils at the site, certain materials are better preserved than would normally be expected. Such is the case with paper products. Paper does not usually survive long in open sites like Harmony. Paper artifacts recovered include the remains of newspaper and notebook paper, pasteboard, a paper label, possible wall paper, and packing material.

Approximately 40 pieces of newspaper were collected, most of which came from the plant. The majority of the scraps were either too small or too badly deteriorated to be diagnostic. Some interesting references were noted, however, on those portions that were decipherable. For example, one specimen from an 1885 San Francisco paper speaks of an auction sale, while another mentions a "Rubber Supply Co." A portion of one newspaper, excavated in Adobe A, contains an advertisement for a patent medicine, called the "Safe Cure". A small scrap had a Gothic German typeface, strangely enough. References to Sutter, Stockton, and Powell streets were noted, along with charges against French President Grevy and M. Wilson in an article with a Paris dateline of November 17. Grevy and Wilson were involved in a scandal which culminated in Grevy's resignation in December of 1887. It seems that the Harmony residents kept abreast of happenings around the world.

One small piece of ruled notebook paper was also recovered. The specimen, excavated from within Adobe A, contained blue lines on a white background. Several numbers were hand-printed on the page in pencil, which were possibly account ledger items.

A total of seven fragments of paper could be classified as pasteboard. Pasteboard is a stiff, firm board made of sheets of paper pasted together, and is generally used for book covers. Two of the pieces were cut to about 4 in. by 4 in. It is possible that this deteriorated pasteboard was once part of a day or record book cover. All items were found within the plant.

A more or less square paper tag, 1-1/2 in. by 1-1/4 in., was uncovered in Adobe A. The paper itself is gray, and contains black, printed lettering. At the top of the tag, in upper and lower case, is "Essence of Jam..."; below is the word "INVALUABLE". This specimen is probably part of a carton or wrapper for a bottle of Essence of Jamaica Ginger, a patent medicine.

One unusual item may be a portion of wall paper. It was also recovered in the Adobe A excavation. The heavy paper contains a green painted floral design on a white background, and is quite intricate.

The packing material is in the form of multiple leaves of paper sewn together with a heavy cotton thread, in an overlapping double chain stitch. This scrap paper may have been part of a packing carton. It was recovered from the lowermost tier of the plant.

Paper products listed in the Coleman Company ledger (1884-1887) were mostly in the nature of office supplies, such as check books; indexed day and copy books; reports, pay rolls and vouchers; letter pads; and manilla paper. In our collection we do see some notebook paper and pasteboard. The packing material and paper tag are evidence of Harmony's supply line to San Francisco. If indeed the decorated item is wall paper, we see another indication that some luxuries were available in Death Valley. The presence of newspaper suggests an informed population.

It would be expected that paper artifacts would come from excavation rather than surface collection units, and such is the case here. The newspaper (except one piece), pasteboard, and packing material were all recovered in the plant, while the notebook

paper, sales tag, and wall paper came from Adobe A. We can tentatively suggest from this inventory that Adobe A was an office building for the plant operation.

Wood

A fairly small sample of wood was recovered during investigations at Harmony, most of it in a deteriorated condition. The 17 pieces included tool handles, barrel parts, a cork stopper, game pieces, and architectural lumber.

Six specimens of wood could be classified as tool handles. One wood handle, possibly from a shovel, is 31 in. long with a center point diameter of 1-1/4 in. The handle is round and tapers at one end. On opposite sides of the narrow end are two iron plates held in place with rivets. Another likely shovel handle is 36 in. long with a maximum diameter of 1-1/2 in. An iron rivet is still in place near one end. Both specimens were found on Tier 2 of the plant.

One wood handle, split lengthwise, is of the bulbous shape commonly seen on a number of hand tools, such as chisels and screwdrivers (Israel 1968). The handle, from Tier 4 of the plant, is 3-1/2 in. long and about 1 in. in diameter. Three lines are incised around the handle. A possible knife handle is composed of two semi-oval pieces of wood held together by a one-inch iron rivet. Total length of the handle is 4-1/4 in. and it contains a circular notch on one end. It was recovered in the plant adobe structure.

Two other handle fragments from Adobe A are of unknown use (and may be horn instead of wood). The length of each more or less triangular piece is 2-3/4 in., with six parallel grooves running around the circumference. One end is socketed and threaded to hold the metal tang of the tool or utensil.

A composite tool of wood and metal was found on Tier 2 of the plant. The object, which may be a homemade rake, is composed of a section of lumber, 11 in. long, 1-3/4 in. high, and 1-1/2 in. wide at the top, tapering to 1 in. where a series of eight square-cut,

30d spikes protrude through the wood. Nail heads, countersunk into the wood surface, are spaced 1-1/2 in. apart. The lumber has been tapered to shape with a draw knife, probably from a 2x2.

One wood fragment may represent a portion of a barrel or keg top. The specimen is badly weathered, and was collected in Unit C1. Dimensions of the semi-oval are as follows: length, 10-1/2 in.; width, 5 in.; thickness, 7/8 in.

A piece of cork found was a cylindrical stopper for a bottle. The cork fragment is 7/8 in. in diameter and of unknown height. The stopper, recovered in Adobe A, was most likely used in a champagne, wine, or beer bottle.

Most of the wood which served architectural purposes was in such a deteriorated condition that it could not be interpreted. One piece of triangular shaped wood was probably a corner seal for one of the wooden drains in the plant, to prevent leakage. The specimen is 14 in. long, 1-1/2 in. wide, and 3/4 in. high. A piece of white canvas, 2 in. by 14 in., is attached to one edge with eight 3d square nails. The cloth is encrusted with waste materials (borax, soda, salt).

A wood fitting was also found in the plant (Tier 3), and is of unknown function. The more or less oval specimen is 8-1/2 in. long, 5 in. wide, and 1-1/2 in. thick. Two holes were drilled through one end, after which the wood was cut to shape with a saw. The side-by-side half-circle grooves now on top may have held piping in place.

A number of gaming items were found by Wallace in Unit C1. Six Chinese dominoes were recovered, with the following dimensions: length, 2-5/8 in.; width, 7/8 in.; thickness, 3/8 in. Dominoes used by the Chinese in this country are usually of ebony. The incised spots on the surface are painted red and white, and there is usually a single red spot incised on the side. Three such spots could also be seen on the bottom of some specimens. The dominoes from C1 are identical in every respect to Culin's (1958: 116) description of 19th century Chinese dominoes, which differ from their European counterparts.

The Coleman Company ledger (1884-1887) lists numerous orders for tool handles, such as the knife, shovel, and chisel types recovered, which evidently did not hold up well. Iron garden rakes were also purchased. Many items were then shipped to Harmony in kegs and barrels. What is missing from our collection is wagon parts. Again the lack of horse-related necessities suggests that both the animals and wagons were cared for at Greenland. The blacksmith shop had to be near the plant because of the many metal features that required service.

The distribution of wood, like paper, is for the most part restricted to excavation units. Tool handles were, not unexpectedly, all from the plant, except for the two carved tool or utensil fragments found in Adobe A. The dominoes came from Unit C1, as did the glass gaming markers. Group activities, such as games, were definitely centered in this area. Architectural wood was mostly noted in the plant, and in general appeared to be commercially prepared and cut. The company (Coleman Co. ledger 1884-1887) ordered pine, clear oak, redwood, and ash lumber in various sizes.

Chapter 6

NON-ARTIFACTUAL MATERIALS

The study of organic habitation remains can be of great importance in reconstructing cultural activities at a site. It provides information about the technology, including what is generally called "subsistence economy", that can usually be collected in no other way. Also available are clues regarding population size and other elements of culture reflected in the differential selection and treatment of items such as plants and animals.

At Harmony we have an added advantage--insight into the diet, the source and availability of food, and the technological inventory is possible through historical records, such as the Coleman Company ledger. We are interested not only in subsistence technology and adaptation to the local environment, and the dependence of the town on its San Francisco supply line, but also in the technological basis of producing borax, particularly the operation and efficiency of the plant.

This chapter deals with a number of non-artifactual materials which could supply information on both the subsistence and industrial economies at Harmony. Included are items such as shell, bone, botanical specimens, and soil samples. Because excavation was limited for the most part to the plant, few botanical materials were recovered from other parts of the site.

Shell

Twenty-five pieces of shell were recovered at Harmony. With the exception of one specimen, all of the shell was unmodified. While most shells in our collection are from edible species, transportation of fresh shellfish to the site from the Pacific Coast or

elsewhere would have been an insurmountable problem. Represented in the Harmony sample are fresh water clam, chiton, limpet, and dye shells.

The majority of shell fragments found (22) belong to the family Unionidae. These fresh water clams are unidentifiable as to genus because they are incomplete. Fresh water clams tend to be quite large and are edible. These shells generally were not used prehistorically since they are hard to work. The distribution of the shells includes all of Arizona and probably California (Sharon Urban 1977: personal communication). Eighteen of the above samples were recovered by Wallace in 1971-72.

One shell fragment was identified as White Chiton, Ischnochiton albus. A Pacific Coast species, it is found as far south as San Diego in moderately deep water (Morris 1966: 115). A File Limpet shell, Acmaea limatula, was also recovered. These limpets range from Puget Sound to Mexico, and are found in rocks between tides (Morris 1966: 57).

The last specimen is a Dye shell, Acanthina angelica, of the family Thaididae. There is no reference to these shells concerning edibility (Sharon Urban 1977: personal communication). Dye shells of this type are restricted to the Gulf of California, and it is surprising to find one in Death Valley. The lip of this shell has been cut off, indicating that it was possibly worked for some unknown purpose.

To summarize, 25 shell fragments were found at Harmony. These include fresh water clam from Arizona and California, chiton and limpet shells from the Pacific Coast, and a dye shell from the Gulf of California. It is difficult to interpret the occurrence of shell at Harmony. They were definitely brought in to the site, but for what purpose? While most are edible, it would not have been feasible to transport fresh food items into Death Valley. One explanation is that the shells were collected as souvenirs and carried to Harmony as personal belongings.

Because the entire shell collection was recovered in Unit C1, we can assume they had not been discarded as formal refuse (in Area T1). The shells were found, then, in the same association as were the glass gaming markers, the dominoes, and the square-hole coins. Culin (1958) notes that shells, particularly clam, were used as game pieces by the Chinese. The Harmony shells may have served this purpose.

Bone

Faunal remains can often contribute important information toward understanding the people and activities of a given site. It is significant to determine the role that mammals played in the economy and culture of those who killed them. How dependent were the residents on domestic as opposed to wild species as food sources? What types of domestic stock were kept by the inhabitants? And were any specific hunting preferences followed? Such questions afford us an opportunity to study human behavior.

Only a small quantity of animal bones, totaling 57 pieces, was obtained in our investigations at Harmony Borax Works. The inadequate size of the sample, as well as the condition of the specimens, makes description all but impossible.

The collection consists of small pieces of bone that are incomplete and fragmentary to the point of being unidentifiable. The badly eroded bone is termed "scrap" in this report. The major reasons for the poor condition of faunal remains at Harmony are likely the nature of the alkaline soils and the bone's exposure to surface elements.

Most of the scrap is unidentifiable mammal bone, classified as artiodactyl. No diagnostic processes were available for further identification. The order Artiodactyla is composed of ungulate quadrupeds, such as deer, sheep, goat, pig, and cow.

The bone samples are too small for us to draw conclusions about the relative numbers of animals indicated, and, since the classification was so general, neither could we determine the minimum number

of individuals included by type. We conclude that most of the species present were indeed food animals, but questions relating to butchering and slaughter patterns and proportions of domestic versus wild game remain unanswered.

Consequently, as a category, the 57 pieces of unidentified artiodactyl bone recovered can tell us very little about behavior at Harmony. The Coleman Company ledger seems to indicate that Harmony did depend on San Francisco markets for at least part of its meat supply. Products such as bacon, hams, and pigs feet are listed, along with dried, roasted, corned and chipped beef by the case. From the archeological record, we have concluded that draft animals were probably kept nearby at the Greenland ranch. It is assumed that other domestic livestock was also present there, although the few references to the ranch fail to mention any. The fact that so few bones were found at Harmony may suggest that food animals were butchered elsewhere, such as at Greenland, or at kill sites for wild game.

The distribution of bone at the site is shown in Table 7. As can be seen, 50 pieces of scrap representing over 87 percent of the faunal material were found in Area C1. Of this total, 36 percent appeared to be burned.

Table 7
Distribution of Bone at Harmony

	P	C1	T1	T2	T3	Totals
Scrap	--	32	--	3	--	35
Burned bone	--	18	4	--	--	22
Areal totals	--	50	4	3	--	57
Percent	--	87.7	7.0	5.3	--	

If, as expected, Area C1 did contain the cooking/dining facility for the Chinese camp, it is not surprising to find burned bone in this vicinity. As can be seen in Figure 28, a pocket of bone fragments was recorded near Feature 4 in this area. It is therefore possible

that a cook shed once sat on this low pebble mound, since it is not unusual for such garbage as bone scraps to be merely tossed out the back door in this situation.

The scarcity of bone in the townsite may reflect not only butchering practices, but also cultural preferences. A typical Chinese camp diet (Chinn 1969: 44) included much fish, along with bacon, pork, and poultry. Most of these types of food products were ordered from San Francisco. It seems apparent that both domestic food animals and wild game played an insignificant role in the subsistence economy at Harmony.

Botanical Specimens

An aspect of the Harmony operation which particularly interested us was the procurement of necessary fuel materials to keep the mining facility running. What was being burned at Harmony to fuel the boiler? Historical sources (Spears 1892: 110-118) indicated that brush, nut-pine, and mesquite were the major sources of desert fuel in Death Valley.

We also wanted to determine the nature of the skimmings pile west of the plant. It had been suggested that extraneous weeds mixed in with the cottonball ore were deposited here after the ulexite itself was dissolved. This supposition was tested by analyzing botanical materials collected across the area.

Identification and interpretation of botanical materials found in archeological sites often depends on a knowledge of the present day flora and ecological relationships within the area. Such information has been provided in Chapter 2. A region's vegetation is closely connected to the climate, soils, topography, drainage, and water supply that typify its location.

In spite of the fact that a number of plants have made drastic adaptations to Death Valley's harsh, dry environment, portions of the region are still essentially abiotic. Such is the case with the salt pan immediately surrounding Harmony. To obtain fuel materials, the residents had to travel short distances to a different ecotone. The

closest vegetation zone is found mainly near canyon springs or springs on alluvial fans (for example, Greenland), and around the perimeter of the salt pan. Species present in these areas, including mesquite, arrow weed, saltbush and various grasses, among others, have a higher tolerance to salinity and put roots down into the water table.

Botanical specimens collected at Harmony were examined with a view to identifying the material and evaluating its presence with regard to associated cultural features. The material recovered consisted primarily of wood, charcoal, and grass. Analysis of species was provided by Jeffrey Zauderer of the University of Arizona Biology Department in Tucson.

Samples collected in the wood storage area east of the plant were identified as mesquite and saltbush. Two varieties of mesquite were present. Wood stems with bark were torrey mesquite (Prosopis glandulosa); the remaining stems either were torrey mesquite or possibly screwbean mesquite (Prosopis pubescens), or were merely identified as Prosopis sp. All types of mesquite range from large single-trunk trees to small shrubs, and often form dense jungles of brush (Vallentine 1971: 25). The saltbush (Atriplex sp.) is a forage species that also tolerates high amounts of salinity. This shrub is generally found in plains desert habitats, and is a nourishment for herbivorous animals (McGinnies and others 1970: 479). Both plant categories were evidently used as fuel at Harmony.

The next area studied was the skimmings pile west of the plant proper. Samples were taken every four meters, bisecting the pile from east to west. All specimens were identified as saltgrass (Distichlis stricta). This grass is a good indicator of saline conditions and is also a general food item for herbivorous animals (McGinnies and others 1970: 483). Saltgrass, growing on the desert salt pan, was probably inadvertently shoveled up with the ulexite ore and taken to the plant.

The last items analyzed were excavated on Tier 4 of the plant (Unit P-134). The macerated material is probably alfalfa (Medicago

sp.). Three seeds were noted. Two were identified as Medicago sativa, while the other is Medicago cf. lupulina. Pieces of saltgrass were also present in this sample.

Alfalfa is a medium-lived high forage yielder and is the most important and widely used forage legume for rangeland and pasture mixtures. Forage is defined as a herbaceous feed available for grazing by livestock or harvested for feeding (Vallentine 1971: 15). It has proven well adapted on many semiarid sites receiving 14 to 20 inches of annual precipitation, and on irrigated lands with good drainage.

Alfalfa is highly productive and nutritious, tolerates grazing, makes rapid regrowth, and is well adapted to seeding with grasses (Vallentine 1971: 217). Hanks (1883: 32) reported that alfalfa was cultivated at Greenland as a feed for the large number of livestock needed to keep Harmony in operation. The Coleman ledger contains an order for a 167-pound sack of alfalfa seed. Other livestock feeds purchased include over 70,000 lbs. of barley and close to 1500 lbs. of hay. (We should note that there is evidence in the archeological record that hay was used as insulation on the settling tanks).

In summation, we now know that mesquite, including torrey and screwbean varieties, and saltbush were used to fuel the boiler at Harmony. This vegetation could be found nearby along springs and around the edge of the salt pan. The area west of the plant is indeed a skimmings pile, containing saltgrass skimmed off the top and shoveled out of the dissolving tank.

Soil Samples

During the excavations conducted at Harmony, a number of soil samples were taken. The analyses of these specimens, along with others collected previously in the vicinity, appear in the Appendix to this report. We will attempt here to interpret the samples in light of what we know historically and archeologically about the site.

Chemical analyses were performed on samples collected in various areas of the plant for two principal reasons. Both relate to the problem of understanding the processes involved in producing borax. Previous research had not uncovered the necessary technical data to reconstruct the precise manufacturing techniques employed at the plant. Therefore, the operation had been left to speculation, based on evidence from similar industrial complexes.

It was hoped that the soil analyses would substantiate some of this speculation. In particular, we were interested in the ability of the operation to obtain as much borax as possible from the raw material. We wanted to measure the efficiency of the plant, rumored to be fairly low, and determine the grade of borax produced.

To comprehend any production procedure, it is first necessary to be able to recognize all of the system components so that we can identify and interpret the various architectural features, especially the numerous tanks and vats. Could soil analysis be used to distinguish between settling tanks, receiving vats, and crystallizing vats? This information would contribute to an understanding of the engineering problems overcome at the site.

The purpose of the Harmony Borax Works was to manufacture borax from cottonball ulexite. Basically, the ore was shoveled off the ground into rows (windrows), allowed to dry, and then hauled to the plant by wagon. This natural ore contained numerous impurities, such as saltgrass, halite (salt), sand, glauberite (sulfate), and other extraneous materials. To create the necessary reaction during heating, soda minerals were added as a flux.

The analysis of samples collected from harvested windrows showed that a high concentration of quality cottonball ulexite has formed in some since initial utilization. This rejuvenation is especially prevalent in areas subject to wet conditions, for example near streambeds. Since most of the harvested windrows remain dry, the ore has dehydrated to a probertite. Morgan (see Appendix) indicates that both types could have been used in the Harmony process. It is possible that some windrows were reharvested during later production seasons.

Not far from the Harmony plant are other windrows which have been labeled as borax gardens. A grid system of rectangular holes was placed across the salt pan, as had been done successfully at other borax plants. The idea was that a crude native borax would form in the pits.

Soil samples collected and examined from several of these gardens (see Appendix) showed a low borax content, although some contained a considerable amount of cottonball ulexite. Whether the ulexite was ever harvested is not known. It should be mentioned that these gridded windrows may not be associated with the active operation of Harmony. Holland and Simmonds (1971: 26) cite a Death Valley National Monument file which states that the grids were created during the period 1905-10 when the Pacific Coast Borax Company was doing assessment work connected with claim patenting.

Another interesting aspect of the analysis is the occurrence of a pile of burlap sacks containing high grade cottonball ulexite along the road to Harmony (Appendix, Table 8: 2). A reference in the San Francisco Mining and Scientific Press for May 10, 1884, noted that Harmony also shipped a great quantity of borax in a crude state. This situation may indicate that the plant could not keep up with incoming raw materials, creating a surplus. Or perhaps a higher quality product would be obtained in the larger processing facilities to the west. Crude borax could be worth more than the refined material in some instances because of its high boracic acid content (Hanks 1883: 49).

The source area for the soda is not yet known, although such minerals are common on desert marshes. The analysis of two dirt piles between the plant and Mustard Canyon (Appendix, Table 8: 5) showed a high soda content, along with a substantial amount of salt. It appears that soda used in the processing of ulexite at Harmony was mostly a mixture of trona and thermonatrite.

It is difficult to interpret the 11 soil samples collected at Harmony. First of all, because of the nature of the site--terraced and wide open--many conditions could have affected the specimens.

We also have the problem of chemical changes in the soil perhaps altering the makeup of the ores over the past 100 years. In any case, we will present the information here and offer, where possible, our interpretation of the analyses. Table 10, found in the Appendix, contains the percentage values tabulated on an insoluble free basis.

After the ulexite ore and soda were combined and dissolved, the liquid was piped into one of several insulated rectangular settling tanks. Undissolved borax and impurities remaining in the bottom of the large digesting tank were eventually either shoveled out and discarded along with the skimmings, or sluiced through a pipe to the waste drain on Tier 3.

Two samples collected in the skimmings pile were analyzed (Table 10: 10, 11). Over 80 percent of both specimens consisted of waste materials such as salt, sulfate, and soda. The same situation is seen with regard to a sample taken from within an *in situ* pipe section, which we believe connected one or both of the dissolving tanks to a mud discard drain on Tier 3. Twenty-three percent of this soil sample was composed of borax, while the remaining 77 percent was mostly sodium chloride (Table 10: 8). At least during the first stage of processing, the borax recovery rate was fairly high.

The settling tanks were situated on Tiers 2 and 3. Here, the fine insoluble material such as sand, clay, sulfate, and undecomposed borate was allowed to settle out. The sludge was later redissolved and settled once more, after which waste mud was sluiced and discarded through the Tier 3 drain.

The analysis of samples taken in the area of the settling tanks seems to indicate that both they and the large dissolving tanks above served somewhat different functions. Two samples were taken on the upper level of settling tanks. If numbered from east to west, the specimens came from spots where Tanks 2 and 3 would have been located. The Tank 2 sample contained 53 percent impurities, compared to 37 percent borax; only 31 percent of the Tank 3 sample, on the other hand, was composed of salt, sulfate, and soda (Table 10: 9, 6).

We conclude from this tabulation that after initial dissolving of the ore, the solution in the digesting tank was transferred to one of the westernmost square tanks and allowed to settle (thus the high percentage of impurities). After the mud was redissolved in the repulp tank, the solution, now fairly low in impurities after two boilings, was piped to one of the easternmost settling tanks. Any mud remaining in these tanks was then sluiced into the Tier 3 drain. A sample taken near the drain showed that by this time, many of the impurities had been removed--the specimen had a borax content of 75 percent--but that undissolved borax was being wasted.

The next two samples came from the first row of round vats on Tier 4. Solutions in the settling tanks were decanted into any of several receiving vats situated in this line. But did all of the containers in this row serve as receiving vats? Perhaps only half were used in this way. The remaining containers would then have been used for crystallizing.

The first specimen (Table 10: 4) was taken from the metal surface of an in-place vat bottom. Analysis showed a very high borax content of 88 percent; another 11 percent was sodium chloride. The other vat sample (Table 10: 7) also had a high borate-low salt ratio (about 10:1). Usually water was added to the receiving vat solutions to prevent crystallization of most of the salts. But since these ratios would probably be much the same for crystallizing vat residues, no distinction can be made at present on the basis of chemical analyses.

The so-called mother liquor left behind in the crystallizing vats after the borax was removed was recycled until it became foul. A portion of this solution would then be piped across the wash north of the plant into one of three rectangular ponds. Evaporation of the water in the reservoirs allowed any remaining borax to crystallize. This new material could then be harvested and recycled with the incoming ore. Morgan (see Appendix) indicated that soda could also be recovered in this manner. Any residual brine left over would be discarded, probably into the wash.

The centermost tailings pond was also sampled and profiled. Two distinct periods of deposition were hypothesized from the stratigraphy. It was hoped that the chemical analysis of material from these soil layers could tell us something more about the efficiency of the operation, and any change over time. For example, was the process improving with regard to extracting borax from the ore?

Three samples were taken from depths of 10-15 cm, 15-25 cm, and 30-35 cm. Below the topsoil crust, there was a thick zone (10-25 cm) of deposits. A lense of humus occurred beneath, followed by another, thinner layer of tailings, resting on the natural terrace. It appears that during a period of non-use, soil accumulated over the tailings, perhaps as a result of a flood. More waste solutions were later deposited above.

The sample from the lowermost deposit had a 77 percent borax content, while the two from the upper zone were only 12 and 13 percent borax, respectively. We believe this difference too dramatic to reflect merely an improvement in efficiency from one period to another. Instead, we theorize that the initial layer of tailings had not been subject to harvesting, while the later zone above had.

The question then arises as to why the early solutions were reserved, if not for reuse. Perhaps the thin (5 cm) basal deposit represents waste solutions deposited during the initial season of processing at Harmony. Before the pond could be harvested, the area was possibly covered by flood sediments. New solutions were then run into the ponds without bothering to dig up the reformed ore. Materials deposited later evidently were harvested one or more times.

The analysis of soil samples collected added little to our understanding of the technological processes operating at Harmony. Too many factors could have affected these deposited materials. Also, most of the architectural features had similar functions--the removal of impurities from the product--so we see much duplication in the analysis tabulation.

We believe that windrow areas could be reharvested from one season to another. It is also possible that some of this crude ore may have been shipped in its natural state to other production facilities for refinement. Borax recovery at the first stage of processing (dissolving) was fairly high. After settling, many of the impurities had been removed, but we begin to see a wastage of borax. This loss continues through the receiving and crystallizing stages. However, some of this lost ore could evidently be recovered in the tailings ponds and processed once again.

On the whole, we conclude that the efficiency of the Harmony operation was moderately high.

Chapter 7 DATA INTEGRATION

Introduction

In this chapter we pull together bits and pieces we've found out about Harmony and try to answer questions posed in the research design.

Information came from analysis of surface and subsurface features and artifacts, historical photographs, the company ledger, and historical accounts of similar borax works.

Also in this chapter, Vincent Morgan, a retired chemist for U.S. Borax & Chemical Corporation, has provided an interpretation of the Harmony refining process.

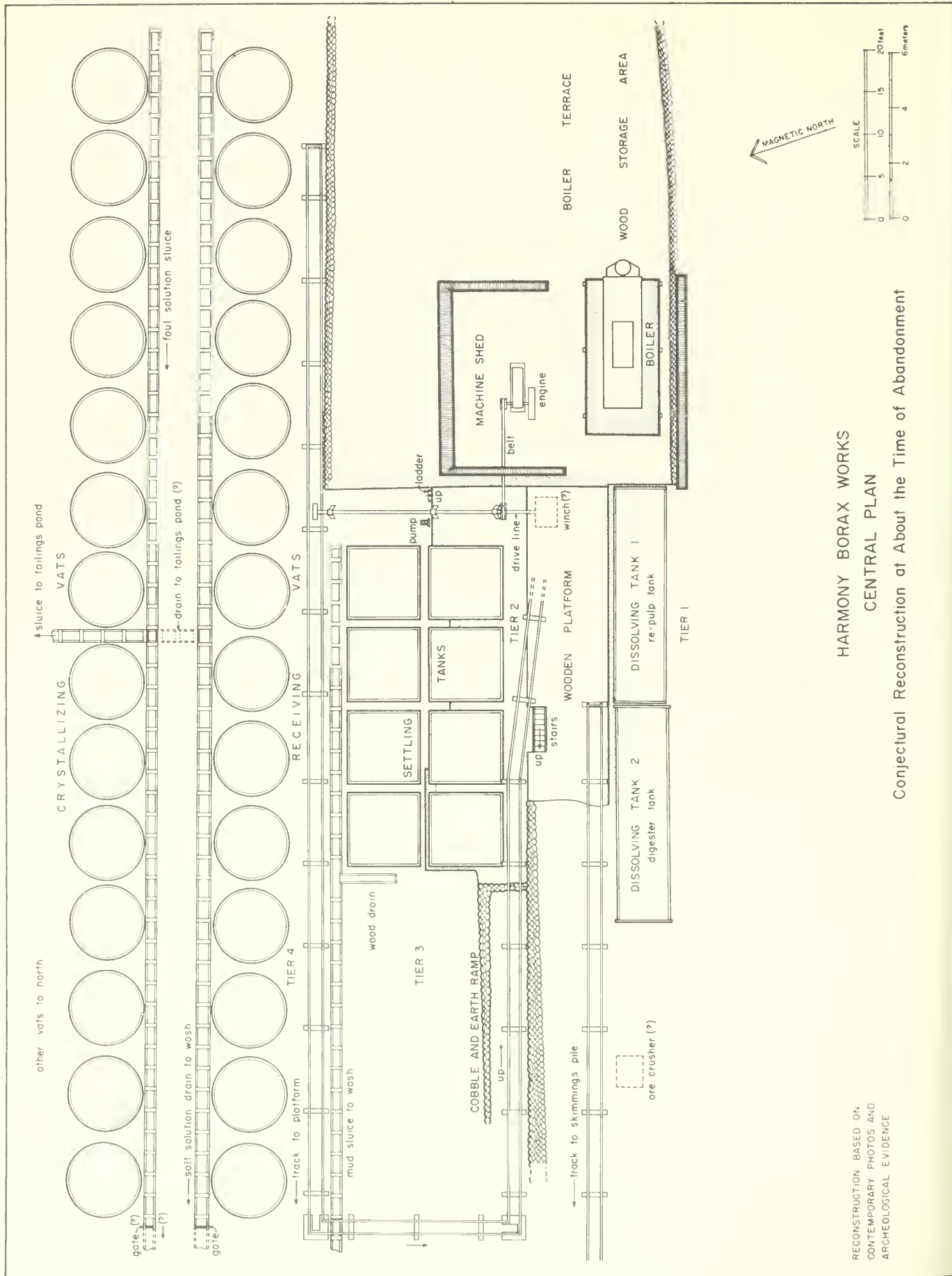
Use of Space

Harmony Plant

The plant went through what was probably constant alteration due to adjustments in procedure and to additions of new equipment. At the time of abandonment, it looked much like the reconstruction offered as Figure 39.

On the lowest level, Tier 4, were 50 or so felt-covered sheet iron vats, some used for receiving solutions, others for crystallizing borax. A network of wooden sluices served to drain vats of mud and foul solution. In all probability, a system of headgates and connecting drains allowed solutions and mud to be run off either into the dry wash or across the wash into the tailings pond.

On Tiers 2 and 3 were rectangular iron settling tanks at two levels. We drew eight of them on Figure 39, but we couldn't tell the exact number from excavated tank footings or from photos.



HARMONY BORAX WORKS
CENTRAL PLAN

Conjectural Reconstruction at About the Time of Abandonment

RECONSTRUCTION BASED ON
CONTEMPORARY PHOTOS AND
ARCHEOLOGICAL EVIDENCE

Serving these tanks was a sluice to the wash and one or more movable wooden drains.

Dissolving tanks were set on Tier 1, and a wooden platform was built to provide access on the north side. Indications are that the platform extended the length of both dissolving tanks.

A simple wood and strap iron track ran between the receiving vats and settling tanks, then up a ramp to the platform level. Implicit in this arrangement is a winch on the platform. A drive line, powered by a steam engine, drove the winch and probably other machinery.

On the boiler terrace, a machine shed was built to house the steam engine. A fire-tube boiler was placed near the dissolving tanks.

Remaining posts, as well as one photo, indicate that a cart track ran out along the skimmings pile so that grass could be removed from the dissolving tanks and dumped.

A machine, which may have been an ore crusher, was once in place just west of Dissolving Tank 2.

Not shown in Figure 39 are the water tanks to the south and the barn and tailings pond to north (see Fig. 4, 6 and 10).

The impression one gets from Figure 39 is of a geometrically precise and rather static assembly of parts. Remember that we haven't illustrated the complex system of pipes and hoses which once tied the plant together. When in operation the plant would have been a maze of water pipes, solution drains, and steam lines, but most of these pipes and hoses have long since disappeared.

Building sequence is hard to determine because historical photos are incorrectly dated or not dated at all. Also, time of occupation is only about five years, deposits are thin, and superposition of features was rarely detected. However, a speculative history has been constructed, as follows.

Most of the plant was constructed at one time, probably during the first season. The hillside was graded and filled (Fig. 9),

tiers were established, and the barn was built. Vats and tanks were set, pipes were laid, and the west half of the Tier 1 platform was built.

The plant was operated for some time before the machine shed was built, as evidenced by a debris and ash level below the machine shed footings. Also, debris and waste were tipped over the boiler terrace north edge for a time.

An ore cart and a quantity of track iron were ordered during the 1884 season, and it is likely that the track and ramp were built at this time.

Later, perhaps during the 1884 or 1885 season, the machine shed was built and roofed. Although fire in the wood storage area destroyed the shed roof at some time, the plant continued to operate unimpaired. Another structure once covered the dissolving tanks, but its tenure was brief, as only one photo attests its existence (Paher 1973: 8). It may have burned, or been pulled down as inefficient.

By the time of abandonment, the machine shed roof had been rebuilt and the boiler replaced by an elaborate fire-tube model, complete with housing. The latter was ordered during the 1886 season.

Other later modifications included an eastern extension of the Tier 1 platform, an extension of the ore cart track, and the construction of a framed insulation mat around the settling tanks.

Materials and techniques of construction owe little to improvisation, although joinery is simple. While some features, like adobes and board walls, are haphazard in construction, techniques are solidly in the 19th century urban manner. Materials were all imported. Wood is predominately fir and pine and was mill cut. Lumber came in a great variety of sizes, and was usually cut to full dimension, a choice not available to carpenters today.

The plant was used for no other purpose than the processing of borax. Most artifacts relate to architecture and machines. Only a handful of ceramic and bottle-glass sherds were found. There is no evidence of reuse after abandonment.

Townsite and Chinese Quarters

The townsite and Chinese quarters have been described in some detail in Chapter 4. Briefly, the townsite is a cluster of features north of the plant, including two ruined adobes, three house pits, and the site of a blacksmith shop. Our work in the townsite was minor, involving only the excavation of four small pits contiguous with the adobes, and surface collection in three areas called Units T1, T2, and T3.

Between the townsite and plant is an area called the Chinese quarters by Wallace in his 1972 report. We collected artifacts and mapped features in this area, which was designated Unit C1.

At one time seven or so buildings stood north of the plant (Holland and Simmonds 1971: Illustration No. 18). The photo which shows these buildings is too indistinct to permit identification of the features that remain.

We feel that the two adobes date from the Harmony occupation. They are identical in style to architectural features within the plant. Composition of adobe blocks, door and window framing techniques, and board dimensions are the same as those found in the plant. Also, the clumsy, stepped-wall technique is present both in the plant and at the adobes.

The only unusual things about the adobes are the fragments of window glass and screen wire, and the furring strips sockets in Adobe A. These indicate that the adobes may have been more elegantly appointed than was expected.

Unfortunately, no artifacts were found in our minor excavations that necessarily date to the time of plant operation; however, such artifacts were found near and around the adobes as surface exposures in Units T1, T2, and T3.

In addition, there was found on the surface a substantial quantity of artifacts, especially bottle fragments, which were manufactured after Harmony was abandoned, but before World War I.

We suggest sporadic reoccupation of the adobes around the turn of the century. This reuse of structures may have been by casual travelers or by Borax Company employees who were required to assess deposits in connection with claim patenting during the present century (Holland and Simmonds 1971: 26). Judging from a photograph, the adobes were in ruins by 1931 (Bourke 1931: 155).

Function of the townsite-Chinese quarters complex has heretofore remained undetermined. Holland and Simmonds (1971: 35) merely state that the townsite consisted of a collection of adobe structures including an office, living quarters, and cooking and dining facilities. Contemporary historical references, such as those by Hanks (1883: 32) and Spears (1892: 145), refer only to the Harmony settlement of Greenland near Furnace Creek. Even here details of living conditions and daily life are absent.

Architectural remains furnish few clues. Nothing in the Chinese quarters indicates shape, type, or even number of buildings. In the townsite there remain only the ruins of two adobes, some house pits, and a few posts from the blacksmith's shop. Nothing about the adobes suggests their function.

Examination of artifact distributions within surface collection units was disappointing. Preliminary scattergrams were plotted to search for patterning, but no distinct clustering of artifact types was observed.

However, comparison of artifact assemblages among gross collection units (C1, T1, T2, T3) proved fruitful. Consider first the distribution of kinds of ceramics. Ninety-three percent of ceramic sherds came from the Chinese quarters (Unit C1). Fully 99 percent of all ceramics are of Chinese origin and reflect the Chinese mode of food storage, preparation, and serving. Only four sherds of the 605 collected were of Anglo-American manufacture.

Of the domestic and personal artifacts (buttons, snaps, buckles, gaming pieces, opium paraphernalia, and so forth), only four were found outside the confines of the Chinese quarters.

Over three-quarters of the tin cans and can fragments came from Unit T1, while a count of minimum number of bottles shows most frequent occurrence in Units T1 and C1.

Taking these distributions into account, we observed the following:

1. Domestic artifacts are of Chinese origin, with rare exception.
2. Domestic artifacts reflect Chinese cultural preference in form and style.
3. Domestic and personal artifacts were centered in the Chinese quarters.
4. Objects relating to food preparation are distributed, in the main, in the Chinese quarters and Unit T1.
5. Objects in Unit T1 reflect only intentional discard as refuse.
6. Artifacts in C1 form functionally diverse categories; the townsite assemblage is restricted and functionally repetitious.

On the basis of these observations we offer the following interpretations:

1. Food preparation and storage occurred exclusively in the Chinese quarters.
2. Formal discard of refuse was limited to Unit T1. Other refuse accumulated casually as sheet trash.
3. Group activities, such as gaming, were centered in the Chinese quarters.
4. No Anglo domestic activity took place at the townsite.

These interpretations can be generalized into the following hypothesis regarding site function:

Buildings at Harmony were associated with laborers' quarters and dining facilities, plant business, or storage. Only Chinese lived at Harmony; Anglos lived elsewhere, doubtless at Greenland. Buildings in the townsites were used as offices, sheds, and for storage. There once were structures in the Chinese quarters area which were used for housing and food preparation for workers.

Manufacturing Process at Harmony

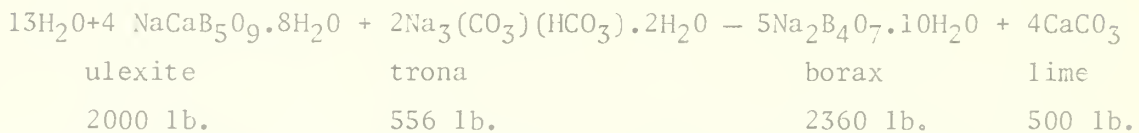
by

Vincent Morgan

Introduction

The Harmony Borax Works was a plant for manufacturing borax from cottonball ulexite. Since the borax of commerce is a highly water-soluble hydrated sodium borate and ulexite is a slightly soluble sodium-calcium borate, the plant was set up to replace the calcium component of the ulexite with sodium, thus forming borax.

The easiest way to do this is to utilize the reaction of ulexite with soda. Commonly occurring soda minerals on desert marshes are trona and thermonatrite. With trona the reaction would be:



Elevated temperatures are necessary for this reaction to occur, hence the elaborate "cooking" equipment.

The ore at Harmony did contain a minor fraction of native borax, but the principal production was from cottonball. Several piles of cottonball ore, and one pile of soda, are still present in the Harmony plant site area. Many remnants of windrows of ore still remain throughout the salt flats of the valley. The soda source is unknown at this time; it may have come from near the mouth of Cow Creek, about a mile or so north of Harmony.

As with almost all natural ores, there were interfering impurities. The native salt grass appeared in every wagonload of ore, along with much halite (ordinary salt, sodium chloride), sand, glauberite, bugs, and other foreign material, both soluble and insoluble. A feasible process for use at Harmony, with the equipment available there, is given below.

Probable Manufacturing Process

Crude ore and soda in the proper proportions (about 4:1) were run through the steam-driven crusher and fed into the first (western-most) digesting tank (Fig. 40). Return mother liquor and fresh water make-up were added as required, and steam was introduced through perforated pipes to heat the tank contents and promote the decomposition of the cottonball ulexite by the soda to form borax. All the while, the solution was stirred by hand using wooden paddles. Weeds were skimmed off into a rail car which ran on a track alongside the digesting vats, and were dumped to form the "skimmings" pile immediately west of the plant proper. After a time the tank contents were emptied through the side port into one of several insulated rectangular mud or settling tanks on the next lower level. Rocks and coarse lumps were retained in the digesting tank, and eventually shoveled out and discarded along with the skimmings.

In the first-stage settling or mud tanks, the fine insoluble material, consisting of sand and clay, glauberite, and undecomposed borate, was allowed to settle out. After siphoning off the supernatant into a receiving tank, the mud was shoveled into a small ore car, hauled up a ramp by a steam-driven hoist, and dumped or shoveled into the secondary digesting or re-pulping tank directly east of and adjacent to the first-stage digesting tank. Return mother liquor, and probably a small amount of soda, was added, and the mixture reboiled by injecting steam, to extract additional borax. After a sufficient period of time the repulp tank was emptied into another mud tank (there were several). After settling and siphoning off the supernatant into a receiving vat, the mud was sluiced to waste and discarded.

The supernatant from all settling tanks was decanted into any of several receiving vats, using a loose-joint siphon installed through the bottom of the settling tanks, whereby the clear solution could be transferred without disturbing the mud. Solutions from several mud tanks could be mixed at will, to give a solution of the proper strength, as determined by hydrometer. A small amount of

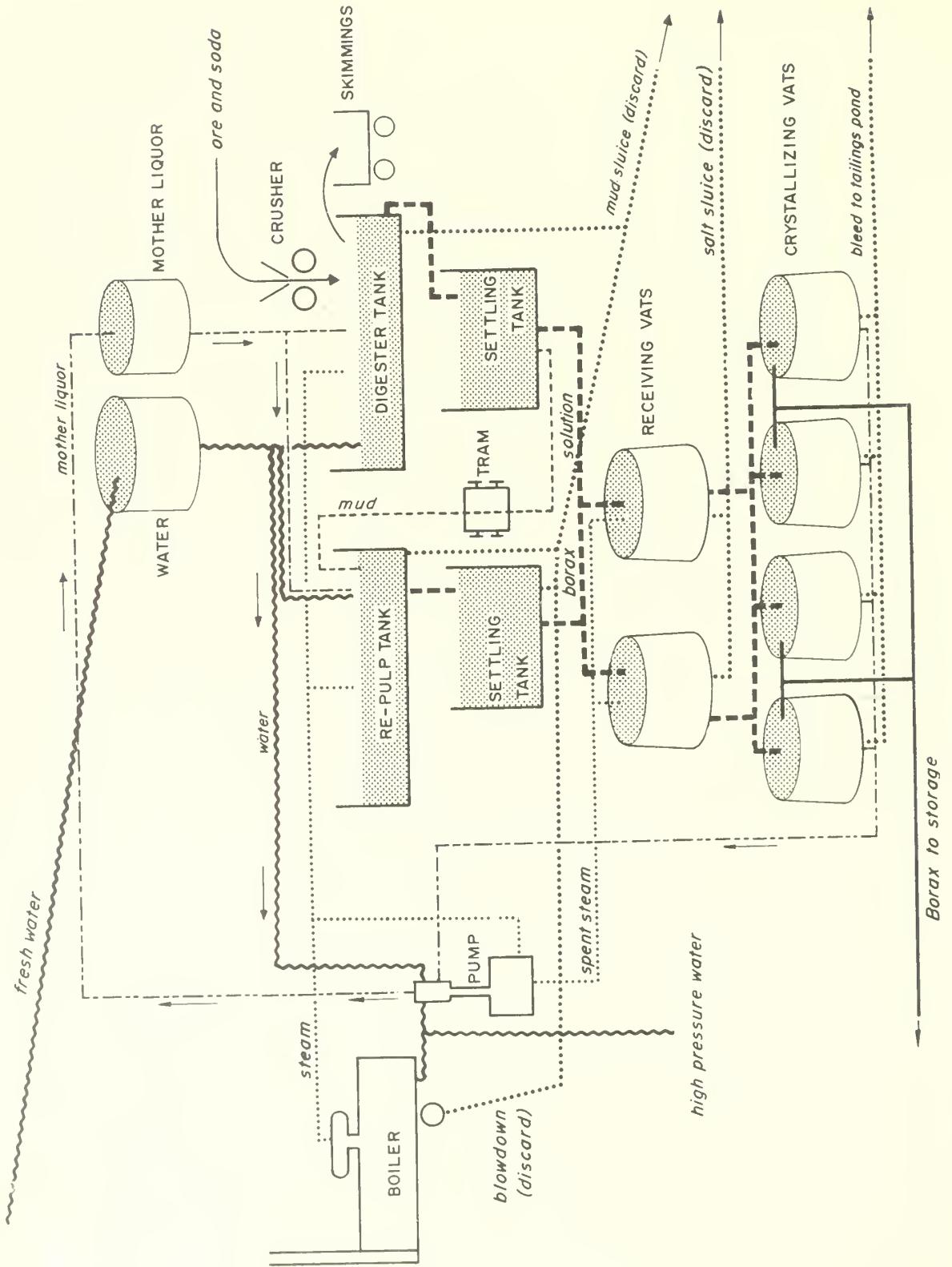


Figure 40. Flow diagram of probable plant operation.

fresh water was probably added to prevent the crystallization of sodium chloride salt. The solution was then pumped into one of the numerous crystallizing vats and allowed to cool. Borax crystallized on the sides and bottoms of the vats, as well as on iron rods hung in the vats. The felt covering could be moistened with fresh water to provide additional cooling, by evaporation. After several days, when the solution would cool no further, the remaining "mother liquor" solution (which still contained a considerable concentration of both borax and soda), was siphoned off and pumped to a storage tank on the hill behind the works to await reuse in processing new ore. The borax was knocked off the rods, sides, and bottoms of the vats, shoveled into wheelbarrows, and taken to the shed for sacking. The texture of the borax so produced was coarse crystals and lumps, unlike the sugary granules produced by current methods.

The solutions at Harmony always contained a high percentage of sodium chloride salt. However, the concentration of salt changes only slightly with temperature change, whereas the solubility of borax decreases greatly with a decrease in temperature, thus allowing the borax to crystallize on cooling, while most of the salt remained in solution.

The mother liquor was recycled until it became so fouled with impurities that off-color borax would be produced. At this time a portion of the mother liquor was bled off through a pipeline which formerly extended across the gully just north of the works, terminating in the nearest rectangular pond. Here some of the water evaporated, allowing much borax and a little salt to crystallize. Eventually the brine was turned into the second pond, for further evaporation. The borax which had crystallized on the bottom of the first pond was then harvested and recycled, being added to the incoming ore. Some soda could be recovered in the same manner from the second pond, after which the residual brine would be discarded.

The Harmony borax process was necessarily a batch process, but virtually continuous production could be achieved, as certain production items such as mud tanks, receiving vats, and crystallizing

vats, which might have acted as bottlenecks, were provided in multiples. A single high-head or high-pressure reciprocating steam pump, still visible at Harmony, could, through suitable valving, be used for several purposes, such as providing boiler feed-water, high pressure water for washing ("hosing down"), fire protection, and mother liquor return to the hillside storage tank, as all of these steps were intermittent.

[This concludes Mr. Morgan's contribution on the processing of borax at Harmony Borax works.]

Efficiency of the Plant Operation

Most of the literature on early borax mining in California is concerned with production rates, profit and loss, and labor statistics. Little has been noted about the engineering problems, machinery, or variations in processing methods encompassed by such industrial undertakings. So, the first questions asked of Harmony related to the technological basis of producing borax. Two important factors--the remoteness of the industrial site and the market value of the end product--affected the success of the operation, which was based, as a result, on its efficiency.

The fields of Death Valley were distant from lines of transportation, and at first could not be developed economically if freighting expenses were added to the basic cost of production. In addition, an 1885 report indicates that the price of borax was very low at this time, and steadily declining. There was just not the demand for the quantity of borax being produced, resulting in rapid price declines. Carload values soon dropped to only 10 cents a pound (Levy 1969: 120).

To make the site a going concern in the world borax market, a number of engineering and technological problems had to be overcome. We were mainly interested in the ability of the operation to obtain as much borax as possible from the raw material, and with the grade or grades of borax being produced. In other words, we wanted to

measure the efficiency of the plant, which was rumored to be fairly low.

Supporting this claim is our belief that mud wastes in the dissolving tanks were merely sluiced by piping and drain to a nearby wash, resulting in the loss of some inclusive borax. On the other hand, the eight square tanks on Tiers 2 and 3 evidently were used to settle other debris out of the solution, which could then be shoveled into ore cars and returned to the top for reboiling. This indicates a concern for limiting wastage and obtaining a pure product in this phase of processing.

Another question concerning the manufacturing process is whether concentrated or refined borax was produced at the plant. Supposedly, in the production of refined borax, the hardened crystals were recycled through the dissolving stage, while concentrated borax was taken directly from the vats and sacked for shipment. But the historical account referring to these borax grades at Harmony may have meant only that crude ulexite ore, as well as processed borax, was produced by the operation. This question needed more investigation.

It was hoped that soil analyses of selected specimens would quantify some of this speculation. The occurrence of a pile of burlap sacks containing high grade cottonball ulexite along the road between Harmony and Mojave may verify that the plant did indeed ship borax in a crude, unprocessed state. Perhaps the operation could not keep up with incoming raw materials, creating a surplus, or maybe a higher quality product could be manufactured in the larger processing facilities to the west. Another consideration is that ulexite was in some cases worth more than refined borax because of its high boracic acid content (Hanks 1883: 49).

The harvested windrows remaining in the vicinity show a high concentration of quality cottonball ulexite that has formed since initial use. It is possible, therefore, that some windrows were harvested more than once during different production seasons. This procedure would have cut down labor expenditure (in shoveling) and opened up a larger area for exploitation.

Grass inadvertently scooped up with the borax ore in the salt marsh was skimmed from the surface of the dissolving tanks, and carried by ore car to a dump on the west end of the site. With the grass were incidental inclusions of borates, soda, and other chemicals. We presumed that the farther from the tanks, the younger the deposits, and the more borax in the discard, the less efficient the process. No change in efficiency through time could be detected in this manner by our analyses. A high percentage of waste materials is present in the skimmings pile, however, indicating that at least during the first stage of processing, borax recovery was high.

The use of settling tanks in processing the natural ores is more evidence of the plant's efforts to run an efficient operation. A high percentage of impurities was removed from the solution during this production phase. By reboiling the settled materials, more borax could be recovered and impurities removed.

It is at this point, however, that we begin to see a slight product loss. Mud finally channeled from the dissolving and settling tanks still contained borax ore. Also, specimens taken from the bottom of the receiving and crystallizing vats showed a high borate/low impurity (in this case salt) ratio of about 10:1.

In order to strengthen the initial solution, liquids (high in borax content) remaining in the vats were reused in the dissolving tanks on top until they became discolored. At this time, the so-called mother liquor was piped into one of the tailings ponds north of the plant. We reasoned that samples taken stratigraphically here would allow us to discover more about plant efficiency, assuming that upper deposits are younger, and that, again, the more borax in the discard, the less efficient the operation.

Differences between the two depositional layers noted are too dramatic to reflect merely an improvement in efficiency from one time to another. Instead, we theorize that the initial layer of tailings and residual borates had not been harvested for reprocessing while later deposits had. The first season's discard was perhaps covered by flood sediments before collection could occur.

To conclude, no change in efficiency over time could be detected in the processing methods utilized at Harmony. On the whole, we have to infer that the efficiency of this borax operation in Death Valley was fairly high by then-current standards. A large percentage of extraneous impurities could be removed in the various production stages, resulting in a quality product. It is true that an unspecified amount of borax was lost at the same time, but some of this ore could be recovered by harvesting residual borates in the tailings ponds.

Harmony supposedly produced some three tons of borax per day, and when figuring a six-day work week for six months of the year, a total production per year in the range of one million pounds would not be unreasonable. If so, the production of borax at Harmony would have been comparable with that of other large Pacific States producers (see Hanks 1883: 78). We conclude that Harmony did overcome most engineering and technological problems to maintain an efficient and successful operation and, by all rights, would have been a going concern in the world borax market had not high-grade deposits of colemanite been discovered.

Harmony's Impact on the Environment

One purpose of the present study was to learn about the technical processes which resulted in the rise or decline of mining enterprises in the 19th century. Of wider consequence than the technological basis of producing borax at Harmony, however, is the ways in which man has changed his environment throughout time and the machines by which he has accomplished the change.

A number of questions posed at Harmony, therefore, related to both technology and environmental adaptation. Every culture is to a large extent the result of the adaptation of a group of people to the environment in which it functions; yet a group also influences its natural environment, with such influence increasing in proportion to technological advancements. It was obvious to most 19th century

utopian planners that the way the physical environment was managed had direct effects on behavior (Leone 1973: 140).

Harmony represents an industrial community of the late 19th century which was planned and constructed from scratch in an area still remote from population centers. We were interested, therefore, in the impact Harmony had on the environment of Death Valley. This delicate ecosystem was governed by hot and arid climatic conditions, resulting in the development, through adaptation, of diverse plant and animal life, and geographic features.

We previously concluded that the residents of Harmony did not depend for survival on available natural resources. Little evidence of hunting or other local procurement activities were noted in the archeological record. Instead, markets in San Francisco served as the major food source for the industrial complex. As far as the subsistence economy was concerned, then, Harmony had almost no effect, adverse or otherwise, on the local environment, except perhaps for the creation of irrigated fields at Furnace Creek.

Features of the plant operation which may have affected the natural environment include the procurement of water and necessary fuel materials, the harvesting of borax ores, and the mining of soda.

Texas Spring supplied water to Harmony via an overland pipeline, traces of which can still be seen today on aerial photographs. Old photographs of the site show large amounts of wood stored to the east of the plant. We now know that mesquite, including torrey and screwbean varieties, and saltbush were used to fuel the boiler at Harmony. This vegetation was abundant and could be found nearby along springs and around the edge of the salt pan. There was no evidence of non-local tree species, which indicates that the local wood supply was not depleted by the borax operation.

During the harvesting of borax ores, materials on the ground surface were shoveled into long rows and allowed to dry. Except for the visual impact remaining today, borax mining at Harmony had little effect on the environment, since new borates soon rejuvenated themselves on the windrows and flat salt pan. The skimmings pile was

also checked to see if there was a change over time in discarded grass species inadvertently collected with the ore. Such a change would possibly indicate a disruption in the natural environment due to borax mining. All specimens analyzed from this feature, however, were identified to a distinct species of saltgrass prevalent in the area to this day.

The source area for the soda used in processing borax at Harmony is not known, so it could not be determined what effect the mining of this material may have had on the local environment.

The construction of the plant in itself had some impact on the surrounding terrain of Death Valley. First of all, it was necessary to terrace a hillside near Furnace Creek to facilitate the movement of solutions during processing. This task involved extensive grading, road building, and the use of artificial fill where needed. Retaining walls were then built to hold these terraces in place, using building materials such as sandstone blocks and cobbles. These items had to be collected or mined from nearby deposits. Mud then had to be excavated from large borrow pits to make adobe bricks for the machine room.

Construction of the industrial complex at Harmony, therefore, did result in some exploitation of the natural environment. But the impact on the previously more or less untouched local resources of the area was probably small. Other building materials, such as pre-cut lumber, along with the machines and tanks necessary to run the operation, were obtained commercially through agents in San Francisco.

The construction of the townsite supporting Harmony called for little alteration of the existing landscape. It appears that most structures, such as the blacksmith shop, cook shed, and Adobes A and B, sat directly on the ground surface, with almost no pre-construction preparation of the house sites. Exceptions would include the subterranean adobe east of the plant, and perhaps the three so-called house pits between Adobes A and B, where some excavation would have occurred prior to building.

The Greenland ranch, with its adobe house, pond, irrigation ditches, and plowed fields, definitely made its mark on the otherwise

barren face of the valley floor. It was the continued development of the area during later years, however, that really had an impact on this "oasis" in the desert. The initial settlement merely led the way for future exploitation.

We have to conclude that the residents of Harmony did not exploit the natural environment of Death Valley to any great extent, either in a subsistence-oriented or industrial capacity. It is true that some building materials and minerals were obtained locally, but this was on such a small scale that there was little noticeable effect. Nor did the mining of borax have much impact, since scraped areas soon returned to their natural state.

One reason the Harmony operation was less damaging to nature than most industrial enterprises was that the site depended on San Francisco markets for almost all food items, goods, and supplies. It was therefore not necessary for the inhabitants to utilize local resources in most instances. Also, the period of occupation was too short for much permanent development or alteration of the natural landscape. Harmony's impact on the environment, therefore, was mainly visual, although it did open up the area to further utilization.

Subsistence Economy

A basic question asked in this study was, "In what way did the inhabitants interact with their natural environment?" This may be characterized as a problem in adaptation. According to historical accounts, Coleman purchased a ranch at Furnace Creek so that the borax plant could be provided with at least some crops for both men and livestock. Other supplies either had to be procured from San Francisco via the railroad station in Mojave, or obtained or manufactured locally from the available resources.

Communities generally adapt their culture to an environment which they then exploit to the limits of their day-to-day requirements and technological competence. Studying man's history is, to a considerable degree, the examination of ecosystems within which

human culture operates, and of the increasing control exercised by man over his environment (Fagan 1972: 142).

The questions posed at Harmony regarding the extent to which this late 19th century populace depended on local resources in such a remote area presuppose a knowledge of the flora and ecological relationships present during occupation. Such information was provided in Chapter 3. We know that even though the climatic conditions affecting Harmony were extremely hot and arid, through adaptation the surrounding area of Death Valley was able to support scattered plant and animal life of great variety and diversity.

The study of organic remains from occupied sites can be of great importance in reconstructing cultural activities at a site. It provides information, often obtainable in no other way, about the technology, including what is generally termed "subsistence economy". Also available are clues regarding population size and other elements of culture reflected in the differential selection and treatment of items such as plants and animals.

At Harmony we had an added advantage: insight into the diet, source, and availability of food was attainable through historical records, such as the Coleman Company ledger. We were interested in both subsistence technology and adaptation to the local environment. In other words, to what extent did the inhabitants depend on available natural resources? Of concern here is evidence of hunting and other local procurement.

Food Sources

The Coleman Company followed the example of other Death Valley settlers and established a ranch to support the borax operation (Spears 1892: 27). The agricultural community which sprang up at the mouth of Furnace Creek was named "Greenland". Eventually, with extensive irrigation, an oasis of sorts was created in this otherwise barren region. Irrigation ditches watered some 30 acres of land on which alfalfa, garden vegetables, melons, fruit trees, and natural grasses were cultivated (Hanks 1883: 32).

We know from the Coleman ledger that a wide range and variety of imported goods was available to the inhabitants of the site. In fact, the communication and transportation network established between Harmony and the West Coast served to restrict the adoption of local materials. Since Harmony could easily fulfill its needs and wants through shipments from San Francisco, the site became entirely dependent on wholesale manufacturers for most supplies and provisions. As a result, the residents improvised or made do with what was at hand only when they had to. Some of the many food products transported to Death Valley by the Harmony enterprise include vegetables by the pound and case, garden seeds, dried and canned fruits, seafood, bacon, hams, beef, Eagle milk, tea, coffee, relishes, rice, crackers, and flour.

Another possible, although minor, food source for the inhabitants of Harmony may have been local resources. Plant and animal life was abundant in the area surrounding Death Valley. Vegetation life zones, such as the salt flat, desertscrub, pinyon-juniper, and forest associations include species with varied requirements of temperature, precipitation, and soil conditions which would assure the continued availability of at least some basic resources. Over 200 species of animal life have been observed in this area, including mule deer, antelope, squirrel, and kit fox.

Well-balanced and varied meals were evidently the rule for such work camps. A concern of the borax company was that the major part of its labor force at Harmony was Chinese. These people in general preferred a culturally traditional diet and industries usually took the advice of Chinese merchants and supplied compatible foods. The workers ate dried oysters and cuttle fish, sweet rice, crackers, dried bamboo, salted cabbage, dried fruits and vegetables, vermicelli, dried mushrooms, peanut oil, tea, rice, pork, and poultry. These items had to be ordered from San Francisco, and could not be procured locally. Most appear on the list of provisions shipped to Harmony. Rumor has it that Anglo laborers at the time chose a more basic, if less interesting, diet of beef, beans, bread, and butter (Chinn 1969: 44).

Dependence at Harmony

Evidence of the part San Francisco played in the subsistence economy will first be discussed as seen through the archeological record.

Case after case of canned food was shipped to Harmony, accounting for the large number of tin cans that remain. The records, and our collection, imply the importation of a great quantity and variety of canned food items. Other food and drink ordered from San Francisco were packed with lead foil, ample remains of which were also found. Cans recovered are similar in form to a variety of turn-of-the-century types which contained vegetables, fruit, fish, beef, evaporated milk, and tobacco.

Only nine identified bottles contained culinary products, suggesting, as expected, that most food products came in tin cans. The Coleman ledger listed few foods which necessarily had to come in glass containers, but cases of Montserat sauce, catsup, and chow-chow were ordered over the years. Items indicated in the artifact inventory are olive oil and sarsaparilla extract, along with a number of club sauces, such as horseradish, French mustard, Lea & Perrins Worcestershire sauce, and pepper sauce.

In determining the emphasis on hunting and other resource procurement, important information can be gained toward understanding the peoples and activities of a given site, and thus human behavior.

Analysis of ammunition remains led to the speculation that weapons used at Harmony probably included a variety of pistols in calibers .38 to .44. It is surprising that only pistol cartridges were found, since a variety of sporting rifles, converted military rifles, and shotguns were available on the Western frontier. While a number of rifles were chambered for pistol rounds for economic reasons, we found no cases or bullets specifically designed in this way. Even the Coleman ledger listed only a half bag of buckshot and one bag of drop shot. Because rifles and shotguns are definitely more efficient hunting weapons than pistols, we believe that the

absence of long guns can be interpreted as indicating that hunting was of little importance to the economy at Harmony.

As a category, the 57 pieces of unidentified mammal bone recovered can tell us very little about behavior at the site. We know from the Coleman ledger that Harmony depended on San Francisco markets for at least part of its meat supply. From the archeological record, we have concluded that draft animals were probably kept at the Greenland ranch, and it is assumed that other domestic livestock were also present there. The fact that so few faunal remains were found at Harmony may mean only that food animals were butchered elsewhere, such as at Greenland, or at kill sites for wild game. The scarcity of bone in the townsite may also reflect cultural preferences. A typical Chinese camp diet included much fish, along with bacon, pork, and poultry, all of which were being ordered from West Coast merchants.

The only analyzed botanical specimen applicable to subsistence was found in the outer area of the plant. This material was identified as alfalfa, a herbaceous feed for livestock. We know that alfalfa was cultivated at Greenland (Hanks 1883: 32), and the Coleman ledger does list an order for alfalfa seed and other livestock feeds. Apparently, even the livestock were dependent on San Francisco to a large extent for their food supply.

Conclusions

We conclude that the inhabitants of Harmony did not depend on available natural resources to any measurable degree. There was little evidence of hunting or other local procurement practices. It seems apparent that both domestic food animals and wild game played an insignificant role in the subsistence economy at Harmony.

The major food suppliers for the industrial complex were San Francisco markets and, to a much lesser extent, the Greenland ranch. We propose (1) that the communication and transportation network established between Harmony and the West Coast served to restrict

the adoption of local materials, and (2) that cultural preference was an important factor determining the diet of the inhabitants. A strong dependence on San Francisco is indicated.

Communication and Transportation

As Burlingame (1961: 227) has noted, the technology behind the advancing frontier was makeshift and, for the most part, wasteful. Yet it was this wastefulness that gave the movement speed; once men were able to exploit the natural resources of the continent, progress could not be stopped.

Continuous transportation improvements were the key to continental migrations, and resulted in the formation of vast communication and transportation networks. Wood-burning steamboats eventually led to the settlement of river towns, and maintained a link between them. Instrumental in the transportation of people and goods between the rivers were canals and railways, which filled in more and more of the empty spaces along the frontier. The occupation of the Pacific Coast advanced, and mining booms drew these settlers eastward toward a meeting with the westward migration (Burlingame 1961: 227). This movement of people culminated in the completion of the transcontinental railroads.

Now that the transportation system could make goods available to all, it was necessary for science to come up with an economical way to produce these items. After the Civil War many inventions were made which would affect the economic history of the country. For example, the interchangeable parts system was established, which, when carried into quantity, led to mass production. The development of substantial transportation networks and mass production were contributing causes in "the realization of the equality concept by making (what had been) luxuries available to the masses" (Burlingame 1961: 228).

The Harmony Situation

One way to survive in an isolated and remote area, such as Death Valley during the 19th century, is by utilizing the local resources. Another way is to depend on communication and transportation links to an outside market for all goods and materials. In the case of Harmony, supplies either had to be obtained or manufactured locally from the available natural resources, or procured from the nearest major town, which was 165 miles away.

One of our initial questions concerned how close the ties were between this Death Valley outpost and civilization. The town of Mojave was Harmony's link to the West Coast markets, via the railroad. To reach the industrial complex from the railroad station one had to travel by wagon over a road constructed using sledge-hammers as grading tools.

We propose here that Harmony overcame these problems and was virtually a satellite of San Francisco. The town seems to have been almost entirely dependent on the outside world for its survival. The development of a reliable communication and transportation network into Death Valley resulted in few restrictions on the populace as regards the fulfillment of needs and wants.

Communication and transportation between Harmony and San Francisco, influenced acculturation and adaptation at the site. We believe that this life line to the West Coast both restricted the adoption of local materials by the inhabitants as a whole and limited the extent to which the Chinese laborers were acculturated into the dominant non-Chinese culture.

The Coleman enterprise was evidently able to supply provisions to this remote area at rather economical costs. It generally was not necessary for the residents to make do with what was at hand, to improvise, or to reuse materials, since a full range of manufactured goods was available. The Coleman ledger, which reads like a hardware and grocery store inventory, lists numerous shipments of goods from various companies in San Francisco to Harmony.

A wide variety of food products were kept in stock, as were personal supplies, patent medicines, and household items. Construction materials, office supplies, and textiles were ordered, in addition to horsegear, wagon parts, blacksmith's stock, and livestock feed. Machine and industrial parts, hardware, and tools were also included in the inventory. Frontier conditions were apparently not terribly uncomfortable by the late 19th century, at least not in Death Valley.

It seems likely from the wide array of equipment, supplies, and provisions shipped to Harmony from San Francisco over the years, that Coleman ran a company store type arrangement in the Valley. For example, on May 5, 1886, whoever was ordering provisions purchased four dozen flannel "shirts and drawers" from the Levi Strauss Company, when plant operations were about to shut down for the summer. So, the store was probably selling goods to prospectors working the mountains nearby. This trading post may have been situated near the Greenland ranch of Furnace Creek, possibly because of its more pleasing location.

From historical records, we know that Harmony was a center of operations for prospectors in Death Valley, it being one of the few links to civilization found in the vicinity. The Coleman store, then, not only provided needed items for the Harmony/Greenland work force, but sold goods to local residents as well. Since Chinese laborers did not usually receive room and board, they may also have had to purchase supplies from this country store.

Since the transportation lines to San Francisco were well-established, the Coleman Company could supply its employees with almost anything they desired. Chinese merchants in San Francisco imported a wide variety of goods which could then be shipped to various communities such as Harmony. Preferred food and material items could also be obtained from U.S. companies.

Change or other hardships were therefore not being forced upon the inhabitants. The Chinese could keep their own ways to a large extent or could adopt the American lifestyle, if they so desired. As far as availability was concerned, we doubt if there were many

luxuries that the transportation network could not supply to the residents of Harmony.

Archeological Data

We will now discuss how the problem of Harmony's remoteness, in reference to communication and transportation, is revealed in the archeological record. We know from the Coleman ledger that a wide range and variety of imported goods was available to the inhabitants of the site. It is interesting to see from the artifact collection just how much and what types of things from this inventory actually turned up at the site.

Over 99 percent of the 605 sherds of ceramics found at Harmony are of Chinese origin. The entire collection can be classified as everyday, common wares. A ceramic inventory can be a good guide to the cultural level of the inhabitants of any household. For example, while it is known from historical records that more than 40 people resided at Harmony, only a minimum number of 39 vessels appeared in our collection. This small figure may perhaps reflect the short occupational time span of the site, or a difficulty in shipping fragile containers from Mohave. No ceramics are listed in the ledger, although other breakable items were ordered. While Chinese ceramics were inexpensive, the absence of more traditional historic common wares, such as ironstone, suggests that culturally-determined preferences are at work here. The Chinese ceramics in our sample may have been among those personal belongings carried to the site by the laborers themselves, accounting for their small numbers and basic types.

Artifacts of glass represented a minimum of 90 bottles, along with window panes and other miscellaneous categories. Most of the identifiable bottles from Harmony are, not unexpectedly, alcoholic beverage containers. Yet, while the Coleman ledger indicates that at least nine dozen such bottles were transported to the site, only 24 wine, champagne, and beer bottles were noted in our collection. The majority, if not all, of this lot was possibly for use by the plant management and not consumed in the laborers' encampment. In

any case, there is no suggestion from the archeological record of the frequent consumption of alcohol by the town residents. The ledger listed few other products which necessarily had to be packaged in glass, probably since cans and barrels would reduce shipping difficulties. We found only nine culinary bottles, although cases of sauces, catsup, and chow-chow were shipped to the site over the years. The same situation is found with regard to patent medicines. The nature of this collection tends to indicate the work camp atmosphere of the townsite. It is likely that all of these supplies ended up in a company store, and were then distributed to the Harmony work force and local prospectors.

Over 2,000 metal artifacts were included in our collection, consisting mostly of tin cans, nails, and blacksmith's stock. The historical record, and our inventory, indicate that a great quantity and variety of canned foods was being imported. Some food and drink items were packed with lead foil for the trip. The many cases of canned paint and grease listed in the ledger account form another portion of our large tin can sample. Only one item of cooking gear, a coffee boiler, was recovered, although other utensils and pots were shipped to Harmony. One reason so many nails were found is because at least nine kegs were ordered during the plant's five years in business. While a full range of blacksmith's stock was ordered, the smithy evidently came to the site well-equipped. Most of the metal artifacts are indicative of the common procedures of late 19th century American industry, and most were probably shipped to Death Valley for use in the plant operation.

The 25 garment buttons in our collection would fit into any inventory of everyday work clothing. The Coleman ledger lists only one supplier of clothing which could be matched to our button sample, the Levi Strauss Company. From the items listed--denim pants, overalls, long underwear--we would expect to find buttons from ordinary work clothing and underwear at Harmony. But again we see evidence, from the large number of things transported to the site, that the Harmony town residents were not the only recipients of these goods.

The company ledger indicates that at least three dozen smoking pipes were purchased in San Francisco and shipped to Harmony. Clay pipes were in steady demand at frontier outposts. At the most, only three of the reported 36 fragile pipes were noted in the archeological record.

As far as textiles are concerned, for the most part, the garment fragments found in our excavations are represented in the records of shipments to Harmony, although again the numbers are not compatible. Only three artifacts of leather were collected. No harness or other horse-related tack was noted, although these animals were very important to the site operation. The company ledger lists a large inventory of purchased horsegear, so its absence in our collection suggests that animals were stabled nearby at the Greenland ranch and not at Harmony. Paper products listed in the records were mostly in the form of office supplies and the presence of this paperwork was verified in the archeological record. More evidence of Harmony's supply line to San Francisco is represented by the packing material we found. What is missing from our wood sample is wagon parts. Such entries are numerous in the ledger, so it is again suggested that both draft animals and wagons were cared for at the support ranch of Greenland.

If Harmony had indeed been in extreme isolation, as romantic tradition insists, then we would have expected to find evidence of this remoteness. The inability to easily satisfy needs and wants would have had to be dealt with by innovative means, which would have been revealed in the archeological record.

First, we would have seen evidence of makeshift structures and features at the site. As Burlingame (1961) noted, the frontier was characterized both by its wastefulness and by its rate of advance. Technology, as a result, exhibited temporary expedience and was adaptive. At Harmony, the settlement was composed of terraced operational levels, such large industrial components as a boiler, tanks, vats, and pumps, and permanent, fairly well constructed buildings of adobe and wood. The plan was for this complex to be

around for awhile, and all items necessary for construction (lumber cut to specification and large sheets of metal for containers), as well as machinery, were transported to the site from San Francisco.

Expedient repairs to facilities would also have been necessary if Harmony was not able to easily procure needed materials. We know, however, that the plant had a well-equipped blacksmith who spent his time fabricating and repairing equipment, making up fittings, and doing farrier work. A full range of blacksmith's stock was shipped to Harmony. For example, one of the dissolving tanks had been patched twice on the bottom with sheet iron and rivets. Apparently the inhabitants did not have to resort to contrived repairs on plant facilities. Lumber and mud for adobe were also available for the upkeep of domestic features.

Nor did Harmony lack such amenities as comfortable housing, medicines, liquor, and exotic food. Although excavations within the town-site were limited, photographs and physical evidence on the ground surface indicate the presence of at least seven buildings in the town-site, representing the blacksmith shop, living quarters, office, and cooking and dining facilities. These structures were of adobe and cobble-and-wood construction, providing more than adequate housing for the laborers. At many work camps, Chinese laborers were provided only with low cloth tents for shelter. Even though only eight patent medicine bottles were recovered, large numbers of family remedies and cure-alls were ordered and kept in stock at the company store. The archeological and company records indicate that liquor was available, but there is no suggestion of frequent alcohol consumption by the town residents. The Coleman ledger lists almost any type of food item imaginable, including such delicacies as salmon, oysters, and ox tongues. There were few things that the company did not make available to the residents of Death Valley.

There was also little sign of expedience modification at Harmony. We would have expected to find many improvised artifacts if the site had been affected by its remoteness. Few were noted. For example, there is evidence that nuts and bolts were occasionally cut from

stock and tapped or threaded at the smithy; and a homemade rake was identified, composed of wood and square-cut nails. All other supplies, from tool handles to smoking pipes, were evidently ordered from and replaced by wholesale manufacturers in San Francisco.

Another trait of isolated sites is the occurrence of many artifacts recycled and used in a different functional context. For example, we might see tin cans wired with handles for use as drinking cups or worn horseshoes used for building hardware. We saw no evidence of this at Harmony.

Conclusions

We must conclude that Harmony was directly dependent on San Francisco for its survival. There is little evidence of expedience modification, improvisation, or the utilization of local natural resources to meet demands. Instead, we find an abundance of amenities such as comfortable housing, medicine, liquor, exotic food, and so forth, all of which were shipped to Harmony from San Francisco via the railroad and supply wagons. Harmony existed as any isolated farm would today, relying on the outside world for most things, and making do only when forced to.

This ability to develop a reliable communication and transportation network into Death Valley resulted in few restrictions on the populace where the fulfillment of needs and wants was concerned. It seems likely from the wide array of equipment, supplies, and provisions shipped to Harmony over the years that Coleman ran a company store in Death Valley. The material culture was reflective of 19th century urban industrial and domestic life, whether in Death Valley or San Francisco.

Sociocultural Interaction

Acculturation

In the process of acculturation which usually occurs when two or more cultural groups interact, economically or politically subordinate groups generally adopt the characteristics of dominant groups.

Knowing from the historical record that Chinese and non-Chinese interacted at Harmony, we felt it would be useful to find out to what extent Chinese laborers had become acculturated into the dominant non-Chinese culture of California. Added to knowledge of the extent of acculturation at other times and places in California, this information could lead to a statement of rates of acculturative change, a statement of importance in predicting the outcome of culture-contact in the modern world.

Our expectation was that acculturation had not proceeded to any great extent. In general, it has been recognized that Chinese immigrant communities are remarkably resistant to change. Further, historical research has indicated that 19th century Chinese in California continued to eat customary food, use imported domestic utensils, and wear traditional clothing (Spier 1958a: 79-80; Chinn 1969). Also, Harmony was occupied just after the Chinese Exclusion Act of 1882, at a time of intense hostility against Chinese immigrants (Chinn 1969). This would, we reasoned, militate strongly against acculturation.

Establishing the extent of acculturation proved hard. Tests and hypotheses have in the past relied on the assumption that acculturation is most readily evidenced through comparison of change between proportions of male-related and female-related artifacts (Deagan 1973; Deetz 1962). This obviously complicated matters at Harmony because we suspect the presence of an all-male Chinese population, characteristic of work camps of this period. In the 1880s very few Chinese women came to the United States (Coolidge 1909), a situation that continued well into the present century. Intermarriage of members of the Chinese community with others was extremely rare (Lyman 1970).

To approach the question from another way, we first considered an article by Spier (1958b). His thesis was that Chinese laborers in the 19th century acculturated to the extent of adopting American tools and tool-use habits under some circumstances. Implicit is the observation that acculturation in other ways was not taking place.

The standard arrangement in work camps was for laborers to come as a group under the direction of Chinese "bosses" who provided all

requirements except tools (Chu 1970: 27). We have no information about the Harmony labor force structure as such, but it is instructive to consult the company ledger (Wm. T. Coleman & Co. 1884-1887). Tools ordered were all of the sort common to American commerce, with no exotic elements. A photograph of laborers at work in the Harmony borax fields shows only standard American tools in use (Holland and Simmonds 1971: Illustration 24). It is interesting to note, also in the company ledger, that large quantities of rice were brought in, and that tea in large lots was ordered from Chinese speciality shops in San Francisco. It may be that the Coleman Company was supplying the labor force with food, either through the foremen or directly.

We have argued in a previous section that Harmony had developed an extremely reliable transportation network between San Francisco and Death Valley. We believe there were virtually no constraints on the kinds or quantities of food and tools which could have been brought in. In evaluating the artifacts found at Harmony, then, we argue that the nature of remains was determined by cultural preference.

To test our proposition we had to know two things: where the Chinese lived, and the context of the objects they left behind. In determining the nature of Chinese remains, and thus the locus of Chinese activity, we may have been misguided by moralistic 19th century tracts which assured us that Chinese were much given to gambling and opium smoking. We did in fact, find a few items of opium and gaming paraphernalia, as well as Chinese coins, but more important was the observation that over 99 percent of ceramics were of Chinese origin. Distribution was heavily centered in Collection Unit C1, otherwise known as the Chinese quarters.

As to context, we have presented the hypothesis earlier that only Chinese lived at Harmony, with Anglos living elsewhere, presumably at Greenland. By default, then, artifacts found both in and around the Chinese quarters are taken to have been discarded or lost by Chinese. This argument is not nearly as clean as it might be. Doubtless some mixing occurred; anybody can throw a can or bottle on

the ground. Also, there may be sample contamination through subsequent reoccupation. It is extremely difficult, if not impossible, to separate an 1885 collection from an 1895 collection. Still, let us proceed hypothetically to an examination of artifacts.

All the personal items, such as buttons, buckles, clothing rivets and snaps are of American manufacture. Remains of food preparation and serving equipment are all of imported Chinese wares, with the exception of four Anglo-American-made ironstone sherds. Ceramic food storage vessels were all Chinese imports, but a considerable amount of American canned and bottled food was consumed. Found in the Unit T1 refuse dump, and as sheet trash, were a minimum of 49 tin cans and a minimum of 90 glass bottles.

From these observations we believe that acculturation was proceeding at a faster rate than previously suspected. Acculturation had, at least in the Harmony operation of the mid-1880s, advanced to the extent that Chinese laborers were adopting American tools, and some articles of clothing and food. Food preparation and serving equipment, however, remained traditional.

Caste and Class

In view of the strong ethnic differences at Harmony we had hoped to refine or reject an hypothesis proposed elsewhere (Shenk and Teague 1975: 173):

Given strong caste and class differences, there will be status and economic differentiation, and this differentiation will be reflected by rigidly defined spatial units, differential patterns of waste disposal, and differential access to goods and food.

Among the implications of this hypothesis are that refuse deposits will differ in quality and context. We expected to find these differences when comparing refuse from Chinese and non-Chinese quarters.

Unfortunately, we have come to the conclusion, however tentative, that only Chinese lived at Harmony, with non-Chinese living elsewhere. This was not clear until analysis was completed in the lab. If we had a sufficiently long time span, with many tightly dated trash dumps,

it might have proved profitable to search for change in status within an ethnic group. At Harmony, of course, we had only a very short occupation and a very sparse density of artifacts.

One thing was brought to light by pursuing this question, however, and that is a cautionary note on interpretation of ethnic group composition.

Archeologists have long enjoyed reconstructing migrations, intrusions, diffusions, trade networks, and all manner of socio-cultural interaction. Usually these reconstructions are based on stylistic elements of artifacts, especially ceramics.

What disturbed us when examining the archeological record at Harmony was that no specifically Chinese artifacts were found in the plant or at the adobes. Had we examined only the most prominent features at the site, and had we not had recourse to the historical record, we would not have recognized the numerically largest ethnic component.

It would seem that extreme caution is indicated in reconstructions of prehistoric cultural interaction based on examination of specialized, as opposed to domestic, facilities.

Chapter 8

SUMMARY

Research Summary

The purpose of this section is to present as succinctly as possible what we learned at Harmony. This will be a quick and rather superficial treatment; statements presented here are supported by lengthy, and sometimes tedious, argument in the body of the text. Please note that, for clarity, we have dispensed with the "probably's," "seemingly's," and other qualifiers. Statements such as "Only Chinese lived at Harmony" are, in fact, hypothetical and reference should be made to the full arguments if questions arise. Hypotheses are, in a sense, tentative answers to questions, and ours will have to do until refined or challenged.

If you have turned to this chapter first, a bit of orientation is called for. Harmony Borax Works refers to a 19th century mining complex in Death Valley. This complex includes a refining plant, a townsite and an area called the Chinese quarters.

Borax ore was discovered in the vicinity in 1881. W. T. Coleman built the Harmony plant and began to process ore in 1883 or 1884. Forty men, mostly Chinese laborers, were employed. Three tons of borax a day were produced during peak operation. Harmony went out of operation in 1888 due to financial reverses in Coleman's other businesses. It never reopened.

At present the Borax Works plant is composed of a four-level ruin built against a hillside. Remaining above ground are ruined buildings, tanks, pipes, and waste tailings. A nearby townsite contains remnants of buildings and refuse dumps.

Excavation and collection were required by Federal legislation in order to prevent information loss due to an upcoming stabiliza-

tion and alteration program. We conducted limited excavation in the plant and townsite and made surface collections in the plant, townsite, and Chinese quarters. All surface features were recorded and mapped.

The research program centered on several problems. We first wanted to know about the use of space so that interpretations and reconstructions of layout, building sequence, and site function could be made. We wanted also to reconstruct the borax manufacturing process, since no historic accounts of the Harmony process have survived. We wanted to know if the plant was efficient and if the operation could have continued had Coleman not gone bankrupt. We also wanted to know if the borax plant had significantly altered the environment through the destruction of vegetation.

Other questions were directed toward subsistence economy, communication and transportation, and sociocultural interaction. We wanted to know about food sources, and the degree of Harmony's dependence on coastal California. We inquired into the efficiency and cost of operating a mine in extreme isolation. Finally, we wanted to know the extent of acculturation of Chinese into the dominant non-Chinese culture of California. We also attempted to refine or reject a hypothesis about caste and class differences as revealed in the archeological record.

Over 6,000 artifacts were recovered from excavations and surface collections. Most were fragments of metal or pieces of broken glass. Metal objects comprised solder-seam, hole-in-top cans of the 19th century, square cut and wire nails, blacksmith's stock, machine parts, tools, and miscellaneous. Glass included broken window panes, chemical glassware, and gaming pieces, but most of the collection was made up of broken bottles that once held alcoholic beverages, culinary products, club sauce, and patent medicines.

Of the more than 600 ceramic sherds, 99 percent were from utilitarian food preparation, serving, and storage vessels of Chinese

origin. Included were porcelain, glazed earthenware and stoneware, bisque pottery, and a few sherds of whiteware.

Also found were cartridges, buttons, and other personal items. Over 200 pieces of textiles, leather, rubber, paper, and wood were recovered, including fragments of borax bags, hose, belting, gasket material, and tool handles..

Shell, bone, soil, and botanical specimens were analyzed. Among the shells were fresh water clam from Arizona and California, Chiton and Limpet from the Pacific Coast, and a dye shell from the Gulf of California. Bone was represented by a limited sample of scrap which was, for the most part, unclassifiable except as artiodactyl, or four-legged hoofed mammals. Botanical specimens were mostly species of mesquite and saltgrass.

Excavations proved very satisfactory for our reconstruction of the use of space. A plan was developed showing what the plant looked like at the time of abandonment (Fig. 39). Included were a boiler, dissolving tanks, settling tanks, receiving vats, and crystallizing vats, connected by pipes and hoses. The plant was served by a tramway and a steam-driven pump.

The plant was built in one season, with minor later additions and modifications. The main plant once was roofed. A fire later razed the structure, but without hindering plant operation. The plant was used only for production of borax. It was not reused after abandonment.

In the townsitè-Chinese quarters, we found that the adobes date from the time of plant operation, and were sporadically reoccupied until about the time of World War I. Fittings were more elaborate than previously suspected, and included glazed and screened windows and interior paneling.

We have argued that buildings at Harmony were associated with laborers' quarters and dining facilities, plant business, or storage. Only Chinese lived at Harmony; Anglos lived elsewhere, doubtless at Greenland. Buildings in the townsites were used as offices, sheds,

and for storage. There once were structures in the Chinese quarters area that were used for housing and food preparation for workers.

The Harmony manufacturing process has been reconstructed satisfactorily using archeological and archival resources. A flow diagram of plant operation is presented in Figure 40.

We concluded from analysis of soil and chemical samples and from archival reference that the Harmony plant was at least of moderate efficiency, its product being equable with that of contemporary plants. Harmony overcame engineering and technological problems sufficiently well to be competitive.

From analysis of botanical specimens we have made the argument that Harmony's effect on natural vegetation and animal life was minimal. Mining operations and tree cutting for fuel changed the environment very little. Harmony was able to use natural resources without depleting them.

For subsistence the Harmony residents did not depend on local natural resources. There is no indication of hunting or plant collecting. Most of the food came from San Francisco and, to a much lesser extent, the ranch at Greenland.

We see evidence for an extremely efficient and reliable network of transportation and communication. There is little evidence of expedience modification, recycling, or improvisation. Goods were shipped to Harmony in great quantity and variety. Instead of the usual picture of Harmony in stalwart and picturesque isolation, we see Harmony as an urban satellite, dependent on San Francisco for its survival.

Examination of artifact distributions within the Chinese quarters lead us to suggest that acculturation of Chinese into the non-Chinese mainstream of 19th century California had progressed faster than previously suspected. At Harmony, Chinese laborers were adopting American tools and some articles of clothing and food. Food preparation and serving equipment, however, remained traditional.

Our data proved not amenable to tests for caste and class structure. Directing attention to this problem did, however, offer

an insight into interpretations of ethnic group composition. We found that extreme caution is indicated when making reconstructions of cultural interaction based on examination of specialized, as opposed to domestic, facilities.

Management Summary and Recommendations

The Harmony project was designed to mitigate the adverse effects of basic stabilization programmed for 1977 and to provide information about proposed restoration of the old parking lot to historic grade and removal of the cobble-based chainlink fence around the plant (Holland and Simmonds 1971). In addition, we were asked about the feasibility of locating and restoring the wooden barn, which once stood in the area that became the old parking lot.

Prestabilization work was required by Federal legislation in order to avoid loss of scientific and historic information due to site alteration. Such work conforms to current management policy (National Park Service 1975). An earlier statement (NPS 1963) indicated to us that site disturbance should be kept to a minimum. Our activities, including excavation and surface collection, were confined to those places which were threatened by site alteration, with the exception of three collection units placed to gather comparative data. A detailed section of Chapter 2 tells precisely why each excavation or collection unit was placed where it was. Locations of the units are shown on maps in Chapter 4.

To address management concerns, we make the following recommendations:

1. Basic Stabilization Work

As evidenced by this report, excavation, recording, and collecting done at Harmony will serve to mitigate potential adverse effects of ruins stabilization. We have recommended to the Ruins Stabilization Unit that stabilization proceed as planned.

2. Restoration of Original Grade

Cross-trenching of the old parking lot revealed that, in most places, the original grade line is only a few inches below surface.

On this original grade can be found undisturbed artifacts and architectural features. Machine grading to restore the parking lot area to its original state would destroy a number of vat bottoms, wooden drains, and artifacts. This would not be allowable under provisions of Federal environmental legislation. The alternative to machines--controlled, hand shovel-stripping--would be prohibitively expensive.

To sum up, machine grading would destroy such features as remain, and shovel-stripping would be too expensive to be justified on a cost-benefit basis. Nonetheless, if the area is altered, archeological excavation would have to be done in mitigation. Therefore, we recommend that the old parking lot be left as it is.

3. Feasibility of Locating the Barn

Trenching in the old parking lot revealed that there may be remains of the barn, or storage shed, still in place. One upright wooden 4x4 post and several smaller ones were found in one of the trenches. These may, or may not, be parts of the original barn. Further archeological excavation to find all of the remaining foundations would be very costly.

If it is deemed appropriate to reconstruct the barn, we suggest that dimensions and placement can be discovered most economically by scaling off from contemporary photos. We recommend that the idea of searching below-ground for the barn be abandoned.

4. Fence Removal

The cobble-based chainlink fence around the plant was set into narrow, fairly shallow footing-trenches. These trenches sometimes cut through archeological features, and in other cases stop at the original plant grade line. Fence removal, if done, should be done with caution. We recommend that footings be broken into sections of a size that will allow for vertical removal by heavy machine. Simply hooking a tractor to the fence and pulling it over would result in a kick-up effect within the plant, destroying sub-surface features.

Appendix
ANALYSIS OF SOIL SAMPLES
FROM THE HARMONY BORAX WORKS

by
Vincent Morgan

The following is a presentation of the analysis of various soil samples from the Harmony Borax Works, Death Valley, California. The chemical identification was performed by the Boron Operations Laboratory of the U.S. Borax and Chemical Company. The interpretations are my own. The specimens include 11 samples gathered in the November, 1976, excavations, as well as eight samples that I collected in the vicinity of the site in February 1976 under a permit issued by the National Park Service.

The eight specimens from the Harmony vicinity were examined using both chemical and optical mineralogical techniques, with findings as indicated in Table 8. No quantitative analyses were made. Photographs were taken at each sample location as a permanent record of the origin of each specimen.

About the only surprise is found in Sample 1. These piles are not soda, as had been suspected, but halite or plain salt, which probably was intended for shipment to some silver smelter. A small amount of soda and borate was also present in this first sample. The source of the necessary soda for producing borax remains a mystery.

The material composing Sample 2 was once in burlap sacks. While the third sample also was cottonball ulexite, it was not as high grade as Sample 2. Sample 4 contained a little soda, in addition to the other items, while Sample 5 was probably originally two piles. Sample

Table 8
Soil Samples from Harmony Vicinity

<u>Sample</u>	<u>Location</u>	<u>Findings</u>
1	"Soda" piles upstream from Mustard Canyon	Virtually all halite
2	Roadside pile near Harmony plant	High-grade cottonball ulexite, with some probertite
3	Small pile adjacent to tailings ponds (west)	Cottonball ulexite with halite
4	Harmony tailings pond, NE corner, 6" below surface	Mostly halite and calcium carbonate, with some ulexite, borax, and tincalconite
5	Pile in the "V" between Mustard Canyon and Harmony Roads	"Soda" and much halite; soda seems to be a mixture of trona, thermonatrite, and gay-lussite
6	White reef about 1 mile NW of Harmony	Mostly halite with some silky white borate, probably originally ulexite, now all probertite
7	Stream encrustation near Harmony	Mostly halite, with some soluble borate
8	Newly formed cottonball in streambed (under about 2" of brine), about 1/2 mile NW of Harmony	Material is all ulexite (no probertite)

6 is from an area that appears to have been harvested. Only a small amount of borate is left. The soluble borate in Sample 7 is probably borax. Sample 8 was collected from a previously harvested area.

During the Harmony operation, cottonball ulexite was generally dug up from various places on the salt marsh and formed into windrows for drying, thus reducing the weight of material to be transported. The operators of Harmony apparently were not content with this method of operation, however, and developed "gardens" for the purpose of growing borax, as had been done successfully at Rhodes Marsh and Teels Marsh. Holes were dug on a 9 by 12 foot rectangular grid, covering many square miles on the salt flats, with the hope that borax would form in the holes. The experiment seems to have been unsuccessful.

Samples obtained in November 1976 from several of these gardens west of Cow Creek showed only a minimal amount of borax. There was a considerable amount of cottonball ulexite in some; all had much halite (salt) and glauberite (sodium sulfate). Several had a high percentage of mirabilite, which somewhat resembles borax in appearance, but contains no borate.

Another area about one-quarter mile west of Harmony (downstream) showed rejuvenation in the streambed adjacent to harvested windrows. A considerable concentration of high grade cottonball ulexite has formed since harvesting a hundred years ago. Where the conditions are always dry, such as in the remnants of harvested windrows, the ulexite has been converted to probertite by dehydration and recrystallation; where wet, only ulexite forms. Both minerals could have been utilized in the Harmony process.

An inventory by location of the soil samples excavated in pre-stabilization studies in and around the plant appears in Table 9.

The samples were tabulated on an insoluble-free basis. All values were then rounded to the nearest whole number. The components found in Table 10 are defined as follows: borax as 10-mol hydrate; salt as sodium chloride; sulfate as anhydrous sodium sulfate, and soda as thermonatrite.

The insoluble matter consisted largely of sandy material and rust. Many samples also contained woody material. Samples 7 and 8 contained charcoal; Sample 8 had been partially fused by heat at some time.

Table 9
Inventory of Plant Soil Samples Analyzed

1. P23B1, 10-15 cm below surface
Sample is from uppermost level of center tailings pond.
2. P23B1, 15-25 cm below surface
Sample is from middle level of center tailings pond.
3. P23B1, 30-35 cm below surface
Sample is from lower level of center tailings pond.
4. P14, Feature 1, Level 1
Sample is from the iron surface of an in-place receiving vat bottom
5. P12B, Level 1, 20.05 m below datum
Sample is from lower level of settling tanks.
6. P9B, Level 1
Sample is from the vicinity of the upper settling tanks.
7. P17C, Level 2 surface, 20.95 m below datum
Sample taken near an iron receiving or crystallizing vat bottom and may represent wastage.
8. P9B, Feature 1, Level 1
Sample taken from inside a large pipe which may have served the settling tanks.
9. P9A, Base of Level 1
Sample was scraped from a plank which may have served as a footing for the upper tier of settling tanks.
10. P20, 20 cm below surface, 4 m west of west CCC fence.
Sample is from the skimmings pile.
11. P20, 20 cm below surface, 6 m west of west CCC fence
Sample is from the skimmings pile.

Table 10
Harmony Soil Samples

<u>Sample</u>	<u>% Borax</u>	<u>% Salt</u>	<u>% Sulfate</u>	<u>% Soda</u>
(1) P23B1	13	46	18	23
(2) P23B1	12	50	28	10
(3) P23B1	77	20	2	1
(4) P14	88	11	0	1
(5) P12B	75	14	10	1
(6) P9B	69	18	12	1
(7) P17C	82	8	9	1
(8) P9B	23	63	12	2
(9) P9A	37	41	17	5
(10) P20	18	54	22	6
(11) P20	14	66	16	4

The probable solution strengths from which samples crystallized are shown in Table 11.

Table 11
Probable Plant Solution Strengths from which Samples Crystallized

<u>Sample</u>	<u>% Borax</u>	<u>% Salt</u>	<u>% Sulfate</u>	<u>% Soda</u>
(1) P23B1	5-10	5-40	2 -12	0 -3
(2) P23B1	5-10	5-40	2 -12	0 -3
(3) P23P1	5-10	5-40	2 -12	0 -3
(4) P14	25-30	3- 4	0	0.3
(5) P12B	25-30	4- 5.5	3.3- 4	0.4
(6) P9B	25-30	6.5- 8	4.3- 5	0.4
(7) P17C	25-30	2.4- 3	2.7- 3	0.3-0.4
(8) P9B	5-10	14-28	2.5- 5	0.4-1
(9) P9A	5-10	5.5-11	2.3- 4.5	0.7-1
(10) P20	5-10	15-30	6 -12	1.7-3
(11) P20	5-10	23-40	5.5-11	1.4-3

Concentrations are probable values based on solubilities and analyses of the dry samples.

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