UNIVERSITY OF ALBERTA

SKELETAL EVIDENCE FOR HEALTH AND DISEASE AT BRONZE AGE TELL LEILAN, SYRIA

BY

HUGH GARNET MCKENZIE

A Thesis Submitted To The Faculty Of Graduate Studies And Research In Partial Fulfillment Of The Requirements For The Degree Of Master Of Arts

DEPARTMENT OF ANTHROPOLOGY

Edmonton, Alberta
Spring, 1999

0-612-40013-1

ABSTRACT

Lying within the Habur Plains of northern Syria, Tell Leilan was continuously occupied for more than three millennia until its sudden abandonment around 2200 BC. On the basis of paleoclimatic data, it has been suggested that this abandonment was the result of rapid and severe changes in environmental conditions that made it impossible to maintain the agriculturally-based city. In a preliminary exploration of this suggestion, skeletal remains of 21 adult individuals from Tell Leilan were examined for evidence of physiological stress and trauma. Stress, resulting from severe environmental degradation and leading to site abandonment, would be expected to manifest itself in chronic infections, nutritionally related diseases and trauma. In the sample examined, a relative lack of evidence for osteoarthritis and relatively high prevalence of chronic infection, anemia, and biomechanical strain as evidenced by periostitis, cribra orbitalia and enthesial alterations respectively, seems to indicate a population that was suffering from some degree of chronic stress. While the exact nature of this stress is unknown, it seems plausible that it is related to the environmental degradation surrounding site abandonment. These conclusions must, however, be considered tentative due to the small skeletal sample available for analysis.

ACKNOWLEDGEMENTS

I would not have been able to complete this thesis without the assistance of a number of individuals.

First I would like to express gratitude to my supervisor, Dr. Nancy Lovell for providing me with the opportunity to participate in her extensive Tell Leilan research project and for her guidance at every stage of my research.

I thank Margaret Judd for generously providing me with copies of her data collection forms, layout space and early morning conversations; Sarah Walshaw and Rebecca Feasby for references on Tell Leilan and Shauna McGarvey for innumerable references on paleopathology as well as her abilities in computer scanning. I also thank Dr. Andrzej Weber for the use of his computer and his assistance in scanning photographs.

I would also like to gratefully acknowledge the two years of financial support provided to me from the Department of Anthropology as well as the incalculable support from Darlene Bagstad, Harvey Friebe, Liz Jobagy, Cheryl Luchkow, Gail Matthew, Pam Mayne Correia and Marlys Rudiak.

To my officemates Derek Honeyman and Marc Pinkoski, and to Rob Wishart who might as well have been an officemate, I give special thanks for their constant encouragement and for providing me with an incredibly enjoyable "work" environment.

Lastly, I thank my parents for never asking me how a degree in Anthropology would allow me to support them in their old age.

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

LIST OF PHOTOGRAPHIC PLATES

CHAPTER ONE -- INTRODUCTION

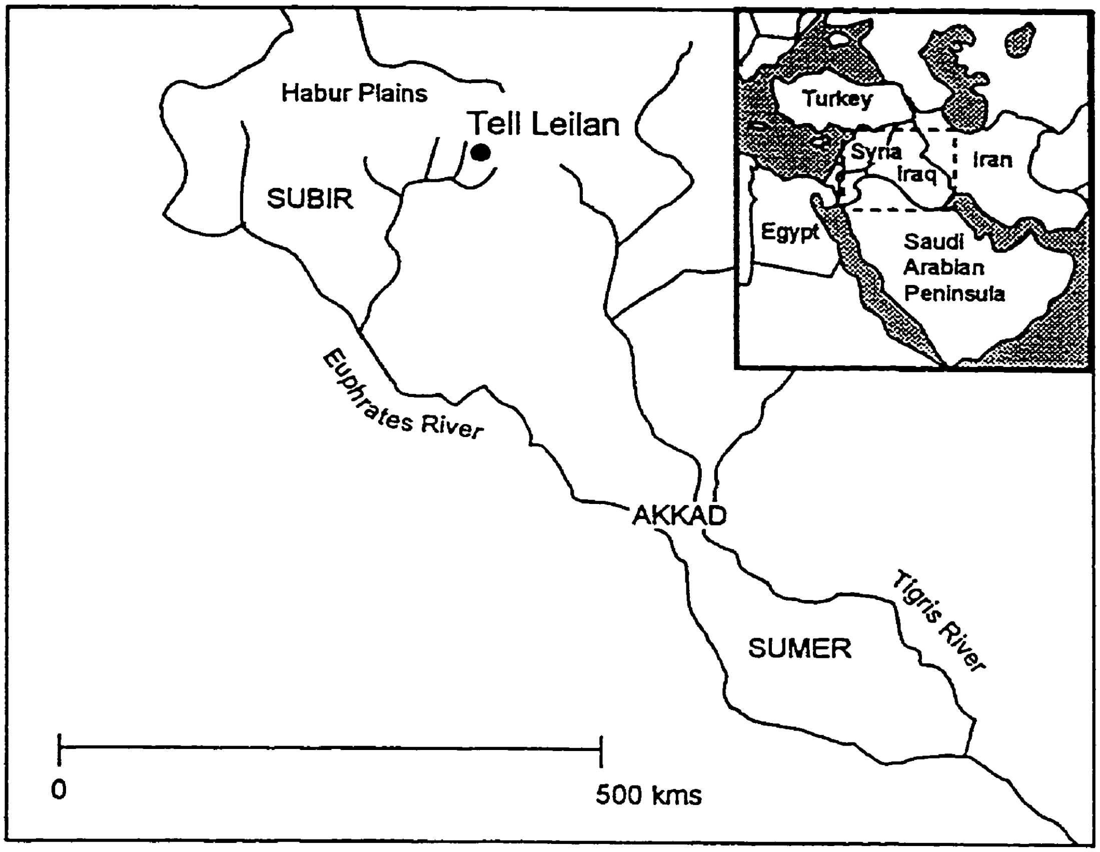
Compared to other areas of the world (*e.g.*, southern Mesopotamia, Egypt, Indus Valley), little is known about the origin and development of complex society in northern Mesopotamia. While the emergence of third millennium cities and states in southern Mesopotamia has been linked to the production and distribution of an agricultural surplus, a phenomenon initiated as early as the sixth millennium B.C. with the precursors of urbanization and irrigation agriculture, contemporary centers in northern Mesopotamia show neither the use of irrigation nor a tradition of long term urban development (Weiss 1985a, 1985b; but see Kühne 1990; Rosen 1995). As such, traditional interpretations have assumed that civilization was brought intact to the north by colonists from the southern based Sumerian and Akkadian empires (*e.g.*, Jawad 1965; Wenke 1990). New archaeological data, however, as well as a new model for the genesis and collapse of Subir (also called Subartu) on the Habur (Khabur) plains of northeastern Syria, have brought this assumption into question (Weiss and Courty 1993, Weiss *et al.* 1993). Rather than viewing the north as a passive recipient of southern civilization, this new model views the relationship between northern and southern Mesopotamia as a complex reciprocal arrangement. Instead of exporting urbanization to the north in the mid-third millennium, the Akkadian Empire apparently made use of existing northern urban centers to support its imperial expansion (Weiss 1983, 1985b, 1986a, 1986b, 1990a, 1990b, 1990c). The sudden collapse of Subir and the abandonment of northern Mesopotamia at around 2200 B.C., is likewise not believed to be a *result* of the collapse of the southern based Akkadian Empire but, rather, as the *cause* of the Akkadian collapse (Weiss and Courty 1993, Weiss *et al.* 1993). Much of the data supporting this model comes from the archaeological site Tell Leilan.

Lying within the Habur Plains of northern Syria (Fig. 1.1), Tell Leilan was occupied for more than three millennia. A typical, small agricultural community between ~4600 B.C. and 2600 B.C., Tell Leilan grew into a city exhibiting state level society and covering more than 200 acres by 2400 B.C. Between 2300 B.C. and 2200 B.C., the city was further expanded by the imperialist Akkadian Empire. Less than a century after the Akkadians took control, however, Tell Leilan was suddenly abandoned and remained unoccupied for approximately two centuries. Weiss *et al.* (1993) have suggested that this abandonment was the result of rapid and severe changes in environmental conditions which made it impossible to maintain the agriculturally-based city. This hypothesis derives most of its evidence from sediment analyses which indicates that at around the time of site abandonment there were "centuries of flailing wind and relentless drought" (Weiss 1996:33). This drought is assumed to have made "rain-fed farming difficult if not impossible" (ibid.) forcing people to abandon the region. While such an environmental shift seems to be well supported by geoarchaeological and paleoclimatic data (Courty 1994; Issar 1995; Otterman and Starr 1995; Weiss 1996; for a summary of the evidence of climate change at the end of the Third millennium B.C. see Rosen 1995), the effect that this shift had on the *people* of northern Mesopotamia (specifically the people of Tell Leilan) remains unknown. In a preliminary exploration of this problem, the research presented here investigates both biological and social responses to changing environmental conditions at Tell Leilan as displayed in the human skeleton.

There has been relatively little work completed on skeletal material from Bronze Age Mesopotamia as a whole and that published has generally been concerned with the analysis of metric traits and the determination of 'race' (*e.g.*, Angel 1968; Buxton and Rice 1931; Cappieri 1969, 1970, 1972, 1973; Krogman 1940a; Rathbun 1979, 1982) or has focused primarily on sites in southern Mesopotamia, Anatolia and the Iranian Plateau (*e.g.*, Angel and Bisel 1986; Krogman 1940b; Rathbun 1972, 1975, 1984; Smith 1989). This thesis presents a reconstruction of the health of the population at Bronze Age Tell Leilan, with the aim of providing insights into the nature of the development and abandonment of the city as well as the lifeways of people living in northern Mesopotamia during the third millennium B.C. Patterns of skeletal markers of physiological stress and trauma provide the primary evidence for the health and nutrition of a person or population living in the past. Malnutrition, infectious disease, occupational stress and trauma can all produce telltale signs on the skeleton which, when carefully interpreted, may provide insights into the bio-cultural adaptation of a population to their environment.

To establish the context of this investigation, Chapter Two reviews the geography and ecology of Mesopotamia, outlines a brief chronology of ancient Mesopotamia, describes in greater detail the model for the origin and collapse of mid-third millennium B.C. civilization on the Habur Plains as proposed by Weiss *et al.* (1993) (see also Weiss and Courty 1993) and identifies alternative interpretations. Chapter Three then presents, in paper format, the methods, results and discussion of the specific application of paleopathology to the site of Tell Leilan and, finally, Chapter Four summarizes the results of this study, critiques the methodology and proposes future avenues of research.

Figure 1.1 – Map of Ancient Mesopotamia Indicating the Location of Tell Leilan



REFERENCES CITED

Angel JL (1968) Appendix: Human Remains at Karatas. American Journal of Archaeology 72:260:263.

Angel JL and SC Bisel (1986) Health and Stress in an Early Bronze Age Population. In JV Canby, E Porada, BS Ridgway and T Stech (eds.): Ancient Anatolia. Madison: University of Wisconsin Press, pp. 12-30.

Buxton LHD and Rice DT (1931) Report on the Human Remains Found at Kish. Journal of the Royal Anthropological Institute of Great Britain and Ireland 61:57-119.

Cappieri M (1969) The Mediterranean Race in Asia before the Iron Age. Occasional Paper No. 8. Field Research Projects. Coconut Grove, Miami

Cappieri M (1970) The Mesopotamians of the Chalcolithic and Bronze Ages. Occasional Paper No. 12. Field Research Projects. Coconut Grove, Miami

Cappieri M (1972) Genotypical and Phenotypical Homogeneity of the Ancient Population of Anatolia. Field Research Projects. Coconut Grove, Miami

Cappieri M (1973) The Iranians of the Copper/Bronze Age. Field Research Projects. Coconut Grove, Miami

Courty M-A (1994) Le Cadre Paléogéographique des Occupations Humaines dans le Bassin du Haut-Khabur (Syrie du Nord-Est). Premiers Résultats. Paleorient 20/1:21-59.

Issar AS (1995) Climatic Change and the History of the Middle East. American Scientist 83:350-355.

Jawad AJ (1965) The Advent of the Era of Townships in Northern Mesopotamia. Leiden: Brill.

Krogman (1940a) The Peoples of Early Iran and their Ethnic Affiliations. American Journal of Physical Anthropology 26: 269-308.

Krogman (1940b) The Skeletal and Dental Pathology of an Early Iranian Site. Bulletin of the History of Medicine 8:28-48.

Kühne H (1990) The Effects of Irrigation Agriculture: Bronze and Iron Age Habitation Along the Khabur, Eastern Syria. In Entjes-Nieborg and van Zeist (eds.): Man's Role in the Shaping of the Eastern Mediterranean Landscape. Rotterdam: Balkema, pp. 15-30.

Otterman J and Star DO'C (1995) Alternative Regimes of Surface and Climate Conditions in Sandy Arid Regions: Possible Relevance to Mesopotamian Drought 2200-1900 BC. Journal of Arid Environments 31:127-135.

Rathbun TA (1972) A Study of the Physical Characteristics of the Ancient Inhabitants of Hasanlu, Iran. Study no. 68. Field Research Papers. Coconut Grove, Miami.

Rathbun TA (1975) A Study of the Physical Characteristics of the Ancient Inhabitants of Kish, Iraq. Study No. 87. Field Research Projects, Coconut Grove, Miami.

Rathbun TA (1979) Metric and Discrete Trait Variation among Metal Age Iranian and Mesopotamian Populations. American Journal of Physical Anthropology 50 (3): 473.

Rathbun TA (1982) Morphological Affinities and Demography of Metal-Age Southwest Asian Populations. American Journal of Physical Anthropology 59: 47-60.

Rathbun TA (1984) Skeletal Pathology from the Paleolithic Through the Metal Ages in Iran and Iraq. In MN Cohen and GJ Armelagos (eds.): Paleopathology at the Origins of Agriculture. Orlando: Academic Press Inc., pp. 137-168.

Rosen AM (1995) The Social Response to Environmental Change in Early Bronze Age Canaan. Journal of Anthropological Archaeology 14: 26-44.

Smith P (1989) The Skeletal Biology and Paleopathology of Early Bronze Age Populations in the Levant. In P de Miroschedji (ed.): L'urbanisation de la Palestine à l'age du Bronze ancient: Bilan et Perspectives de Recherches Actuelles. Actes du Colloque d'Emmaüs (20-24 Octobre). BAR International Series 527(ii): 297-313.

Weiss H (1983) Excavations at Tell Leilan and the Origins of North Mesopotamian Cities in the Third Millennium B.C. Paleorient 9: 39-52.

Weiss H (1985a) Introduction. In H Weiss (ed.): Ebla to Damascus: Art and Archaeology of Ancient Syria. Washington: Smithsonian. pp. 30-44.

Weiss H (1985b) Third Millennium Settlement and Subsistence. In H Weiss (ed.): Ebla to Damascus: Art and Archaeology of Ancient Syria. Washington: Smithsonian. pp. 123-129.

Weiss H (1986a) Introduction: The Origins of Cities in Dry-farming Syria and Mesopotamia in the Third Millennium B.C. In H Weiss (ed.): The Origins of Cities in Dry-Farming Syria and Mesopotamia in the Third Millennium B.C. Guildford: Four Quarters, pp. 1-6.

Weiss H (1986b) The Origins of Tell Leilan and the Conquest of Space in Third Millennium Mesopotamia. In H Weiss (ed.): The Origins of Cities in Dry-Farming Syria and Mesopotamia in the Third Millennium B.C. Guilford: Four Quarters, pp. 71-108.

Weiss H (1990a) "Civilizing" the Habur Plains: Mid-third Millennium State Formation at Tell Leilan. In CM vanLoon, P Matthiae, and H Weiss (eds.): Resurrecting the Past. Leiden: Nederlands Instituut voor het Nabije Oosten, pp. 387-407.

Weiss H (1990b) Tell Leilan 1989. New Data for Mid-Third Millennium Urbanization and State Formation. Mitteilungen der Deutschen Orient-Gesellschaft 122:193-218.

Weiss H (1990c) Third Millennium Urbanization: A Perspective from Tell Leilan. In S Eichler, M Wafler and D Warburton (eds.): Tall Al-Hamidiya 2: Recent Excavations in the Upper Khabur Region. Netherlands: Universitatsverlag Frielburg Schweiz.

Weiss H (1996) Desert Storm. The Sciences May/June: 30-36.

Weiss H and Courty M-A (1993) The Genesis and Collapse of the Akkadian Empire: The Accidental Refraction of Historical Law. In M Liverani (ed.): Akkad: The First Empire. Padua: Sargon, pp. 129-154.

Weiss H, M-A Courty, W Wetterstrom, G Guichard, L Senior, R Meadow, A Curnow (1993). The Genesis and Collapse of Third Millennium North Mesopotamian Civilization. Science 261:995-1004.

Wenke RJ (1990) Patterns in Prehistory: Humankind's First Three Million Years (3rd ed.). Oxford: Oxford University Press.

CHAPTER TWO -- ENVIRONMENTAL AND ARCHAEOLOGICAL CONTEXT

2.1 Mesopotamia - A Brief Geographical/Ecological Overview

The varied geography and ecology of Mesopotamia has, in many ways, conditioned its cultural development. Consequently, before presenting a cultural chronology of Mesopotamia it is instructive to have some knowledge of its various geographic zones. Specifically, it is necessary to point out the differences between northern and southern Mesopotamia and to describe the Habur Plains of northeastern Syria, the region with which this research is concerned.

Greater Mesopotamia, broadly defined as the land between the Tigris and Euphrates rivers (Postgate 1992), is divided into two regions on the basis of their geography, ecology and dependent forms of agriculture (Fig. 2.1). **Southern Mesopotamia** (often referred to simply as Mesopotamia) consists of the alluvial plains of the Tigris and Euphrates rivers in what is now Iraq. In terms of physical geography, this region is characterized by the flatness of its terrain, the landscape remaining only 20 m above sea level as far as 500 km north of the Persian Gulf (Postgate 1992). Climatically, southern Mesopotamia is distinguished by low annual rainfall (< 200mm) and high intra-annual variability. The lack of moisture here makes non-irrigation agriculture (also called 'dry farming') impossible. As such, farmers in southern Mesopotamia made use of the easily diverted water courses across the alluvium in order to irrigate their crops.

Northern Mesopotamia, lying within the arc defined by the Zagros and Taurus Mountains and the western reaches of the Euphrates, contains the northern highland plains stretching across northern Iraq and Syria, as well as the flood plains of the Euphrates and its two major tributaries the Habur and Balikh. In many ways, northern Mesopotamia is in direct contrast to the southern region. In terms of physical geography, northern Mesopotamia is characterized by rolling hills cut by deep ravines making irrigation difficult. Climatically, however, northern Mesopotamia is defined by high annual rainfall (> 300 mm) and low intra-annual variability making irrigation unnecessary for agricultural production (Postgate 1992, Weiss 1983a). As a result, farmers in northern Mesopotamia have traditionally relied on rain-fed agriculture (dry-farming). The southern border of northern Mesopotamia is, in fact, delineated by the 200 mm isohyet which marks the boundary between dry farming and irrigation agriculture regimes (Postgate 1992) (Fig. 2.2).

Located in what is now northeastern Syria, the Habur Plains are characterized by gently rolling hills along the Habur River drainage. The fertile brown or red soils tend to be shallow but well drained and lie over limestone or basalt bedrock (Weiss 1990). Annual rainfall in the region averages between 300 and 500 mm, well above the level necessary for dry-farming cereal production (Weiss 1983a). Today, the Habur plains provide over a quarter of the cereal production for Syria without the use of irrigation (Weiss 1983a, 1986). Tell Leilan is located in the center of the Habur Plains along the left bank of the Wadi Jawah.

2.2 Ancient Mesopotamia - A Brief Chronology

This section provides a brief summary of the chronology of ancient Mesopotamia from approximately 5000-2100 B.C. (Fig. 2.3). Where appropriate, regional (*i.e.* northern vs. southern) differences are noted. Because the research presented here is specifically concerned with developments on the Habur Plains, special attention is paid to the chronology of this area and of the archaeological site Tell Leilan in particular. A more detailed account of mid-third millennium development at Tell Leilan (and the rest of the Habur Plains) is presented in the following section.

'Ubaid Period (~5000-4000 B.C.)

While small agricultural settlements were present in the north at least as far back as the seventh millennium B.C. (Bader 1993a, 1993b, 1993c, Moore 1985; Weiss 1985a), widespread settlement in Mesopotamia as a whole did not begin until what is termed the 'Ubaid Period dating from sometime in the late sixth or early fifth millennium B.C. and ending somewhere around the beginning of the fourth millennium B.C. (Adams 1981, Porada *et al.* 1992, Postgate 1992, Wenke 1990). Defined by a series of painted ceramic styles, 'Ubaid sites are found throughout southern and northern Mesopotamia.

In southern Mesopotamia, early 'Ubaid settlements are characterized by small (less than 10 hectares), undifferentiated villages, which seem to be evenly and sparsely distributed across the alluvium. Towards the end of the 'Ubaid period, there appears to be some indication of larger sites containing evidence for social differentiation and greater complexity (*e.g.*, Uruk, Tell 'Uquair). The relationship between these larger sites and the typical smaller sites is, however, unclear. While on the southern part of the alluvium there is some evidence that the larger sites may have served as centers for exchange of goods from the surrounding agricultural hinterlands, the dispersed nature of settlements in the northern and central parts of the alluvium does not seem to support such a scenario (Adams 1981). Instead, Adams (1981) believes that a pastoral way of life was still important in these regions indicating, to him, that irrigation agriculture was not yet the dominant form of subsistence.

In northern Mesopotamia, 'Northern 'Ubaid' settlements are essentially the same as those in the south and links between the two regions are indicated by similar ceramic traditions as well as other material elements such as bent clay nails that are found at a variety of both northern and southern sites (Schwartz and Weiss 1992). It should be noted, however, that many northern settlements did not use or produce 'Ubaid pottery but instead used distinct local pottery styles as well as the "chaff-faced" wear from southeastern Anatolia and the Levant (Surenhagen 1986).

The earliest evidence for settlement at Tell Leilan (Leilan Period V) corresponds to the Late Northern 'Ubaid Period and dates to around 4600 B.C. Since sterile sediments at the site were never reached, however, the potential exists for this sequence to go back even further (Schwartz and Weiss 1992).

Uruk Period (~4000-3200 B.C.)

The Uruk Period, beginning in southern Mesopotamia at approximately 4000 B.C. and ending around 3200 B.C. is often cited as the period in which primary state formation first took place in Mesopotamia (Wenke 1990). It is during this period that we see the transition from simple undifferentiated farming villages, as exemplified in the 'Ubaid period, to large urban centers containing, among other things, evidence for monumental architecture, writing, specialized labour, and the mass production of commodities.

In southern Mesopotamia the rapid growth of cities such as Uruk seems to be related to the simultaneous abandonment of surrounding rural settlements (Adams 1972). Despite the apparent 'revolutionary' nature of this transition, however, the changes appear to be simply an extension of local processes that were beginning at the end of the 'Ubaid period. Evidence for the endogenous nature of the transition is seen in the continuity between late 'Ubaid and early Uruk sequences at sites such as Eridu and Uruk (Postgate 1992). The material hallmarks of this period are light-coloured, unpainted ceramics and the beveled-rim bowl, both of which are ubiquitous at Uruk period sites. While it has been argued that the beveled-rim bowls represent a system of centralized grain-rationing (Beale 1978, Nissen 1988, Wright and Johnson 1975), Adams (1981) notes that the lack of a close relationship between site size and bowl frequency precludes this interpretation. Whatever their function, however, there is no question that the bowls were produced in a standardized fashion and on a scale previously unknown in Mesopotamia indicating the operation of some sort of centralized administration.

In northern Mesopotamia, evidence for the Uruk period is less straightforward. Unlike in the south, the early Uruk period in northern Mesopotamia is not characterized by large scale urbanization but, rather, by small farming villages virtually indistinguishable from the villages of the sixth and fifth millennia B.C. It is not until the Late Uruk expansion (beginning ~3400 B.C.), that we first see evidence for the existence of cities in the north. During this period, southern based Uruk states expanded into the northern rain-fed regions and established 'colonies' such as Habuba Kabira South and Tell Quannas along the shores of the Euphrates (Surenhagen 1986). While the purpose of this expansion is unknown, the distribution of 'colony' sites along trade routes through the Zagros and along the Euphrates may indicate the need for raw materials such as metals or wood, or, for more exotic materials for southern elites (Adams 1981, Weiss and Courty 1993).

In northeastern Syria, the situation appears to be slightly different. Rather than finding the sudden appearance of full blown Uruk 'colonies', sites on the Habur Plains possess a mixture of local and Uruk assemblages and, as a result, are referred to as 'Uruk related' sites (Surenhagen 1986). Apparently the Uruk developments at these locations do not represent the sudden intrusion of southern populations as is hypothesized at the 'colonies' but, rather, represent the continued evolution of long term local traditions (Weiss 1985b).

At Tell Leilan, Uruk period remains are found in Leilan Periods V and IV. While both periods are characterized by a local 'chaff-faced' ceramic assemblage, Period V is distinguished by the appearance of beveled-rim bowls (Schwartz and Weiss 1992).

Suddenly, however, at the end of the fourth millennium B.C., Uruk settlements in the north are abandoned. It is possible that this abandonment was related to the actions of Anatolian groups who began restricting Uruk access to northern materials thereby collapsing the Euphration trade route (Surenhagen 1986). Whatever the cause, none of the Uruk colonies show evidence of occupation in the next period and settlement in the north returns to a pattern of small, dispersed farming villages. For the next 400 years or so (from ~3000-2600 BC), southern and northern Mesopotamia develop in relative isolation from each other.

Ninevite V Period

Following the Late Uruk period on the Habur Plains is the poorly understood Ninevite V period. While the duration of this period has been estimated to be as long as 800 years (*e.g.*, Weiss 1983a, 1983b, 1990; Schwartz and Weiss 1992), the most recent chronology from Tell Leilan indicates that it probably only extended from approximately 3000-2400 B.C. (Weiss 1994). Characterized by the Ninevite V ceramic style, little is known about this period. Settlements were apparently small (sites in the region surrounding Tell Leilan averaged ~5.5 hectares) and evenly distributed with no evidence for social stratification (Schwartz 1986, 1987). Remains from Tell Leilan itself (Leilan Period III) indicate that it was a farming village of no more than 15 hectares. Around 2600 B.C., however, Tell Leilan, and other northern Mesopotamian sites suddenly expand and, within 200 years, are fully urban (see below).

Jemdet Nasr and Early Dynastic Periods

The period of isolation in southern Mesopotamia corresponds to the enigmatic and short lived Jemdet Nasr period (~3200-3000 B.C.) and the beginnings of the Early Dynastic period (3000-2350 B.C.). Characterized by polychrome pottery, very little is known about the Jemdet Nasr period except that it seems to be restricted to southern Mesopotamia.

The Early Dynastic period in southern Mesopotamia is associated with the rise of the Sumerian city-states, which are ruled by successive royal dynasties. Evidence for the secular nature of leadership is clear in the monumental architecture that includes, for the first time, rich palaces as opposed to temples and huge royal cemeteries. There were, apparently, up to thirty different city-states that controlled various parts of southern Mesopotamia during the Early Dynastic period (Postgate 1992). The relations between these polities varied from both political and economic cooperation, to military confrontation. While it appears that some city-states were dominant over others (*e.g.*, Kish appears to be the dominant city for much of the period), there is no evidence that any one city imposed itself on the internal affairs of another city (*ibid.*). This picture changes radically, however, during the middle of the third century with the emergence of the Akkadian Empire.

Akkadian Period

With the rise to power of Sargon of Akkad at approximately 2350 B.C. (using the standard middle chronology[1]), southern Mesopotamian once again comes into direct contact with northern Mesopotamia. Through extensive military campaigns, Sargon and his descendants defeated and unified all of southern and most of northern Mesopotamia into what is known as the Akkadian empire. The Akkadian empire dominated Mesopotamia for less than 200 years, however, and sometime around 2200 B.C., collapsed. It was not until 2100 B.C. that political control was once again established over the southern alluvium by the Ur III dynasty (Wenke 1990).

Akkadian influence on northern Mesopotamia is discussed in the next section within the context of urbanization on the Habur Plains during the mid-third millennium.

[1] Three absolute chronologies have been proposed for the 14th - 27th Centuries B.C.: the High Chronology, the Middle Chronology and the Low Chronology. The Middle Chronology has acquired general acceptance in the English-speaking world (Weiss 1985c)

2.3 The Origins and Collapse of Third Millennium Civilization in Northern Mesopotamia

Following three centuries of small village life, the settlement pattern on the Habur Plains was substantially altered with the sudden appearance of state level society at around 2600 B.C. A model for the genesis and collapse of this civilization, termed the Subir or Subartu, has been outlined by Weiss *et al.* (1993); see also Weiss and Courty (1993) and is described here. Table 2.1 provides a summary of the model.

Stage 1. Leilan IIId (ca. 2600-2400 B.C.): Secondary State Formation

In the 200 years represented by Stage One, Tell Leilan grew from a 15 hectare Acropolis-based settlement to a 100 hectare settlement which expanded beyond the boundaries of the Acropolis to include the Lower Town (Fig. 2.4). The Lower Town appears to have been carefully planned with paved streets and alleys that were lined by walls probably delimiting property lines. In the Acropolis, the transition from a simple village economy to a centrally administered economy is indicated by the replacement of previous village domestic buildings with large rectangular storerooms containing cylinder seal impressions. Analysis of these seals indicate that they are local imitations of the contemporary Early Dynastic II-IIIa seals from southern Mesopotamia. This seems to indicate that northern leaders were attempting to emulate southern administrative iconography in order to legitimize their own incipient power. Ceramics during this period were of the late Ninevite V incised tradition.

On a regional scale, this stage also sees a reorganization of settlement patterns across the Habur Plains. Two other sites, Tell Brak and Tell Mozan show the same kind of rapid urbanization as Tell Leilan and, together, these three roughly equidistant sites seem to have controlled the entire region.

It has been suggested that the changes observed in Stage One may have been a response to climatic deterioration (Weiss and Courty 1993). Centrally administered economies and mixed land-use strategies were, it is argued, better adapted to circumstances of increased variability of rainfall.

Stage 2. Leilan IIa (ca. 2400-2300 B.C.): Consolidation of State Power

Consolidation of State power in Stage 2 is marked at Tell Leilan by two major innovations. First, we see the construction of a 2.5 meter thick wall around the Acropolis. The purpose of the wall was apparently to protect the city's storerooms and administrative buildings as well as to protect and isolate the city's elite population from the residents of the Lower Town and the surrounding hinterlands (Weiss and Courty 1993, Weiss *et al.* 1993).

The second innovation is the change in ceramic technologies from the labour intensive Ninevite V incised tradition to a 'mass produced' style. It is argued that the production of ceramics was centrally controlled and that the vessels were used not only as containers but also as a form of standardized measurement for such things as payment distribution and tax collection (Weiss and Courty 1993, Weiss *et al.* 1993).

Stage 3. Leilan IIIb (ca. 2300-2200 B.C.): Imperialization

In Stage 3 the Akkadian Empire expanded its borders to conquer northern Mesopotamia including the Habur Plains. The conquest of Subir was accomplished by Sargon's grandson Naram-Sim who established an Akkadian center at Tell Brak from which control over the rest of the Plains was exercised. At Tell Leilan, Akkadian control is indicated on the basis of five features:

1) Population redistribution: larger settlements around Tell Leilan were reduced in size while smaller village sized settlements were maintained. It is argued that the larger sites were reduced in an effort to centralize the administrative body and to prevent the traditional local elite from playing a part in the administration of production. Smaller villages were apparently preserved in order to maintain the imperialized agricultural production.

2) Two concentric 8 m thick walls were constructed around the entire city in order to protect the imperial administrative centers and storehouses.

3) Analysis of plant remains from house floors and courtyards in the Lower Town South indicate that the grains had already undergone primary and secondary processing prior to entering the city. This is taken as evidence that the grain was processed and stored elsewhere before being distributed, probably as labour ration payments.

4) Leilan sila bowls are found only in this period and seem to be standardized in terms of their capacity (0.3 L, 1 L and 1.5 L). It is argued that these were used for distribution of grain and oil rations according to Akkadian imperial standards (see also Blackman *et al.* 1993; Senior and Weiss 1992).

5) Agricultural production was intensified through the construction of canals and the deepening and straightening of existing water channels.

Stage 4. Habur Hiatus 1 (ca. 2200-1900 B.C.): Collapse

At approximately 2200 B.C. three apparently simultaneous events occur. First, Tell Leilan is suddenly abandoned and remains unoccupied until around 1900 B.C. During the same time period, termed the 'Habur Hiatus 1', settlements all across northern Mesopotamia are also abandoned. Second, as evidenced by an analysis of soil characteristics, there is an abrupt climate change characterized by an intensification of wind, an increase in dust, and increased aridity. Third, the Akkadian Empire collapses in southern Mesopotamia. Weiss *et al.* (1993) believe that these three events are causally related.

It is hypothesized that the abrupt climate change made agriculture difficult if not impossible in northern Mesopotamia due to a decrease in soil moisture and an increase in aeolian soil loss. The reduction of agricultural productivity would have, in turn, forced the people of northern Mesopotamia to abandon the region. Around Tell Leilan it is estimated that there would have been a net loss of approximately 182 hectares of agricultural land which would have displaced between 14 000 and 28 000 people within 15 km of the site and three to four times that many people when adjacent settlement systems are considered. The loss of agricultural returns from the northern lands, plus the massive southern movement of northern settlers is hypothesized to have overwhelmed an already suffering Akkadian empire engendering its collapse. As further evidence that climate change led to the Akkadian collapse, Weiss *et al.* (1993) point to apparently simultaneous collapses in the Aegean, Egypt, Palestine and the Indus Valley.

While the model just outlined for the origin, development, and collapse of Mesopotamian civilization has, as of late, been widely publicized (Issar 1995, Weiss 1996, Wright 1998), it is by no means a perspective which is agreed upon by all scholars. Many researchers doubt the validity of using resource depletion as a cause for the collapse of any civilization. To cite environmental factors as prime movers, they claim, is to state that either a civilization does nothing to try to adapt and overcome the changing conditions, or that the conditions are such that the civilization cannot overcome them (Tainter 1988, Rosen 1995, 1997). Because it seems unlikely that any group of people would remain idle in times of stress, one must ask *why* a particular society was unable to adapt to the changing conditions. The important questions, then, should deal with the organization of the society and not the depleting resources (Rosen 1995, Tainter 1988, Kaufman 1988). "What structural, political, ideological, or economic factors in a society prevented an appropriate response? (Tainter 1988:50)." As support for this perspective, conflicting cases are often presented in which some societies, in the face of depleting resources, collapse while others increase in complexity (*e.g.*, Doyel 1981 as cited in Tainter 1988).

In Mesopotamia, a great number of alternative explanations have been proposed. Oates (1979) and Diakonoff (1969), for example, attribute the downfall of Sargon to Gutian invaders from the East. Struve (1969) and Tyumenev (1969) argue that the fall of Akkad was the result of economic weaknesses caused by the development of slave economies. Yoffee (1979, 1988) has ascribed the collapse of the Akkadian empire to the inability of Akkadian leaders to integrate within their rule the traditional leadership of the various city states. As such, political and economic institutions could not be legitimized over the entire Mesopotamian region allowing local political forces to regain their autonomy. Rosen (1995) has proposed that a number of factors may have inhibited Bronze Age societies from successfully adapting to changing climatic conditions including, among other things: a reliance on unsustainable "cash crops"; elite control over surplus resources preventing local farmers from preparing for drought; the removal of labour from agricultural production as specialization increased; and the possibility that elite segments of a society can profit from short term stress.

One way of examining a society's adaptation to changing environmental conditions is to examine the health and nutrition of its population. Environmental changes, such as those proposed at Tell Leilan, have the potential to affect health in a number of ways. First, a reduction in subsistence productivity would be expected to lead to conditions of undernutrition and/or malnutrition. Additionally, when we consider the synergistic relationship between nutritional deficiency and susceptibility to infection, we should also expect to find a high frequency of infectious disease. Both nutritional deficiency and infectious disease can manifest themselves on the skeleton in a variety of recognizable pathological conditions.

Besides direct biological stresses, such as nutritional deficiency and infectious disease, there are also potential social stresses that accompany rapid and severe environmental change. These social stresses can be reflected in such things as changing patterns of health and nutrition between different segments of society (*e.g.*, age, sex, status) (Schell 1997, Powell 1988). One might expect, for example, that elite members of a population, who presumably control the subsistence economy, would suffer less from a food shortage than would lower class members. This difference would be even more pronounced if, as Rosen (1995) proposes, elite segments of society can, in fact, profit from short term environmental stress. Similarly, one might speculate that in situations of social breakdown the potential exists for increased incidents of interpersonal violence, which could be reflected in trauma frequencies.

The remainder of this thesis will deal with the specific application of paleopathology to the site of Tell Leilan.

Table 2.1 - Summary of the Genesis and Collapse of Ancient Subir (adapted from Weiss and Courty 1993)

Stage	Temporal Period	Characteristics
Secondary State Formation	Leilan IIId ca. 2600-2400 B.C.	Urbanization and state formation; Leilan Acropolis "palace" and storerooms; administrative iconography/technology change from "piedmont" to local "Subarian" style.
Consolidation of State Power	Leilan IIa ca. 2400-2300 B.C.	Acropolis fortification; ceramic technology change to mass production.
Imperialization	Leilan IIb ca. 2300-2200 B.C.	Akkadian conquest and reorganization of regional production from nodal Brak imperial administrative centre; Leilan City wall construction; sila bowl production; channelization
Collapse	Habur Hiatus I ca. 2200-1900 B.C.	Desertification and desertion

Figure 2.1 – Map of Ancient Mesopotamia Indicating the Location of Tell Leilan

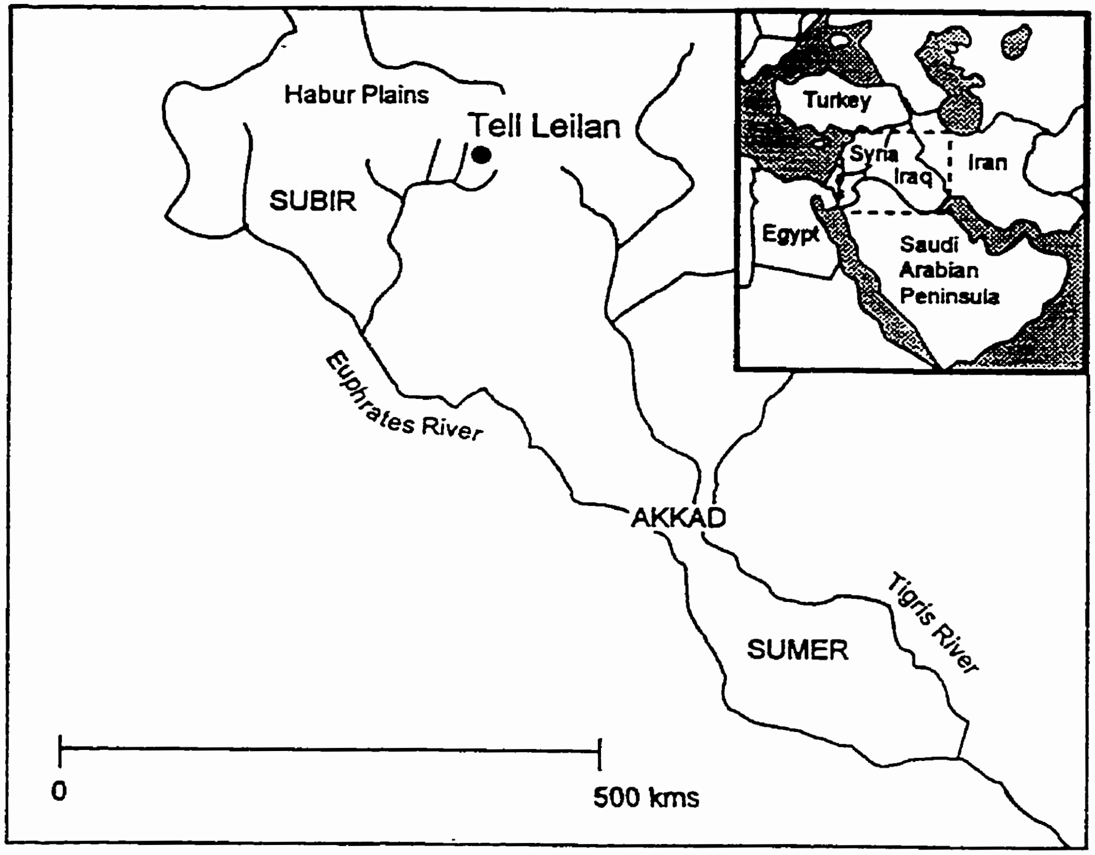
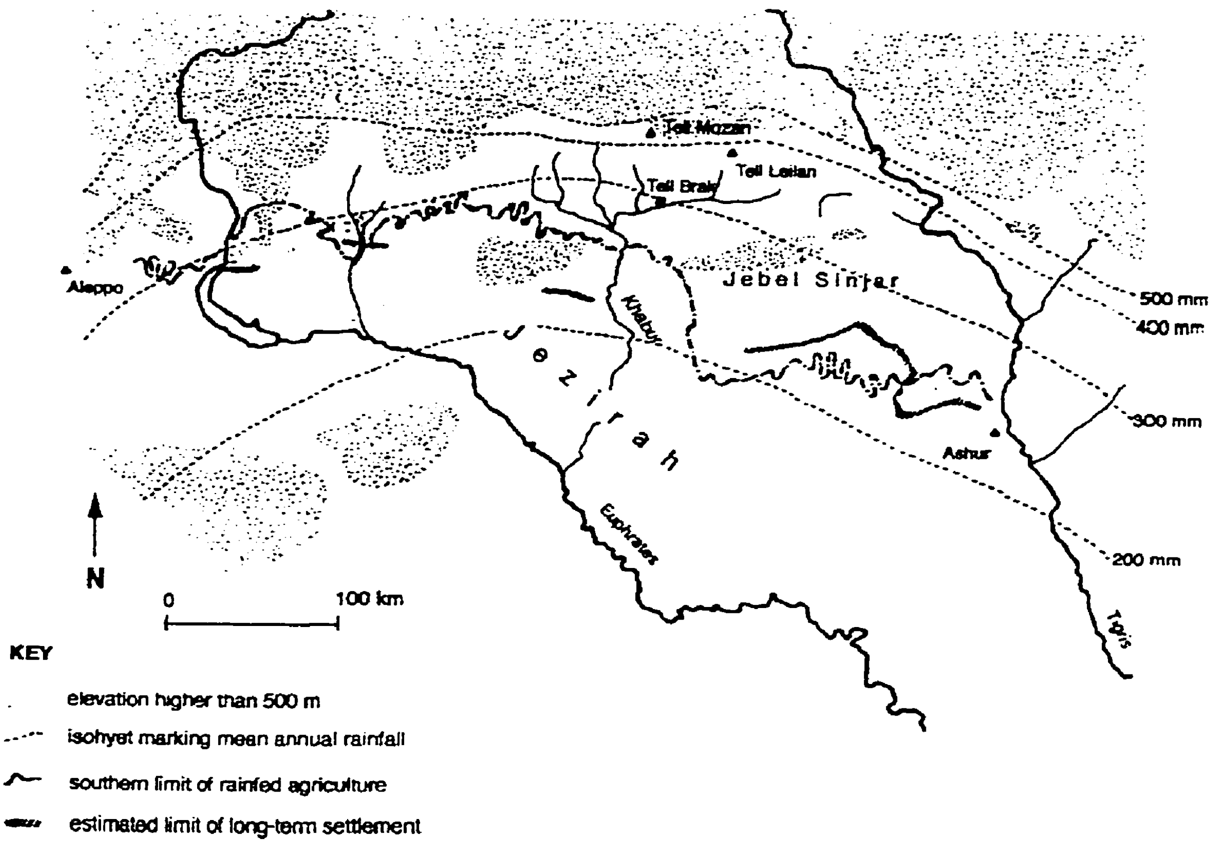
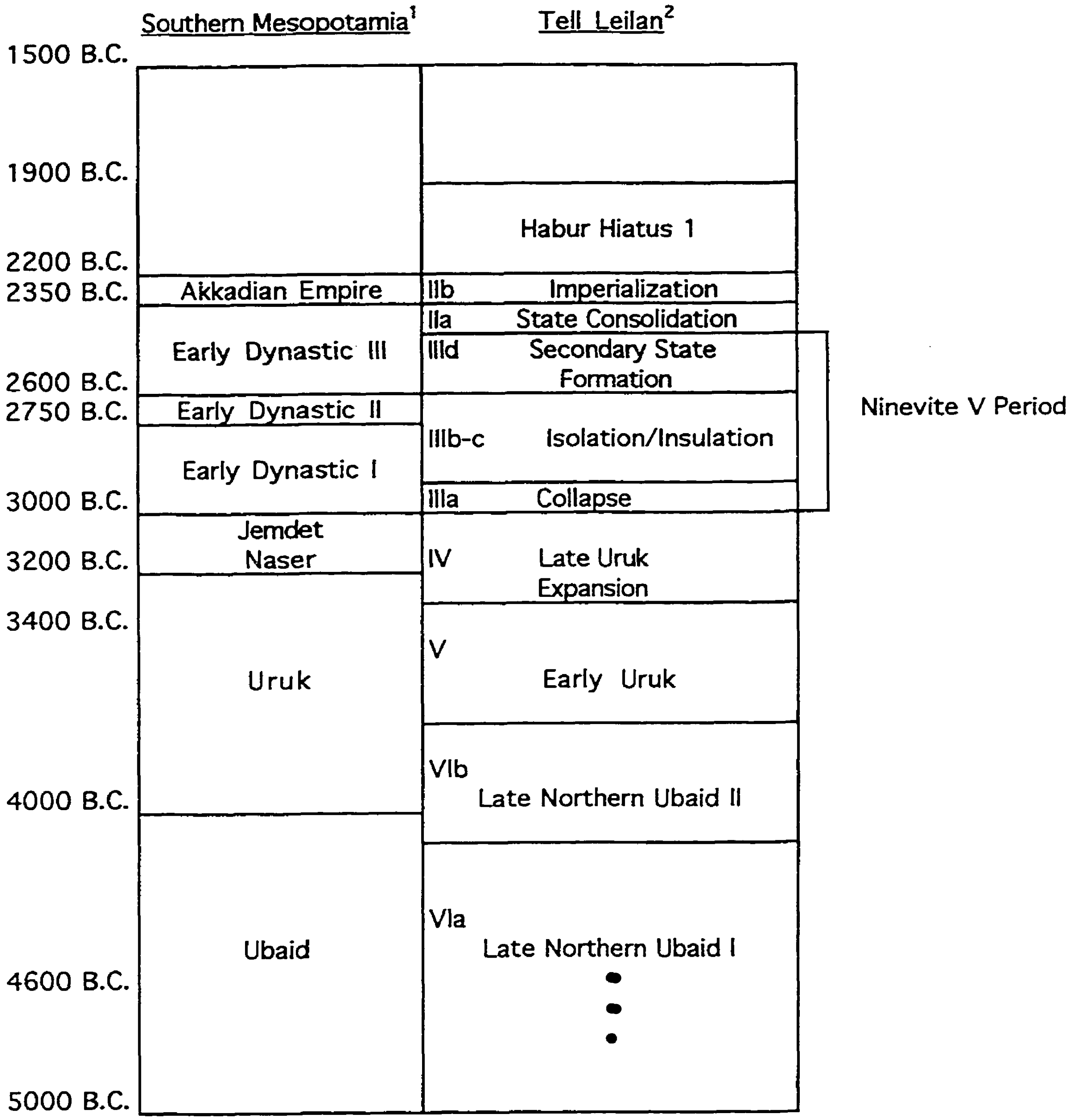


Figure 2.2 – Map of Ancient Mesopotamia Indicating Land Elevation Above Sea-level, Rainfall Isohyets, the Estimated Range of Longterm Settlement and the Southern Limit of Rainfed Agriculture (adapted from Wilkinson 1994:485).

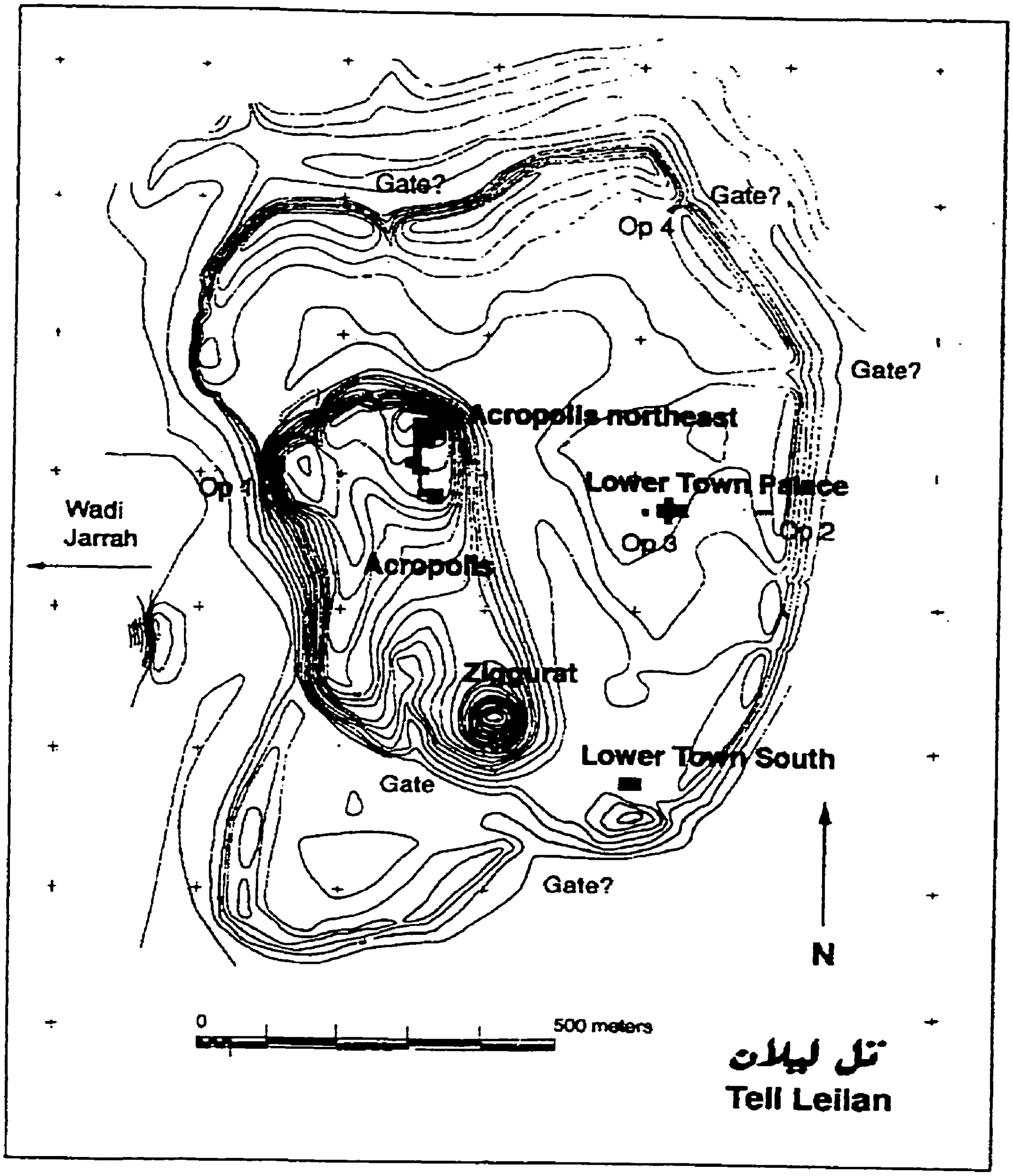




1Complied from Postgate 1992, Porada *et al* . 1992
2Weiss 1994

Figure 2.3 - Cultural Chronology for Ancient Mesopotamia and Tell Leilan

Figure 2.4 – Site Plan of Ancient Tell Leilan (adapted from Weiss 1983b)



REFERENCES CITED

Adams R McC (1972) Patterns of Urbanization in Early Southern Mesopotamia. In PJ Ucko, R Tringham and G Dimbleby (eds.): Man, Settlement and Urbanism: Proceedings of a Meeting of the Research Seminar in Archaeology and Related Subjects held at the Institute of Archaeology, London University. London: Duckworth, pp. 735-749.

Adams R McC (1981) Heartland of Cities. Chicago: University of Chicago Press.

Bader NO (1993a) Tell Maghzaliya: An Early Neolithic Site in Northern Iraq. In N Yoffee and JJ Clark (eds.): Early Stages in the Evolution of Mesopotamian Civilization: Soviet Excavations in Northern Iraq. Tucson: University of Arizona Press, pp. 7-40.

Bader NO (1993b) The Early Agricultural Settlement of Tell Sotto. In N Yoffee and JJ Clark (eds.): Early Stages in the Evolution of Mesopotamian Civilization: Soviet Excavations in Northern Iraq. Tucson: University of Arizona Press, pp. 41-54.

Bader NO (1993c) Summary of *The Earliest Agriculturalists of Northern Mesopotamia (1989).* In N Yoffee and JJ Clark (eds.): Early Stages in the Evolution of Mesopotamian Civilization: Soviet Excavations in Northern Iraq. Tucson: University of Arizona Press, pp. 63-72.

Beale TW (1978) Beveled Rim Bowls and Their Implications for Change and Economic Organization in the Later Fourth Millennium B.C. Journal of Near Eastern Studies 37: 289-313.

Blackman MJ, Stein GJ, Vandiver PB (1993) The Standardization Hypothesis and Ceramic Mass Production: Technological, Compositional, and Metric Indexes of Craft Specialization at Tell Leilan, Syria. American Antiquity 58(1): 60-80.

Diakonoff IM (1969) The Rise of the Despotic State in Ancient Mesopotamia. In IM Diakonoff (ed.): Ancient Mesopotamia: Social-Economic History. Moscow: Nauka, pp. 173-203.

Doyel DE (1981) Late Hohokam Prehistory in Southern Arizona. Gila Press Contributions to Archaeology 2.

Issar AS (1995) Climatic Change and the History of the Middle East. American Scientist 83:350-355.

Kaufman H (1988) The Collapse of Ancient States and Civilizations as a Organizational Problem. In N Yoffee and GL Cowgill (eds.): The Collapse of Ancient States and Civilizations. Tucson: University of Arizona Press, pp. 219-235.

Moore, MTA (1985) Syria and the Origins of Agriculture. In H Weiss (ed.): Ebla to Damascus: Art and Archaeology of Ancient Syria. Washington: Smithsonian, pp. 50-56.

Nissen H (1988) The Early History of the Ancient Near East, 9000-2000 B.C. Chicago: University of Chicago Press.

Oates J (1979) Babylon. London: Thames and Hudson.

Porada E, DP Hansen, S Dunham, SH Babcock (1992) Mesopotamia. In RW Enrich (ed.): Chronologies in Old World Archaeology: Third Edition, Volume I (pp. 77-121) and Volume II (pp. 90-124).

Postgate JN (1992) Early Mesopotamia: Society and Economy at the Dawn of History. London: Routledge.

Powell ML (1988) Status and Health in Prehistory. Washington: Smithsonian Institution Press.

Rosen AM (1995) The Social Response to Environmental Change in Early Bronze Age Canaan. Journal of Anthropological Archaeology 14: 26-44.

Rosen AM (1997) What Hath Drought Wrought. The Sciences July/August: p. 47.

Schell LM (1997) Culture as a Stressor: A Revised Model of Biocultural Interaction. American Journal of Physical Anthropology 102:67-77.

Schwartz GM (1986) Mortuary Evidence and Social Stratification in the Ninevite V Period. In H Weiss (ed.): The Origins of Cities in Dry-Farming Syria and Mesopotamia in the Third Millennium B.C. Guildford: Four Quarters, pp. 45-60.

Schwartz GM (1987) The Ninevite V Period and the Development of Complex Society in Northern Mesopotamia. Paleorient 13/2:93-100

Schwartz GM and Weiss H (1992) Syria, ca. 10 000-2000 B.C. In RW Enrich (ed.): Chronologies in Old World Archaeology: Third Edition, Volume I (pp. 221-243) and Volume II (pp. 185-202).

Senior L and Weiss H (1992) Tell Leilan "sila bowls" and the Akkadian Reorganization of Subarian Agricultural Production. Orient-Express 1992:2: 16-24.

Surenhagen D (1986) The Dry Farming Belt: the Uruk Period and Subsequent Developments. In H Weiss (ed.): The Origins of Cities in Dry-Farming Syria and Mesopotamia in the Third Millennium B.C. Guildford: Four Quarters, pp. 7-44.

Struve VV (1969) The Problem of the Genesis, Development, and Disintegration of the Slave Societies in the Ancient Orient. In IM Diakonoff (ed.): Ancient Mesopotamia: Socio-Economic History, Moscow: Nauka, pp. 17-69.

Tainter JA (1988) The Collapse of Complex Societies. Cambridge: Cambridge University Press.

Tyumenev, AI (1969) The State Economy of Ancient Sumer. In IM Diakonoff (ed.): Ancient Mesopotamia: Socio-Economic History. Moscow: Nauka, pp. 70-87.

Weiss H (1983a) Excavations at Tell Leilan and the Origins of North Mesopotamian Cities in the Third Millennium B.C. Paleorient 9: 39-52.

Weiss H (1983b) Tell Leilan in the Third and Second Millennia B.C. Annales archeologiques arabes syriennes 33:47-73.

Weiss H (1985a) Protohistoric Syria and the Origins of Cities and Civilization. In H Weiss (ed.): Ebla to Damascus: Art and Archaeology of Ancient Syria. Washington: Smithsonian. pp. 77-82.

Weiss H (1985b) Third Millennium Settlement and Subsistence. In H Weiss (ed.): Ebla to Damascus: Art and Archaeology of Ancient Syria. Washington: Smithsonian. pp. 123-129.

Weiss H (1985c) Introduction. In H Weiss (ed.): Ebla to Damascus: Art and Archaeology of Ancient Syria. Washington: Smithsonian. pp. 30-43.

Weiss H (1986) The Origins of Tell Leilan and the Conquest of Space in Third Millennium Mesopotamia. In H Weiss (ed.): The Origins of Cities in Dry-Farming Syria and Mesopotamia in the Third Millennium B.C. Guilford: Four Quarters, pp. 71-108.

Weiss H (1990) Third Millennium Urbanization: A Perspective from Tell Leilan. In S Eichler, M Wafler and D Warburton (eds.): Tall Al-Hamidiya 2: Recent Excavations in the Upper Khabur Region. Netherlands: Universitatsverlag Frielburg Schweiz.

Weiss H (1994) Archaeology in Syria. American Journal of Archaeology 98:101-158.

Weiss H (1996) Desert Storm. The Sciences May/June: 30-36.

Weiss H and Courty M-A (1993) The Genesis and Collapse of the Akkadian Empire: The Accidental Refraction of Historical Law. In M Liverani (ed.): Akkad: The First Empire. Padua: Sargon, pp. 129-154.

Weiss H, M-A Courty, W Wetterstrom, G Guichard, L Senior, R Meadow, A Curnow (1993). The Genesis and Collapse of Third Millennium North Mesopotamian Civilization. Science 261:995-1004.

Wenke RJ (1990) Patterns in Prehistory: Humankind's First Three Million Years (3rd ed.). Oxford: Oxford University Press.

Wilkinson TJ (1994) The Structure and Dynamics of Dry-Farming States in Upper Mesopotamia. Current Anthropology 35:483-520.

Wright and Johnson (1975) Population, Exchange, and Early State Formation in Southwestern Iran. American Anthropologist 77: 267-289.

Wright K (1998) Empires in the Dust. Discover March, pp. 94-99.

Yoffee N (1979) The Decline and Rise of Mesopotamian Civilization. American Antiquity 44: 5-35.

Yoffee N (1988) The Collapse of Ancient Mesopotamian States and Civilization. In N Yoffee and GL Cowgill (eds.): The Collapse of Ancient States and Civilizations. Tucson: University of Arizona Press, pp. 44-68.

CHAPTER 3 -- SKELETAL EVIDENCE FOR HEALTH AND DISEASE AT BRONZE AGE TELL LEILAN, SYRIA

INTRODUCTION

As a primary source of evidence in a current academic debate, the Syrian archaeological site Tell Leilan has recently been the focus of much interest in both the scholarly (*e.g.*, Rosen 1995, 1997; Weiss 1997) and lay scientific literature (*e.g.*, Gibbons 1993; Issar 1995; Weiss 1996; Wright, 1998). Lying within the fertile Habur Plains of northeastern Syria (Fig. 3.1), the site was occupied for more than three thousand years (Fig. 3.2). Originating as a small agricultural community around ~4600 B.C., Tell Leilan grew into a city exhibiting state level society and covering more than 200 acres by 2400 B.C. The city was further expanded by the imperialist Akkadian Empire between 2300 B.C. and 2200 B.C. Less than one hundred years after the Akkadians seized control, however, Tell Leilan was suddenly abandoned and remained unoccupied for nearly two centuries. It has been suggested that this abandonment was the result of rapid and severe changes in environmental conditions that made it impossible to maintain the city's rain fed agricultural economy (Weiss *et al.* 1993; Weiss and Courty 1993). This hypothesis draws most of its support from paleoclimatic and geological data (Courty 1994; Issar 1995; Otterman and Starr 1995; Weiss *et al.* 1993, and see Rosen 1995 for a summary of the evidence of climate change at the end of the third millennium B.C.) which indicate that around the time of site abandonment there was a period of desertification resulting from decreased soil moisture and increased aeolian soil loss. Interestingly, while this environmental shift seems to be well supported, the effect that this shift had on the people of northern Mesopotamia remains a matter of speculation. Many researchers doubt the validity of using catastrophic environmental models in order to explain the collapse of entire civilizations. To cite environmental factors as prime movers, they claim, is to state that either a civilization does nothing to try to adapt to the changing conditions, or that the conditions are such that the civilization cannot overcome them (Tainter 1988, Rosen 1995, 1997). Since it seems improbable that any group of people would not react to changes in their environment, the real question becomes why did a society fail to adapt to the changing conditions? Or, to phrase the problem in a positive way, why was collapse the most adaptive response for a society? Rather than investigating the environmental change then, the real focus of study should be the adaptive response of the society to the changing conditions. One way of investigating biocultural adaptation to changing environmental conditions is to examine a population's health and nutrition.

Pathological lesions of the skeleton provide the primary evidence for the health and nutrition of a person or population living in the past. Malnutrition, infectious disease, occupational stress and trauma can all produce indicators on the skeleton which, when carefully interpreted, can provide insights into the biocultural adaptation of a population to its environment. This paper describes and interprets those indicators in adult skeletal remains from Tell Leilan in order to evaluate the health status of the population living there in the past.

There has been relatively little work completed on the skeletal material from Bronze Age Mesopotamia, and that which has been published is generally concerned with the analysis of metric traits and the determination of 'race' (*e.g.*, Angel 1968, Buxton and Rice 1931, Cappieri 1969, 1970, 1972, 1973, Krogman 1940a; Rathbun 1979, 1982) or focuses primarily on sites in southern Mesopotamia, Anatolia and the Iranian Plateau (*e.g.*, Angel and Bisel 1986; Krogman 1940a, 1940b; Rathbun 1972, 1975, 1984; Smith 1989). The skeletal remains from Tell Leilan are currently being analyzed under the direction of Dr. Nancy Lovell at the University of Alberta, however, for the purpose of reconstructing past health and diet (*e.g.*, Feasby 1998). It is hoped that the health profile presented here can yield insights into the nature of the development and abandonment of Tell Leilan, and will provide information which can be used to elucidate the lifeways of people living in northern Mesopotamia as a whole.

MATERIALS AND METHODS

> The fully preserved, gleaming white skeleton is a thing which survives only in the minds of writers of fiction; the reality is quite likely to be something which resembles well chewed digestive biscuit and which may be about as easy to deal with.
>
> Waldron 1994: 14

The skeletal assemblage of Tell Leilan was recovered during five field seasons (1979, 1980, 1985, 1987, 1989) under the direction of Harvey Weiss from Yale University. Unfortunately there is no documentation outlining the specific excavation procedure. It would appear, however, that most burials were encountered during the excavation of building floors. While some burials are well documented, including verbal descriptions and diagrams, others have very little or nothing recorded. The records which do exist, however, indicate that in some instances skeletons were not fully excavated if they were located partially within excavation baulks. This, of course, decreases the sample size as well as makes analysis of complete skeletons impossible. Additionally, during the excavation procedure many bones were treated with PolyVinyl Acetate (PVA), a consolidant designed to prevent the bones from further fragmenting after excavation. Unfortunately, the consolidant was applied, in many cases, while the skeletal material was still in the ground, allowing considerable amounts of dirt, grass and other extraneous material to fix to the bone. The presence of the consolidant itself, along with the various debris, made examination of these bones impossible and so they were treated as unobservable in the calculation of frequency data. The collection currently resides at the University of Alberta, Canada, where, during the winter of 1997 and fall of 1998, the data presented in this paper were collected.

A total of 19 adult burials representing four distinct time periods were excavated at Tell Leilan between 1979 and 1989. The age, sex and time period of each burial is summarized in Table 3.1. Unfortunately, the skeletal remains are extremely fragmentary and incomplete. There are no complete crania, no complete ribs, few intact major appendicular bones and very few complete vertebrae.

A skeletal inventory for each burial was performed by recording the preservation and condition of each bone. Preservation refers to whether the bone was complete (>90%), partially complete (50-90%) or incomplete (<50%) while condition refers to whether the bones were fragmentary or very fragmentary. In order to inventory long bones, each was divided into five segments: proximal epiphysis, proximal third, middle third, distal third, and distal epiphysis (following Buikstra and Ubelaker 1994). The presence or absence of each segment was recorded for each bone. This collection procedure makes possible a greater range of analyses than would a more superficial approach. Recording an inventory by bone segment also reveals the fragmentary and incomplete nature of the sample (Table 3.2). For example, in the Tell Leilan assemblage there are 21 humeri present from 13 individuals (8 individuals posses both humeri). Upon closer inspection, however, we see that only one humerus is complete and that the remaining 20 are in various stages of partial completeness. 'Complete' for the purposes of the long bone inventory indicates only that all five segments of a long bone are present. In order to be scored as present, at least 50% of a bone segment must have been represented.

The Minimum Number of Individuals (MNI), according to burial forms recorded at the time of excavation, is 22. Upon examination, however, many of the burials described as single interments in the burial forms were found to contain skeletal elements from multiple individuals. If the MNI for the total collection is calculated by summing the MNIs from each of the catalogued burials, a figure of 29 is reached. In many cases it seems likely that the discrepancy between the burial forms and the skeletal inventories is due to errors in the collection and packaging of burials during excavation rather than the existence of additional individuals. This is especially true when it is considered that, in most cases, the additional individual is only represented by a single bone or bone fragment. Unfortunately, the incomplete and fragmentary nature of the collection precludes any attempts at reconstructing the original sources of the additional bones. Taking into consideration both the burial forms and the skeletal remains, an MNI of 23 seems the most likely figure:

Period I (1900-1700 BC) - 3
Period II (2500-2200 BC) - 15
Period III (3000-2500 BC) - 4
Period VI (4100-3700 BC) - 1

The period of greatest interest is Period II since it immediately precedes site abandonment.

It should be noted that in the analysis of multiple burials it was, in most cases, impossible to reconstruct individuals. The existence of multiple individuals is known through the presence of duplicate elements, however it was often difficult to determine with which individual skeleton the duplicate element belonged. As such, for most of the analyses presented here, the MNI of the multiple burials was, in practice, one. The exception, of course, was when pathological lesions were noted on each of the duplicate bones in which case the MNI equaled the number of duplicate bones possessing the lesions.

An 'individual' as the term is used here, does not imply the existence of a complete skeleton. On the contrary, an 'individual' can be described on the basis of a single bone or bone fragment. Similarly, the term 'burial', as used here, only refers to the presence of an individual or, individuals (in the case of a multiple burial), and does not imply the existence of a formal grave. Burial L87 76F20 Lot 45, for example, was not found in a grave context and consists primarily of a single arm.

Age and sex were determined using the standardized morphological criteria described by Buikstra and Ubelaker (1994). In addition to these criteria, sex was also determined in 3 cases (L79 57F02 Lot 18 B.1, L85 55E13 Lot 41, L85 Op4a Lot 18 B2) through discriminate function analysis of the talus (Steele 1976). Due to the fragmentary nature of the skeletal sample, sex could only be determined for 12 of the 23 individuals (52%). Likewise, based on the skeletal remains, only four individuals could be classified into an age range more specific than "Adult".

The following categories of pathological lesions were used in this study: (1) osteoarthritis, (2) trauma, (3) vertebral disorders (which includes trauma and osteoarthritis of vertebral joints), (4) inflammation/infection and (5) metabolic disorders. These conditions represent the most commonly observed pathological conditions and, when analyzed together, can be used to produce a general profile of the health of a person or population. Dental disease is being analyzed by other researchers and is not described in this paper. All pathological lesions were identified, described and diagnosed according to the conventions outlined in standardized works such as Buikstra and Ubelaker (1994), Mann and Murphy (1990), Ortner and Putschar (1985) and Steinbock (1976) (see Appendix A for data collection forms). Specific descriptive protocols, described below, were employed for osteoarthritis, trauma and vertebral disorders.

Osteoarthritis (also referred to as Degenerative Joint Disease) is the progressive breakdown of a synovial joint through the destruction of surrounding cartilage and is the most common condition observed in archaeological skeletal remains. As the cartilage deteriorates, bone to bone contact can cause the articular surfaces to become hard (sclerosis) or polished (eburnation) (Roberts and Manchester 1995). Additionally, osteolytic activity can induce the breakdown of the articular surface itself, resulting in pitting. At the same time bone formations known as osteophytes often develop around the articular surfaces. Because most joints consist of a number of articular surfaces (*e.g.*, the knee consists of seven joint surfaces: medial and lateral femoral condyles, patellar surface of the femur, medial and lateral tibial condyles and medial and lateral patellar facets), and because these various joint surfaces often behave independently of each other (Jurmain 1980, 1991), each joint surface was assessed separately. Later these joint surfaces were combined to give a total score for the entire joint. This form of analysis not only makes possible the examination of partially complete joints, but also allows the analysis of patterns within the joints themselves. Each joint surface was assessed in terms of three osteoarthritic lesions: marginal lipping, porosity and eburnation. The presence or absence of each joint surface was also recorded. By recording missing/unobservable surfaces it is possible to determine the minimum number of observable joint surfaces which is essential for calculating rates of prevalence (Rogers and Waldron 1995). Although the severity of each osteoarthritic lesion was originally recorded, the small sample size as well as the absence of any severe expressions dictated that this data be amalgamated into the categories of 'Present' or 'Absent'. Similarly, results from left and right sides were also pooled (although individuals with bilateral expression are noted).

Following Lovell (1997), each traumatic lesion was first described in terms of the bone involved, location, and basic type (*i.e.*, dislocation or fracture). Fractures were then described by type (*e.g.*, stress, transverse, spiral, crush etc.) as well as by length, apposition, rotation and angulation (LARA). Finally, all traumatic lesions were described on the basis of their stage of healing.

Vertebrae were examined in terms of lesions of the articular facets and those of the vertebral body. Description of lesions on the articular facets used the same protocol as was used to record osteoarthritis. On the vertebral body, the following pathological lesions were recorded: osteophytes, Schmorl's nodes and surface porosity. Following Buikstra and Ubelaker (1994), osteophytes were assigned scores of 0 (absent), 1 (barely discernible), 2 (elevated ring), 3 (curved spicules), and 4 (fusion present). Although none were observed, the description of Schmorl's nodes were to be recorded as 0 (absent), 1 (mild - < 2 mm deep and an area < 1/2 anteroposterior length of vertebral body), or, 2 (severe - values in excess of mild values) following the procedure outlined by Knüsel *et al.* (1997) in their examination of joint disease at a Medieval monastic cemetery in England. Porosity on vertebral bodies relied upon the same scoring criteria that was used to score osteoarthritis and data were then pooled into 'present' and 'absent' categories for analysis.

Due to the fragmentary nature of the collection, frequency of pathological lesions was analyzed not only per individual but also, more meaningfully, per observable bone or bone group. While age, sex and status comparisons could not be made, comparisons were attempted, where possible, between the various time periods at Tell Leilan and between Tell Leilan and published reports from other Mesopotamian sites.

RESULTS AND DISCUSSION

In general, the skeletons from Tell Leilan show relatively few pathological lesions (Table 3.3). There is no evidence for specific infectious diseases such as tuberculosis or leprosy and, while evidence for osteoarthritis, vertebral disorders and trauma exists, it is of low frequency and mild in nature. Evidence for non-specific infections and inflammation, as well as anemia, however, is fairly common among the people at Tell Leilan as is that for enthesophytic activity, including unusual activity on the bones of the ankles and feet of four individuals.

Osteoarthritis

At Tell Leilan, eight out of 18 (44%) individuals with observable joint surfaces show arthritic changes in at least one of the major joints (shoulder, elbow, wrist, hip, knee and ankle) (Table 3.4). All of the evidence is, however, mild in nature and consists primarily of slight lipping and/or porosity (Plates 3.1 and 3.2). The 10 individuals who show no signs of arthritis are extremely incomplete and very badly fragmented. As a result, the lack of arthritis is likely, in part, a function of the lack of observable joint surfaces. Because the skeletal material is so incomplete and because osteoarthritis affects joints differentially (Jurmain 1980, 1991), it is more appropriate to examine the frequency per joint rather than per individual.

Temporomandibular Joint

Out of the five observable mandibular fossae (from four individuals), none showed evidence of arthritic change.

Shoulder

The shoulder joint is composed of the glenoid fossa, the humeral head and the articulation between the clavicle and the acromion of the scapula. In the entire Tell Leilan assemblage, four out of 11 joints (36%) from three out of seven individuals (43%) show evidence of mild arthritis. Only one of the individuals (Period III) shows arthritic changes in both shoulders. The changes observed were lipping and porosity of the glenoid fossa and porosity of the lateral clavicle. In the Tell Leilan assemblage as a whole, prevalence of osteoarthritis at the shoulder is highest per joint and second highest per individual.

Elbow

The joint of the elbow is composed of the capitulum, trochlea, and olecranon fossa of the humerus; the trochlear notch and radial notch of the ulna; and the radial head. Components of 16 elbow joints from 11 individuals are present in the sample. Four out of 16 joints

(25%) from three out of 11 individuals (27%) show evidence of mild arthritic changes. The most common site of arthritic change in the elbow is the trochlear notch where moderate lipping was observed on two individuals and mild lipping on one individual. Mild lipping was also observed on one radial notch.

Wrist

The wrist consists of the radiocarpal joint and the ulnar head. Only one individual (11% of observable individuals) shows evidence of osteoarthritis of the wrist. Both wrists were affected (18% of observable joints) with moderate porosity and mild lipping.

Hip

The hip consists of the acetabulum and the femoral head. Three joints out of 9 (33%) from three out of 8 individuals (38%) show mild evidence of osteoarthritis. In two cases the arthritic change consists of lipping of the acetabulum while in one case there is lipping on the femoral head.

Knee

The knee consists of the medial and lateral femoral condyles, the patellar surface of the femur, the medial and lateral tibial condyles, and the medial and lateral patellar facets. In the Tell Leilan assemblage four joints out of 14 (29%) from four out of nine (44%) individuals show evidence for osteoarthritis. The evidence consists of mild lipping and eburnation on one medial patellar facet, moderate porosity on two patellar facets and mild lipping and porosity on one medial tibial condyle. It should be noted that for each of these individuals few additional joint surfaces were available for observation. It seems likely that had more of the joint been present more changes would have been found. Associated with the moderate porosity on one of the patellae was a large surface osteophyte.

Ankle

The ankle consists of the articular surfaces between the talus of the foot and the distal tibia and fibula. Three out of 14 joints (21%) from three out of 10 (30%) individuals show evidence for osteoarthritic change. The evidence for arthritis on the ankle consists of slight lipping and mild porosity on the distal tibiae.

Patterns of Osteoarthritis

Osteoarthritis at Tell Leilan was not severe. The overall frequency of 44%, reported here however, is similar to that reported in Angel and Bisel's (1986) study of two Bronze Age Anatolian populations (36% and 40% respectively), although no indication is provided in their study as to how, nor on which joints, arthritis was calculated. Very little has been reported for other Mesopotamian groups. Krogman (1940b) describes arthritic change in skeletons from Bronze Age Tepe Hissar, Iran, but only states that "the majority of adult skeletons show arthritic lipping to a greater or lesser degree (p. 42)." Other skeletal reports from Mesopotamia (*e.g.*, Smith 1989, Ortner 1979, Field 1932) do not include information on osteoarthritis. Because of the lack of standardized protocols for the collection and presentation of osteoarthritis data, comparison of frequency rates between different populations is problematic. Broad comparisons can still be made, however, if the general patterning of arthritis among populations is considered.

At Tell Leilan the highest frequency of arthritis by joint is found in the shoulder followed by the hip, knee, elbow and then the ankle and wrist. Per individual, the highest frequency occurs in the knee, followed by the shoulder, hip, ankle, elbow and finally wrist. This pattern is similar to that found in modern Black and White populations in the United States (Jurmain 1977, 1980). The relatively low prevalence of osteoarthritis at the elbow is also similar to modern epidemiological data (Kellgren 1961, but see Heine 1926 as cited in Jurmain 1980). This is the opposite of many archaeological populations, which tend to have a high frequency at the elbow and a low frequency at the hip (*e.g.*, Bridges 1991, Merbs 1983, Williams 1994). Similar to archaeological populations, on the other hand, and contra modern clinical and autopsy studies, is the relatively high involvement of the shoulder at Tell Leilan. It should be noted, however, that in his study of modern Blacks and Whites, Jurmain (1980) also found more involvement of the shoulder and hip than is usually the case in clinical/autopsy investigations. The difference between archaeological/skeletal data and clinical/autopsy data may be the result of many factors including the small sample sizes in skeletal populations as well as the differences among various researchers in the coding of osteoarthritic changes.

In order to increase sample sizes, joints were grouped into those of the upper skeleton and those of the lower skeleton (Table 3.5). At Tell Leilan, osteoarthritis is more common in lower appendicular joints than upper. This finding is opposite Jurmain's (1980) assertion that, in contrast to modern groups, archaeological populations (both hunter-gatherer and agriculturalists) show a higher prevalence of degenerative joint disease in the upper limbs. Interestingly, as we have already seen, the pattern of osteoarthritis per individual joint at Tell Leilan is also similar to modern urban dwellers. This pattern should, perhaps, be unsurprising considering that the population of Tell Leilan was fully urban by at least 2400 B.C.

Osteoarthritis has multiple etiologies including age, sex, hormonal influence, heredity, trauma and functional stress (Jurmain 1977, 1991; Ortner and Putschar 1981; Sokoloff 1978, 1980; Steinbock 1976). Of these factors, age is positively correlated with osteoarthritis at every major joint. Despite this, however, the degree to which each joint, as well as each joint surface, is affected, varies. The shoulder and hip seem to be best associated with biological age while the elbow and knee seem to be best associated with functional stresses (Jurmain 1977, 1980). Likewise marginal areas of joints (i.e., marginal lipping/osteophytes) seem to be more dependent upon age than mechanical forces. It has been suggested that individuals facing mechanical stress from a young age (when the bone remodeling processes are still active) would be expected to develop bony alterations such as lipping and osteophyte development rather than the lytic changes characteristic of older individuals facing similar stresses (Bridges 1991, Jurmain 1980, Knüsel 1991). This relationship has led some researchers to doubt the validity of using marginal alterations as a criteria for diagnosing osteoarthritis (*e.g.*, Bourke 1967, Rogers and Waldron 1995).

The results obtained at Tell Leilan, therefore, where the arthritic change consists primarily of marginal joint alterations, seems to indicate that most of the arthritis observed is part of the aging process and reflects normal 'wear and tear'. There are no severe cases or exaggerated frequencies at any joint which would seem to indicate that unusual functional stresses are at work. In addition, because osteoarthritis is largely a function of the normal aging process (Jurmain 1977, 1980, 1991; Ortner and Putschar 1981; Sokoloff 1978, 1980; Steinbock 1976), an overall lack of osteoarthritis in a population would seem to indicate a paleodemographic sample that is skewed towards younger individuals. As such, with a pattern of low frequency consisting primarily of marginal joint alterations, it would appear that the skeletal sample so far obtained from Tell Leilan represents individuals who died in their early adulthood. Additionally, the pattern of joint involvement seems to point to a population facing similar stresses as modern urban groups.

Trauma

Evidence for trauma at Tell Leilan is uncommon and, in the entire sample, only six bones show evidence of healed fracture or dislocation. These include two rib fractures, two fractured/dislocated toes, one parry fracture of the left ulna and one possible partial hip dislocation (Plates 3.3 and 3.4)

More commonly observed was the formation of musculoskeletal stress markers including enthesophytes at the sites of various tendon and muscle attachments (Plates 3.5 and 3.6). Enthesophytes, or bone spurs, are reactions to pulling stresses and, as a result, can represent chronic trauma or, potentially, acute traumatic events such as sprains or muscle tears. Mann and Murphy, for example, state that enthesophytes at the posterior calcaneus represent "repeated or acute trauma (bleeding and inflammation) of the Achilles tendon (1990:129)." At other locations, such as the insertion of the *brachialis* on the radius, the new bone development should more appropriately be viewed as a reaction to an increase in the size of the associated muscles, which can be a reflection of age or habitual ('occupational') stresses (*e.g.*, Hawkey and Merbs 1995, Lai and Lovell 1992, for a summary see Kennedy 1989). Stress lesions, which are observable as cortical pitting at insertion points (often resembling lytic lesions) (Hawkey and Merbs 1995) were not observed.

The highest frequency of skeletal enthesopathies at Tell Leilan is found on the patella (five out of six individuals with observable patellae). The most common expression is bone growth on the superoanterior surface, although one individual also possesses an ossified patellar tendon as well as an elongated inferior pole. Enthesopathies on the superoanterior surface indicate pulling stresses of the quadriceps tendon while an elongated inferior pole is a reflection of pulling stresses of the patellar tendon during the process of ossification (Smillie 1962 as cited in Mann and Murphy).

Two individuals have spurs on the posterior calcaneus (out of 11 observable) at the insertion of the Achilles tendon. Enthesophytic activity at this location is found today in marathon and long-distance runners (Clement *et al.*, 1984) and has been reported in Neolithic Saharan populations (Dutour 1986) who are assumed to have done most of their activities on hard, stony ground.

Four individuals have unusual enthesophytes on the superior surfaces of tarsals and/or metatarsals (Plate 3.7). Specifically the bone growth, in all cases, affected the cuneiforms and, in varying degrees, the bones articulating with the cuneiforms (navicular, cuboid and metatarsals). These bones are the location of the insertion for the *tibialis posterior* muscles that act in the plantar flexion and inversion of the foot. Interestingly, the *peroneus brevis* muscle, which is also involved in plantar flexion as well as eversion of the foot, originates at the distolateral fibula, which shows enthesophytic activity in three individuals (out of six observable distal fibulae).

Three individuals have enthesophytes at the insertion of the biceps brachii muscle on the radial tuberosity. Enthesophytes at this location are uncommon today and are most strongly associated with carrying heavy loads while keeping the elbows bent (*e.g.*, masons, bakers) (Genety 1972 as cited in Dutour 1986).

Six individuals (out of 10 with observable phalanges) have enlargements of the attachments for the tendons of the *flexor digitorum profundus* muscles in the palm. Enlargement of these attachments have been linked to habitual "gripping" including writing by Egyptian scribes (Kennedy *et al.* 1986) and canoe paddling by Canadian *voyageurs* (Lai and Lovell 1992).

Moderate enlargements of muscle attachments were also observed on the humerus, radius, ulna and scapula of several individuals.

Patterns of Trauma

Overall, trauma appears to be uncommon among Tell Leilan individuals. Signs of acute trauma are rare and there is no clear evidence for violence. The few signs of direct trauma observed (i.e., fractures/dislocations), while possibly due to interpersonal violence, could also be the result of accidental injuries. Enthesophytes at the sites of numerous muscle attachments do, however, seem to indicate the people were subject to functional stresses especially in the lower skeleton (knee, ankle, foot). Interestingly, as was described earlier, the lower skeleton is more affected by osteoarthritis than is the upper skeleton.

The relationship between osteoarthritis and biomechanical stress is, presently, unclear. If osteoarthritis is associated with functional or mechanical stresses placed on the body, as is commonly asserted (*e.g.*, Hawkey and Merbs 1995, Jurmain 1977, Merbs 1983) then we should expect to see a positive correlation between patterns of osteoarthritis and patterns of biomechanical alteration including, among other things, enthesophytes. Indeed, this correlation is borne out at Tell Leilan where both osteoarthritis and enthesophytes occur at highest frequency in the lower skeleton.

Using a different measure of functional stress (diaphysial strength), however, Bridges (1989, 1991) found no relationship between osteoarthritis and biomechanical alteration in Archaic hunter-gatherers and Mississippian agriculturalists from the southeastern United States. This led her to speculate that the two indicators measure entirely different sorts of activities. Osteoarthritis, she proposed, may be a response to high intensity but infrequent activities whereas biomechanical factors are a response to long term repetitive mechanical loading. She uses this relationship to indicate that the functional stresses associated with an agricultural lifestyle were greater than those of hunter-gatherers among Mississippian prehistoric groups. Studies on other populations, however, indicate that femoral strength declines between preagricultural and agricultural groups (Ruff 1987, Ruff *et al.* 1984).

Another suggestion states that individuals who commence "adult" (*i.e.*, chronic and functionally stressful), activities at a young age will tend to adapt by developing greater bone mass as well as enthesial alterations (Knüsel 1993). It is further suggested that this response may act to protect the joints against the onset of degenerative osteoarthritis. Individuals, on the other hand, who begin strenuous physical activity later in life (at which point bone is less capable of change) are less able to adapt and so tend towards degenerative osteoarthritic changes.

As we have already observed, the osteoarthritic change at Tell Leilan consists primarily of marginal/osteophytic activity rather than severe degenerative changes. This, as we have already noted, likely indicates that the individuals were relatively young at the time of death. In light of the relatively frequent enthesophytic activity, the predominance of mild as opposed to severe arthritic changes might also partially be viewed as a byproduct of the early commencement of physically stressful activities.

The argument has been made that the demands of agricultural production necessitate the early commencement of subsistence activities by children in agricultural groups (Cohen 1977). Ethnographic evidence among hunter-gatherers such as the !Kung San, in contrast, seems to indicate that individuals in these groups often do not participate in subsistence activities until late in adolescence (Lee 1979). Among modern groups, agriculture is more labour intensive than hunting and gathering and includes physically demanding and repetitive activities such as hoeing, and pounding of seed crops (Bridges 1989, Lee 1968, Sahlins 1972).

While based on an agricultural economy, the urban population of Tell Leilan was likely not directly involved in agricultural production. Analysis of plant remains from house floors and courtyards in the Lower Town South indicate that the grains had already undergone primary and secondary processing prior to entering the city. This is taken as evidence that the grain was processed and stored elsewhere before being distributed, probably as labour ration payments (Weiss *et al.* 1993, Weiss and Courty 1993). Additionally, as we have seen, the pattern of osteoarthritis at Tell Leilan is more similar to modern urban populations than either hunter gatherers or peasant agriculturalists. While children at Tell Leilan were likely not directly involved in agricultural activities, then, it still seems plausible that they would have had other responsibilities within the urban domestic sphere. Among urban populations, children are often called upon to perform such repetitive tasks as fetching water and gathering fuel. The pattern among agricultural groups of early commencement of stressful activities then, may be retained even when a portion of the population becomes isolated from the actual food production. Unfortunately, in the absence of ethnographic material from this time period, it is unlikely that it will ever be possible to positively associate any specific activity with the alterations (Stirland 1988, Jurmain 1991).

Inflammation/Infection

At Tell Leilan there are no cases of specific infectious diseases. However, at least 12 individuals show non-specific infection/inflammation in the form of periostitis (Table 3.6). Periostitis can occur as a primary response to local or systemic infection or as a secondary response to specific pathogens or pathological conditions affecting the underlying bone. Accordingly, periostitis is a non-specific response to a variety of conditions including osteomyelitis, tuberculosis, syphilis, scurvy, hypervitaminosis A, and hypertrophic pulmonary osteoarthropathy (HPO) (Fennell and Trinkaus 1997). While each of these conditions is characterized by periosteal lesions, many can be ruled out by examining the pattern, form and distribution of these lesions.

At Tell Leilan, all of the evidence for inflammation is mild and consists primarily of cortical striations, fine pitting and small regions of bone deposition (Plates 3.8, 3.9). Most often affected are the bones of the lower limbs and the distribution is often bilateral or affects multiple bones. Worldwide, the bones of the lower limbs (especially the tibia) are the most commonly affected by periostitis, and, although the cause for this localization is unclear (Steinbock 1976, Ortner and Putschar 1985), it has been speculated that the tibia, since it is relatively close to the surface of the skin, may be cooler than bones which are surrounded by large layers of muscle and fat (Ortner and Putschar 1985). The effect that temperature has on the development of periostitis, however, is not made explicit. Ortner and Putschar (1985) also point out that bones nearer the skin are subject to more direct trauma than those which are protected by layers of muscle and fat. At Tell Leilan, the frequency of periostitis of the femur is slightly higher than that of the tibia although this may simply be an artifact of the small sample. The majority of cases at Tell Leilan are inactive as indicated by the sclerotic nature of the new bone and likely represent healed inflammation in which the bone has been, or is in the process of being, remodeled. Only two individuals possess lesions displaying recent osteosclerotic activity. While it is likely that these cases were still active at the time of death it would be spurious to attribute the infections to the cause of death.

In addition to the periostitis seen on the large long bones, cortical striations and periosteal bone growth were also observed (in four individuals) on the shafts of metatarsals (especially the hallux), metacarpals and phalanges. A localized infection was also observed on the dorsal surface of a single navicular. This is a healed destructive lesion approximately 2 cm x 1 cm and since there is no evidence for trauma the lesion possibly represents an overlying skin infection that moved into the bone.

Inflammation/Infection Overall

Overall at Tell Leilan infection/inflammation is mild in expression. The frequency and distribution of periostitis is, however, worth discussing. While no figures have been reported from the Mesopotamian region, the frequency of periostitis at Tell Leilan is high when compared to other areas. Williams (1994), for example, reports a per bone prevalence for the tibia of only 14% from Archaic and Woodland populations in the northern plains of the United States compared with a per bone occurrence of 43% at Tell Leilan. In spite of the fact that this difference may partially reflect different data collection protocols, it is clear that the people of Tell Leilan were under some sort of chronic (although not necessarily severe) stress.

None of the bones from Tell Leilan possess the sequestrum and involucrum diagnostic of osteomyelitis. Likewise, none of the individuals posses the destructive lesions of the cranium which are characteristic of treponemal diseases such as yaws and syphilis. Since the distribution of lesions is restricted to the long bones, it is unlikely that metabolic or nutritional conditions such as scurvy, genetic anemias or hypervitaminosis A, which affect both the cranial and axial skeleton, are responsible. Similarly, since the distribution of periostitis is not restricted to sites of muscle or tendon insertions, musculoskeletal stress lesions, which often resemble the cortical pitting of lytic lesions, (Hawkey and Merbs 1995) seem an unlikely diagnosis. Hypertrophic pulmonary osteoarthropathy (HPO), as recently described by Fennell and Trinkaus (1997) in the La Ferrassie 1 Neanderthal, is a syndrome usually associated with pulmonary infection and carcinomas. The syndrome is characterized by bilateral and symmetrical periostitis of the tubular bones (especially the diaphyses of the tibia and fibula) and, in severe cases, clubbing of the digits. While at Tell Leilan the lack of severe involvement of the hands and feet and the lack of strict symmetry of lesions does not permit the diagnosis of HPO, the fact that the observed periostitis is often bilateral and affects multiple bones does seem to indicate the existence of some sort of chronic and/or systemic stress, possibly related to the initial stages of pulmonary infection.

The diagnosis of chronic systemic infection at Tell Leilan seems plausible when the nature of the population is considered within the proposed context of environmental degradation. Among high-density sedentary populations, such as Bronze Age Tell Leilan, chronic respiratory infections are common. If, as has been hypothesized, there was a period of severe drought during this period, it is conceivable that the frequency of infection would be greater still. As the environment deteriorates, a corresponding deterioration in both the quality and quantity of food available for consumption seems likely. Since malnutrition and undernutrition hamper the body's ability to respond to invading pathogens, increased frequencies of infection and inflammation would be expected in times of nutritional stress. Additionally, an increase in the number of pathogens themselves, as might be expected in times of social upheaval when social/hygienic conditions deteriorate, would also be expected to increase infection rates. While direct evidence for this sort of urban decay has yet to be explicitly demonstrated in the archaeological record, it is interesting to note that Period II, which immediately precedes site abandonment, contains the only individuals with bilateral involvement and all but one of the cases involving multiple bones.

Metabolic Disorders

At Tell Leilan, the only metabolic disorder observed is anemia, which in modern populations has been linked to, among other health problems, retarded skeletal growth, delayed sexual maturity and impaired mental development (Laor *et al.* 1982; Pollit 1987). Defined as a subnormal level of hemoglobin or red blood cells (and so more accurately classified as a hemopoietic disorder), anemia can be both genetic in origin or acquired during an individual's lifetime. While there are a variety of anemias, recent work suggests that only genetic hemoglobin disorders (such as sickle cell anemia or thalassemia) and chronic iron deficiency anemia promote skeletal changes (Stuart-Macadam 1992b).

In order to compensate for low levels of hemoglobin, the production of red blood cells increases, leading to the hypertrophy of hemopoietic (red) marrow and a subsequent expansion of the diploe, or trabecular bone. The internal expansion and corresponding thinning of the outer table of compact bone leads to macroscopically observable pitting and porosity. Paleopathologists (*e.g.*, Ortner and Putschar 1985, Steinbock 1976) have traditionally referred to this porosity as *porotic hyperostosis* when it is observed on the cranial vault (especially frontal and parietal bones) and *cribra orbitalia* when observed on the orbital roofs. While the nature of the relationship between porotic hyperostosis and cribra orbitalia is debated (Steinbock 1976, Ortner and Putschar 1985, Stuart-Macadam 1989), and their exact etiologies are not fully understood, it is generally accepted that both conditions represent a response to anemia (*e.g.*, Lallo *et al.* 1977, Mensforth *et al.* 1978, Stuart-Macadam 1987). Although cranial lesions have historically been the primary indicator of anemia in skeletal populations, recent work suggests that recognition of post-cranial lesions are essential for differentially diagnosing genetic anemias such as sickle cell anemia and thalassemia (Singcharoen 1989; Hershkovitz *et al.* 1997; see Lovell 1998 for a summary of the specific skeletal manifestations for thalassemia, sickle cell anemia, and iron deficiency anemia).

The most dramatic skeletal changes occur with the anemia of thalassemia, which is found today in populations of central and eastern Mediterranean and south and southeast Asia. Characteristic of thalassemia is a "hair-on-end" appearance of the subperiosteal bone in the cranial vault as well as hypertrophy of the marrow in the frontal and facial bones. Post-cranial changes include expansion of the medullary cavity in long bones, along with a coarsening of trabeculae and a corresponding thinning and porosity of the cortical bone (Hershkovitz *et al.* 1997, Ortner and Putschar 1985). Enlarged nutrient foramina in phalanges have also been observed, presumably in response to the increased vascularity associated with the marrow hypertrophy. General disturbances in skeletal development such as premature epiphysial union and dental maleruption may also occur, especially in children.

While individuals suffering from sickle cell anemia have many of the same characteristics as those afflicted with thalassemia, such as premature epiphyseal union and hypertrophy of marrow in the cranial bones, they do not usually possess 'hair-on-end" trabeculation (Hershkovitz *et al.* 1997, Ortner and Putschar 1985). Additionally, the abnormally shaped "sickle" cells can often block small blood vessels leading to necrosis of bone tissue, especially in the hip but occasionally in the shoulder and temporomandibular joints (El-Sabbagh and Kamel 1989). Poor circulation, caused by blockages, can also lead to leg ulcers resulting in periostitic lesions. The geographic distribution of sickle-cell anemia also differs from thalassemia in that it is found primarily across tropical Africa.

Unlike the genetic anemias, iron deficiency anemia does not generally result in many skeletal alterations and has no specifically diagnostic changes. When skeletal lesions do occur they tend to be mild and are generally restricted to the cranium (porotic hyperostosis/cribra orbitalia).

At Tell Leilan, evidence for metabolic disorders is limited to the skull where lesions are observed on the cranial vault (porotic hyperostosis) and orbital roof (cribra orbitalia) (Plate 3.10). Out of six individuals with sufficient observable cranial material, four (67%) display cribra orbitalia. One of the individuals also exhibits evidence of porotic hyperostosis in the form of porosity of the frontal and parietal bones and thickening of the diploe (Plate 3.11). Three of the individuals come from Period II while one comes from Period III. Two individuals (one adult female, one unsexed adult) exhibit lesions which have been remodeled while two individuals (one female aged 15yrs ±36mo, one unsexed adult) display lesions which were either active at the time of death or were not as extensively remodeled. It has been suggested that porotic hyperostosis and cribra orbitalia are indicative of stress episodes of early childhood and that new lesions are not produced in adults (Stuart-Macadam 1985). This relationship seems to hold true at Tell Leilan where the older adults show more extensive remodeling than does the younger individual (15yrs ± 36mo.).

The frequency of anemia lesions of 67% at Tell Leilan is surprisingly high when compared with the 11% reported from the early Anatolian Bronze Age site of Karatas (Angel and Bisel 1986). Unfortunately, no frequency data have been reported for other Mesopotamian groups. While it is likely that the small sample size at Tell Leilan is, at least in part, responsible for this contrast, other explanations should also be contemplated.

It is generally believed that genetic anemias are maintained in populations due to the protection offered by heterozygous expressions in endemic malarious regions (*e.g.*, Yuthavong and Wilairat 1993). The riverine nature of Mesopotamia likely made it one of the most important malarious regions of the ancient world. The library of Ashurbanipal, dating to 2000 BC contains numerous references to deadly fevers and a cylinder seal found at Susa contains an incantation against mosquitoes (Bruce-Chwatt 1988). Today, malaria (*P. falciparum*, *P. vivax* and *P.malariae*) has been largely eliminated in Syria, but before and during the second World War 60 000 cases were reported annually resulting in 600-700 deaths per year. Also, Thalassemia is common among modern Syrian Arab populations (Rucknagel 1966). The potential for genetic anemias to have existed at Tell Leilan, therefore, seems high. Despite this, however, the lack of diagnostic post-cranial indicators at Tell Leilan would seem to indicate that the individuals were suffering from chronic iron deficiency anemia instead.

While iron deficiency anemia can be acquired in a number of ways including: blood loss due to hemorrhage or gastrointestinal parasites, increased demands for iron during periods of growth or pregnancy, inadequate absorption of iron due to conditions such as diarrhea, and infection with blood adapted parasites such as malaria which destroy red blood cells, the anthropological literature has, as a rule, attributed evidence of anemia in prehistoric populations to diets deficient in iron. In fact, porotic hyperostosis has often been cited as an indicator of nutritional stress (*e.g.*, Goodman *et al.*, 1988, Mensforth *et al.* 1978, Martin *et al.* 1985) and has frequently been used to examine the dietary change in the transition from hunting and gathering to sedentary agriculture (*e.g.*, Armelagos 1990, Huss-Ashmore *et al.* 1982, Kent 1987).

While nutrition undoubtedly played a part in many prehistoric situations, it now seems unlikely that diet was the sole or even the primary cause of the observed iron deficiency anemia. Instead, iron deficiency anemia may, in fact, be better correlated with other conditions such as chronic infections or pathogen load (Stuart-Macadam 1992b, Weinberg 1984). From this point of view, evidence of porotic hyperostosis and cribra orbitalia should be viewed as indicators of generalized stress rather than specific nutritional deficiencies.

The Relationship between Iron Deficiency Anemia and Infection

Although the relationship between iron deficiency anemia and infection is not entirely clear, there does appear to be a significant association between the two conditions (*e.g.*, Lallo *et al.* 1977, Palkovich 1987, Stuart-Macadam 1992a). This association can be interpreted in various ways. First, it can be considered that the two stresses are involved in a positive feedback loop as the result of the synergistic relationship between nutrition and infection. Individuals who are nutritionally deprived (*i.e.*, iron deficient) are less able to respond to infection, while individuals suffering from infection are less able to absorb nutrients. Thus, anemia leads to infection and infection leads to anemia resulting in individuals suffering from both conditions. An alternative perspective views iron deficiency anemia as a reaction, by the body, to limit the amount of iron that can be utilized by invading pathogens (Stuart-Macadam 1992b). In other words, anemia, rather than being a detriment to the body, is an adaptive response to infection. According to this concept, anemic and periosteal lesions are mutually exclusive and should not be observed on the same individual. In practice, however, it is realized that both anemic and periosteal lesions are likely the result of numerous factors including climate, geography, hygiene, diet, and economy (Stuart-Macadam 1992b). All of these factors can be implicated in the observed anemia at Tell Leilan.

As was discussed earlier, a period of severe drought such as that hypothesized at Tell Leilan is likely to lead to the deterioration of a population's subsistence base. Diet, as we have seen, can contribute to anemia in three ways. First, as has been discussed, a diet low in iron can lead directly to iron deficiency anemia. Second, an individual suffering from malnutrition or undernutrition is more susceptible to infection, which may indirectly result in anemia as the body attempts to respond by limiting the amount of circulating iron available for invading pathogens. Finally, infections can reduce the ability of the digestive system to absorb nutrients. The combination of skeletal evidence for both infection and anemia at Tell Leilan makes this scenario plausible.

It is interesting to note that while there are high frequencies of both anemia and periostitis overall, none of the individuals possessing cribra orbitalia exhibit signs of periostitis or have only slight healed cortical striations. Although this relationship is what one would expect if anemia is, in fact, an adaptive response by the body to infection and inflammation, caution must be taken when formulating this conclusion. The fact that individuals with evidence for anemia at Tell Leilan possess only mild periosteal lesions could also be taken as an indication that the two types of lesions represent two separate and unrelated stress episodes (*e.g.*, during childhood vs. adulthood). This is especially true when anemia lesions are observed on adult remains since cribra orbitalia is believed to represent a childhood, rather than adult, response. Additional skeletal material with more specific age data is necessary in order to clarify this situation.

Pathological Conditions of Vertebrae

Evidence for vertebral lesions are virtually absent at Tell Leilan and consist almost entirely of mild osteoarthritis (a total lack of eburnation) and spondylosis deformans (Table 3.7). Osteoarthritis, as was already discussed in relation to the major appendicular joints, results from the destruction of focal cartilage in a synovial joint and a subsequent bone reaction that is characterized by marginal lipping, porosity and eburnation. In the vertebrae, osteoarthritis can be observed among the synovial joints of the posterior articular facets. Spondylosis deformans, on the other hand, occurs at the fibrocartilaginous joints between the vertebral bodies. Characterized by marginal lipping (vertebral osteophytosis), spondylosis deformans is a non-inflammatory condition which arises from degeneration of the intervertebral disks as the result of age and possibly functional stress (Bridges 1994; Knüsel *et al.* 1997; Resnick and Niwayama 1988; Rogers *et al.*, 1987).

The overall lack of vertebral disorders at Tell Leilan, then, would seem to add more evidence to the conclusion that the skeletal sample consists of relatively young adults. It must, however, also be considered that very few vertebral elements were preserved well enough to allow sufficient observation.

There is one individual, a Period II adult male, with complete fusion of the second and third cervical vertebrae. While unusual, and perhaps somewhat debilitating in terms of head flexion and extension, there is no evidence that this fusion was the result of trauma and so likely represents congenital block vertebra.

Seronegative Spondyloarthropathies

In light of the data presented so far, an additional set of pathological conditions must be discussed. For many of the lesions presented above, differential diagnosis included consideration of the seronegative spondyloarthropathies. The seronegative spondyloarthropathies (which include primarily ankylosing spondylitis, Reiter's Syndrome and psoriatic arthropathy) are a group of erosive, inflammatory conditions which affect joints as well as the ligamentous insertions (entheses) surrounding joints (Rogers and Waldron 1995). Closely related to rheumatoid arthritis, the seronegative spondyloarthropathies have similar clinical features including sacro-iliitis, spondylitis and peripheral arthritis. The disease process begins with the inflammation of the synovium leading to destruction of articular cartilage and proliferative erosions. Joint fusion is common as is new bone formation (which is typically not found in rheumatoid arthritis). Tendon and ligament ossification, commonly found in the hands and feet, is considered to be diagnostic (Rothschild and Woods 1991) and very often results in some degree of bone fusion, especially in the spine. Periostitis is also often observed on the shafts of long bones of hands and feet.

As we have seen, many of the lesions characteristic of the seronegative spondyloarthropathies are present in the Tell Leilan skeletal sample. Extensive bone formation at the sites of various tendons and ligaments has been observed (especially on the tarsals); periostitis is observed on the shafts of metatarsals and metacarpals, and there is one case of vertebral fusion. At this time, however, the nature of the evidence does not permit the diagnosis of spondyloarthropathy. Few vertebrae, sacra or innominates were preserved well enough to permit observation and, in the absence of sacroiliac or extensive spinal diarthrodial joint erosion or fusion, the diagnosis of spondyloarthropathy is problematic. While attempts have been made at developing standards for recognizing the disease in skeletal populations (*e.g.*, Rothschild and Woods 1991, Rogers and Waldron 1995), these depend upon knowledge of the complete distribution of lesions throughout the skeleton and the population. The fragmentary nature of the Tell Leilan sample makes this impossible. Additionally, while extensive enthesial activity is observed in the Tell Leilan sample, the bone growth is not usually associated with proliferative erosions as would be expected in spondyloarthropathy. Future excavations, however, may produce material which allows more firm diagnoses to be made.

CONCLUSIONS

The analysis of pathological lesions on skeletal remains from Tell Leilan seems to point to a population that was suffering from some degree of biological stress. Whereas the amount of observed enthesial alteration indicate a population that was engaged in physically demanding activities, possibly commencing at a young age, data from both the spine and appendicular joints show very little arthritic change. This would seem to suggest that the people were dying at a relatively young age. Although the ultimate cause of death for these individuals is unknown, evidence for chronic stress is present in relatively high frequencies in the form of non-specific infection/inflammation and anemia, a pattern which is not inconsistent with the proposed environmental degradation circa 2300 B.C. It has, however, been noted that confident classification of pathological processes in an individual depends upon the distribution of lesions throughout the entire skeleton (Ortner 1988; Rogers *et al.* 1987). Unfortunately, the nature of the Tell Leilan sample makes this type of analysis impossible. Consequently, in order to confirm the conclusions presented here, larger samples are required, especially from the periods immediately prior to site abandonment (Leilan Periods II and III). Additionally, a more precise analysis of the relationships between health, gender, age, and status should be completed, as should an examination of skeletal remains from other sites in order to determine the nature of the transition across the region.

The character of Northern Mesopotamian civilization remains largely unknown in comparison to other world areas. Skeletal data, such as that presented here, have the potential to provide an additional source of information and it is hoped that continued research in this area will be used to refine and develop our knowledge of the region.

Table 3.1 - Distribution of Adult Human Skeletons from Tell Leilan by Time Period, Sex and Age

Specimen No.	Time Period	Sex[5]	Age
L85 55E13 Lot41	I[1]	M	Adult
L85 Op.4a B.5	I	M	Adult
L79 57F02 Lot18 B.1	I	F	Adult
L85 Op.4a Lot18 B.2	II[2]	F	Adult
L85 Op.4a Lot18 B.3	II	M	Adult
L85 Op.4a Lot18 B.4	II	U	Adult
L87 76F20 Lot45	II	U	Adult
L87 76F20 Lot46	II	U	Adult
L87 77G01 B.1	II	U	Adult
L87 77G01 B.2	II	F	15yrs±36mo
L87 77G01 B.3 -1	II	M	15yrs±36mo
L87 77G01 B.3 -2	II	F	16-21
L89 76E20 B.6 -1	II	U	Adult
L89 76E20 B.6 -2	II	U	Adult
L89 76E20 B.6 -3	II	U	Adult
L89 76E20 B.7	II	U	Adult
L89 76F20 B.5/9	II	U/U	Adult
L89 76F20 B.7	II	M/U	Adult
L80 Op. 1 Lot108 B. 2	III[3]	F	35-50 yrs
L80 Op.1 Lot61 Strata19 B.1	III	M	Adult
L80 Op.2 Lot33 & Lot36 -1	III	F	Adult
L80 Op.2 Lot33 & Lot36 -2	III	U	Adult
L80 Op.1c Lot26	VI[4]	U	Adult

[1] (1900-1700 BC)
[2] (2500-2100 BC)
[3] (3000-2500 BC)
[4] (4100-3700 BC)
[5] M=Male, F=Female, U=Unknown

Table 3.2 - Summary of Adult Long Bone Inventory

	Humerus	Radius	Ulna	Femur	Tibia	Fibula
Complete (all 5 segments represented)	1	4	2	0	1	2
Missing one epiphysis	1	3	2	1	2	4
Missing both epiphyses	4	0	1	2	2	4
Missing one shaft segment	2	0	2	0	1	0
Missing at least 2 bone segments	13	8	12	20	8	8
Total Bones Represented	21	15	19	23	14	18
Number of Individuals Represented	13 (8 bilateral)	11 (4 bilateral)	11 (8 bilateral)	15 (8 bilateral)	9 (5 bilateral)	12 (6 bilateral)

Table 3.3 - Summary of Adult Pathological Lesions

Individual	Time Period	Sex[5]	Age	Arthritis	Trauma	Exostosis	Cranial Porosity	Cranial Thickening	Cribra orbitalia	Infection/Inflammation
L85 55E13 Lot41	I[1]	M	Adult	—	—	Manual Phalanges, Calcaneus, Radius	—	—	—	Femur, Metacarpal III
L85 Op.4a B.5	I	M	Adult	Elbow, Wrist	—	Manual Phalanges, Tarsals/Metatarsals	—	—	—	Metatarsals II and III, Manual phalanges
L79 57F02 Lot18 B.1	I	F	Adult	—	—	Metatarsal V, Patellae	—	—	—	Femur, Fibula, Metatarsal I
L85 Op.4a Lot18 B.2	II[2]	F	Adult	—	—	Patella Manual phalanges Tarsals/Metatarsals	—	—	—	Tibiae, Femur
L85 Op.4a Lot18 B.3	II	M	Adult	—	1st toe fractured/dislocated?	Manual Phalanges	—	—	—	—
L85 Op.4a Lot18 B.4	II	U	Adult	Elbow	—	Patella, Radius, Fibula	—	—	—	Femur
L87 76F20 Lot45	II	U	Adult	Shoulder Knee	—	—	—	—	—	Scapula, Humerus, Femur, Tibia
L87 76F20 Lot46	II	U	Adult	—	—	—	—	—	—	—
L87 77G01 B.1	II	U	Adult	—	—	Carpals, Radius	—	—	—	Femora
L87 77G01 B.2	II	F	15±36mo	—	—	—	—	—	√	—
L87 77G01 B.3	II	M/F	15±36mo 16-21	Ankle	—	Humerus, Navicular	—	—	—	Navicular
L89 76E20 B.6	II	U	U	—	—	Fibula	√√	√	√√	Femora
L89 76E20 B.7	II	U	Adult	—	—	Manual Phalanges	—	—	—	—
L89 76F20 B.5/9	II	U	Adult	—	Rib Fracture	—	—	—	—	—
L89 76F20 B.7	II	M	Adult	Shoulder, hip knee, ankle*	—	Patella, Fibula, Calcaneus	—	—	—	Tibia, Fibulae, Right and Left 1st Metatarsals
L80 Op.1 Lot61 Strata19 B.1	III[3]	M	Adult	Hip, Knee	—	Patellae, Tarsals/Metatarsals Manual Phalanges	—	—	—	Femur
L80 Op.2 Lot33 & Lot36	III	F	Adult	Shoulder, Elbow, knee	Parry Fracture (L. Ulna)	—	—	—	√	Tibia
L80 Op. 1 Lot108 B. 2	III	F	35-50	—	Rib fracture	Cuboid	—	—	—	Femur
L80 Op.1c Lot26	VI[4]	U	U	—	—	—	—	—	—	—

[1] (1900-1700 BC)

[2] (2500-2100 BC)

[3] (3000-2500 BC)

[4] (4100-3700 BC)

[5] M=Male, F=Female, U=Unknown

* 2 individuals

Table 3.4 - Frequency of Osteoarthritis from Major Joints

	Shoulder			Elbow			Wrist			Hip			Knee			Ankle		
	n[1]	N[2]	(%)[3]	n	N	(%)	n	N	(%)	n	N	(%)	n	N	(%)	n	N	(%)
Period I (Per Joint)		-		2	1	(50)	2	2	(100)	3	1	(33)	2	0	(0)	4	0	(0)
Period I (Per Individual)		-		2	1	(50)	1	1	(100)	2	1	(50)	1	0	(0)	3	0	(0)
Period II (Per Joint)	9	2	(22)	10	2	(20)	8	0	(0)	4	1	(25)	10	2	(20)	7	3	(43)
Period II (Per Individual)	6	2	(33)	7	1	(14)	7	0	(0)	4	1	(25)	6	2	(33)	5	3	(60)
Period III (Per Joint)	2	2	(100)	4	1	(25)	1	0	(0)	2	1	(50)	2	2	(100)	3	0	(0)
Period III (Per Individual)	1	1	(100)	2	1	(50)	1	0	(0)	2	1	(50)	2	2	(100)	2	0	(0)
Period VI		-			-			-			-			-			-	
Total (Per Joint)	11	4	(36)	16	4	(25)	11	2	(18)	9	3	(33)	14	4	(29)	14	3	(21)
Total (Per Individual)	7	3	(43)	11	3	(27)	9	1	(11)	8	3	(38)	9	4	(44)	10	3	(30)

[1]Number of joints observed
[2]Number of joints affected
[3]Percentage of joints affected (N/n x 100)

Table 3.5 - Frequency of Osteoarthritis by Upper vs. Lower Appendicular Skeleton and Time Period

	Upper Appendicular			Lower Appendicular		
	n[1]	N[2]	(%)[3]	n	N	(%)
Period I (Per Joint)	4	2	(50)	9	1	(11)
Period I (Per Individual)	2	1	(50)	3	1	(33)
Period II (Per Joint)	27	4	(15)	21	6	(29)
Period II (Per Individual)	10	3	(30)	7	4	(57)
Period III (Per Joint)	7	3	(43)	7	3	(43)
Period III (Per Individual)	2	1	(50)	2	2	(100)
Period VI	No Observable Joint Surfaces					
Total (Per Joint)	38	9	(24)	37	10	(27)
Total (Per Individual)	14	5	(36)	12	7	(58)

[1]Number of joints observed
[2]Number of joints affected
[3]Frequency of joints affected (N/n x 100)

Table 3.6 - Prevalence of Non-Specific Infection/Inflammation

Individual	Time Period	Sex[5]	Age	Femur	Tibia	Fibula	Other Bones
L85 55E13 Lot41	I[1]	M	Adult	+	-	-	Metacarpal III
L85 Op.4a B.5	I	M	Adult	N/O[6]	N/O	N/O	Metatarsals II, III, Phalanges
L79 57F02 Lot18 B.1	I	F	Adult	+	N/O	+	Metatarsal I
L85 Op.4a Lot18 B.2	II[2]	F	Adult	+	++	-	
L85 Op.4a Lot18 B.3	II	M	Adult	-	-	-	
L85 Op.4a Lot18 B.4	II	U	Adult	+	-	N/O	
L87 76F20 Lot45	II	U	Adult	+	+	-	Humerus, Scapula
L87 76F20 Lot46	II	U	Adult	N/O	N/O	N/O	
L87 77G01 B.1	II	U	Adult	++	N/O	N/O	
L87 77G01 B.2	II	F	15±36mo	-	-	-	
L87 77G01 B.3	II	U	15-21	-	-	-	Navicular
L89 76E20 B.6	II	U	Adult	++	N/O	-	
L89 76E20 B.7	II	U	Adult	-	N/O	N/O	
L89 76F20 B.5/9	II	U	Adult	N/O	N/O	-	
L89 76F20 B.7	II	M	Adult	-	++	+	Right and Left Metatarsal I
L80 Op.1 Lot61 Strata19 B.1	III[3]	M	Adult	+	N/O	-	
L80 Op.2 Lot33 & Lot36	III	F	Adult	-	+	-	
L80 Op. 1 Lot108 B. 2	III	F	35-50	+	N/O	N/O	
L80 Op.1c Lot26	VI[4]	U	Adult	N/O	N/O	N/O	

++ = Bilateral

[1] (1900-1700 BC)
[2] (2500-2100 BC)
[3] (3000-2500 BC)
[4] (4100-3700 BC)
[5] M=Male, F=Female, U=Unknown
[6] N/O = Nothing Observable

Table 3.7 - Frequency of Arthritic Change for Vertebral Bodies and Facets[1]

	Margin Fragments with Lipping			Articular Surface Fragments with Pitting		
	n[2]	N[3]	(%)[4]	n	N	(%)
Bodies						
Cervical	9	6	(66)	5	2	(40)
Thoracic	13	0	(0)	13	5	(0)
Lumbar	7	0	(0)	7	0	(0)
Unidentified	16	5	(31)	38	3	(8)
Total	45	11	(24)	63	5	(8)
Posterior Facets						
Cervical	15	2	(13)	15	0	(0)
Thoracic	21	2	(9)	21	0	(0)
Lumbar	13	0	(0)	13	0	(0)
Unidentified	37	0	(0)	37	0	(0)
Total	86	4	(5)	86	0	(0)

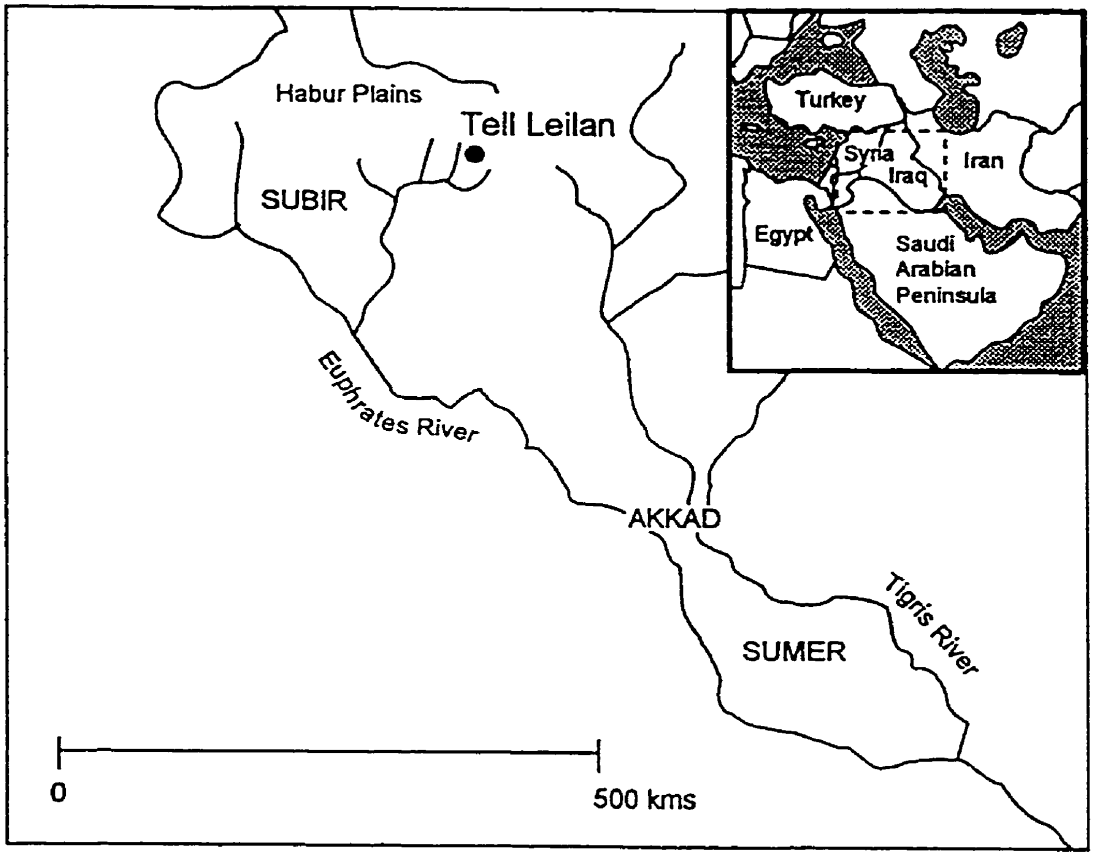
[1]All levels of severity combined

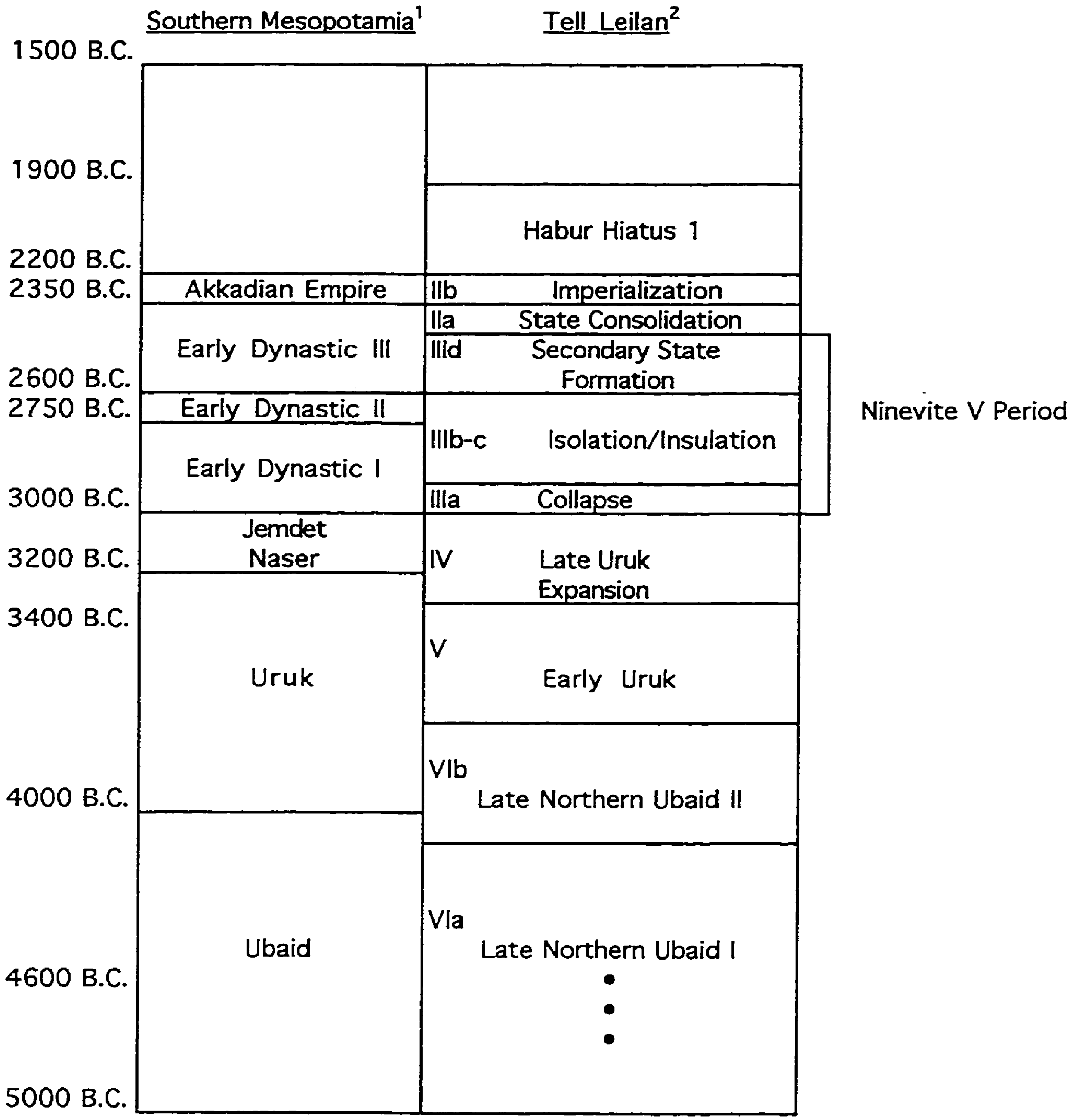
[2]Number observed

[3]Number affected

[4]Frequency affected (N/n x 100)

Figure 3.1 – Map of Ancient Mesopotamia Indicating the Location of Tell Leilan





1Complied from Postgate 1992, Porada *et al* . 1992
[2]Weiss 1994

Figure 3.2 - Cultural Chronology for Ancient Mesopotamia and Tell Leilan

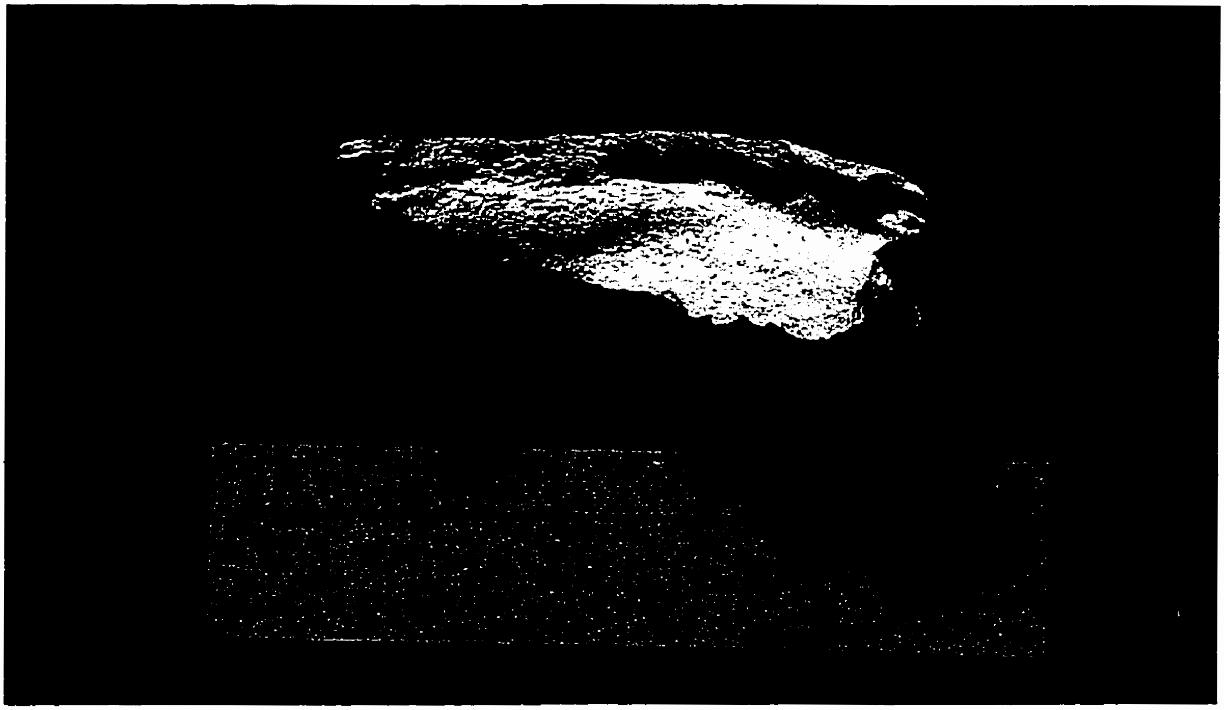


Plate 3.1 – Acetabular rim fragment exhibiting moderate lipping

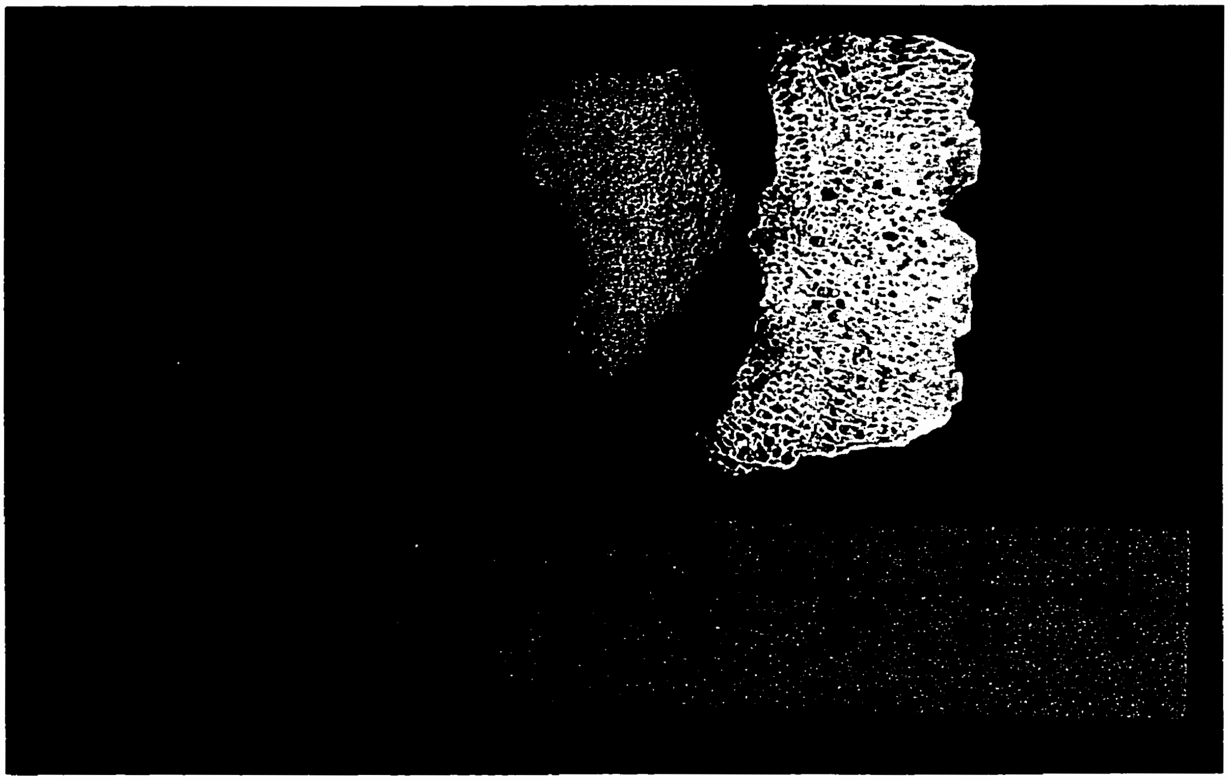


Plate 3.2 – Distal tibia exhibiting mild porosity

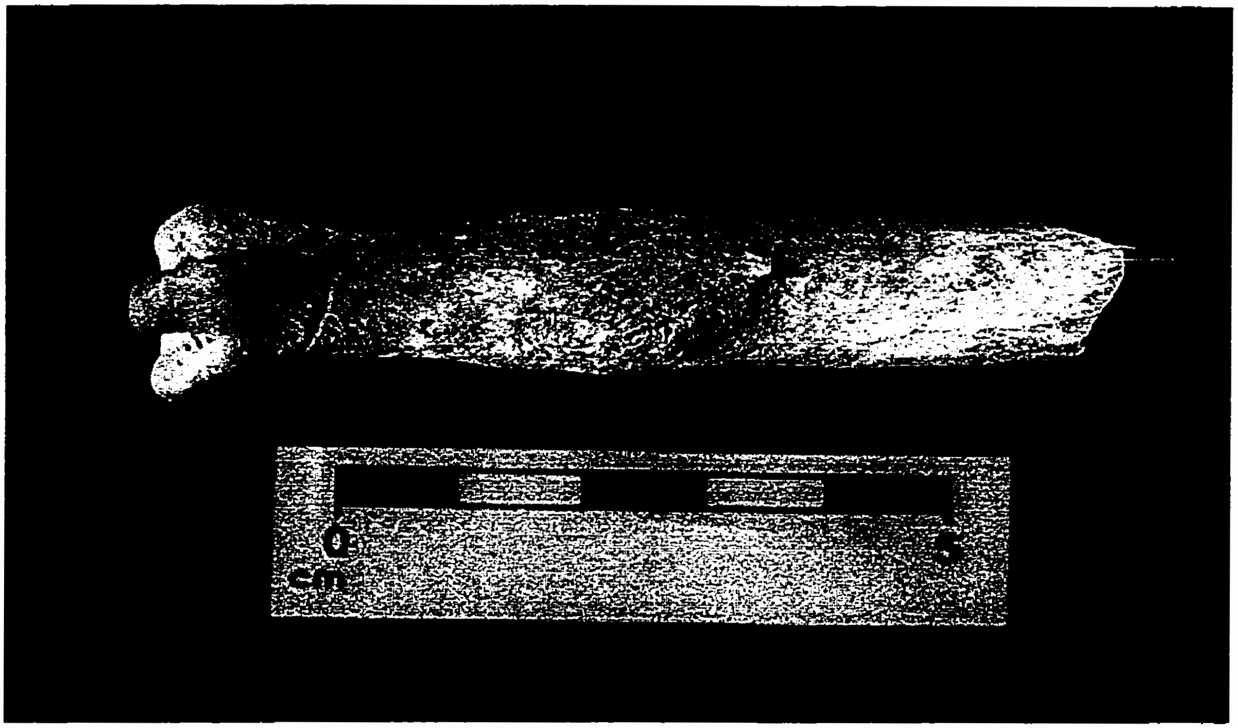


Plate 3.3 – Distal ulna exhibiting a healed Parry fracture

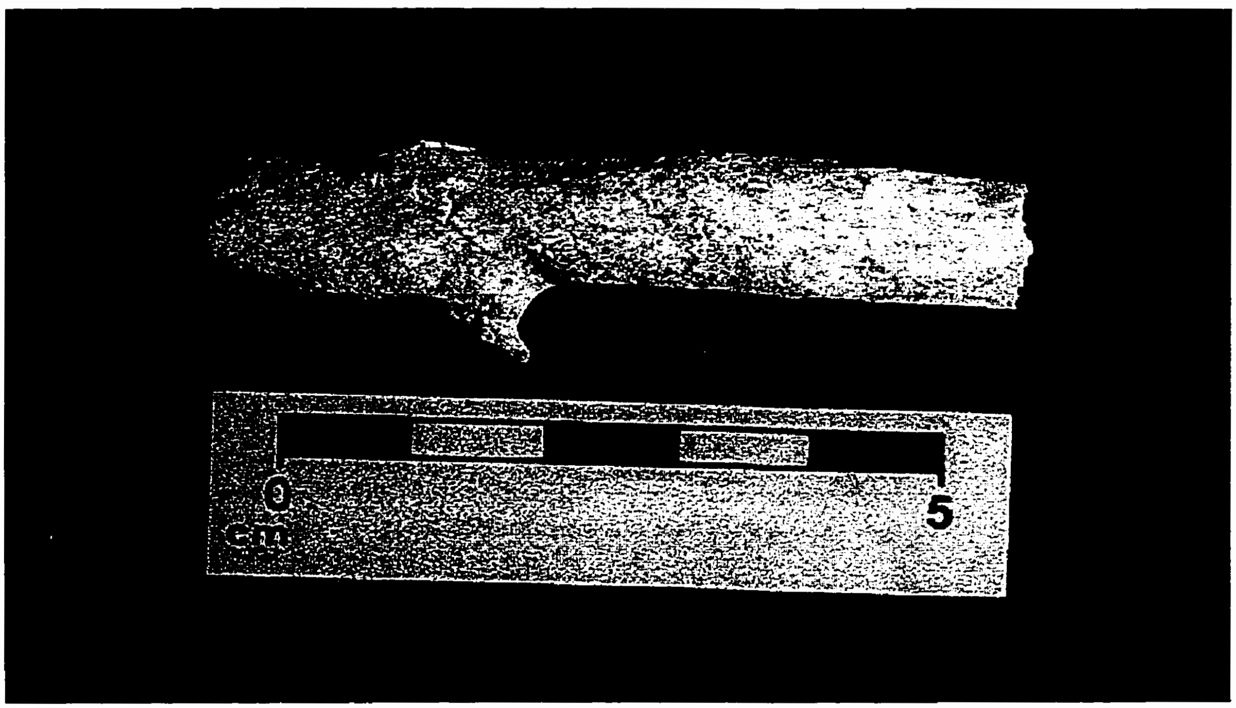


Plate 3.4 – Healed rib fracture

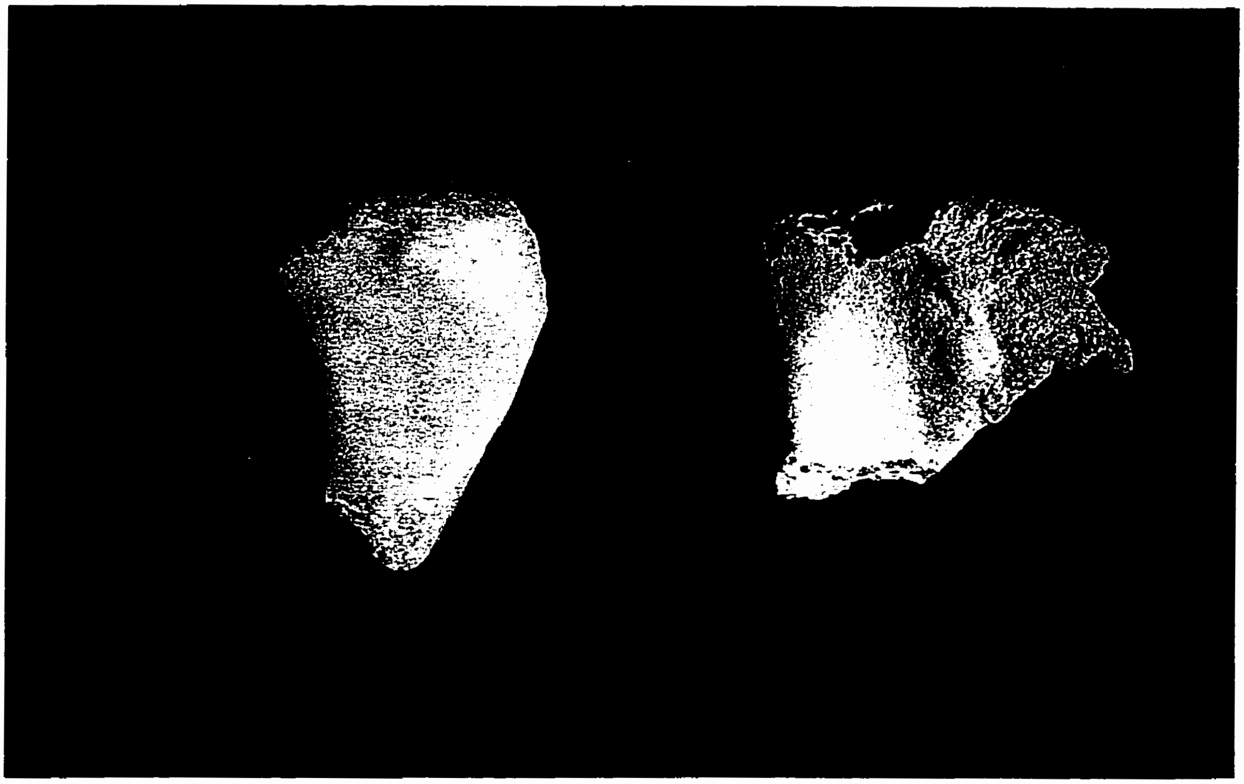


Plate 3.5 - Intermediate cuneiform exhibiting enthesophytic bone growth (normal bone shown at left)

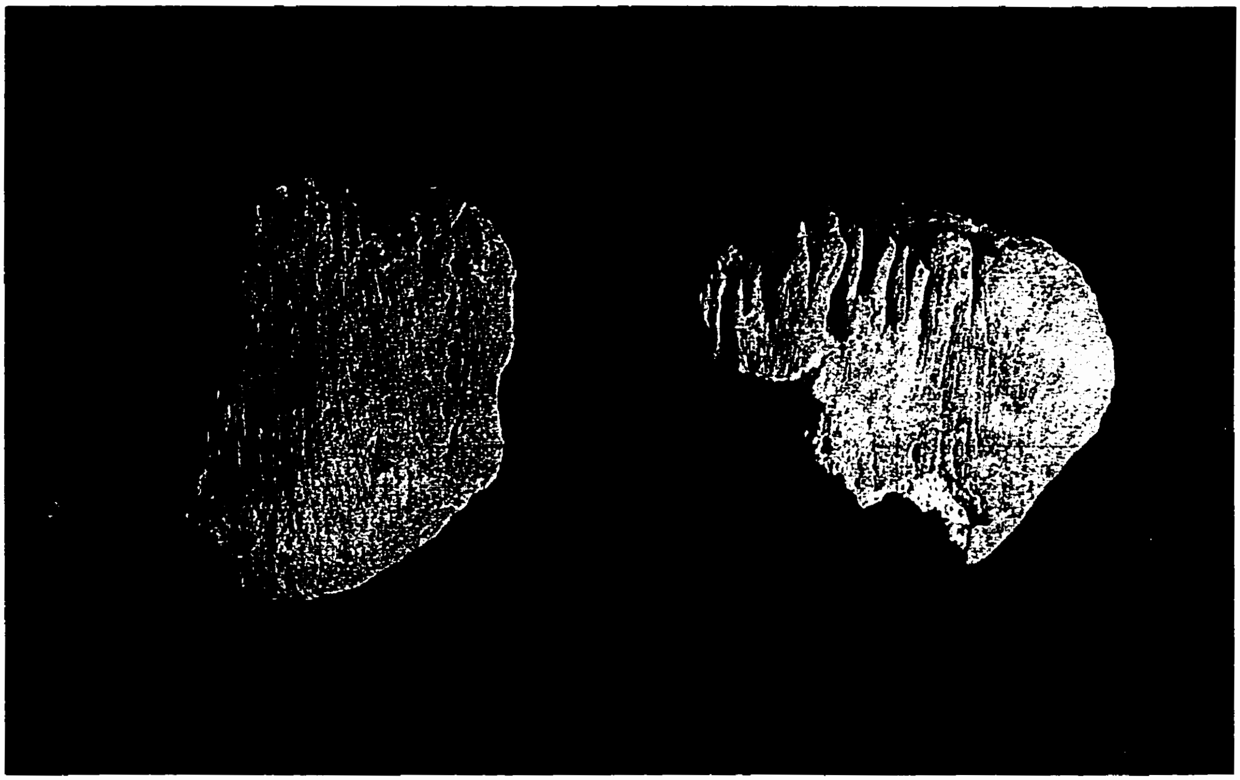


Plate 3.6 – Patellar fragments exhibiting enthesophytic bone growth on the superoanterior surface

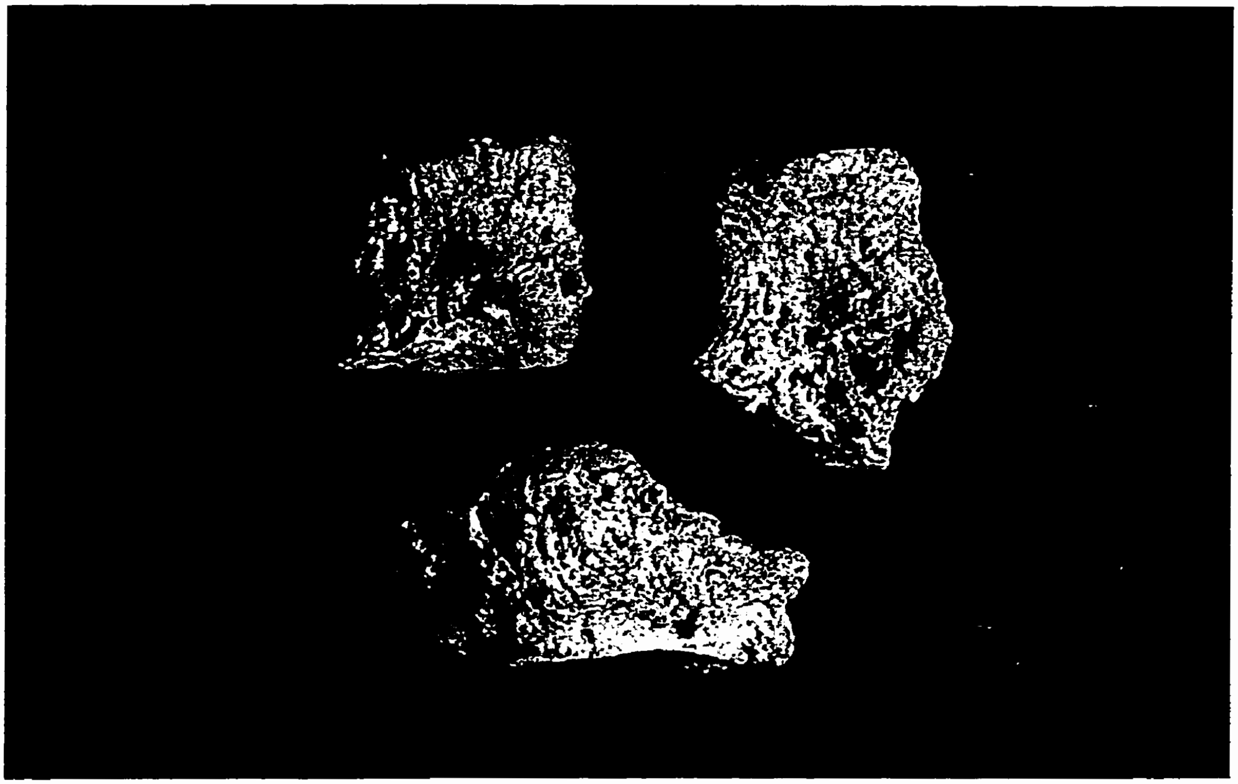


Plate 3.7 – Enthesophytic bone growth on the dorsal surface of three tarsals (intermediate cuneiform, lateral cuneiform, navicular)

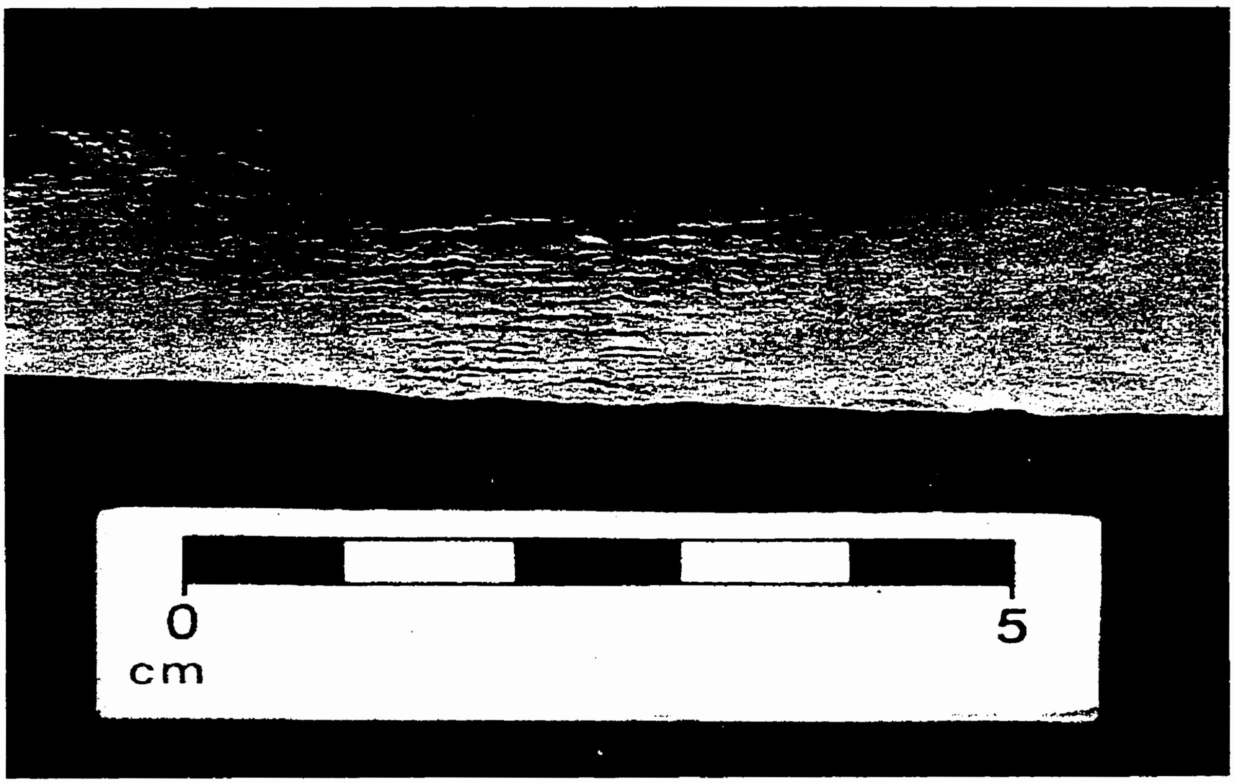


Plate 3.8 – Fibular shaft exhibiting focal periostitis

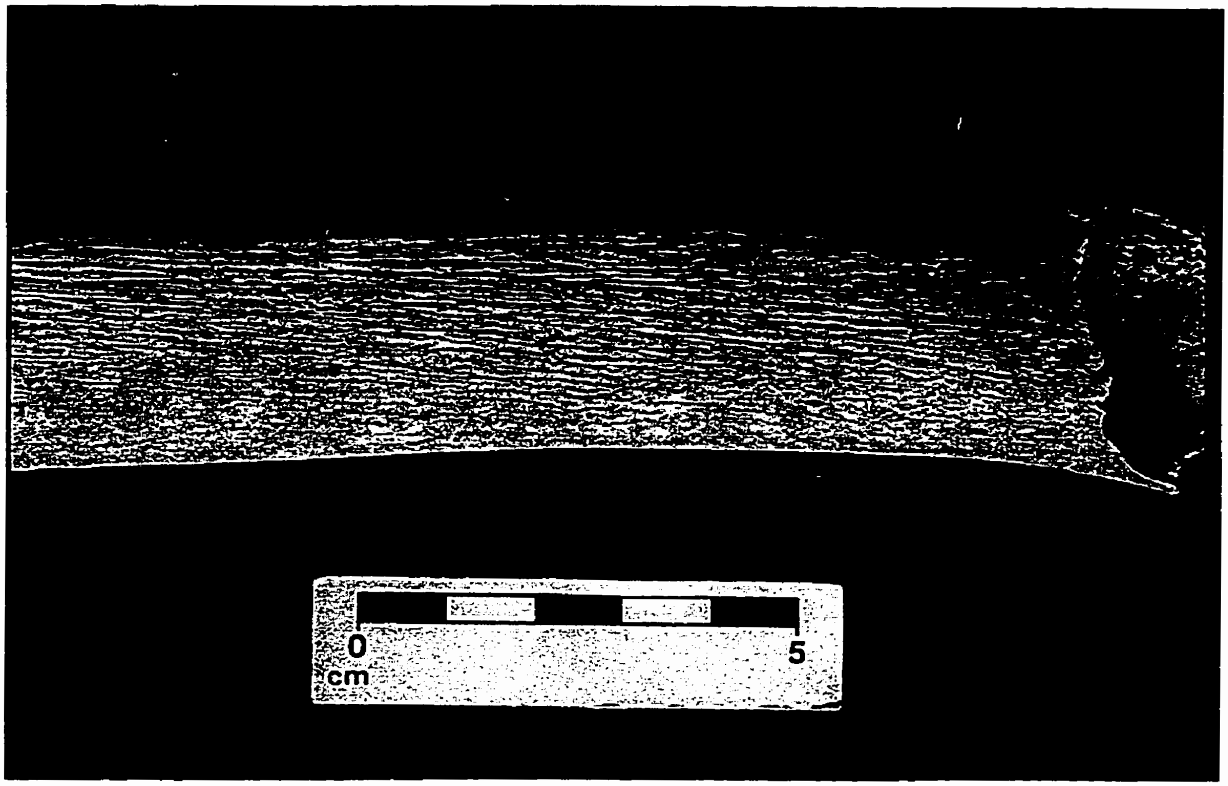


Plate 3.9 – Tibial shaft fragment exhibiting cortical striations

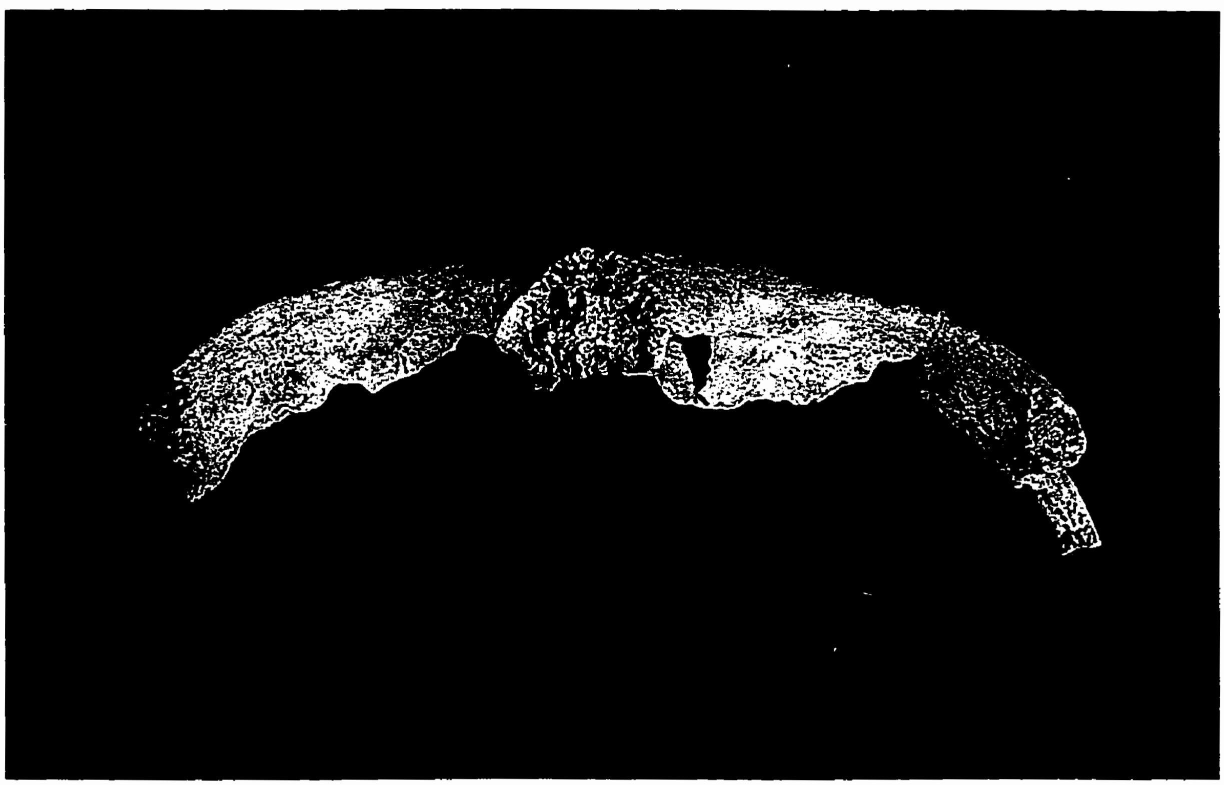


Plate 3.10 – Frontal orbits exhibiting mild cribra orbitalia

Plate 3.11 – Parietal fragment exhibiting thickening of the diploe

REFERENCES CITED

Angel JL (1968) Appendix: Human Remains at Karatas. American Journal of Archaeology 72:260:263.

Angel JL and SC Bisel (1986) Health and Stress in an Early Bronze Age Population. In JV Canby, E Porada, BS Ridgway and T Stech (eds.): Ancient Anatolia. Madison: University of Wisconsin Press, pp. 12-30.

Armelagos GJ (1990) Health and Disease in Prehistoric Populations in Transition. In AC Swedlund and GJ Armelagos (eds.): Diseases in Populations in Transition. New York: Bergin and Garvey, pp. 35-48.

Bourke JB (1967) A Review of the Paleopathology of the Arthritic Diseases. In DR Brothwell and AT Sandison (eds): Diseases of Antiquity. Springfield: Charles C. Thomas, pp. 352-370.

Buikstra JE and Ubelaker D (eds.) (1994) Standards for Data Collection From Human Skeletal Remains. Fayetteville: Arkansas Archaeological Survey Research Series, No. 44.

Bridges PS (1989) Changes in Activities with the Shift to Agriculture in the Southeastern United States. Current Anthropology 30(2):385-394.

Bridges PS (1991) Degenerative Joint Disease in Hunter-Gatherers and Agriculturalists from the Southeastern United States. American Journal of Physical Anthropology 85:379-391.

Bridges PS (1994) Vertebral Arthritis and Physical Activities in the Prehistoric Southeastern United States. American Journal of Physical Anthropology 93:83-93.

Bruce-Chwatt LJ (1988) History of Malaria From Prehistory to Eradication. In WH Wernsdorfer and I McGregor (eds.): Malaria: Principles and Practice of Malariology (vol. 1). Edinburgh: Churchill Livingston, pp. 1-32.

Buxton LHD and Rice DT (1931) Report on the Human Remains Found at Kish. Journal of the Royal Anthropological Institute of Great Britain and Ireland 61:57-119.

Cappieri M (1969) The Mediterranean Race in Asia before the Iron Age. Occasional Paper No. 8. Field Research Projects. Coconut Grove, Miami

Cappieri M (1970) The Mesopotamians of the Chalcolithic and Bronze Ages. Occasional Paper No. 12. Field Research Projects. Coconut Grove, Miami

Cappieri M (1972) Genotypical and Phenotypical Homogeneity of the Ancient Population of Anatolia. Field Research Projects. Coconut Grove, Miami

Cappieri M (1973) The Iranians of the Copper/Bronze Age. Field Research Projects. Coconut Grove, Miami

Clement DB, Taunton JE and Smart GW (1984) Achilles Tendinitis and Peritendinitis: Etiology and Treatment. American Journal of Sports Medicine 12:179-184.

Cohen MN (1977) The Food Crisis in Prehistory: Overpopulation and the Origins of Agriculture. New Haven: Yale University Press.

Courty M-A (1994) Le Cadre Paléogéographique des Occupations Humaines dans le Bassin du Haut-Khabur (Syrie du Nord-Est). Premiers Résultats.

Dutour O (1986) Enthesopathies (Lesions of Muscular Insertions) as Indicators of the Activities of Neolithic Saharan Populations. American Journal of Physical Anthropology 71:221-224.

El-Sabbagh and Kamel M (1989) Avascular Necrosis of Temporomandibular Joint in Sickle Cell Disease. Clinical Rheumatology 8:393-397.

Feasby R (1998) Stable Isotope Evidence for Dietary Patterns and Environmental Conditions at Tell Leilan, Syria, ca. 2900-1900 B.C. M.A. Thesis. Department of Anthropology, University of Alberta, Edmonton.

Fennell KJ and Trinkaus E (1997) Bilateral Femoral and Tibial Periostitis in the La Ferrassie 1 Neanderthal. Journal of Archaeological Science 24:985-995.

Field H (1932) Human Remains from Jemdet Nasr, Mesopotamia. Royal Asiatic Society of Great Britain and Ireland Journal October II(IV):967-970.

Gibbons A (1993) How the Akkadian Empire Was Hung Out to Dry. Science 261:985.

Genety J (1972) La maladie des insertions des tendons. Cahiers de Médicine Lyon 48:4685-4690.

Goodman AH, Thomas RB, Swedlund AC and Armelagos GJ (1988) Biocultural Perspectives on Stress in Prehistorical, Historical and Contemporary Population Research. Yearbook of Physical Anthropology 31:169-202.

Hawkey DE and Merbs CF (1995) Activity-induced Musculoskeletal Stress Markers (MSM) and Subsistence Strategy Changes among Ancient Hudson Bay Eskimos. International Journal of Osteoarchaeology 5:324-328.

Heine J (1926) Uber die Arthritis deformans. Virchow's Archive a Pathological Anatomy, 260:521-663.

Hershkovitz I, Ring B, Speirs M, Galili E, Kislev M, Edelson G and Hershkovitz A (1997) Possible Congenital Hemolytic Anemia in Prehistoric Coastal Inhabitants of Israel. American Journal of Physical Anthropology 85:7-13.

Huss-Ashmore RA, Goodman AH and Armelagos GJ (1982) Nutritional Inferences from Paleopathology. Advanced Archaeological Method and Theory 5:395-474.

Issar AS (1995) Climatic Change and the History of the Middle East. American Scientist 83:350-355.

Jurmain RD (1977) Stress and the Etiology of Osteoarthritis. American Journal of Physical Anthropology 46:353-366.

Jurmain RD (1980) The Pattern of Involvement of Appendicular Degenerative Joint Disease. American Journal of Physical Anthropology 53:143-150.

Jurmain RD (1991) Degenerative Changes in Peripheral Joints as Indicators of Mechanical Stress: Opportunities and Limitations. International Journal of Osteoarchaeology 1:247-252.

Kellgren JH (1961) Osteoarthritis in Patients and Populations. British Medical Journal 2:1-6.

Kennedy KAR (1989) Skeletal Markers of Occupational Stress. In MY Iscan and KAR Kennedy (eds): Reconstruction of Life from the Skeleton. New York: Alan Liss, pp. 129-160.

Kennedy KAR, Plummer J and Chiment J (1986) Identification of the Eminent Dead: Penpi, a Scribe of Ancient Egypt. In K Reichs (ed): Forensic Osteology: the Recovery and Analysis of Unknown Skeletal Remains. Springfield: Charles C. Thomas, pp. 290-307.

Kent S (1987) The Influence of Sedentism and Aggregation on Porotic Hyperostosis and Anaemia: A case study. Man 21:605-636.

Knüsel CJ (1993) Notes and Comments: On the Biomechanical and Osteoarthritic Differences Between Hunter-Gatherers and Agriculturalists. American Journal of Physical Anthropology 91:523-527.

Knüsel CJ, Göggel S and Lucy D (1997) Comparative Degenerative Joint Disease of the Vertebral Column in the Medieval Monastic Cemetery of the Gilbertine Priory of St. Andrew, Fishergate, York, England. American Journal of Physical Anthropology 103:481-495.

Krogman (1940a) The Peoples of Early Iran and their Ethnic Affiliations. American Journal of Physical Anthropology 26: 269-308.

Krogman (1940b) The Skeletal and Dental Pathology of an Early Iranian Site. Bulletin of the History of Medicine 8:28-48.

Lai P and Lovell NC (1992) Skeletal Markers of Occupational Stress in the Fur Trade: a Case Study from a Hudson's Bay Company Fur Trade Post. International Journal of Osteoarchaeology 2:221-234.

Lallo J, Armelagos GJ and Mensforth RP (1977) The Role of Diet, Disease and Physiology in the Origin of Porotic Hyperostosis. Human Biology 49(3):471-483.

Laor E, Garfunkel A and Koyoumdjisky-Kay E (1982) Skeletal and Dental Retardation in Beta Thalassemia Major. Human Biology 54:85-92.

Lee RB (1968) What Hunters Do For a Living, or, How to Make Out on Scarce Resources. In RB Less and I DeVore (eds.): Man the Hunter. Chicago: Aldine, pp. 30-48.

Lee RB (1979) The !Kung San: Men, Women, and Work in a Foraging Society. Cambridge: Cambridge University Press.

Lovell NC (1997) Trauma Analysis in Paleopathology. Yearbook of Physical Anthropology 40:139-170.

Lovell (1998) The Biocultural Context of Anemia in the Ancient Indus Valley. Journal of Human Ecology 9(3): 205-219.

Mann RW and Murphy SP (1990) Regional Atlas of Bone Disease: a Guide to Pathologic and Normal Variation in the Human Skeleton. Springfield: Charles C Thomas.

Martin D Goodman A and Armelagos GJ (1985) Skeletal Pathologies as Indicators of Quality and Quantity of Diet. In R Gilbert and J Meilke (eds.): The Analysis of Prehistoric Diets. New York: Academic Press, pp. 227-279.

Mensforth R, Lovejoy C, Lallo J and Armelagos G (1978) The Role of Constitutional Factors, Diet and Infectious Disease in the Etiology of Porotic Hyperostosis and Periosteal Reactions in Prehistoric Infants and Children. Medical Anthropology 2(1):1-59.

Merbs C (1983) Patterns of Activity-Induced Pathology in a Canadian Inuit Population. Archaeological Survey of Canada Paper No. 199. Ottawa, National Museum of Canada.

Ortner DJ (1979) Disease and Mortality in the Early Bronze Age People of Bab edh-Dhra, Jordan. American Journal of Physical Anthropology 51:589-98.

Ortner DJ (1988) Theoretical and Methodological Issues in Paleopathology. In DJ Ortner and AC Aufderheide (eds.): Human Paleopathology: Current Syntheses and Future Options. Washington: Smithsonian Institution Press, pp. 5-11.

Ortner DJ and Putschar WJ (1985) Identification of Pathological Conditions in Human Skeletal Remains (2nd edition). Washington DC: Smithsonian Institution Press.

Otterman J and Star DO'C (1995) Alternative Regimes of Surface and Climate Conditions in Sandy Arid Regions: Possible Relevance to Mesopotamian Drought 2200-1900 BC.

Palkovich AM (1987) Endemic Disease Patterns in Paleopathology: Porotic Hyperostosis. American Journal of Physical Anthropology 74:527-537.

Pollitt E (1987) Effects of Iron Deficiency on Mental Development: Methodological Considerations and Substantive Findings. In FE Johnston (ed.): Nutritional Anthropology. New York: Alan R. Liss, pp. 225-254.

Rathbun TA (1972) A Study of the Physical Characteristics of the Ancient Inhabitants of Hasanlu, Iran. Study no. 68. Field Research Papers. Coconut Grove, Miami.

Rathbun TA (1975) A Study of the Physical Characteristics of the Ancient Inhabitants of Kish, Iraq. Study No. 87. Field Research Projects, Coconut Grove, Miami.

Rathbun TA (1979) Metric and Discrete Trait Variation among Metal Age Iranian and Mesopotamian Populations. American Journal of Physical Anthropology 50 (3): 473.

Rathbun TA (1982) Morphological Affinities and Demography of Metal-Age Southwest Asian Populations. American Journal of Physical Anthropology 59: 47-60.

Rathbun TA (1984) Skeletal Pathology from the Paleolithic Through the Metal Ages in Iran and Iraq. In MN Cohen and GJ Armelagos (eds.): Paleopathology at the Origins of Agriculture. Orlando: Academic Press Inc., pp. 137-168.

Resnick D and Niwayama G (1988) Degenerative Disease of the Spine. In D Resnick and G Niwayama (eds.): Diagnosis of Bone and Joint Disorders (2nd edition), volume 3. Philadelphia: WB Saunders Company, pp. 1480-1561.

Roberts C and Manchester K (1995) The Archaeology of Disease (2nd edition). Ithaca: Cornell University Press.

Rogers J and Waldron T (1995) A Field Guide to Joint Disease in Archaeology. Chichester: John Wiley and Sons.

Rogers J, Waldron T, Dieppe P and Watt I (1987) Arthropathies in Palaeopathology: the Basis of Classification According to Most Probable Cause. Journal of Archaeological Science 14:179-93.

Rosen AM (1995) The Social Response to Environmental Change in Early Bronze Age Canaan. Journal of Anthropological Archaeology 14: 26-44.

Rosen AM (1997) What Hath Drought Wrought? The Sciences July/August: p. 47.

Rothschild BM and Woods RJ (1991) Spondyloarthropathy: Erosive Arthritis in Representative Defleshed Bones. American Journal of Physical Anthropology 85:125-134.

Rucknagel DL (1966) On the Geographical Distribution and Ethnic Origin of Thalassaemia. New Zealand Medical Journal 65:826-831.

Ruff CB (1987) Postcranial Adaptation to Subsistence Changes on the Georgia Coast. American Journal of Physical Anthropology 72:248.

Ruff CB, Larsen CS and Hayes WC (1984) Structural Changes in the Femur with the Transition to Agriculture on the Georgia Coast. American Journal of Physical Anthropology 64:125-136.

Sahlins MD (1972) Stone Age Economics. Chicago: Aldine-Atherton.

Singcharoen T (1989) Unusual long Bone Changes in Thalassaemia: Findings on Plain Radiography and Computed Tomograpy. British Journal of Radiology 62:168-171.

Smillie IS (1962) Injuries of the Knee Joint (3rd edition). Baltimore: Williams and Wilkins.

Smith P (1989) The Skeletal Biology and Paleopathology of Early Bronze Age Populations in the Levant. In P de Miroschedji (ed.): L'urbanisation de la Palestine à l'age du Bronze ancient: Bilan et Perspectives de Recherches actuelles. Actes du Colloque d'Emmaüs (20-24 Octobre). BAR International Series 527(ii): 297-313.

Sokoloff L (1978) Osteoarthritis. In WH Simon (ed.): The Human Joint in Health and Disease. Philadelphia: University of Pennsylvania Press, pp. 91-111.

Sokoloff L (1980) The Pathology of Osteoarthrosis and the Role of Aging. In G Nuki (ed.): The Aetiopathogenesis of Osteoarthrosis. Tunbridge: Pittman Medical Publishing, pp. 1-15.

Steele DG (1976) The Estimation of Sex on the Basis of the Talus and Calcaneus. American Journal of Physical Anthropology 45:581-588.

Steinbock RT (1976) Paleopathological Diagnosis and Interpretation. Illinois: Charles C. Thomas.

Stirland A (1988) Diagnosis of Occupationally Related Paleopathology: Can It Be Done? In DJ Ortner and AC Aufderheide (eds.): Human Paleopathology: Current Syntheses and Future Options. Washington: Smithsonian Institution Press, pp. 40-47.

Stuart-Macadam P (1985) Porotic Hyperostosis: Representative of a Childhood Condition. American Journal of Physical Anthropology 66:391-398.

Stuart-Macadam P (1987) Porotic Hyperostosis: New Evidence to Support the Anemia Theory. American Journal of Physical Anthropology 74:521-526.

Stuart-Macadam P (1989) Porotic Hyperostosis: Relationship between Orbital and Vault Lesions. American Journal of Physical Anthropology 80:187-193.

Stuart-Macadam P (1992a) Anemia in Past Human Populations. In P Stuart-Macadam and SK Kent (eds): Diet, Demography and Disease: Changing Perspectives on Anemia. New York: Aldine De Gruyter, pp. 51-170.

Stuart-Macadam P (1992b) Porotic Hyperostosis: A New Perspective. American Journal of Physical Anthropology 87:39-47.

Tainter JA (1988) The Collapse of Complex Societies. Cambridge: Cambridge University Press.

Waldron T (1994) Counting the Dead. The Epidemiology of Skeletal Populations. New York: Wiley.

Weinberg ED (1984) Iron Withholding: A Defense Against Infection and Neoplasia. Physiology review 64:65-102.

Weiss H (1996) Desert Storm. The Sciences May/June: 30-36.

Weiss H (1997) Reply to Rosen: What Hath Drought Wrought? The Sciences July/August: p. 47.

Weiss H, M-A Courty, W Wetterstrom, G Guichard, L Senior, R Meadow, A Curnow (1993). The Genesis and Collapse of Third Millennium North Mesopotamian Civilization. Science 261:995-1004.

Weiss H and Courty M-A (1993) The Genesis and Collapse of the Akkadian Empire: The Accidental Refraction of Historical Law. In M Liverani (ed.): Akkad: The First Empire. Padua: Sargon, pp. 129-154.

Williams JA (1994) Disease Profiles of Archaic and Woodland Populations in the Northern Plains. In DW Owsley and RL Jantz (eds.): Skeletal Biology in the Great Plains: Migration, Warfare, Health and Subsistence. Washington: Smithsonian Institution Press, pp. 91-108.

Wright K (1998) Empires in the Dust. Discover March, pp. 94-99.

Yuthavong Y and Wilairat W (1993) Protection Against Malaria by Thalassaemia and Haemoglobin variants. Parasitology Today 9:241-245.

CHAPTER 4 -- CONCLUSIONS

4.1 Paleopathological Analysis of Health -- Problems and Limitations

Paleopathological analyses have provided archaeologists with another means of examining the adaptation of a group of people to their natural and social environment. The great potential of such information should not, however, obscure the fact that the ability of these analyses to provide meaningful information depends upon a number of conditions. Paleopathological analysis consists of three basic steps:

1) description of lesions
2) diagnosis (where possible) and classification of lesions and,
3) paleoepidemiological summary and interpretation.

Interpretive assumptions and practical problems occur at each of these stages.

4.1.1 Description of Lesions

Many researchers have emphasized the need for careful description of pathological conditions in archaeological remains (see for example Mann and Murphy 1990; Rothschild and Martin 1992; Steinbock 1976) but none as forcefully as Ortner (*e.g.*, 1991, 1992, 1994; see also Ortner and Putschar 1985). Accurate and comprehensive description of pathological lesions is not only necessary for accurate diagnoses, but it also allows researchers, who do not have direct access to the bones, to make their own evaluations regarding the observed pathological conditions. While Ortner and Putschar (1985), as well as others (see for example Mann and Murphy 1990), have argued for the use of an unambiguous and specialized terminology in such descriptions, there is not yet a single established methodology (for examples of various proposed protocols see Buikstra and Ubelaker 1994, Ortner and Putschar 1985, Powell 1988). The variable and often ambiguous terminology used in many, especially older, investigations makes comparison between published reports difficult. In an attempt to provide some measure of consistency with other studies, the pathological conditions observed in this thesis were described using the terminology provided in the glossary of *Standards For Data Collection From Human Skeletal Remains* edited by Buikstra and Ubelaker (1994), as well as the proposed nouns and adjectives suggested in the Paleopathology Newsletter (Ragsdale 1992).

4.1.2 Lesion Diagnosis and Classification

Specific diagnosis of pathological conditions in skeletal remains is inherently problematic and this is, perhaps, the most difficult aspect of any paleopathological investigation. First, bone has a limited response to stress and, as such, many different pathological conditions can appear similar on the skeleton. Second, as Ortner has pointed out, paleopathology suffers from an "overreliance on clinical diagnostic criteria " (1991:6). Specifically, he is concerned with the clinical observations derived from radiology which have a number of limitations when applied to skeletal material. For example, many lesions (those with a change in bone density of less than 40%) will not show up on radiographs of living individuals and so will not be included in clinical diagnostic criteria. Third, the fragmentary nature of archaeological remains often makes it impossible to document the full extent and distribution of a condition making precise diagnosis impossible. Rothschild and Martin (1992:131) have pointed out three further assumptions of paleopathological diagnosis:

1) diagenesis has not altered the skeletal tissue
2) the disease has not changed over time
3) no other disease existed in the past that had a similar appearance but now no longer exists

The fragmentary and poorly preserved skeletal material from Tell Leilan makes several of these assumptions especially relevant. It was, for example, not possible to establish the full extent and distribution of lesions. This was, however, an unavoidable problem that can only be remedied with additional material. In an attempt to avoid the pitfalls of diagnoses based on limited material, precise diagnosis was, in most cases, not attempted beyond simple descriptive categories.

4.1.3 Paleoepidemiological Summary/Interpretation

Once the individual pathological conditions have been described and classified, this information must be placed within the broader biological and cultural context so that meaningful conclusions can be drawn about the population from which they were observed. In order to generate substantial conclusions, however, it is necessary to have a sample which is representative of the population as a whole. This is, in most cases, impossible in the archaeological record. Certainly the sample investigated in this study should not be considered representative of the population as a whole. Not only is the sample small, but all of the individuals were adults, found, for the most part, in a non-cemetery context. The role that these individuals played in the social life of Tell Leilan is unknown. Despite this, however, information regarding the types of pathological conditions present at Bronze Age Tell Leilan can be determined, as can a tentative account of frequencies so long as the nature of the sample is kept in mind.

An additional problem with generating health profiles for populations is what has been termed the "osteological paradox" (Wood *et al.* 1992). While it is usually assumed that low rates of skeletal lesions are evidence for low morbidity, and thus good health, Ortner (1994) has pointed out that there are, in fact, three basic options for interpreting the evidence of disease presence or absence. First, a person can die before the skeleton has had a chance to respond to the stress, second the person can recover before the skeleton is affected, or third the stress can become chronic and affect the skeleton. Rather than indicating good health then, a lack of lesions may point to a lack of immune response indicating poor health. A high frequency of lesions, on the other hand, may indicate that an individual was able to adapt to and live with the chronic stresses until finally dying as the result of related or unrelated causes. In order to determine which of these scenarios is most likely, paleopathological data must be considered within a framework of demographic variables (especially age at death).

4.1.4 Additional Problems at Tell Leilan

Besides the general limitations of paleopathology outlined above, the excavation and collection of the skeletal remains from Tell Leilan presented some additional analytical problems. First, in some cases only parts of individual skeletons were excavated since the remaining skeletal material was located in excavation baulks, which were not excavated, thus preventing complete analysis. Second, many of the bones were treated with PolyVinyl Acetate (PVA), a consolidant designed to prevent the bones from further fragmenting after excavation. Unfortunately, the consolidant was applied, in many cases, while the skeletal material was still in the ground, allowing considerable amounts of dirt, grass and other extraneous material to fix to the bone. The presence of the consolidant itself, along with the various debris, can prevent examination of the bone surface and make the identification of pathological lesions impossible. Third, the written documentation of the burials is limited at best and is, in many cases, entirely absent. This lack of documentation made it difficult to sort out individuals in the multiple burials especially when bones became commingled during excavation and packing. A lack of *in situ* age and sex data also represented a loss of data which was in many cases impossible to recover. The problems just described, while not as constraining as many of the other problems and limitations outlined above, are significantly more disturbing in light of their preventable nature. Careful excavation, collection, and documentation of skeletal remains are essential if reliable and consistent conclusions are to be drawn.

4.2 Conclusion

Given the potential pitfalls of paleopathological analyses presented above, all conclusions generated from the analysis of the Tell Leilan material must be considered tentative pending the collection of further skeletal and archaeological data. Despite this, however, a number of preliminary conclusions can be drawn. The skeletal remains from Tell Leilan seem to point to a population that was suffering from some degree of biological stress. Whereas the amount of observed enthesial alteration appears to suggest a population that was engaged in physically demanding activities, possibly commencing at a young age, data from both the spine and appendicular joints show very little arthritic change. This would seem to indicate that the people were dying at a relatively young age. Although the cause of death for these individuals is unknown, evidence of chronic stress is present in relatively high frequencies in the form of non-specific infection/inflammation and anemia. While it is plausible that this chronic stress is related to the proposed environmental degradation circa 2200 B.C., further work is necessary to confirm this conclusion.

4.3 Recommendations for Future Research

In light of the analysis presented here, a number of directions for future research become readily apparent.

Additional skeletal material should be sought at Tell Leilan, especially from Periods II and III, in order to establish the frequency pattern of pathological lesions through time. Increasing the size of the skeletal sample is also necessary in order to confirm or refute the conclusions offered here. Additionally, a more precise analysis of the relationships between health, gender, age and status should be completed. This analysis requires a large, representative sample of individuals as well as the documentation of detailed information concerning associated grave goods. Special attention should be paid to the excavation, collection and documentation of the skeletal material, including *in situ* analysis if necessary. Skeletal material from other sites in northern Mesopotamia must also be examined in order to determine the regional extent of the trends identified in this study. If possible, comparable methodological and analytical techniques should be used.

4.4 Final Thoughts

While it is recognized that further work is required before conclusive statements can be offered, this study has presented preliminary results that indicate that the population of Bronze Age Tell Leilan was suffering from some degree of biological stress, a finding that is not inconsistent with the proposed environmental disruption circa 2200 B.C. Finally, the character of northern Mesopotamian civilization remains largely unknown in comparison to other world areas. Skeletal data, such as that presented here, have the potential to provide an additional source of information and it is hoped that continued research in this area will be used to refine and develop our knowledge of the region.

REFERENCES CITED

Buikstra JE and Ubelaker D (eds.) (1994) Standards for Data Collection From Human Skeletal Remains. Fayetteville: Arkansas Archaeological Survey Research Series, No. 44.

Mann RW and Murphy SP (1990) Regional Atlas of Bone Disease: a Guide to Pathologic and Normal Variation in the Human Skeleton. Springfield: Charles C Thomas.

Ortner DJ (1991) Theoretical and Methodological Issues in Paleopathology. In DJ Ortner and AC Aufderheide (eds.): Human Paleopathology: Current Syntheses and Future Options. Washington: Smithsonian University Press, pp. 5-12.

Ortner DJ (1992) Skeletal Paleopathology: Probabilities, Possibilities, and Impossibilites. In, JW Verano and DH Ubelaker (eds.) Disease and Demography in the Americas. Washington: Smithsonian Institution Press, pp. 5-15.

Ortner DJ (1994) Descriptive Methodology in Paleopathology. In, DW Owsley and RL Jantz (eds.) Skeletal Biology in the Great Plains: Migration, Warfare, Health and Subsistence. Washington: Smithsonian Institution Press, pp. 73-80.

Ortner DJ and Putschar WGJ (1985) Identification of Pathological Conditions in Human Skeletal Remains. Washington: Smithsonian Institution Press.

Powell ML (1988) Status and Health in Prehistory. Washington: Smithsonian Institution Press.

Ragsdale B (1992) Task Force on Terminology: Provisional Word List. Paleopathology Newsletter no. 78:7-8.

Rothschild BM and Martin LD (1992) Advances in Detecting Disease in Earlier Human Populations. In: SR Saunders and MA Katzenberg (eds.), Skeletal Biology of Past Peoples: Research Methods. New York: Wiley -Liss, pp. 131-151.

Steinbock, RT (1976) Paleopathological Diagnosis and Interpretation: Bone Diseases in Ancient Human Populations. Springfield: Charles C Thomas.

Wood JW, Milner GR, Harpending HC, Weiss KM (1992) The Osteological Paradox: Problems of Inferring Prehistoric Health from Skeletal Samples. Current Anthropology 33(4): 343-370.

Appendix A - Data Collection Forms and Protocols

PROTOCOL USED TO RECORD OSTEOARTHRITIC LESIONS

Each score consists of two components: **Severity Score - Extent Score**

SEVERITY SCORE

Lipping (**L**) - (indicate maximum expression observed)

0	absent
1	slight (sharp ridge, sometimes curled with spicules)
2	moderate (extensive osteophytes)
3	severe (fusion of osteophytes)
9	surface unobservable

Note: Lipping is only scored if it is marginal to the joint surface and does NOT include osteophytic activity away from the articular surface.

Porosity (**P**) - (indicate maximum expression observed)

0	absent
1	slight (pin-prick size)
2	moderate (coalesced pits)
3	severe (large erosions)
9	surface unobservable

Eburnation (**E**) - (indicate maximum expression observed)

0	absent
1	slight (barely discernible)
2	moderate (polish only)
3	severe (polish with grooves)
4	surface unobservable

EXTENT SCORE (use same codes for all alterations)

1	<1/3 of the articular surface
2	1/3-2/3 of the articular surface
3	>2/3 of the articular surface
9	extent can not be established

SURFACES EVALUATED FOR OSTEOARTHRITIS

UPPER BODY

Mandibular Condyle

Mandibular Fossa

Sternal Clavicle
Lateral Clavicle

Clavicular Notch

Acromial Facet
Glenoid Fossa

Humeral Head
Capitulum
Trochlea

Radial Head
Radial Scaphoid Surface
Radial Lunate Surface

Ulna Head
Radial Notch
Trochlear Notch

LOWER BODY

Acetabulum

Femoral Head
Medial Femoral Condyle
Lateral Femoral Condyle
Patella Surface (femur)

Medial Patellar Facet
Lateral Patellar Facet

Medial Tibial Condyle
Lateral Tibial Condyle
Distal Tibia

Fibular Head Facet
Facet for Talus on Lateral Malleolus

RIBS

Head

Tubercle

HAND

Scaphoid/Radius
Scaphoid/Lunate
Scaphoid/Trapezium
Scaphoid/Capitate
Scaphoid/Trapezoid

Lunate/Radius
Lunate/Scaphoid
Lunate/Triquetral
Lunate/Hamate
Lunate/Capitate

Triquetral/Lunate
Triquetral/Pisiform
Triquetral/Hamate

Trapezium/Trapezoid
Trapezium/Scaphoid
Trapezium/MC1
Trapezium/MC2

Trapezoid/Trapezium
Trapezoid/Capitate
Trapezoid/Scaphoid
Trapezoid/MC2

Pisiform/Triquetrum

Hamate/Triquetral
Hamate/Lunate
Hamate/Capitate
Hamate/MC4
Hamate/MC5

Capitate/Hamate
Capitate/Trapezoid
Capitate/Scaphoid
Capitate/Lunate
Capitate MC2
Capitate MC3
Capitate MC4

MC1/Trapezium
MC1 Head

MC2/Capitate
MC2/Trapezoid
MC2/Trapezium
MC2/MC3
MC2 Head

MC3/Capitate
MC3/MC2
MC3/MC4
MC3 Head

MC4/Capitate
MC4/Hamate
MC4/MC3
MC4/MC5
MC4 Head

MC5/Hamate
MC5/MC4
MC5/Head

Base and Head of Proximal and Middle Phalanges / Base of Distal Phalanges

FOOT

Talar Trochlea (superior surface)
Talus/Medial Malleolus (of tibia)
Talus/Lateral Malleolus (fibula)
Talus/Calcaneus (posterior, middle, anterior)
Talar Head (artic. w/navicular)

Calcaneus/Talus (posterior, middle, anterior)
Calcaneus/Cuboid
Cuneiform 2/3

Navicular/Talar Head
Navicular/Medial Cuneiform
Navicular/Intermediate Cuneiform
Navicular/Lateral Cuneiform

Medial Cuneiform/Navicular
Medial Cuneiform/Intermediate Cuneiform
Medial Cuneiform/MT1
Medial Cuneiform/MT2

Intermediate Cuneiform/Navicular
Intermediate Cuneiform/Med Cuneiform
Intermediate Cuneiform/Lateral Cuneiform
Intermediate Cuneiform/MT2

Lateral Cuneiform/Navicular
Lateral Cuneiform/Intermediate Cuneiform
Lateral Cuneiform/Cuboid
Lateral Cuneiform/MT2
Lateral Cuneiform/MT3
Lateral Cuneiform/MT4

Cuboid/Calcaneus
Cuboid/Lateral Cuneiform
Cuboid/MT4
Cuboid/MT5

MT1/Medial Cuneiform
MT1 Head
MT1/MT2 (sometimes)

MT2/Medial Cuneiform
MT2/Intermediate Cuneiform
MT2/Lateral Cuneiform
MT2/MT1 (sometimes)
MT2/MT3
MT2 Head

MT3/Lateral Cuneiform
MT3/MT2
MT3/MT4
MT3 Head

MT4/Lateral Cuneiform
MT4/Cuboid
MT4/MT3
MT4/MT5
MT4 Head

MT5/Cuboid
MT5/MT4
MT5 Head

Base and Head of Proximal and Middle Phalanges
Base of Distal Phalanges

PROTOCOL USED TO RECORD PATHOLOGICAL VERTEBRAL LESIONS

VERTEBRAL BODY

Vertebral Osteophytosis (**VOP**) - Severity Score (indicate maximum expression observed)

0	absent
1	slight (elevated ring)
2	moderate (curved spicules)
3	severe (ankylosis)
9	surface unobservable

Schmorl's nodes (**SN**) - Severity Score (Knüsel et al 1997)

0	absent
1	mild (slight depression)
2	moderate (<2mm deep, area <1/2 of AP vertebral body length)
3	severe (in excess of moderate values)
9	surface unobservable

VERTEBRAL FACETS

Lipping (**L**) - Severity Score (indicate maximum expression observed)

0	absent
1	slight (sharp ridge, sometimes curled with spicules)
2	moderate (extensive osteophytes)
3	severe (fusion of osteophytes)
9	surface unobservable

Note: Lipping is only scored if it is marginal to the joint surface and does NOT include osteophytic activity away from the articular surface.

Porosity (**P**) - Severity Score (indicate maximum expression observed)

0	absent
1	slight (pin-prick size)
2	moderate (coalesced pits)
3	severe (large erosions)
9	surface unobservable

Eburnation (**E**) - Severity Score (indicate maximum expression observed)

0	absent
1	slight (barely discernible)
2	moderate (polish only)
3	severe (polish with grooves)
4	surface unobservable

EXTENT SCORE (same codes for all alterations)

1	<1/3 of the articular surface
2	1/3-2/3 of the articular surface
3	>2/3 of the articular surface
9	extent can not be established

SAMPLE RECORDING FORM FOR VERTEBRAL LESIONS

Vertebra: ________

BODY				FACETS											
				Articular						Costal					
				Left			Right			Left			Right		
	VOP	P	SN	L	P	E	L	P	E	L	P	E	L	P	E
Superior															
Inferior															
Transverse															

TERMINOLOGY USED TO RECORD TRAUMATIC LESIONS
Following Lovell (1997)

TRAUMA TYPE

1. Dislocation
2. Fractures

2a. Direct Trauma

Penetrating
Comminuted
Transverse
Crush
- depression
- compression
- pressure

Linear (skull)

2b. Indirect Trauma

Spiral
Oblique
Torus/Greenstick
Impacted
Burst
Comminuted
Avulsion

2.c Stress

<u>Position on Bone:</u>

Proximal 1/3	Anterior 1/3
Middle 1/3	Posterior 1/3
Distal 1/3	Circumferential
Proximal epiphysis	Superior Surface
Distal epiphysis	Inferior Surface

HEALING

none (potential perimortem fracture)
incomplete callus formation (woven bone only)
complete callus (lammellar bone present)
remodelling (radiographically visible)

COMPLICATIONS OF HEALING

periostitis
osteomyelitis

non-union
malunion

avascular necrosis
atrophy
Post-traumatic ossification (e.g., ossified haematoma)

osteoarthritis

SAMPLE RECORDING FORM FOR TRAUMATIC LESIONS

Site: | Skeleton ID: | Date:
Age: | Sex: | Stature:

Bone (and side) ____________ Trauma Type:____________
Position on Bone:____________

Length: Left:______mm Right:______mm Overlap:______mm

Apposition: A-P:______% Lateral:_____%

Rotation: Internally Externally

Angulation: Anterior Posterior _____%
Medial Lateral _____%

Healing
Stage:________________
Complications: