THE ARCHAEOLOGY OF HUMAN BONES: PREHISTORIC COPPER PRODUCING PEOPLES IN THE KHAO WONG PRACHAN VALLEY, CENTRAL THAILAND.

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ABSTRACT

This paper presents bioarchaeological results focusing mainly on the human skeletal collection excavated from the Bronze Age site of Non Pai Wai in central Thailand . This collection contains 15 individuals represented fairly well by both cranial and postcranial remains. The results of this study reveal demographic and palaeopathological data. It is suggested that many of the unique physical anthropological implications might reflect skeletal responses to cultural-economic mandates and biophysical mechanical stressors directed by both the physical and social environments.

Archaeological excavations conducted by the Thailand Archaeometallurgy Project (TAP) have brought to light the remains of human settlements and activity areas at the Non Pai Wai and Nil Kham Haeng sites in the Khao Wong Prachan Valley in central Thailand (Pigott *et al.* in press). Non Pa Wai is dated from the late 3rd to the early 1st millennium BC and Nil Kham Haeng to the 1st millennium BC. TAP investigations have provided archaeological evidence indicating large-scale copper production and systems of exchange within village communities. TAP hopes to produce a comprehensive evaluation of the technological, economic and socio-cultural contexts within which large-scale copper production developed.

During the processes of recovery and documentation of the archaeological record, TAP unearthed a significant number of relatively well-preserved human skeletal remains from both sites, interred in primary contexts in burial grounds. Physical anthropological and archaeometric-forensic analyses of the skeletal record, counseled by the breadth of a population/ecological approach, should be able to offer fine-tuned interpretation of aspects of the human condition during this era in Southeast Asia.

ANALYSIS AND RESULTS

Demography: Age and Sex Determinations (Table 1)

Age assessments involving the fifteen individuals comprising this collection indicated the presence of a variety of subgroups ranging from perinatal to middle adulthood. Sex evaluations indicated the presence of five females and three males. The rest of the individuals were either represented by incomplete and deteriorated skeletal remains, or revealed immature skeletal structures, subject to the young age, for purposes of sex determinations.

Prevalence of Pathological Manifestations (Table 2)

Forensic analyses of the skeletal record indicated that eight (53.33%) out of the fifteen individuals comprising the skeletal collection disclosed palaeopathological conditions and markers of *ante mortem* stress. Five individuals (33.33%) revealed incomplete skeletal remains, restraining a thorough examination for palaeopathological conditions, while only 2 individuals (13.33%) showed absence of skeletal changes owed to pathogenesis.

Dental Pathologies

Ten out of the fifteen individuals (66.66%) preserving teeth and their supporting hard tissues preserved expressions of dental pathogenesis. Four individuals (26.66%) were lacking dentitions and alveolar bones, while in one case only (6.66%) it was possible to ascertain the absence of dental disease. Further, eight individuals (53.33%) preserving dentitions revealed traits of dental epigenetic non-metric variation. Shovel-shaped incisors, a dental

Table 1: Thailand Archaeometallurgy Project (TAP), Non Pa Wai site: demographic information.

Site Provenance	Field Catalog No.	Homo Lab. No.	Age Assessment	Age Group Category	Sex Assessment
NPW:A	1	1	>25 y.	Middle Adult	Female
NPW:A	2	2	>21 - <25 y.	Young Adult	Female
NPW:A	3	3	4/5 - <6 y.	Infancy I	Indeterminate
NPW:A	4	4	3.5 - 5.5 y.	Infancy I	Indeterminate
NPW:A	5	5	>35 y.	Middle Adult	Male
NPW:A	6	6	4.0 - <6.0 y.	Infancy I	Indeterminate
NPW:B	1	7	Perinatal	Perinatal	Indeterminate
NPW:B	4	8	>19 - <25 y.	Young Adult	Male
NPW:B	4a	9	19 - 25 y.	Young Adult	Indeterminate
NPW:B	4b	10	> 12-14/15 y.	> Puberty	Female
NPW:B	4c	11	> 12 y.	> Infancy II	Female ?
NPW:B	5	12	>6 - <7 y.	Infancy II	Indeterminate
NPW:B	6	13	6-9mos +/-2mos	Infancy I	Indeterminate
NPW:C	1	14	>15 - <17/18 y.	Juvenile/SubAdult	Male
NPW:C	2	15	16/17 - 18 y.	SubAdult	Female

Table 2: TAP, Non Pa Wai site: manifestations of disease, epigenetic variation and trauma.

Homo Lab. No	Taphonomy/ Preservation	Skeletal Pathologies	Dental Pathologies	Epigenetic Traits	Traunatic Conditions
1	Good	Present	Present	Dental/InfraCranial	Dental
2	Good	Present	Present	Cranial/Dental/InfCr	Dental
3	Poor	Absent (2)	Present	Dental	N/A
4	Poor	Present	Present	Indeterminate	Absent
5	Good	Present	Present	Dental/InfraCranial	Dental/InfraCranial
6	Poor	Absent	Present	Dental	Absent
7	Poor	Absent	Absent	N/A (1)	N/A
8	Poor-Fair	Present	Present	Dental/InfraCranial	Dental
9	Poor	Present	N/A (1)	Absent (2)	Absent (2)
10	Poor	Absent (2)	N/A (1)	N/A/ (1)	Absent (2)
11	Poor	Absent (2)	N/A (1)	N/A (1)	Absent (2)
12	Fair	Present	Present	Dental	Absent
13	Poor	Absent (2)	Present	Absent (2)	Absent
14	Poor	Present	Present	Dental	Dental
15	Poor	Absent (2)	N/A (1)	Absent (2)	Absent (2)

Note: (1)= Not available for study; (2)= Incomplete skeletal or dental record.

trait most common among Asian peoples, were disclosed with the greatest prevalence. Studies of dental surfaces revealed the presence of unique, uneven and severe wear patterns on selected labial and buccal surfaces, specifically on the incisors and canines of upper and lower jaws, indiscriminately with respect to sex. Such alterations of incisal surfaces were not the result of abrasion owed to the mastication of food prior to ingestion, but rather the result of a synergistic process which included: a) the selective deterioration of labial dental surfaces, due to frictional contact mandated by an "end on end bite", a type trait of Asian orofacial characteristics with unique jaw dimensional interrelationships and dental superio-inferior counterpart alignments; and b) the results of functional modification related to cultural mechanisms, reflecting on *ante mortem* habitual and/or occupational functions (Table 3). The first process, considered the consequence of degenerative biophysical processes, could be traced through discernible markers affecting specifically the mesial surfaces of the maxillary and distal surfaces of the mandibulary canines. The second mechanism, however,

Table 3: TAP, Non Pa Wai site: selected aspects of palaeopathological information.

Homo Lab. Number	Sex & Age Assessments	Acquired Modification of Dental Surfaces Owed to MHOS (*)	Spondyloarthropathies, and Osteoarthritis Affecting the Infra Cranial Skeleton
1	Female, Middle Adult	Maxillary labial teeth	Appendicular skeleton
2	Female, Young Adult	Maxillary labial & buccal	Axial & appendicular skeleton
3	Infancy I	Absence of modifications (#)	Absence (#)
4	Infancy I	Absence of modifications (#)	Absence (#)
5	Male, Middle Adult	Maxillary labial teeth	Axial & appendicular skeleton
6	Infancy I	Absence of modifications (#)	Absence (#)
7	Perinatal	Absence of modifications (#)	Absence (#)
8	Male, Young Adult	Mandibular labial & buccal	Axial & appendicular skeleton
9	Young Adult	Absence of dental record (1)	Axial & appendicular skeleton
10	Female, > Puberty	Absence of dental record (1)	Absence of articular surfaces
11	Female, > Infancy II	Absence of dental record (1)	Absence of articular surfaces
12	Infancy II	Absence of modifications (#)	Appendicular skeleton
13	Infancy I	Absence of modifications (#)	Absence (#)
14	Male, Juvenile-SubAdult	Maxillary labial teeth	Absence of osteoarthritis (@)
15	Female, SubAdult	Absence of dental record (1)	Absence of osteoarthritis (@)

Note: (*) MHOS= Markers of Habitual and/or Occupational Stress; (1)= Material not available for study;
(#)= Not applicable owing to age;
(@)= A thorough examination for osteoarthritic changes was conducted despite the discriminatory factor of age at this pathological context.

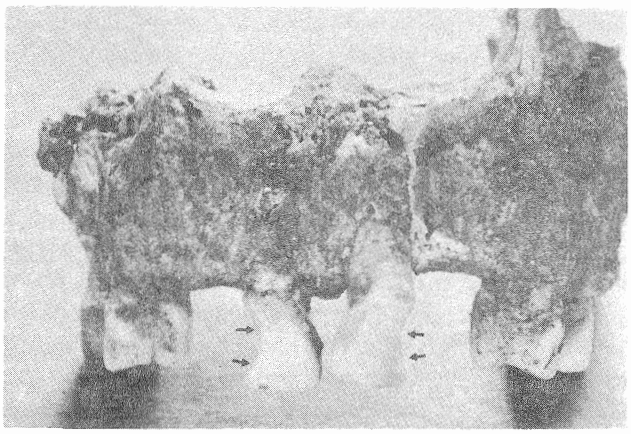

Figure 1: Anterior view of maxillary teeth showing ante mortem *loss of the lateral incisors and characteristic indentations at the distal surfaces of both incisors, markers of habitual and/or occupational stress.*

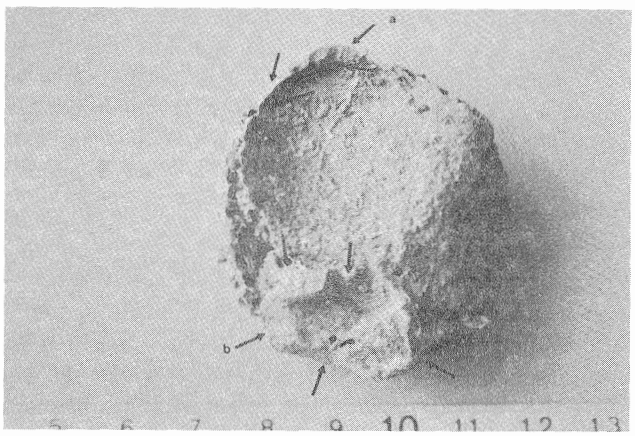

Figure 2: Patellar dorsal view showing significant osseous changes to articular surfaces at specific trajectory loci of stress.

is suggested to represent dental acquired and degenerative markers reflective of the use of teeth as a third hand, during procedures of manipulation and conversion of organic, soft and fibrous raw materials (Agelarakis 1987a, 1987b) for basketry and rope making (Figure 1). However, other materials could have been used as well, and a combination of scanning electron-microscopic and spectra-photometric analyses have been suggested for better determinations of the materials used.

Observations pertaining to masticatory dental wear patterns revealed oblique occlusal surface platforms for all buccal teeth. These wear patterns were indicative of dietary patterns comprising agricultural, very well prepared foods before consumption. It is interesting to note that dietary grit (a by-product of food preparation

through the utilization, for instance, of stone mortars and pestles) was not included in their dietary intake. It is possible that hardwood materials were used for the tasks of food processing and preparation. *Bone isotopic analyses on carbon for apatite and gelatin, and nitrogen for gelatin, conducted for dietary evaluations, are still in the process of evaluation and integration with the rest of the record.

Further evidence for the soft and well prepared nature of the bulk of the foods consumed was provided by the deposits of calculus on dental surfaces at a supragingival level. In addition, periodontal disease, of a moderate degree, had affected all five individuals who were of appropriate age and had sustained dentitions and alveolar bones, consequently indicating a decreased general hygiene status.

Dental enameloblastic hypoplastic defects observed on labial surfaces had marked the dental remains of 8 out of the 10 individuals (80%) with preserved dentitions. Hypoplasias were assessed as permanent markers of constitutional early life-stress owed to instances of cessation and recuperation of growth processes, such as would be caused by childhood diseases, fevers, exanthemas, malnutrition, and trauma coupled with opportunistic and debilitating diseases (Goodman and Rose 1990). Such early life conditions of stress increase the prevalence of morbidity, usually impairing the long term livelihood of affected individuals and often resulting in early death (Agelarakis 1989).

Post-cranial Pathologies

In examining the post-cranial skeletal remains, it was apparent that the predominant pathological manifestations were these of spondyloarthropathic and osteoarthritic nature. All adult individuals were found to have been affected (Table 3). Spondyloarthropathies had affected the vertebral column with osteophytic growths and lipping, while osteoarthritis had affected the joints with synovial lining with hyperporosity, marginal lipping and distinct levels of severity of bone eburnation, secondary to osteoarthritis.

Articular surfaces of the innominate bones, particularly the acetabulae, the caput femorae, the knee joints, the vertebrae, the scapulae, the claviculae, the tarsal and metatarsal bones, the distal articular surfaces of the forearm bones and the joints of the hands were affected with diminishing frequency in the order presented. It should be noted that the primary causative agent for osteoarthritic changes is considered to be the extensive use of the particular articulation, resulting in varying degrees of degeneration and wear of the articular components, although genetic predisposition coupled with environmental factors can be recognized as well.

Markers of Habitual and Occupational Stress

Osteoarthritic changes involving the appendicular skeletal components were coupled with distinct manifestations of osseous plasticity affecting selected loci of the diaphyseal and metaphyseal skeletal structures under study, owed to *ante mortem* conditions of occupational stress, referred to as markers of occupational stress (MOS) by Kennedy (1989), and markers of habitual and occupational stress (MHOS) by this author (Agelarakis 1992a, 1992b).

Investigations of bone plasticity and transformation in reference to occupational stress were first carried out by Wolf in 1892. Of significant importance for anthropology is the archaeological forensic evaluation of osseous responses to stress, the morphological modification of osseous architecture and the behavioral function of bone responding to focalized stress asserted by muscular tissue and physiological compression to particular trajectory points (Agelarakis 1987a, 1987b). The most predominant osteoplastic changes were observed with the claviculae, the patellae, the acetabulae and proximal femoral thirds, the radio-ulnar interosseous crests, the distal tibio-fibular interosseous crests, and the carpals and tarsals, with diminishing prevalence in the order presented.

In evaluating the features and properties of each individual trajectory point, as a corporeal unit involved in the integrated framework of an *ante mortem* functional system, a more esoteric and coherently synergistic pattern of osseous responses to conditions of physiological stress affecting the skeletal structures could be distinguished. It is suggested that the patellar involvement exhibit characteristics indicative of what could be classified as "miner's knees", caused by the maintaining of a squatting posture for lengthy periods (Figure 2). This argument could be further supported by forensic correlations of additional anthroposcopic manifestations revealed on the bones of the lower extremities: a) the platymeric indicia of the femorae suggestive of squatting (Buxton 1938; Kennedy 1989); b) the focal enlargements of the ischial loci of the acetabular regions coupled by the emphasized subperiosteal robusticity at the attachments of the muscle obturator externus (indicative of flexion and abduction of the hip joints); and c) the epigenetic expressions of the trait of Allen's Fossa (Finnegan and Faust 1974), which, according to Angel (1964), reveals squatting through the extensive hyperflection of the hip and knee joints, accompanied by dorsiflection of the tarsal region.

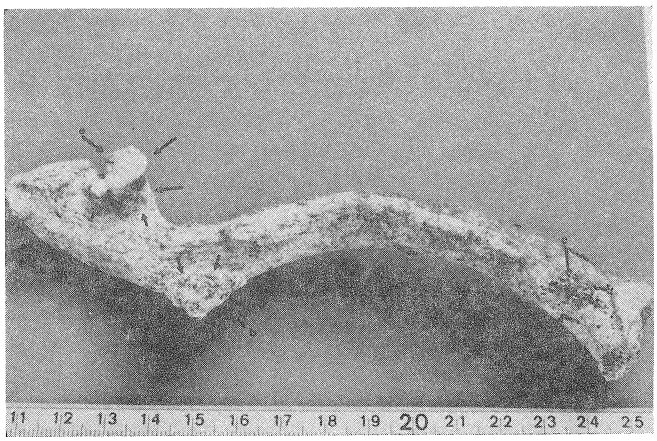

Figure 3: Clavicular inferior view showing osteoplastic responses at selected trajactory loci of stress.

The osseous plasticity changes pertaining to the skeletal structures of the upper extremities of all adults indicated the highest prevalence of involvement at the clavicular extremitas sternalis and acromialis, and the ulnar margo anterior and radio-ulnar margines interossei. Specifically, the clavicular manifestations affected the loci of the linea trapezoidea (ligamentum trapezoideum), the tuberculum conoideum (ligamentum conoideum), clavicula, both components of the ligamentum coracoclaviculare, and the impressio ligamenti costoclavicularis (ligamentum costoclaviculare) (Figure 3). The remodeling and reformation of the clavicular surfaces, coupled by hyperporosity and marginal osteophytes of the articular surfaces were assessed to indicate strenuous physical activities suggestive of repetitious impact loading of the sternoclavicular and acromioclavicular articulations (Radin *et al.* 1972). It is apparent the entire glenohumeral joint must have been affected.

The above manifestations could be correlated with the conditions observed among the bones of the upper arms and forearms (muscle brachialis: tuberositas deltoidea of the humerus to the tuberositas ulnae of the ulna). Osseous hyperplasia was registered at the ulnar crista supinatoris tuberositas ulnae and margo anterior, involving the muscle supinator (supinating the forearm), brachialis (flexing the forearm) and flexor digitorum profundus (flexing and slightly adducting the hand (ulnar deviation) respectively (Figures 4 and 5).

The indications for supination of the hand imply the parallel alignment of the forearm bones if extended (Kelley and Angel 1983), suggesting the presence of the "Vagus angle", or carrying angle between upper arm and forearm, the range of which can be controlled by the degree of flexion and adduction of the forearm and hand. Such a hypertrophy of muscular attachments and insertions could be explained by means of mechanical necessities in maintaining an efficient weight transfer on trajectory upper arm loci during impact loading, and/or physiological stress of compression (Kapandji 1974; 1982) owed to extensive activities pertaining to tool use.

At this juncture, an archaeological forensic reconstructive scenario can be suggested. In conjunction with the rest of the archaeological record, forensic evidence from the skeletal collection could reflect on aspects of the archaeo-metallurgical mining activities and processing, and its *in vivo* effects on the human skeletal structures. Nevertheless, it is appropriate to indicate that an anthropological holistic approach by no means could allow the exclusion of habitual and/or cultural conditions that required similar bodily postures and limb activities.

Elaborating on the complexity of archaeological interpretations and reconstructions it should be noted that in Southeast Asia, compared to other areas of the world, there are few relative records of reference for purposes of comparative assessments. In trying to derive deductive assessments relative to the human environments of prehistoric populations it is imperative that multiple, competing explanatory hypotheses should be tested before we even attempt theory and model building according to our databases. Continuing research and exploration is mandatory. In addition, a close collaboration of physical anthropologists working in the region is strongly suggested for the exchange of information and the sharing of data for purposes of better elucidating reflections of the ancient human condition.

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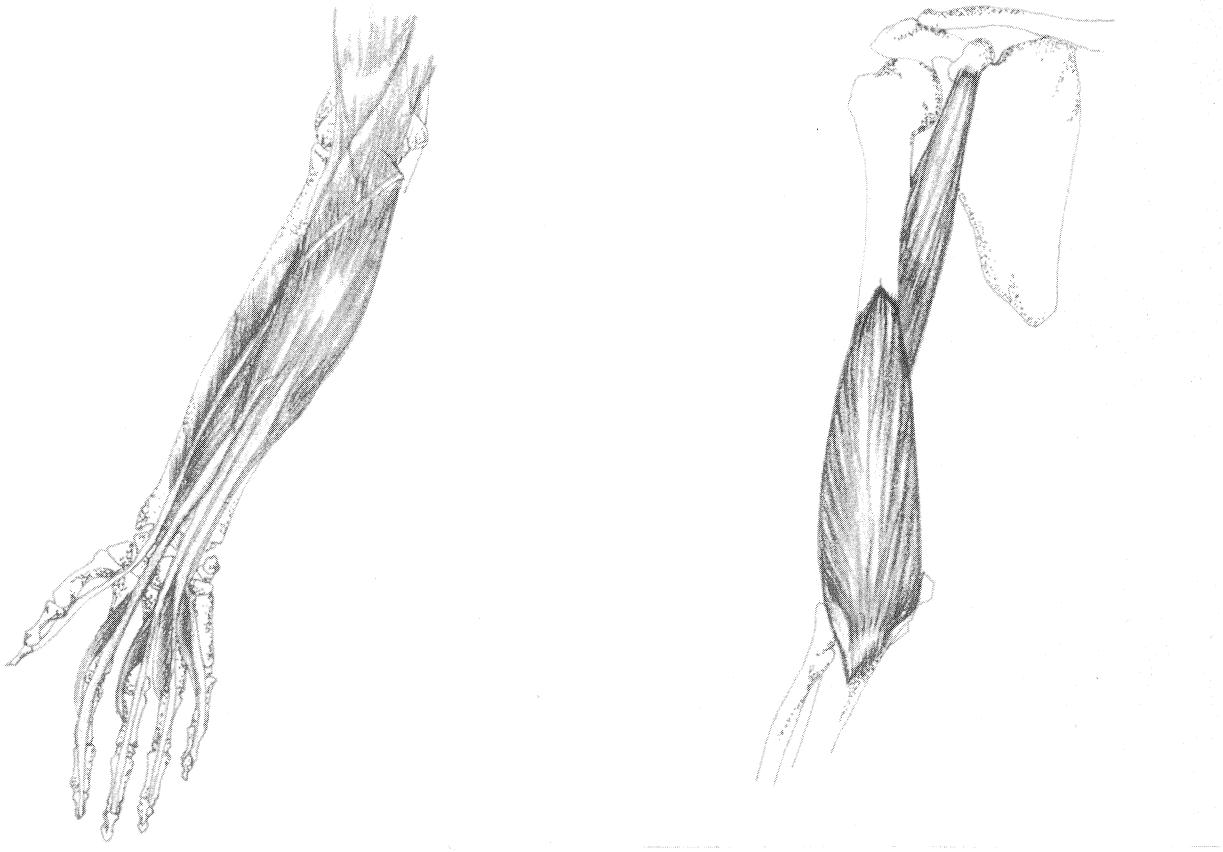

Figure 4: Reconstructions of upper arm, forearm and hand bones with pertinent muscular systems according to the very emphasized periosteal imprints of muscular insertion and attachment loci. These imprints result from strenuous ante mortem *impact loading on these trajectory areas.*

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