Radiometric evaluation of the prehistoric mortuary practices of the Chinchorro culture in northern Chile

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RADIOMETRIC EVALUATION OF THE PREHISTORIC
MORTUARY PRACTICES OF THE
CHINCHORRO CULTURE
IN NORTHERN
CHILE

by

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Bachelor of Science
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of the requirements for the degree of

Master of Arts

in

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Department of Anthropology and Ethnic Studies
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ABSTRACT

Radiometric Evaluation of the Prehistoric Mortuary Practices of the Chinchorro Culture in Northern Chile

by

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The Chinchorros were the aboriginal, pre-ceramic peoples of the northern Chilean and southern Peruvian coastline. The Chinchorro culture used four types of mummification techniques (red, black, natural and mud-coated). Each of these types may be distinct to the chronological time period in which it was used and, therefore, the typology would be used to define the Chinchorro chronology. Also, if the mummification styles are unique to a particular time period it would support the idea that this was an egalitarian group that did not recognize individual social rank in mortuary practices. To test these hypotheses 16 samples from 15 Chinchorro mummies of the Arica, Chile area were \(^{14}\)C dated. These figures were then compared to 23 previously published dates. Results demonstrated that the classification scheme proposed by Arriaza (1995a, 1995b) is supported with one exception. The exception, in which natural mummies are dated within the periods of other techniques, may demonstrate the use of a social ranking within the Chinchorro culture. Another conclusion the dating gives support to the idea that Chinchorro cemeteries have been in constant re-use.
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CHAPTER 1

INTRODUCTION

Reporting $^{14}$C Dates

Throughout this study $^{14}$C dates are reported and compared using guidelines established by *Radiocarbon* Instruction for Authors. Radiocarbon dates reported as years before present (BP) refer to conventional $^{14}$C dates before 1950 AD. The reporting format is uncalibrated age in years followed by the reporting laboratory's estimate of error at the one standard deviation level. Radiocarbon dates that have been calibrated are reported relative to the BC/AD calendar. The calibrated dates are not point estimates in single calendar years, but are shown in one or several ranges of years based on statistical probability of curve intercepts. The format for these dates are given as a range and or intercept followed by the appropriate confidence level. Furthermore, as recommended by the Society for American Archaeology, information in parentheses that follow dates will be the laboratory number, followed by the type of sample, and, if available, isotopic correction factors.

The laboratory number is preceded by a code particular to that lab. The following are the codes and their labs that are seen in this study: Beta, Beta Analytic (US); DRI, Desert Research Institute (US); ETH (AMS lab), Swiss Institute of Technology (Zurich); GAX, Gakushuin University (Japan); GX, Geochron Laboratories (US); I, Teledyne Isotopes (US); IVIC, Caracas (Venezuela).
Introduction

The Chinchorros were the aboriginal, pre-ceramic peoples of the northern Chilean and southern Peruvian coastline. Their economy was based on the exploitation of marine resources including fishing, sea lion hunting, and shellfish gathering (Arriaza 1995a). As a demonstration of their dependency on the ocean, the word “Chinchorro” means “gill nets”, referring to the fine fishing nets the Chinchorro manufactured. The activity that is of great interest to researchers is the Chinchorro mortuary practices and funerary preparations performed on the decedents of their society. The preparations included extensive reconstruction of the human body, resulting in artificial mummification.

The scholars that have studied the Chinchorro culture have used a variety of approaches to develop their chronologies, resulting in many different subdivisions and an unclear understanding of Chinchorro cultural evolution. Rivera (1991, 1995) used technical development, such as maritime subsistence, and cultural associations, while Bird (1943) and Llagostera (1979) used technology, such as fishhooks. Arriaza (1993, 1995a, 1995b), Guillen (1992), Standen (1991), and Allison et al. (1984) approached Chinchorro chronology from the perspective of funerary behavior and dated the mummified remains. The result of these different approaches are different ideas about the chronology of the Chinchorro. For example: Allison (1985), establishes that the Chinchorro mummies are 9000 years old, while Standen (1991) asserts that the Chinchorro are 7000 years old. This difference in dates makes one ask: are these dates the reflection of dating different type of mummies, cemeteries, or
regional variations within the mummies? While all of these approaches are valid, this
author feels that the direct dating of the mummies could be a better tool to create a
Chinchorro chronology. The focus of this study is the $^{14}$C dating of mummified
remains themselves to reevaluate the Chinchorro chronology. This thesis is important
in further validating the Chinchorro chronology as developed by $^{14}$C dating. The
refinement of this chronology is a critical step in understanding the development of
mummification practices in northern Chile. The chronology is a key issue because it
is the baseline for understanding if mummification styles changed through time or if
they existed simultaneously. Furthermore, dating cemeteries may shed light on the
mobility of the Chinchorro and if the different types of mummies are a reflection of
social stratification or status of the individual. A solid chronology could be applied to
a regional setting, such as Arica, or to a larger geographical area to include all the
Chinchorro sites. This thesis will attempt to validate the Chinchorro chronology by
focusing on the Arica region because 218 of the 284 (77%) Chinchorro mummies
have been found in this region. Specifically, they have been found in 10 cemeteries
within a few minutes walking distance of each other, supporting the assertion that
Arica is the cultural epicenter of the Chinchorro people (Arriaza 1995a).

Chinchorro sites have been discovered from Ilo, Peru to Antofagasta, Chile, a
900 km segment along the Pacific Ocean (Figure 1). This is the western border of the
Atacama Desert, the driest desert on Earth. Because of the environmental conditions
natural desiccation of human remains occurs easily and many examples of
mummification are found in this region. Chinchorro remains are most frequently
encountered in Arica, Chile, which is a modern city of 120,000 people approximately
30 km south of the Peruvian-Chilean border. Today the mainstay economy is still fishing. In the southern area of Arica rises a 100m high sandy cliff named El Morro (Figure 2). It is this site that in 1983, while the local water company was digging a trench that exposed human remains, 96 Chinchorro mummies were found. This excavation represents the largest single find of Chinchorro remains, many of which still remain in the Arica area stored at the Museo Arqueologico San Miguel de Azapa.

From previous $^{14}$C dates Chinchorro mummies have been dated as old as 7020 BC (Aufderheide et al. 1993), demonstrating the antiquity of the peoples who occupied this region. In this case the remains were of a naturally mummified human buried wrapped in a reed mat found at Acha 2 T-1 (8970±255 BP, calibrated to 8475-7448 BC, 2σ, [GX-15082, muscle]) a site located 5 km east of Arica. The use of artificial mummification, in which the decedent is purposely prepared in an artificial manner, dates to 5050 BC from the Camarones 14 site 100 km south of Arica (Schiappacasse and Niemeyer 1984). By 1700 BC the artificial mummification practices had waned in use leaving again naturally mummified remains to be discovered. It is this transition that also marks the end of the Chinchorro Culture and the beginnings of the Quiani Complex in this region (Arriaza 1995a; Rivera 1991).
Figure 1. Chinchorro sites located along the Peruvian-Chilean coast (Arriaza 1995).
Figure 2. The Chinchorro cemeteries in the Arica region (Arriaza 1995).
The material remains of the Chinchorro are limited, as their economy and environment required minimal material needs. The artifacts that remain in abundance are fishhooks made of cactus, shell, or a composite. There are also finely made nets, fishing line weights, grass clothing, woven headbands, and spears and darts for hunting. Their shelters were simple and efficient for the moderate climate, leaving little to the archaeological record. The most significant artifact left by the Chinchorro were the mummies that were so elegantly prepared.

The Chinchorro are defined by their mortuary practices and pre-ceramic technology (Arriaza 1995a). The practices include extended burial and artificial mummification. Artificial mummification is the deliberate modification of human remains to interrupt the natural decomposition process. Many of the Chinchorro mummies are naturally mummified as a result of exposure to the dry Atacama Desert environment. These mummies are found in extended burial positions and wrapped in a reed mat. This is natural, but intentional, mummification. The term natural mummy used in this work refers to naturally desiccated human remains that have been buried in an extended position with a reed wrapping or other indicator of intentional preparation. Because of this intentional mortuary practice, this author includes natural Chinchorro mummies as part of the intentional mummification category. Uhle (1919, 1922) classified these anthropogenically made mummies as complex and recently Arriaza (1995a, 1995b) used a similar classification, but-subdivided the complex category. Arriaza divided the complex category to reflect the predominate styles of red and black. Other styles are mud-coated and deliberate natural mummification. Of the 284 mummies discovered, Uhle would have considered 122
complex with no other specification to typology. Arriaza further defined the complex mummies into the red and black categories, with 27 mummies being classified as black, 80 classified as red, and 15 left with the unspecified category of complex. Also, there are 133 natural and 27 mud-coated mummies (Arriaza 1995a).

The coastal environment provided an abundance of resources that the Chinchorro utilized through hunting and gathering techniques. However, where other hunting and gathering cultures have existed, the funerary preparation of the dead has not been as complex. The complex preparation of human remains is not seen until more sedentary, agrarian economies were developed (Binford 1971). The energy required to make such preparations is a large investment and is the center of focus of study regarding the Chinchorro culture (Allison et al. 1984; Arriaza 1995; Standen 1991).

The artificial mummification in the Chinchorro culture is highly complex and requires skillful knowledge of a specialist. Compared to other societies, this energy investment is unusual for the economy the Chinchorros developed. That they may have had specialists, at least for funerary preparation, and the use of cemeteries suggests that they were sedentary. It may also indicate, unlike other groups with similar economies, there may have been a social hierarchy within the Chinchorro culture (Standen, 1991).

The Research Questions and Hypotheses

There are two principal concerns about this research: the first is to test whether the classification scheme proposed by Arriaza (1995a, 1995b) as a
chronological representation of Chinchorro mummification is correct. The second is to evaluate whether different styles of mummies coexisted, reflecting social stratification.

**Hypothesis 1: Typology as a Chronological Representation**

According to Arriaza (1995a, 199b) the mummification processes the Chinchorros employed resulted in mummies that can be categorized into four major classification schemes: natural, mud-coated, red and black. Arriaza also suggested the classification may be enough to use these typologies to develop a chronology of the Chinchorro culture. Therefore a mummy of a particular typology can be easily classified into a time period. In order to develop a time scale, however, an absolute dating method must be used to give the chronology a temporal meaning and to evaluate the Chinchorro culture within the context of world prehistory by using calibrated dates.

Therefore, the focus of this hypothesis is the dating of Chinchorro mummies based on their typology according to the classification scheme put forth by Arriaza (1995a). The hypothesis is that, given that mummy typologies evolved over time and that different mummification techniques were not contemporaneous, the absolute dates will demonstrate different typologies dating into discrete time periods. If the hypothesis is correct a mummy of a particular typology that is discovered can be readily assigned to a chronological period. If the hypothesis is not correct the mummies of different types will not show a discrete temporal pattern and the classification scheme to assign chronological periods to the Chinchorro will not work.
Hypothesis 2: Mummy Typology as a Social Status

The Chinchorro Culture, which has already shown that it is different from other gathering groups by having complex mortuary practices, may have used the different mummification techniques to differentiate a decedent’s social status in death. Frequently, Chinchorro mummies of different types are found in close proximity to each other, raising issues about their social organization (Standen 1991, Muñoz et al. 1993).

The difficulties in working with the Chinchorro chronology is the cemeteries are often in sandy, unstratified matrices in which superposition is difficult to determine. This results in a lack of orientation for contemporaneity (Figure 3). This was a particular problem in the Morro-1 excavation, as the Morro is a sandy escarpment in constant reuse as a cemetery, in which examples of all types of mummies have been found. An additional consideration is that the Morro excavation undertaken by Standen and Focacci reveal the complex use and possible re-use of a Chinchorro cemetery. Most of the Chinchorro sites are found where construction was taking place, requiring a rapid rescue of remains due to the destruction of the site by construction equipment. These reasons create the need to use a dating method independent of stratigraphic position; therefore, $^{14}$C dating is the most pragmatic solution. The focus of the second hypothesis is the use of different mummification techniques as a means to differentiate social distinction of the society. The hypothesis tests if the dates of different typologies are discrete, then the likelihood of the mummification technique being used for social differentiation is minimal. If the dates
are contemporaneous for different typologies then, the possibility of social differentiation is not excluded.

To test these hypotheses it was necessary to travel to Chile in the summer of 1997. Sixteen $^{14}$C samples were collected and transported back to the United States. Results showed the youngest sample, from a red mummy, to be $3254 \pm 210$ BP (DRI-3454, reeds), and the oldest sample, from a black mummy, dated to $5791 \pm 380$ BP (DRI-3445, bone). The results actually give support to both hypotheses, because as the dates were plotted, very distinct patterns were clear. However, there are anomalies indicating there were possibly two types of mummification practices being used at one time. The results of this are certain styles were definitely used at different times, but within those stylistic periods another style is seen. This mixture of styles supports both hypothesizes to a partial extent.
Figure 3. Distribution of Chinchorro mummies in the Morro-1 Site demonstrating the complex relationships of deposition (Arriaza 1995).
CHAPTER 2

CHINCHORRO CHRONOLOGY RESEARCH

Research into the antiquity and the cultural evolution of the Chinchorro began in the second decade of the twentieth century and is currently drawing researchers from around the world. This study investigated the evolution of ideas about the Chinchorro chronology by reviewing the research of other investigators. The results yielded conflicting dates and different schemes to organize the Chinchorro chronology with no apparent consensus of how the mummification practices evolved. The Chinchorro chronology of other researchers is presented relative to Arriaza (1995a, 1995b). Because it is his chronology scheme being tested, a summary of his classification scheme follows. And, finally, I present a brief synopsis of the Arica region mummies that have been $^{14}$C dated.

In 1917 Max Uhle published the first study of the Chinchorro, or as he termed “Arica aborigines,” as artificially mummified remains were discovered on the beaches of Arica. In his publications, Uhle made three classifications of the mummies he found. The first is Type I, or simple mummification, in which the body was naturally desiccated by the desert and subsequently buried in an extended position wrapped in a reed or camelid wool mat. Type II were complicated mummies that Arriaza (1995a, 1995b) reclassified as red and black styles and Type III were clay-covered (also referred to as mud-coated). Uhle based his chronology on the
absence of technology and estimated the beginnings of the Chinchorro Culture around the time of Christ because they had no ceramics, agriculture, or permanent housing structures. Furthermore, he thought that the sequence of the mummy was Type I (natural) followed by Type II (complex) and then Type III (mud-coated). Although the dates have drastically changed the sequence of the use of typology is still basically the same.

Since Uhle’s work, many researchers have attempted to develop a chronology of the Chinchorro Culture. Regardless of the approach they took, technological or funerary, researchers now have the advantage of $^{14}$C dating. Núñez (1965) was the first researcher to use $^{14}$C, dating a complex style mummy from Pisagua Viejo 4 Tumba 2 and resulting in a date of 4880 ± 320 BP (IVIC-170; wood/vegetable material). Since then other investigators have been using $^{14}$C to demonstrate the antiquity of the Chinchorro and develop their cultural chronology. However their results are sometimes in conflict. For example, Allison et al. (1984) dates the artificially prepared mummy Morro-l T-7 C-1, of the Arica region, to 7810 ± 180 BP (I-13653; camelid fur) while Standen (1991) redates the same mummy to 4520 ± 90 BP (Beta-40956; muscle), resulting in a wide discrepancy requiring validation. Standen (1991) and Arriaza (1995a, 1995b) are of the position that the second dating represents a better date, because it matched the expected type sequence of mummies they proposed for Arica.

Another dilemma of dating is the understanding of the evolution of mummification practices. For example, is an abundance of children being mummified in the black style a reflection of high mortality or, as suggested by
Schiappacasse and Niemeyer (1984), did mummification start with children? If they are correct, this could be social stratification based on age.

Although this study is focused on chronology, it is important to define the different classifications for the mummification types. Uhle (1919, 1922) suggested three (natural, complex, and mud), Allison et al. (1984) suggested multiple types classified by a complex numbering system. Guillen (1992) suggests six categories similar to that of Allison et al. (1984). Standen (1991) used three major classification schemes. Arriaza (1995a, 1995b) suggested four, and his typology is presented as follows:

Black: these are bodies that have been extremely altered by complete evisceration, emaciation, and dismemberment. This was followed by reinforcement of the axial and appendicular skeleton by using long sticks. The internal thoracic and abdominal cavity was dried and stuffed with vegetable matter and soil or ash. Finally, the body was reassembled, covered with white paste, covered with the original intact skin and painted by a black manganese coating. The scalp was covered with short hair and the face had remodeled eyes, nose and mouth. These are considered the most complex mummies created by the Chinchorro (Arriaza 1995a).

Furthermore, in this study, there is one mummy (Morro-1 T-10B) not classified as black or red, but as the non-specific complex category. However, the description given in Standen (1997) shows this mummy has the mummification styling similar to black mummies, but it is not complete over the entire body. Because of the stylistic elements, I have associated this mummy with the black category.
Red: these are also complex mummies in which the variation of the technique is more pronounced. It involved the evisceration of the body but not as extensively as the black style. There are major incisions performed and sticks used to reinforce the skeleton. The body was again stuffed with a variety of materials and the body was reassembled. In this style, the scalp is covered with long hair and the body coated with a red tinted material, most likely ochre. Also, it is often seen that there are open eyes and the mouth is molded into the facial area (Arriaza 1995a).

Mud-coated: the bodies were encased in a cement-like mixture of sand, a binding material, and a hardening agent. The result is a hard plaster coating over the body. With this type of preservation evisceration was rare (Aufderheide et al. 1993).

Natural: these bodies were desiccated by the dry environment of the Atacama desert and usually found wrapped in reed mats or camelid furs. This was an intentional process, in which the body was wrapped for burial either before or after desiccation of the remains.

There are different approaches to how the different type of mummies may be assigned to a specific period. The chronological epochs developed by Arriaza (1995a, 1995b) are presented here as a basis of comparison to other researchers' approaches to developing a chronology (Figure 4). Other researchers chronologies are presented in Figure 5.

An early period defined by Arriaza is based on the discovery of naturally mummified remains that had been purposely buried, wrapped in reed mats. The period is set at 7020 BC to 5020 BC because the oldest natural mummy found has
been dated at the latter age while the first artificial mummy has been dated at the former age. Arriaza has named this the Founder Chinchorro Epoch.

Five artificially mummified children found at the Camarones 14 site (Schiappacasse and Niemeyer 1984) were used by Arriaza (1995a) to define his Initial Epoch (5020 BC to 4980 BC). The technique used concentrated on preparation of the face and the trunk. Because only children were found with artificial mummification it is possible to consider that artificial mummification began with the purposeful mummification of children. The end of this epoch is marked by the appearance of black mummies, which define the start of the Classic Chinchorro epoch.

The Classic Chinchorro (4980 BC to 2800 BC) represents the use of complex mummification practices, more specifically the black style. The earliest examples are from Camarones 17 and Arica (to include the Morro-1 site). There have been a total of eight mummies found at the time of Arriaza’s 1995 publication. After two millennia the tradition started to phase into a more transitional style, thereby establishing a new epoch.

The next period is the Transitional Chinchorro (2620 BC to 1720 BC) and two mummification styles are present during this phase. In this period the red style is most abundant and is dated as the older style. This style, according to Arriaza, lasted approximately 500 years. The second type of style is the mud-coated mummy, of which two mummies have been dated to this period. In Arriaza’s view they came at the end of the Transitional Chinchorro and demonstrate the abandonment of the red style.
Figure 4. Arriaza (1995a) scheme of Chinchorro mummification practices.
Once the abandonment began it was not long before the Chinchorro stopped using all complex mummification and use natural mummification techniques. This is the Late Chinchorro (1720 BC to 1110 BC) and is the last epoch of the Chinchorro Culture, as the Quiani complex was phased in at this point.

At the end of the Initial Epoch, as defined by Arriaza (1995a), black mummies appear as part of the Classic Chinchorro Epoch (4980 BC to 2800 BC). Several other researchers to begin their timelines also use this demarcation. Rivera (1991) starts the Chinchorro I Phase at 4900 BC and ends at 3600 BC, with a chronology based on technological development and cultural association.

Rivera (1991) breaks down the Chinchorro Culture into three phases based on the same criteria as above. The phases are approximately 6000 BC to 4000 BC, 4000 BC to 2000 BC, and 2000 BC to 500 BC. These three phases correspond roughly with three patterns of Chinchorro mortuary practices. Pattern I is the use of clay to fill the orbits and to cover the face with a plaster coating. Pattern II is the use of complex mummification as defined by Uhle. Pattern III is a simplification of the mummification process. Of these mortuary practices, Rivera has suggested that they are reflective of social differentiation.

Aufderheide et al. (1993) states that the presence of naturally mummified bodies contemporaneous with artificially mummified bodies suggests there is an elite subset of the population. They also used the classification developed by Uhle.

Guillen (1992) based her chronology on funerary behavior similar to Arriaza (1995a, 1995b). Her scheme is an early phase of 11000 BC to 8000 BC based on naturally mummified remains buried wrapped in reed mats similar to the burial at
Acha 2. The middle and late periods cannot be defined by mummification style but on other behaviors such as mass graves. In order to define the boundaries of the late and middle periods, Guillen (1992) suggested to use grave goods as they become more abundant. In her chronology the end of the Chinchorro is identified as 400 BC similar to Rivera (1991).

Standen (1991) uses artificial mummification and funerary artifacts to define her chronology. Her older Phase I is defined by the mummies found in the Morro-1 site. The Phase II of Standen’s chronology is defined by the use of natural mummification as seen in Figure 5.

![Figure 5. Various Chinchorro chronologies from Arriaza (1995a).](image-url)
Llagostera's (1992) chronology was primarily based on fishhook technology, cactus fishhooks representing the earlier Camarones Complex and shell fishhooks characterizing the Quiani Complex. From the time frame established by the tool technology, Llagostera placed the mummies into the chronology accordingly. In the Camarones Complex chronology, Llagostera defines this as the height of complex mummification processes.

Although all scholars that study the Chinchorro consider the mummification practices the most distinctive feature about the culture, only Arriaza (1995a, 1995b) uses the mummies themselves, via radiocarbon dating, as the key indicator of the chronological scheme. Most Chinchorro scholars (Allison et al 1984; Guillen 1992; Rivera 1991; and Standen 1991) have used a composite of mummies, midden dates, and food technologies to create their cultural sequences. Table 1 is the number of mummies that have been dated in the Arica region.

As can be seen in Table 1, 11% of the Arica region mummies have been dated, with the black style represented by the largest percentage of 31%. The dates determined from these mummies are presented in Table 2 and their representation is in Figure 6. Calibration of these radiocarbon ages was done with OxCal v.3b2 (Ramsey 1998). The results are plotted in Appendix I. These dates are a portion of the dates of all Chinchorro mummies that Arriaza (1995a, 1995b) used to develop his chronology. Even though this is only the Arica area it is still very clear that these dates follow his scheme very closely. This is the starting point in which this endeavor begins to collect samples from the mummies themselves of the Arica region and date them using precision radiometric techniques.
Table 1. Number of Chinchorro mummies dated in the Arica region

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<th>Site</th>
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<th>Red</th>
<th>Natural</th>
<th>Mud</th>
<th>Total</th>
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<td>36</td>
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<td>96</td>
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<td>9</td>
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<td>0</td>
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<td>0</td>
<td>69</td>
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<td>1</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Morro</td>
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<td>9</td>
<td>1</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>2</td>
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<td>2</td>
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<td>0</td>
<td>4</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>3</td>
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<td><strong>Total</strong></td>
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<td><strong>63</strong></td>
<td><strong>110</strong></td>
<td><strong>27</strong></td>
<td><strong>216</strong></td>
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</table>

Number Dated  

| Number Dated   | 5   | 5   | 11 | 2 | 23 |
| Percent Dated  | 31% | 8%  | 10%| 7% | 11% |

*Note: Data from Arriaza (1995) and Standen (1997).*
<table>
<thead>
<tr>
<th>Site and Mummy number</th>
<th>Style</th>
<th>Lab</th>
<th>Sample</th>
<th>14C age (BP)</th>
<th>Error (1\sigma)</th>
<th>Calibrated range (2\sigma) (BC)</th>
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<td>90</td>
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<td>90</td>
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<td>100</td>
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<td>100</td>
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<td>140</td>
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<td>140</td>
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<td>70</td>
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<td>155</td>
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<td>5520-4334** 5550-4360**</td>
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</tbody>
</table>

* The probability has been calculated relative to the 95.4% significance level.
** As listed in Arriaza (1995a).
Table 2 continued

<table>
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<td>Lab record, University de Tarapaca</td>
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<td>Focacci and Chacon (1989); Aufderheide and Allison (1994)</td>
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<td>Muñoz et al. (1993); Aufderheide et al. (1993)</td>
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</table>
Figure 6. Representation of Arica region Chinchorro mummies $^{14}$C age in years BP with their respective 1σ error bars.
CHAPTER 3

METHODOLOGY

Research Design

This research will test the hypotheses by \(^{14}\text{C}\) dating on the mummies themselves. The hypotheses being tested are, first, that the different mummy typologies will date into discrete groups. The second hypothesis is that mummies discretely grouped by style do not support the theory of complex stratification or unique individual status. The relationship between the method and the hypothesis is inference. The intended use of the relationship between the hypothesizes and the methodology is to demonstrate that a particular mummy typology corresponds to a unique time frame. If the different typologies date in discrete ranges of age with no overlap with other typologies, it can be inferred that the particular typology was used during this time, and Arriaza’s cultural sequence (Figure 4) will be correct. If the different typology dates have no pattern of discreteness it can be inferred that the change of typology is not evolutionary or of a temporal nature, therefore another explanation is needed. If there is no connection between the chronological ages of the mummies and the complexity of their preparation, then the likelihood has increased that the mummification may reflect a complex social stratification or individual social
ranking. This research is important to understand the evolution and implementation of mummification practices in the Arica region.

The reason this research was conducted this way is that the stratigraphic context of the Morro has been altered to a great extent by human activity, such as reuse as a cemetery and being the site for new construction projects. The mummies are found with horizontal sequence as opposed to a vertical stratigraphy, which makes temporal inferences more difficult. Because no geomorphologic relationship exists we must use experimental methods to develop the chronology. The research was done by traveling to Chile to collect samples from Chinchorro mummies that had been excavated or rescued and were stored in Chilean museums. Then the samples were brought to the United States and $^{14}$C dated at DRI or ETH. The data are then compared to previously published dates of other researchers. What this author expected to find was an increased number of mummies dating to the chronological periods already defined by Arriaza (1995a, 1995b) and the subsequent endorsement of the theory that there is no complex social stratification in the Chinchorro culture.

**Materials**

The materials dated were organic samples that came directly from a mummy or its wrapping. Three Chilean museums house the collections that the mummies were selected from: the Museo Arqueologico San Miguel de Azapa de Universidad de Tarapacá (the Azapa Museum of the University of Tarapacá) in Arica, the Museo Nacional de Historia Natural (National Museum of Natural History) in Santiago, and
the Museo Chileno de Arte Precolombino (Chilean Museum of pre-Columbian Art),
also in Santiago. All mummies stored in Santiago came from Arica cemeteries.

Collection, Storage and Transportation of Samples

Collection of samples was done in 1996-1998 on three different visits to
Chile on mummies that were in storage at museums or excavated just prior to taking a
sample. Collection was done by selection of material that could be considered in
excess and a removed sample would not hinder future research efforts. Important
considerations were the availability of mummy style and if the mummy was found in
close proximity to a different styled mummy. A few muscle tissue samples were
available from previous analyses from autopsies performed in the 1980s. Other
mummies were not in an autopsied state, so removal of a sample was carefully
considered with the participation of museum officials.

A total of 16 samples were taken and placed in untreated aluminum foil,
weighed, wrapped, labeled, and overwrapped in a plastic bag. All samples were then
packed in a briefcase and handcarried back to the United States.

The following samples were taken. All material was removed with the
expressed permission of museum officials. In all cases the museum designation has
been used to identify the samples removed. Table 3 presents a listing of mummies
dated and the sample material.
Samples Collected at the Azapa Museum of the University of Tarapacá

Samples collected at the Museo Arqueologico San Miguel de Azapa came from the Morro-1 and Maestranza sites. The new samples were taken to verify if Morro-1 Tomb 7 mummies were contemporary and if the red mummies co-existed with the mud-coated and natural mummies.

Morro-1 T-7 C-4: Red mummy stored at the Azapa Museum. The sample taken was muscle tissue from the feet. This mummy was selected because it exists in a cluster of six mummies that are believed to be a family. The sample collection was done by Bernardo Arriaza and Vivien Standen in 1996.

Morro-1 T-7 C-5: Red mummy stored at the Azapa Museum. The sample was taken from reeds that wrapped the body. This mummy was selected because it exists in a cluster of six mummies, which are believed to be a family. The collection was done by Bernardo Arriaza and the author using scissors to cut a reed 16 x 4cm length (Figure 7). The reeds were used in this case as nothing internal could be used without causing destruction to the body.

Morro-1 T-7 C-6: Red mummy stored at the Azapa Museum. The sample taken was a combination of wool and hair (most likely camelid) and muscle. This mummy was selected because it exists in a cluster of six mummies believed to be a family. The collection was done by Bernardo Arriaza and Vivien Standen in 1996.
<table>
<thead>
<tr>
<th>Mummy</th>
<th>Style</th>
<th>Sample dated</th>
<th>Wt. (g)</th>
<th>Sex</th>
<th>Age</th>
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<td></td>
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<td></td>
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<tr>
<td>Morro-1 T-7 C-4</td>
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Sex: F= Female, M= Male, U= Undetermined.
Age: A= Adult, C= Child, U= Undetermined.
Morro-1 T-25 C-5: Red mummy stored at the Azapa Museum. The sample was camelid wool and hair taken from the wig of the mummy by Bernardo Arriaza and the author. This sample was selected to prevent damage to the body. The mummy was selected at a meeting between Vivien Standen, Bernardo Arriaza, and the author to test whether the red-coated style co-existed with the mud-coated style. Morro-1 T-25 C-5 was excavated next to C-6, a mud coated mummy dated by Allison et al. (1984) (See Table 2).

Morro-1 T-23 C-5: Adult natural mummy stored at the Azapa Museum. The samples were of muscle tissue removed from the body at a previous autopsy by Allison et al. (1984). The samples were collected by Bernardo Arriaza and the author...
to test whether the red-coated style co-existed with the natural style. This mummy was selected at a meeting between Vivien Standen, Bernardo Arriaza, and the author. This mummy was discovered next to Morro-1 T-23 C-12, a mud-coated mummy to be dated by this research.

**Morro-1 T-23 C-12: Mud-coated mummy stored at the Azapa Museum.** The samples were of muscle tissue removed from the body at a previous autopsy by Allison et al (1984). Bernardo Arriaza and the author collected the samples. This mummy was selected at a meeting between Vivien Standen, Bernardo Arriaza, and the author because of its proximity to Morro-1 T-23 C-5, a naturally mummified body.

**Morro-1 T-10 B: Complex mummy stored at the Azapa Museum.** The two samples taken were vegetable matrix and human rib bone. Each sample was dated separately and this is the only mummy in this study to have two ages measured. The first sample is vegetable matrix in pieces 0.5 to 1.5 cm long. The vegetable material was selected because it was used to stuff the mummy. The bone was selected in case the vegetable material could not be dated. The mummy was selected because it was found in close proximity to a mud-coated mummy. Bernardo Arriaza and the author did the sample collection.

**Maestranza C-1: Natural mummy discovered in 1997 near the rail yard.** The sample taken was vertebrae bone by Bernardo Arriaza and Vivien Standen. This mummy was selected because it was found in the same proximity as Maestranza C-4, a black style mummy.
Maestranza C-4: Black mummy discovered in 1997 near the rail yard close to Maestranza C-1. The sample taken was a wooden stick from inside the mummy collected by Bernardo Arriaza and Vivien Standen.

Samples Collected at the National Museum of Natural History (MNHN)

PLM 8 #3524: Black mummy from Playa Miller 8 (PLM 8) site stored at the MNHN. The sample of human mandible bone was collected by Vivien Standen and Oscar Espoueys. The mummy was selected because it represents a black style mummy in which a sample could be taken without harming the remains.

MNHN #10955: Red mummy stored at the Chilean National Natural History Museum. The sample was a section of red turban cord wrapped around a human cranium and was taken by Bernardo Arriaza and the author. Access to the collections and assistance was provided by Silvia Quevedo Kawasaki. Uhle excavated the mummy and it was selected for $^{14}$C because none of the Uhle mummies have been dated. Apparently this mummy came from the Morro site (Figure 8).

![Figure 8. MNHN 10955 with cords around cranium. (Photo by M.Doubrava)](image-url)
MNHN #10988: Red adult of unknown sex stored at the National Museum of Natural History (MNHN). The sample was a section of red turban cord wrapped around a human cranium and was taken by Bernardo Arriaza and the author. Access to the collections and assistance was provided by Dr. Silvia Quevedo Kawasaki. The criteria for dating this mummy were the same as the previous case (Figure 9 and Figure 10).

Figure 9. MNHN 10988 cords. (Photo by M.Doubrava)
MNHN Caja #72: Red mummy stored at the National Museum of Natural History. The sample of reeds and was taken from the trunk by Bernardo Arriaza, Silvia Quevedo Kawasaki, and the author. The criteria for dating this mummy were the same as the previous case (Figure 11 and Figure 12).

Figure 10. MNHN 10988 cords. (Photo by H. Haas)

Figure 11. MNHN Caja 72. (Photo by M. Doubrava)
Figure 12. Wood samples from MNHN Caja 72. (Photo by H. Haas)

MNHN 11.040: A complex adult mummy of the red style stored at the National Museum of Natural History. Bernardo Arriaza, Silvia Quevedo Kawasaki, and the author took the sample of reeds from the outer wrapping. The criteria for dating this mummy were the same as the previous case (Figure 13).

Figure 13. MNHN 11.040. (Photo by M.Doubrava)
Sample Collected at the Chilean Museum of Pre-Columbian Art

Morro-1 T-1 C-5: Black mummy stored at the Chilean Museum of Pre-Columbian Art. The sample was a small segment of reed mat that was wrapped around the mummy when it was sent there by the 1983 excavation of the Morro-1 site. Bernardo Arriaza, Luis Solar, and the author took the sample from the exterior reed wrapping around the mummy. The mummy is a very young sub-adult with a high degree of completion of the mummification, as the extremities have received extensive treatment. This mummy was part of the Morro-1 T-1 family; a group of 7 black mummies. It was dated to test if it matched the previous and only $^{14}$C date, for this burial group (Figure 14).

Methodology

All samples were processed at the Desert Research Institute’s (DRI) Radiocarbon Laboratory in Las Vegas, Nevada. This included all pretreatment and, except for two samples, synthesis, counting, correction and calibration. The two segregated samples, Morro-1 T-25 C-5 and Maestranza C-1, were sent to ETH (Swiss Institute of Technology, Zurich) to be dated by accelerator mass spectrometry (AMS) dates because of the small sample size. Conventional dating techniques of these two samples would have resulted in large errors. All other samples were dated in the DRI lab using beta-decay ($\beta$-decay) liquid scintillation counting as described by Polach (1992).

Carbon exists in nature in several elemental forms: $^{12}$C, $^{13}$C, and $^{14}$C. The first two forms, $^{12}$C (the most abundant form) and $^{13}$C are not radioactive. However, $^{14}$C is
radioactive; meaning it will decay into a different element by releasing a beta-particle (essentially an electron) in order to obtain a stable form. The stable element formed is nitrogen gas ($^{14}$N). The production of $^{14}$C is the result of cosmic rays striking $^{14}$N in the upper atmosphere. The yield of $^{14}$C on a global scale closely matches the $^{14}$C loss through decay. Therefore, the $^{14}$C content in the atmosphere and the ocean remains nearly constant over time. Atmosphere and oceans are the sources for $^{14}$C in the mummy samples. The declining amount of $^{14}$C left in a sample is a measure of the sample's age.

Figure 14. Morro-1 T-1 C-5. An excellent example of a black mummy. (Photo by M.Doubrava)
As with any use of instrumentation and analysis there are assumptions made and operational terms used in order to develop a framework in which to conduct research. In radiocarbon dating in general there are several assumptions made about equilibrium of carbon in the atmosphere (Taylor 1997): 1) The metabolic process of living organisms are in approximate equilibrium with the atmosphere. When the metabolic process ends, the amount of \(^{14}\)C decreases by decay activity. 2) Radiometric dates are based on measurements of residual \(^{14}\)C content. 3) The \(\delta^{13}\)C/\(^{12}\)C ratio has not altered since death of the organism.

The age can be determined because the \(^{14}\)C decays at a constant rate. The time it takes for one-half of the original amount of \(^{14}\)C to decay is the half-life of \(^{14}\)C. Libby measured this rate at 5568±30 years (Taylor 1997) which is known as the Libby half-life. Later, a more accurate measurement of 5730±40 years was calculated (the Cambridge half-life). The measurements using the new half-life will give a 3% older date. Dates of samples are then compared and corrected to the known \(^{14}\)C amounts from tree rings, which can be accurately calculated from independent methods (dendrochronology).

**Pretreatment**

Pretreatment is the first step in preparing a sample to be dated. Its purpose is to eliminate any contaminates of an organic nature that may have been absorbed by the sample that could interfere with the accuracy of the counting procedure.

Pretreatment of most samples was carried out using standard pretreatment techniques as described in Hedges (1992) for the particulars of each sample material. This
usually consists of treatment with a weak phosphoric or hydrochloric acid solution to remove carbonates. The Chinchorro samples were treated with a base solution of sodium hydroxide, in a closed container, to extract humic acids that are present in many soils which can readily contaminate a sample. Finally the sample is retreated in a weak acid solution to remove any remaining carbonates and to prevent any remaining base from absorbing modern atmospheric carbon dioxide. The sample was then dried in an oven and weighed before being transferred to a glass vial. All glassware was carefully cleaned by micro-cleaning detergents and distilled water prior to any contact with a sample.

All samples were pretreated at the DRI facility, even the two samples (Morro-1 T-25 C-5 [red] and Maestranza C-1 [natural]) sent to ETH for AMS dating.

**Combustion, Synthesis, and Counting**

After pretreatment the samples were placed into a vacuum system and combusted in oxygen to convert organics into the carbon dioxide. From there the carbon dioxide is reacted with heated and molten lithium metal to form lithium carbide. The lithium carbide was then reacted with tritium-free deionized water to yield acetylene. The acetylene was then exposed to a vanadium oxide catalyst to form benzene. Benzene is a clear liquid at room temperature. The carbon present in the benzene is the same carbon, including $^{14}$C, which was present in the original sample. Each benzene molecule is composed of 6 carbon atoms and 6 hydrogen atoms in the shape of a six-sided ring. This organic structure is very stable and functions as a solvent for scintillation powder.
Scintillation powder (Butyl PBD) was dissolved in the benzene. It enables the detection of the $^{14}$C decay, during which a beta ($\beta$) particle is released. The scintillation powder releases a burst of photon light energy as a $\beta$-decay event occurs. The mixture was placed in a scintillation counter for a minimum of two days to measure the rate of decay of the $^{14}$C. The sample is sealed in a calibrated quartz vial, it will rest in the counter where it is surrounded by photon sensitive detectors.

In addition, when the sample was combusted in the vacuum system and carbon dioxide was formed, a very small sample of the carbon dioxide gas was removed and sealed into a glass tube. The carbon dioxide gas sample was sent to DRI's stable isotope laboratory for mass spectrometric measurement of the $\delta$ $^{13}$C/$^{12}$C ratio. This value is used to derive a correction factor for the radiocarbon age and it compensates fractionation of $^{14}$C during photosynthesis and metabolism in plants and animals.

When compared to $^{12}$C, $^{13}$C makes up about 1.11% of the carbon available in nature and it is heavier by 1 atomic mass unit. This is important because some environmental or metabolic processes will favor or discriminate against the heavier isotope of carbon and will enrich it or deplete it accordingly (Hoefs 1987). The relative enrichment or depletion is commonly referred to as isotopic fractionation ($\delta$ $^{13}$C/$^{12}$C). This measurement is important because similar processes will effect the $^{14}$C isotope and the $\delta$ $^{13}$C/$^{12}$C fractionation will be used to determine if $^{14}$C is enriched or depleted relative to $^{14}$C that is considered normal for the age of the sample. Ocean based organisms have more $^{13}$C giving them a heavier isotope ratio. The Chinchorro, whose diets consist of sea-borne food sources (Arriaza 1995a), will reflect the heavier
isotope ratio in their tissue. Land-borne reed used for mummy wrappings would not have a heavy isotope ratio. Therefore, any comparison of these two sample types must use dates that have been corrected by fractionation. The $\delta^{12}\text{C}/^{13}\text{C}$ values were given relative to the $-25$ per mil standard used to determine enrichment or depletion.

**Correction and Calibration**

Correction factors are used to model possible fractionation that may effect the calibrated age of the sample. Because of this, some labs use tables that recommend correction factors based on certain variables, such as geographic source of the sample. The only correction factor was applied to previous dates was done by Arriaza (1995a) Forty years to each $^{14}\text{C}$ age was subtracted, as recommended for samples that are from the southern hemisphere. At DRI, dates were first calculated to uncorrected $^{14}\text{C}$ ages in years before present (BP) and then corrected using the $\delta^{13}\text{C}/^{12}\text{C}$ correction factors calculated for each sample at DRI. Only the corrected $^{14}\text{C}$ ages (Morro-1 T-25 C-5 and Maestranza C-1) are reported from ETH.

The ages were then calibrated by using the computer program OxCal v2.0 by Ramsey (1993). This calibration program correlates the radiocarbon age with the amount of $^{14}\text{C}$ present in the atmosphere at the time of sample formation as determined by dendrochronologic methods. This is the calibration curve. The calibration process is based on the intersection of the radiocarbon age and the associated error distribution with the calibration curve. The result is a calibrated date (BC/AD) that can be compared with other dates developed by similar methods.
Appendix II shows the calibration curves generated from the 16 dates that were measured at DRI.

Since the calibration curve contains "wiggles", the $^{14}$C age may intersect the curve more than once. If this happens, the result is more than one calibrated date. Each intersection of that calibrated date will have a probability associated with that intersection. The probabilities vary from high, 0.99, to low, 0.01. But, no matter how slight the probability is, there still is a finite possibility that it is the true date. So, for comparison purposes, the probabilities of calibrated dates can be ranged according to statistical $\sigma$ (Bowman 1990).

In the case of the samples dated at DRI or ETH, the calibrated dates will be presented at a $1\sigma$ confidence level because of the confidence of the materials and the dating methodologies used by these labs.

Comparison

The analysis for this study will compare the DRI derived dates with the rest of the dates published by others at the $2\sigma$ confidence interval. Previously published dates came with unknown correction factors. Since the error is unknown, it is best to use a wide range of dates, as given by the $2\sigma$ level, to ensure the actual calendar date is within the range with 95% probability. The dates calculated at DRI can be compared to each other at the $1\sigma$ confidence interval because the correction factors are known and calculated for each sample specifically, as stated earlier. The comparison of previously published dates to the DRI dates are done using a $2\sigma$ confidence interval.
because the correction factors of previously published are unknown, creating a possibility of greater error.

Radiocarbon ages are presented within the parameters of the half-life of 5568 years. The year 1950 AD is the reference point to which the age is compared. The current accepted half-life value is 5730 years; however, this value is not used because the first radiocarbon dates were calculated using the original half-life value. It was decided by convention to continue using the original half-life value to maintain continuity among the dates being generated. The calibration process compensates for the difference (Taylor 1997).

It is further assumed that this approach of using the 2σ calibrated date ranges for all the dates from different laboratories is valid. Also it is assumed that the dates derived from the material is representative of that mummy, unless otherwise demonstrated.
CHAPTER 4

RESULTS AND DISCUSSION

The results of the dating done at DRI are presented in Table 4. Figure 15 is the graphical representation of the corrected ages with $1\sigma$ error for each sample.

The findings were similar to the scheme developed by Arriaza (1995a, 1995b). All black style mummies, except one (Morro-1 T-1 C-5), date older than 5453 ± 170 BP. The red style forms a major cluster of dates from 4481 ± BP (Morro-1 T-7 C-4) to 3927 ± BP (MNHN 10955), which is similar to the 500 year period Arriaza (1995a, 1995b) suggested. What was interesting, though, were the mummies that dated in an unexpected manner. The Morro-1 T-1 C-5 is a black mummy dated to a radiocarbon age of 3440 BP ±317 BP. Even after calibration, the $1\sigma$ range of dates is inclusive of 2196-1324 BC. This was 2497 years (comparing the median of their $1\sigma$ calibration ranges) younger than the next older black mummy dated at DRI (Maestranza C-4, 5453 ± 170 BP, 4460 - 4054 BC). When compared to the other Arica area black mummies, there is an approximately 1721 year discrepancy (Table 5, median, $2\sigma$ comparison). There are two possible reasons that this occurs: it may be that Morro-1 T-1 C-5 was manufactured at a later date than other black mummies, or the mummy was re-wrapped in later years due to reuse of the cemetery. This author supports the second explanation.
This mummy is an excellent example of the black technique and was only about 0.5 m in length. Since the sample taken had to be as small as possible without damaging the mummy, 4 small reeds were taken form the mat surrounding the remains. The time gap suggests that reeds were not associated with the mummy at the time of death. The other black and complex mummy samples included bone (Morro-1 T-10B, PLM 8 #3524), which certainly is a greater possibility to be present at death, and a section of wooden stick (Maestranza C-4) that was removed from the interior of the mummy. The stick is also an artifact that is most likely to be associated with the death of this individual, since locally grown sticks were an integral element of the funerary preparation of the black style mummies. The $^{14}$C date is measuring the age of the wood, which could be older than the mummy, but the 1cm thickness of the stick indicates it was rapidly grown. Moreover, it is unlikely they used an old piece of stick to reinforce the mummy, being newly grown sticks would be stronger and more resilient (Arriaza 1995a).

Another intriguing question is whether the black mummies coexisted with the naturally mummified bodies. At the Maestranza site, a natural style mummy (Maestranza C-1, 5170±70 BP) was found in proximity with a black mummy (Maestranza C-4, 5453±170 BP). Upon examination of the calibration curves and evaluation of their $^{14}$C ages it is possible, but unlikely, that these two mummies were contemporaneous.
Table 4. Radiocarbon dates of Arica region Chinchorro mummies dated at the Desert Research Institute

<table>
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<tr>
<th>Site and mummy</th>
<th>Style</th>
<th>Lab number</th>
<th>Sample type</th>
<th>14C Age (BP)</th>
<th>Error (1σ)</th>
<th>δ 13C/12C</th>
<th>Corrected 14C age (BP)</th>
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<td>Probability</td>
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<td></td>
<td>4999-4339</td>
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Figure 15. Chinchorro mummies of Arica dated at DRI in corrected years before present (BP) with 1σ error.
However, this is only relative to these two mummies. When compared to the entire group of black mummies dated from Arica this does not explain why there is a natural mummy dated among them. The next natural mummy dated at DRI was Morro-1 T-23 C-5, dated at 3891± 60 BP, which calibrates to 2457 - 2289 BC (1σ), a difference of 1279 radiocarbon years. Therefore, in the overall picture Maestranza C-1 is contemporaneous to other black mummies in the sense that this is a natural mummy buried within the black style period.

In continuation with our analysis, the previously published dates for the Arica region must be integrated with the mummies dated at DRI. Due to the nature of how different radiocarbon laboratories use a variety of correction factoring techniques, the conservative way to compare them is to use the 2σ confidence interval level, as there is a 95.4% chance that the age will fall in the given range. For comparison, the maximum and minimum values of the 2σ range are presented in Table 5, plus the average value of these dates. In most of the radiocarbon ages given there are calibration curves that give more than one intersection with a weighted probability. However, because there is a limited, but finite, chance that the real age is the smaller probability, the median was taken as the central tendency of the complete set of ranges given for intersections of the calibration curve. So, even if a 2σ calibration gives two intersections where the probability of one intersection is 0.99 and the probability of the other is 0.01, the median will be calculated as if the probabilities were equal (see example of the calibration curve in Appendix 1). Even though it will skew the central tendency, it is a conservative approach that goes back to any probability that has a limited, though finite, chance of being correct. The results of all
Arica Chinchorro mummies that have been radiometrically dated by this study and other researchers are presented in Table 5. Figure 16 is a graphic comparison of these results, given in calibrated minimum and maximum ranges to the 2 σ confidence interval level.

**Black and Complex Mummies**

Black style mummies were dated to be the oldest style in the Arica area, which is very interesting because the black style is the most complex. They came from four cemeteries (Morro, Chinchorro, Maestranza, and PLM 8) all within a few minutes of walking distance. For all black style mummies (with the exception of Morro-1 T-1 C-5) the calibrated 2σ range of dates is from 5520 BC to 3000 BC, with the median dates ranging from 4927 BC to 3475 BC. This is a discrete group in which only one natural mummy typology has been dated within this period. The natural mummy dated, Maestranza C-1, was found in 1997 located next to Maestranza C-4, a black style mummy. The radiocarbon ages are 283 years different, but the calibration at 1σ gives them 31 years of overlap. Given what the ages and dates have been calculated for the Maestranza C-1 mummy compared to the black Maestranza C-4 mummy, one cannot say for sure that C-1 is definitely younger. But, in the Arica area, there are no other black mummies that have been found to date younger than the mud-coated mummy. This is, of course, excluding the unusual date for the Morro-1 T-1 C-5 black mummy. When the previously published dates of mummies are compared, there are significant overlaps in the 2σ confidence range. Since there is no other
Chinchorro mummy in this region that dates older than the black style, it suggests that
this style is the oldest used in the Arica area.

**Red Style Mummies**

As can be seen in Table 5 and Figure 16, the 2 σ range of possible dates for
the red style mummies are 3500 BC to 937 BC, with the median ages ranging from
3190 BC to 1486 BC respectively. This group presents a difficult case for arguing
discreteness relative to mud-coated or natural typologies. The red period is a
challenge due to the presence of natural and mud-coated mummies. Median values in
Table 5 show the difference between the oldest red mummy (Morro-1 T-7 C-1) and
the youngest black mummy (Maderas Enco C-1) to be 275 years without any overlap.
When compared to the black mummy style the ranges overlap and have a difference
of 500 years, because the oldest date for a red mummy is 3500 BC while the youngest
date for a black mummy is 3000 BC. Even though there is some overlap in this
comparison this author concluded that the red and black styles are distinct from each
other. If the two styles co-existed, the patterns of the dates would not be as distinct as
they are seen in Figure 16. It is reasonable to assign a red styled mummy to a period
that is younger than the black period. It also seems reasonable that a black styled
mummy can be considered as part of the oldest style in Arica.
Table 5. Maximum, median, and maximum values of calibrated dates for all Chinchorro mummies from Arica using a $2\sigma$ confidence interval level

<table>
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<tr>
<th>Mummy</th>
<th>Style</th>
<th>Minimum calibration range at $2\sigma$ (BC)</th>
<th>Median</th>
<th>Maximum of calibration range at $2\sigma$ (BC)</th>
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<td>1677</td>
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<td>937</td>
<td>1486</td>
<td>2035</td>
</tr>
<tr>
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<td>Natural</td>
<td>1311</td>
<td>1523</td>
<td>1734</td>
</tr>
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<td>1990</td>
<td>2281</td>
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<tr>
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<td>2272</td>
</tr>
<tr>
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Figure 16. Graphical representation of Table 5.
Another consideration are the ages of the red mummies MNHN 11.040 (1486 BC with a 2σ range of 2035 BC to 937 BC; reed mat dated) and MNHN #10988 (2011 BC, 2σ range 2272 BC to 1749 BC; reed mat dated), which are clustered among the bodies with natural mummification. Just as it was for Morro- T-1 C-5, the same circumstances could apply for the MNHN 11.040 and even MNHN #10988; that is, the dates obtained were for the mats and not the actual mummies then the red period may actually extend 3200 BC to 2600 BC, a difference of 600 years, which is closer to the original estimate of Arriaza’s 500 year period. Furthermore, the 3 youngest red mummies (MNHN 11.040, MNHN #10955, and MNHN #10988) in the Arica area were all stored in the collections of the National Museum of Natural History in Santiago. The MNHN officials stated that these were mummies excavated by Uhle and sent to the museum in the early part of the 20th century. The samples that were dated all came from the exterior of the mummies and include cord wrappings and reed mats. The Caja #72 mummy, also from MNHN, has a median date of 2915 BC with a 2σ range of 3334 BC to 2495 BC, and clustered well among the other red style mummies. However, the reeds dated from Caja #72 were removed from the interior of the mummy. The difference of these dates could be explained by the constant reuse of the cemetery where later populations re-wrapped the mummies or that the red mummies from the MNHN have been erroneously classified. It seems the Morro and the other cemeteries have been in constant reuse and the idea (Arriaza 1995) that mummies could be reworked at later times may have a basis as seen by the anomalous dates.
Natural and Mud-Coated Mummies

Natural mummies seem to appear with great frequency in the Arica area and are readily available for dating. This latter point may indicate a past tendency to date the natural mummies more often with a destructive process like $^{14}$C, leaving the more complex mummies free from harm.

Six of the natural mummies clustered into a group dating from 2349 BC to 2175 BC (comparing medians in Table 5). The remaining seven natural mummies were sporadically dated, but they appear in every major complex period.

Mud-coated mummies appear only three times in the list of Arica area mummies, of which one was dated at DRI. The dates (2500-1750 BC for Morro-1 T-28 C-9, 3650-2900 BC for Morro-1 T-25 C-6, and Morro-1 T-23 C-12 at 3632-3370 BC) occur between red and black styles for two of the mummies. The mud mummy dated at DRI was Morro-1 T-23 C-12 and it dates closely to the mummy from Morro-1 T-25 C-6 dated by Allison et. al (1984). Maderas Enco C-1, a black mummy, has a median date of 3486 BC and lies in between Morro-1 T-23 C-12 and Morro-1 T-25 C-6 and gives it a difference of 26 years younger than Morro-1 T-23 C-12 (compared to the median date in Table 5). This seems relative in that the mud-coated mummy selected and dated at DRI clusters around the mummy used to define the mud-coated period as illustrated by Arriaza (1995a, 1995b). The date supports his division of the black style being bordered by the mud style before the red style was used. Even though there is overlap in the dates between the mud-coated and black mummies, this author believes this is not a contemporaneous use of these mummy styles. The pattern of the distributions of dates (Figure 16), combined with the fact that the one
mud-coated mummy dated at DRI is similar in age to the mummy that defines a
border of style between red and black, supports the idea that there is a mud-coated
style transitional between the red and the black styles.

Morro-1 T-28 C-9, a mud-coated mummy, dates to 2500-1750 BC (Table 5), a
much younger age than expected. The material dated from this mummy is internal
organs, so it is likely the date is representative of the remains. Why this appears at
this date, or why this style of mummification was used is unknown. Because of this
the mummy should be dated to verify the age, and other mud-coated mummies should
be dated to further clarify this inconsistency in the data.

The cluster of natural mummies, if taken into account with the possibility that
the red period lasts only 800 years, would seem to indicate that the natural style
dominated for a period of 400 years. If this is the true picture, then there would be
three discrete periods of a black style lasting from 4927 BC to 3475 BC, followed by
a brief mud style, a red style lasting from 3200 BC to 2428 BC, and a natural style
lasting 2349 BC to 2175 BC. This would work well for a scheme in which mummies
of a typology could be assigned to a chronological period.

However, their seems to be mummies that date unexpectedly young, such as
Morro-1 T-1 C-5 and the three red mummies from MNHN. Upon inspection the
materials dated from these samples came from the exterior and therefore are subject
to environmental contamination, or the possibility that the mummies were reworked
and reburied at later times. If the anomalous dates were discounted, there would
clearly be a long lasting segment of natural style mummies in the Arica region before
the practice faded away. This leaves the possibility that the natural lasted from 2600
BC to 1530 BC, a duration of 1070 years. This would not explain the presence Morro-1 T-28 C-9, a mud style mummy dating at 2125 BC.

There is definitely a chronological distinction between the red and black mummy styles, enough that a red or black style could be categorized as being part of the oldest style in the Arica region or the younger complex style. In terms of the social status or individual ranking the findings are suggestive too. Although the different typologies appear in a pattern of discreteness, within each of those styles there are mummies of other typologies that cannot be explained by an unrepresentative sample or cemetery reworking. So, within these stylistic periods there maybe a recognition of social rank or individual status that is expressed in different funerary preparation or absence of artificial mummification, as in the case of naturally preserved bodies clustered among the red and black styles.
CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

When looking at the Chinchorro Culture and their mortuary practices, the question has been asked about the relationship between the different typologies of mummification and the time periods they belong to. This was done in order to clarify if the different typologies could be used as a mechanism to classify the Chinchorro Culture into distinct periods. In order to accomplish this, radiocarbon dating was used to determine the age of 15 mummies from the Arica, Chile area. The results were then compared to another 20 sets of dates from previously published materials. The results of the comparison showed that certain mummification practices can be clearly distinguished from each other. Table 6 lists the new number of Arica region mummies that have been dated as a result of this study. The total count is higher than in Table 1 because two mummies were discovered while collecting samples for dating (Arriaza 1997). Figure 17 is the chronology that is being proposed based on all mummies that have been dated for the Arica region. Although it is similar to Arriaza (1995a, 1995b), the red period has been extended from 500 years to 800 years in duration. The natural period lasts over 1000 years before the practice of artificial mummification faded from this area. The mud period, which is listed as lasting for
approximately 300 years, is again similar to Arriaza's boundary between the red and black periods. However, the mud mummy this study dated gave a similar date to the original mud mummy that defined this transition. As a result, the hypothesis that the mummies will date into discrete temporal units relative to their typology is partially correct. It can be seen that the red and black styles are clearly distinct and the natural style also has a very particular cluster that could be a discrete unit. However, since there are different typologies with highly reliable dates that fall into these discrete periods it discounts from the original hypothesis. It may be possible that within each of these defined periods of mummy style (black, red, and natural) there may have been other typologies used. The natural Maestranza C-1 mummy that dated within the black period and the mud Morro-1 T-28 C-9 that dates within the natural period are examples of this phenomenon. Therefore, the second hypothesis that the mummy typology indicates social rank or individual status may have merit.

Table 6. Total number of Chinchorro mummies by type and cemetery

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<th>Red</th>
<th>Natural</th>
<th>Mud</th>
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<th></th>
<th>Number Dated</th>
<th>Percent Dated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td><strong>59%</strong></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td><strong>21%</strong></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td><strong>12%</strong></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td><strong>11%</strong></td>
</tr>
<tr>
<td></td>
<td><strong>39</strong></td>
<td><strong>18%</strong></td>
</tr>
</tbody>
</table>

Note: Data from Arriaza (1995, 1997) and Standen (1997)
Figure 17. Proposed schematic of the Chinchorro chronology in the Arica region.
The assumption that each sample drawn from a mummy to be radiocarbon
dated is representative may be incorrect, as seen by the red mummies (MNHN
11.040, MNHN #10955, and MNHN #10988) that dated to an unexpectedly young
age. The fact that they all came from the same museum makes this too much of a
coincidence to believe these results are independent. This is perhaps evidence of
reworking mummies at later dates. The fourth red mummy dated from MNHN used a
sample from the internal structure of the mummies and, therefore, is most likely
representative at the time of death. The same situation is probably true for Morro-1
T-1 C-5, in which the date was derived from the exterior reed mat wrapping the
mummy. This should be take as an indicator of reburial and/or re-use of the cemetery.

In the Arica region the oldest mummy typology is the black style. From the
dates derived, its occurrence appears suddenly. Since there are no other typologies,
this complex mummification practice must have been imported when this area
became populated. Therefore, this complex process must have been developed
outside the Arica region. Arriaza (1995a, 1995b) indicated the oldest complex
mummy (black style at 5050 BC dated by Schiappacasse and Niemeyer (1984)) is
found in the Camarones Valley, 100 km south of Arica. If this is true, then the dating
of typologies could be used to confirm the origin of the Chinchorro mummification
practices.
Recommendations

Radiocarbon dating has proven to be an excellent tool to develop prehistoric chronologies and its future use in exploring the past of the Chinchorro Culture is indispensable. As the results of this study indicate there are several areas that should be focused on to better develop the prehistory of northern Chile.

Mummies that are suspected to be younger and that represent different typologies should be dated next. This should allow a greater clarity as to the use of mummification techniques toward the end of the Chinchorro practice. Also, any different typologies that are discovered in proximity should be immediately considered for radiometric dating. It was truly a fortuitous event that Maestranza-1 (natural mummy, 5170 BP ±70) and Maestranza-4 (black mummy, 5433 BP ±170) were discovered together. Also, the next set of radiocarbon dates should concentrate on mud-coated mummies to further determine where they lie in the chronology.

For future research, the issue of reworking and reburying mummies should be tested in a more formalized manner. If this activity occurred on a regular basis, it will impact how the Chinchorro chronology will have to be studied. It will also lead to other questions of why such activity would take place. Furthermore, when dating these remains the opportunity to date the interior portion of the mummy, without its destruction, of course, should be maximized. One of the most valuable lessons from this study is the selection of where the sample comes from may have a significant impact on the representation of the sample for that mummy. Another future study would be to try to pinpoint the origins of complex mummification both in location and in the chronology.
Unfortunately, conventional radiocarbon dating is a destructive process and the conservation of artifacts is a paramount issue. Accelerator mass spectrometer dates, on the other hand, requires only a few milligrams of material to measure a useful $^{14}\text{C}$ age. The disadvantage is the cost. The advantages of dating can solve many questions of an origin of a people or a cultural tradition. It can certainly demonstrate the antiquity of a culture. However, any future endeavors to date the Chinchorro must be done with extreme caution to conserve the remains as much as possible. The Chinchorro mummies are certainly among the unique burials in the world and their conservation must become a priority in South American archaeology.
APPENDIX I

CALIBRATION GRAPHS OF PREVIOUSLY PUBLISHED DATES

67
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Morro 1-6 T-27 : 3750±140BP

Ratiodcarbon determination

3500BP  3000BP  2500BP  2000BP  1500BP  1000BP

Calibrated date

Morro-1 T-28 C-8 : 3790±140BP

Ratiodcarbon determination

3500BP  3000BP  2500BP  2000BP  1500BP  1000BP

Calibrated date

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Arica: 5240±110BP

68.2% probability
-4230BC (68.2%) 3950BC
95.4% probability
-4350BC (95.4%) 3750BC

Calibrated date

Chinchorro 1 T-1 C-2: 5560±175BP

68.2% probability
-4220BC (68.2%) 4200BC
4190BC (1.6%) 4160BC
95.4% probability
-3950BC (95.4%) 3750BC

Calibrated date
Chinchorro 1 T-1 C-1: 6070±285BP

68.2% probability
5350BC (68.2%) - 4600BC
95.4% probability
5600BC (95.4%) - 4300BC

Calibrated date

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APPENDIX I

CALIBRATION GRAPHS OF PREVIOUSLY PUBLISHED DATES
DRI 3446 MNHN 10988 : 3640±83BP

68.2% probability
2140BC (68.2%) 1880BC
95.4% probability
2300BC (95.4%) 1700BC

DRI 3390 Morro 1 T-23 C-5 : 3891±60BP

68.2% probability
2470BC (68.2%) 2290BC
95.4% probability
2560BC (1.9%) 2500BC
2500BC (93.5%) 2190BC
DRI 3450 MORRO-1 T-10 : 5533±59BP

- 68.2% probability
- 4460BC (68.2%) - 4330BC
- 95.4% probability
- 4500BC (95.4%) - 4240BC

Calibrated date:

- 5000BP
- 4000BP
- 3000BP
- 2000BP
- 1000BP
- 0BP
- 1000BP
- 2000BP
- 3000BP
- 4000BP
- 5000BP
- 6000BP
- 7000BP
- 8000BP

DRI 3445 CMP, PLM8 #3524 : 5791±310BP

- 68.2% probability
- 5050BC (68.2%) - 4300BC
- 95.4% probability
- 5400BC (95.4%) - 3500BC

Calibrated date:

- 6000BP
- 5000BP
- 4000BP
- 3000BP
- 2000BP
- 1000BP
- 0BP
- 1000BP
- 2000BP
- 3000BP
- 4000BP
- 5000BP
- 6000BP
- 7000BP
- 8000BP

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