



# ARCHAEOLOGY AND CONSERVATION ALONG THE SILK ROAD

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# Archaeology and Conservation along the Silk Road

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## Preface – University of Applied Arts Vienna

Initiated and supported by the Eurasia Pacific Uninet (EPU), the Second International Conference on “Archaeology and Conservation along the Silk Road” was held on May 20–22, 2016 in Nanjing, China.

The first conference of this series in May 2014 was organised by the Northwest University in Xi’an; Prof. Liangren Zhang acted as coordinating partner for the Institute of Conservation of the University of Applied Arts Vienna. Soon after the conference Prof. Zhang was appointed to Nanjing University, and subsequently the project moved with him to the megacity in Southern China. In order to facilitate cooperation, Nanjing University became a member of the EPU network in 2015.

With this event it was possible not only to link as many EPU members as possible – university institutes, specializing in archaeology and conservation-restoration, in Austria, China, Mongolia and Central Asia, but also to call in other experts whose research focuses on the Silk Road(s). The University of Applied Arts Vienna was responsible for gathering researchers, especially those from Austrian universities and specialist institutions as speakers at the conference, to deliver a broad spectrum of Silk Road topics. The Institute of Conservation also invited professors and researchers from Dresden, Potsdam, Berlin, Rome and Berne to Nanjing to report on their current projects and dissertations. Prof. Zhang organised the attendance of Chinese colleagues as well as experts from Iran and Russia, where he is currently involved in field projects.

52 participants from China, Austria, Germany, Switzerland, Iran, Russia, Italy and the U.K. as well as the U.S.A. gathered at the 2016 conference. In over 40 lectures a variety of topics were presented, including research into the migration of nomads, the spread of a variety of grains as a basis for human and animal diets, but also bio-archaeological research into the spread of diseases and epidemics between East and West. The reports featuring conservation sciences in artistic technology (the production of glass, tiles and bronze casting), as well as painting techniques were especially fascinating for the conservators, though problems of preservation and conservation of the different sites along the Silk Road were of no lesser interest. The University of Applied Arts Vienna was represented by a lecture on the training of conservators in Austria and a presentation of a pertinent diploma thesis on Ephesos.

Thanks to the financial support from the EPU, 7 Austrian experts from EPU Member Institutions could participate in the conference. The lectures of the Austrian group made distinct contributions to affirming Austria’s excellent international reputation in the field of archaeology and conservation and its innovations. The conference also provided invaluable opportunities for exchanging experiences and networking.



This publication, a compilation of the conference lectures, represents a substantial step towards the expansion of cooperation between Nanjing University and University of Applied Arts Vienna and in a broader context between China and Austria.

I would like to gratefully acknowledge all the colleagues who made their presentations available for the publication. In particular, I would like to thank my colleague Tanushree Gupta who has undertaken the editing of the conference papers. Martina Haselberger deserves my thanks for her collaboration in the organisation of the conference. I am grateful to Sabine Ladstätter, Director of the Austrian Archaeological Institute (ÖAI), for her assistance in putting together the conference programme and for sharing her expert contacts. I thank my colleague and friend Liangren Zhang for his splendid collaboration over the course of many years. I look forward to our next joint Silk Road conference, which will be held in Iran in 2018!

Gabriela Krist  
Vienna, April 2018

## Preface – Nanjing University

Coined by Ferdinand von Richthofen, the term Silk Road has become a handy concept for scholars who attempt to deal with the trans-continental cultural movements between Europe and Asia. Although much has been achieved in the field of history, archaeology and art history, a lot of potential of this concept remains to be explored. The One Belt - “The Silk Road Economic Belt” and One Road - “the 21st-century Maritime Silk Road” initiatives advocated by the Chinese government since 2013, albeit ignoring the historical complexity, appears to be a well-thought-out exploit of the historical Silk Road to address the contemporary political and economic challenges. The initiatives, in return, have instigated Chinese research institutions, which have long shied away from the foreign land, to start research work in Silk Road countries. In this milieu, Nanjing University has initiated an archaeological field project in Russia and Iran respectively since 2015.

In the same mode, the Eurasia Pacific Uninet (EPU) was found to unite universities of Austria, East Asia, Central Asia, South Asia and the Pacific Region. With a total of 146 member institutions, the network has been fostering joint research centres, inter-institutional research projects, conferences, as well as faculty and student exchange. The timely marriage of the initiative of the former president Brigitte Winklehner and the rising interests of Chinese scholars towards archaeology of foreign countries gave birth to the first “Archaeology and Conservation along the Silk Road” International Conference at Xi’an in May 2014, which was organised by Northwest University and University of Applied Arts Vienna. The success of this conference inspired us, now representing Nanjing University and University of Applied Arts Vienna respectively, to organise the second conference in the series at Nanjing in May 2016.

The second international conference “Archaeology and Conservation along the Silk Road” was planned in such a way that it played out the spirit of the Silk Road in the academic world. On the one hand, the Silk Road has been a popular theme of conferences over the world, yet scholars from many countries, such as Russia and Iran, are under-represented. Seven scholars from Russia and five from Iran presented the steppe Silk Road and the Iranian part of the Silk Road, both of which have often been forgotten in the international conference. On the other hand, archaeologists and conservators, because of the unfortunate separation of the two disciplines, have been sitting in different conferences without communicating with each other. This conference instead brought them together in the hope of providing them with an opportunity to exchange questions and approaches. Although designed as a small conference, 52 scholars from ten countries, including China, Russia, Germany, Austria, and Iran, joined, presenting a variety of subjects.

For various reasons, the majority of the papers delivered in the conference are not available for publishing. Those included in this volume are 13 articles, which nevertheless speak well for the disciplinary and geographic scopes of this conference. In the field of cross-regional phenomenon, Michaela Binder from the Austrian Institute of Archaeology, employing modern DNA and isotopic analyses, explores into the population migration and plague dissemination in the antiquity of Eurasia. Martin Steskal from the same institution finds the DNA components from Europe, Asia, and Africa among the population of the cemetery at the Roman city of Ephesus in Turkey, which depicts a mixed population in this city. Andreas Heiss from the University of Vienna provides a detailed account of the species and sources of the charcoal found at Ephesus. Peter Jia from University of Sydney, based on starch analysis, narrates the dissemination of wheat from the western Tianshan Mountains into Xinjiang, and further into the other regions of China. Hossein Tofighian from the Iranian Centre for Archaeological Research surveys the torpedo jars, which denote active maritime trade across the Persian Gulf and the Indian Ocean in the Parthian and Sasanian periods. Alexey Tishkin from the Altai State University demonstrates the excavation materials from the Yaloman-II cemetery, which denotes the intimate cultural connection with Han China, regardless the great distance. Kira Samosiuk from the State Hermitage Museum exposes the little-known field drawing and photographs of the Berezovskiy brothers at the “Tajik” Grottoes in the Kucha Oasis in the late 19<sup>th</sup> century.

As stated above, conservation is another major theme of this conference, and it is well represented in this volume. Birgit Schmidt from the Federal Institute for Materials Research and Testing analyses the fresco fragments cut by German explorers from the Semsim Grottoes in the early 20<sup>th</sup> century, and attempts to reconstruct the original context of the fresco. Ellen Egel from Berlin State Museum studies the composition and conservation materials of the fresco fragments cut away also by German explorers, and discovers the different sources of pigments. Zhou Shuanglin from Peking University examines the material, production techniques, and conservation problems of the gold-coated silverwares from a Tubo-period cemetery in Dulan County, Qinghai Province. Steffen Lue from the Potsdam University of Applied Sciences describes his conservation work on the mausoleum Ishrat-Khana in Samarkand, where he discovers some unique local techniques, such as “Gansch” plastering and “Kundal” gilded relief. Marisa Laurenzi Tabasso from University of Rome and honorary professor at University of Applied Arts Vienna has been conserving the rock structures of Persepolis and finds white or gray coating on them. Barbara Rankl from the University of Applied Arts Vienna presents a conservation program of the stone sarcophagus discovered at the cemetery of Ephesus.

The organisation of this conference and the publication of this volume cannot be possible without support from various institutions and individuals. In a time of shrinking funding and tightening schedule, we owe our gratitude to all the colleagues who were willing to sacrifice funding and time to attend this conference; to the volunteers who ensured the successful delivery of the event; to Nanjing University for providing funding; to the EPU for paying the travel expenses of the European participants; to Martina Haselberger from University of Applied Arts Vienna for her assistance in the organisation of the conference; to Sabine Ladstätter for her assistance in assembling the conference program and for sharing her expert contacts. The publishing of papers of such diverse disciplines and academic traditions presents a tremendous challenge to the editors. We would like to gratefully acknowledge all the colleagues who made their presentations available for the publication. We would like to thank Tanushree Gupta from University of Applied Arts Vienna for editing the papers of this volume.

Liangren Zhang  
Nanjing, July 2017



# Plagues and Peoples<sup>1</sup> – a Bioarchaeological Perspective on Trade Routes

MICHAELA BINDER

**ABSTRACT:** Movement and transport along transcontinental trade routes can influence populations and settlements along its course in a wide range of ways. It is inherently connected with mobility and migration of individuals or groups which aside from goods can also carry new diseases. These processes can have considerable impact on cultural, social, political and biological developments along the routes. They, therefore, represent key elements of studies seeking to elucidate the history and dynamics of trade routes. Through the integration of modern scientific methods such as stable isotope and ancient DNA (aDNA)-analysis, skeletal human remains from archaeological sites represent an important source of information that can help shedding light on the origin of people(s) and population affinities but also the presence of diseases. This paper will discuss the possibilities of modern bioarchaeological research in contributing to the comprehensive study of ancient trade routes. It will introduce the methods available to study mobility, migration, mortality and morbidity in past human populations and set them within the research context of the wider Silk Road region and trade routes in general.

**KEYWORDS:** Bioarchaeology, Palaeopathology, Biomolecular Archaeology, Migration

## INTRODUCTION

The purpose of transcontinental trade routes is movement, an activity that can involve different things that move or are moved – the movement of goods, people, ideas, religions, and concepts, but also of pathogenous agents. This can have a significant impact on the communities settling along their courses, whether in the form of population structure, ethnic or cultural identity, material wealth or health. Investigating these processes in history can be based on a wide range of sources including historic records, material culture or architecture. This contribution will discuss how the scientific study of human remains from archaeological sites, aided by novel biomolecular methods can be used to inform historic and archaeological research into how trade, travel, migration

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1 Title in reference to McNeill 1998

and warfare along the routes of the Silk Road impacted health, living conditions as well as population structure of the groups settling along their course.

#### HUMAN REMAINS AS A SOURCE OF INFORMATION ABOUT LIFE IN THE PAST

Human remains represent one of our most direct sources of information about life in past human populations because the skeleton stores considerable information about the identity of a person such as biological sex, age-at-death, health and disease, diet, place of origin, activity but also genetic relationships.<sup>2</sup> With new scientific techniques, such as stable isotope analysis or aDNA-analysis, skeletons and mummies from archaeological sites allow for increasingly detailed insights into many aspects of the life of past human populations such as living conditions, subsistence strategies but also determining the focus of this contribution: the presence of diseases, origin and relationships of and between



Figure 1 “The Beauty of Xiaohé”. Photo: Matt Rourke / AP / picturedesk.com.

populations in the past. Archaeological research in the Silk Road region can draw upon a remarkably rich record of human remains, including large collections of skeletons but also due to very dry environmental conditions, groups of well-preserved mummies (Fig. 1). Nevertheless, human remains are still vastly under-used as a resource to study how movement along the Silk Road impacted the life of the populations settling within its realm of influence. This is partially also due to the fact that bioarchaeology as a subject is not very well established and the necessary laboratory facilities are not available in the main countries of the silk road. Thus, research mainly has to rely on collaborations with institutions in Europe or the US. Using selected examples of current bioarchaeological research on human remains from the silk road region,

2 E.g. Larsen 2015

this contribution aims to showcase the vast potential held by human remains as a source of information on life of past human populations, focussing on two major themes of Silk Road research – the movement of people(s) as well as the movement of plagues.

#### MOVEMENT OF PEOPLE(S)

Throughout the time period of its existence, the silk roads enabled and attracted movement of people both on an individual level in form of traders, pilgrims, scholars or other kinds of travellers but also on a larger scale in form of nomadic tribes or conquering armies such as the Xiongnu or the Mongols.<sup>3</sup> All these people(s) would have significantly influenced the population structure of the regions which they crossed and where they ultimately settled. The impact of these migrations and movements is still well visible in the genetic make-up of many areas along the Silk Road.<sup>4</sup> However, in many areas still very little is known about the origins and history of settlement dynamics that led to the modern population structure. Human remains from archaeological sites could be used to shed light on these questions.

#### TRACING MIGRATION AND POPULATION HISTORY IN THE BIOARCHAEOLOGICAL RECORD

The human skeleton contains a record of both genetic and geological information that allows for inferences about long- and short-term relationships but also the geographical origin of an individual. It, therefore, provides a valuable source of data to study kinship, population history, mobility and migration in the past. The bioarchaeological tool kit offers a sophisticated set of traditional and biomolecular methods that allow for increasingly detailed and high-resolution insights into these processes.

The relationship between individuals and populations represent one of the most traditional research themes in the field of studying human remains from archaeological sites. Inspired by the then thriving field of evolutionary biology, scientists already started in the 19<sup>th</sup> century to use metric analysis of the shape of the skull and to a lesser degree also bones of the post-cranial skeleton to infer individual and population affinities.<sup>5</sup> In addition, so-called non-metric traits, non-pathological anatomic variants of morphological features in the skeleton and teeth were soon recognized as a marker of the biological relationship between individuals and groups and integrated into the methodological canon of physical anthropology. Both approaches are based on the premise that the mor-

3 E.g. Romgard 2008; Hansen 2012

4 E.g. Comas et al. 1998

5 Pietrusewsky 2008



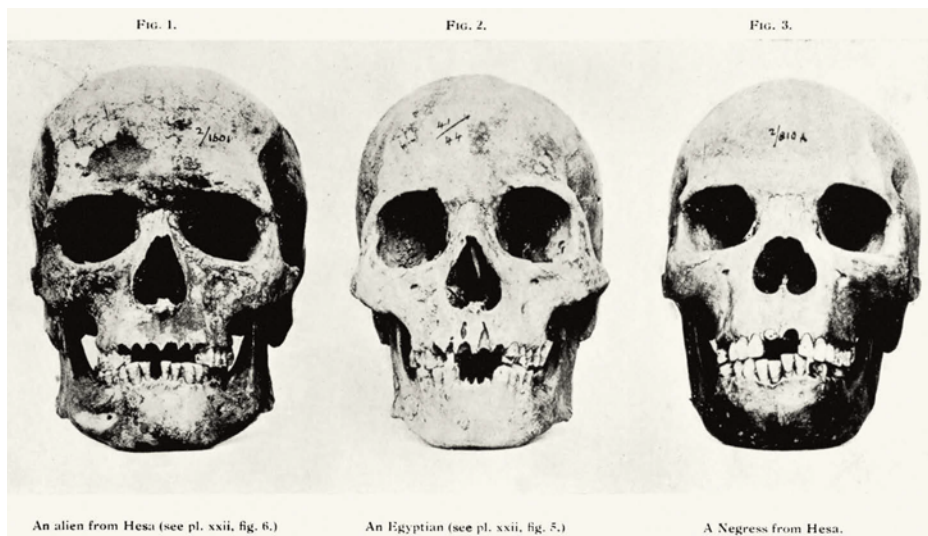


Figure 2 Different skull shapes supposedly identifying different population affinities. Image: M. Binder, reproduced after Smith & Jones 1910, Pl. XXV.

phology and shape of the skull, teeth or long bones reflect the genetic background of an individual (Fig. 2). Similar appearances, therefore, indicate relatedness while differences between individuals and diachronic changes occurring within a population are explained through the presence of non-local individuals.

However, the scientific value and validity of inferences about population history based on morphological and morphometric studies have been increasingly called into question in recent decades.<sup>6</sup> This is largely due to the recognition that despite a general heritability, both metric and non-metric traits can also be influenced by non-genetic parameters such as environmental factors or muscular activity during mastication.<sup>7</sup> In addition to these extrinsic factors, genetic processes like gene drift, alterations in the genetic pool of a population caused by random mutation rather than external genetic input can lead to significant changes in skeletal morphology of an individual. Consequently, due to a large variety of underlying factors causing many of the morphological traits traditionally used in population history studies, their heritability remains imprecisely understood.<sup>8</sup>

Therefore, despite significant improvements in the methodologies applied in quantitative studies of population history over the past decades, both what regards acquisition of data as well as statistical processing, moving from simple uni- and bi-variate statistics and

6 Ibid.

7 Carson 2006

8 Hughes and Townsend 2013

indices to complex multi-variate analyses, the results of these studies, now referred to as biodistance studies, remain problematic due to the complex background of many of the observed parameters.<sup>9</sup>

In recent years, the introduction of new biomolecular methods has opened new pathways in the study of the population history of past human populations based on human remains. The most widely used new method is the analysis of stable strontium isotopes from bone and teeth.<sup>10</sup> The ratio of the strontium isotopes,  $\text{Sr}^{87}/\text{Sr}^{86}$ , varies between different types of underlying bedrock. These values are reflected in the Sr-content in water and, through ingestion by animals and people, consecutively also incorporated into bone and teeth.<sup>11</sup> In theory, this principle allows for the detection of the geographic region of origin of a person. However, several caveats limit the value of the results. In the human skeleton, Sr-isotopes are found in the mineral portion of bone and teeth. In teeth, they are only incorporated during childhood when the tooth enamel is forming and, therefore, only reflect the place of residence of a person during childhood. Bone, on the other hand, undergoes constant remodelling and consequently only stores the isotope signatures of the past ten years prior to death, but, on the other hand, is considerably more prone to diagenetic contamination. The second major issue is related to the fact that many geographical regions around the world share a similar geological background and, therefore, produce very similar strontium signatures.<sup>12</sup> Moreover, geological zones are often relatively large, thus, providing rather unspecific results what regards the place of origin of a person. As a consequence, Sr-isotopes in skeletal human remains only allow for a distinction between local versus non-local individuals but cannot be used to identify the exact origin of a person. Nevertheless, they represent a useful tool to gain some insights into mobility and migration in past human populations.

New momentum in bioarchaeological studies addressing population history was gained with the introduction of scientific methods allowing for the detection and analysis of remnants of genetic information preserved in bones, teeth and soft tissue of archaeological human remains.<sup>13</sup> With our genes storing information about our ancestry ranging from immediate parents back in time to the phylogeny of our species, they allow for detailed insights into a wide range of parameters such as kinship, migratory patterns, and wider population history. The majority of studies investigating aDNA have used the DNA present in the mitochondria which are located in the cytoplasm and produce

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9 Larsen 2015: 361

10 Katzenberg 2008; Brown and Brown 2011

11 Bentley 2006

12 Katzenberg 2008

13 Stone 2008; Brandt et al. 2013

energy for the cells.<sup>14</sup> Mitochondrial DNA (mtDNA) has several advantages. It is present in a high number of copies in each cell and is, therefore, more likely to survive over time than nuclear DNA. Moreover, due to the fact that mtDNA is only inherited from the mother, has a higher rate of mutation, and does not recombine, it is particularly useful for analyses of population genetics even though it only allows for inferences about the female line of ancestry. With increasingly sophisticated analytical techniques, researchers have started also to turn more attention to the study of DNA from the nucleus of the cell which is far more difficult to detect because it is only present in one copy per cell. It holds a large number of different loci yielding information about relationships between populations and individuals, but of course also sex, phenotype or alleles leading to diseases. Nuclear DNA is inherited from both parents, recombination in each generation results in a mosaic of DNA from all ancestors.

Survival of DNA in archaeological human remains is variable and highly dependent on environmental conditions.<sup>15</sup> While cooler temperatures, low humidity and neutral to alkaline soils act favorably for the preservation of the biomolecules carrying genetic information; heat, water and high acidity, all lead to their rapid degradation. In addition, DNA is prone to contamination by modern materials even though modern techniques such as next-generation sequencing allow for better differentiation between original and intrusive material.

#### MOVEMENT OF PEOPLE(S) IN THE SILK ROAD REGION

Through millennia of travel, trade, and migration, the entire Silk Road region experienced a highly complex population history.<sup>16</sup> Despite a vast amount of written and archaeological sources of considerable time depth, many questions are still remaining. Theories and models of migration and settlement dynamics have so far largely been based on written sources, material culture or linguistics despite it is now generally recognised that there are a large number of problems inherent to these parameters potentially leading to erroneous inferences about population history. Despite some exceptions,<sup>17</sup> human remains representing direct evidence so far remain a vastly under-used resource in Silk Road archaeology. In the following, I will discuss a number of studies highlighting the potential of bioarchaeological research to shed light on many important aspects of movement of people(s) along the Silk Roads.

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14 Stone 2008

15 Ibid.

16 E.g. Comas et al. 1998

17 E.g. Kuzmina 1998; Kuzmina and Mair 2007

One notable example is a set of studies carried out on the mummified remains of the Tarim Basin.<sup>18</sup> Dating to the 3<sup>rd</sup> and 2<sup>nd</sup> millennia BC, these have become widely known for their morphological resemblance to European populations despite their origin deep in the Central Asian plains.<sup>19</sup> Based on the archaeological and anthropological evidence including funerary ritual, aspects of material culture and craniometric studies, two main theories had been brought forward to explain the European feature of the Tarim basin inhabitants.<sup>20</sup> One hypothesis suggests that the earliest settlers of this part of Asia were nomadic herders from the steppes of Russia and Kazakhstan, while the other suggests that people came first from the oases of Bactria, or modern Uzbekistan, Afghanistan, and Turkmenistan. In order to clarify the genetic heritage and ancestry, skeletal and mummified human remains from several sites in the region were subjected to aDNA-analysis,<sup>21</sup> most recently Li and co-workers<sup>22</sup> studied the cemetery of Xiaohe. The results of this new study revealed multiple lineages of mtDNA, indicating a complex settlement history of the Tarim Basin. In the earliest layers, the main component was a lineage originating in Siberia as well as a contribution from Western European populations. This confirmed to the original steppe hypothesis with close genetic ties to the Russian/ Kazakh plains. Only during the later period, a small signal of a Southern Asian lineage was detected, indicating a small amount of gene influx from the oases of Bactria as well.

Another area of research exemplifying how archaeological human remains can be used to elucidate the population history of the Silk Road region are burials related to Xiongnu, the confederation of nomadic tribes which ruled over large parts of Central and Northern Asia between the 3<sup>rd</sup> century BC and the late 1<sup>st</sup> century AD.<sup>23</sup> In posing a major opponent to the Han Chinese involved in frequent raids and battles, the impact of Xiongnu is reflected in a large number of written documents of the Chinese. Nevertheless, their origin and relationships to other peoples in Europe and Asia remained unclear until recently. Studies using both traditional, morphological approaches<sup>24</sup> and aDNA-analysis<sup>25</sup> on skeletal human remains revealed a heterogenous mixture of genetic affiliations including North-East Asian tribes but also with influences of Siberian, Turkic and Indo-European tribes. In addition, these analyses were used to address questions of

18 E.g. Cui et al. 2009; Li et al. 2010; Li et al. 2015

19 E.g. Mallory and Mair 2000

20 Mair 2005; Hemphill and Mallory 2004; Barber 1998; Han 1998; Kuzmina 1998

21 Cui et al. 2009; Li et al. 2010

22 Li et al. 2015

23 Higham 2004: 390–392

24 Non-metric traits: Ricaut et al. 2010

25 Keyser-Tracqui, Crubézy, and Ludes 2003; Keyser-Tracqui et al. 2006; Kim et al. 2010

kinship patterns and social organisation within Xiongnu cemeteries.<sup>26</sup> The results suggest burial of family groups within close vicinity of each other.

#### MOVEMENT OF PLAGUES

Travellers along the Silk Road not only carried goods or knowledge but in many cases they were also accompanied by pathogens which people or animals were infected with and, thus, led to the spread of a wide variety of infectious diseases between Asia and Europe. The effect of the movement of pathogenous agents could be devastating particularly because of the fact that they were carried to populations which had never been exposed to them before and, therefore, lacked any immunity to fight the disease.<sup>27</sup> This is based on the evolutionary principle that if a population is exposed to a pathogen over many generations, the immune system develops resistance and the population gets less vulnerable to the disease. If in contrast, an individual or population is exposed to an unfamiliar pathogen, they are much more likely to contract the disease or succumb from it.

Based on historic records, the transmission and spread of several diseases are famously connected to movement along the Silk Roads, first and foremost the plague but also measles, smallpox, anthrax, and leprosy.<sup>28</sup> According to these documents, some of them had a devastating impact on populations on both ends of the Silk Road and consequently on major historic developments.

However, historic records are not necessarily the most trustworthy sources, particularly what regards the diagnosis of diseases because, of course, the diseases as we know them today were only named and defined during the late 19<sup>th</sup> or early 20<sup>th</sup> century. Even though medical descriptions of Chinese or Roman physicians are often very detailed and thorough, they often do not allow for exact identification of a disease. Consequently, many factors about the origin, evolution, identity and spread of many plagues remain unknown.

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26 Keyser-Tracqui, Crubézy, and Ludes 2003

27 McNeill 1998: 192

28 Monot et al. 2009; Schmid et al. 2015; Simonson et al. 2009

## TRACING DISEASES IN THE BIOARCHAEOLOGICAL RECORD

Similar to the place of origin and genetic heritage, skeletal or mummified human remains can also preserve information about the diseases a person once suffered from. Again, several different methods are available to specialists working in the field of palaeopathology, the study of diseases in the past. The most common method relies on the fact



Figure 3 New bone formation on the shin bone. Photo: M. Binder/OEAI-OEAW.

that many pathological conditions can also leave an imprint in the skeleton.<sup>29</sup> Depending on the underlying disease there are generally four different forms of how bone can respond to a disease:

- new bone formation (by far the most common form): infectious diseases, nutritional deficiencies, neoplastic diseases, vascular diseases, trauma (Fig. 3)
- bone destruction: infectious diseases, neoplastic diseases
- abnormal formation of shape: nutritional/metabolic diseases, developmental disorders
- abnormality in size: developmental disorders

Unfortunately, studying diseases based on morphological changes in skeletal and mummified human remains is very complex and is faced with a number of problems inherent to methodology and physiology.<sup>30</sup> The skeleton is generally very slow to react to a disease process and, therefore, only long-standing, chronic processes will lead to bone changes.<sup>31</sup> The development of a bone response further pre-supposes a certain degree of strength and resilience of the diseased individual. Otherwise, it will die before any signs in the skeleton develop. Moreover, the skeleton has only very limited ways to respond

29 Ortner 2003; Ortner 2011

30 Ortner 2011

31 Ortner 2003: 110

to a disease. Therefore, many diseases can lead to the same response, and the resulting changes are often very unspecific. Only some pathogens can lead to more diagnostically distinctive features that allow for attributing them to a specific disease. The most common pathological processes found in skeletal human remains are degenerative disorders (osteoarthritis), dental diseases (caries, plaque, periodontal disease), trauma, nutritional deficiencies (rickets, scurvy) and unspecific signs of infectious diseases.<sup>32</sup> Moreover, infections such as tuberculosis, leprosy or syphilis can lead to changes in the skeleton and have, therefore, received considerable interest in human palaeopathology.

More specific insights into diseases in past human populations can be gained through the identification of DNA of the disease causing pathogens.<sup>33</sup> Especially the DNA of bacteria such as those associated with tuberculosis, plague, leprosy, typhus or typhoid fever can survive in human remains over millennia even though preservation is highly dependent on environmental conditions.

Other pathogens that can survive in archaeological contexts are different endo- and ecto-parasites.<sup>34</sup> Soils from latrines and the gut area of skeletal human remains but also mummified coprolites have been shown to preserve the eggs of intestinal parasites such as hookworms, tapeworms or bilharzias.<sup>35</sup> Moreover, in environmental conditions allowing for the preservation of organic substances, ecto-parasites such as lice or fleas have been found associated with hair, skin or textiles.<sup>36</sup>

## MOVEMENT OF PLAGUES ALONG THE SILK ROAD

Largely based on written records, the Silk Roads have famously been blamed for the spread of several diseases, some of which with significant consequences for historical developments in the East and West. From a European point of view, the most famous and devastating of all epidemics associated with travel along the Silk Roads is the plague pandemic of the 14<sup>th</sup> century, known as the “Black Death”, that decimated the continent’s population by at least one-third.<sup>37</sup> Due to its devastating impact on European history but also the availability of a large number of written and archaeological sources the historic epidemiology of disease has been extensively researched and is, therefore, relatively well-established. It is now generally accepted that *Yersinia pestis*, the plague causing pathogen had long been endemic in rodent populations in the borderland between India,

32 E.g. Goodman and Martin 2002; Ortner 2003; Larsen 2015

33 Stone 2008

34 Bouchet et al. 2003; Dutour 2013

35 E.g. Bouchet, Harter, and Le Bailly 2003; Yeh et al. 2016

36 Bouchet et al. 2003

37 McNeill 1998: 176–180





Figure 4 Skeletons in a plague pit who died from the Black Death in the 14<sup>th</sup> century. East Smithfields Cemetery, London. Photo: Museum of London.

China, and Burma in the Himalayas.<sup>38</sup> People settling in these regions had presumably adjusted their behaviour in order to minimize exposure to infected animals and, thus, chances of contracting the disease. After establishing itself in Central Asia, the Silk Roads provided a viable route for spread of the plague into the Middle East, Northern Africa, and Europe. The transmission was particularly associated with the Mongols who controlled the routes during the 14<sup>th</sup> century and travelled extensively along its course both as warriors and as traders. Their subsistence was mainly based on nomadic pastoralism and involved travel in large caravans with great numbers of horses and livestock that gave off large amounts of waste, which attracted the main hosts of the pathogen causing the plague. As a consequence, their temporary camps and settlements also led to the development of large populations of rats at various points along the Silk Road, making it easy for fleas to spread *Yersinia pestis* from one infected rat population to another. Some infected rats would have also been able to travel along the Silk Roads, hidden inside of

38 Ibid.: 163–176



caravans. Eventually, the plague spread to humans along the Silk Road, early on reaching cities in Palestine and Syria such as Jerusalem and Damascus and then making its way into Europe.

However, and this brings us back to bioarchaeology, there has long been debate as to whether bubonic plague was indeed the underlying disease that caused the Black Death in Europe. This is due to the fact that diagnosis of the disease based on historic records was not unambiguous. The final resolution of the problem was only achieved through the identification of DNA in the skeletons of plague victims recovered during archaeological excavations.<sup>39</sup> A recent study employing novel techniques in aDNA-analysis further shed light on the origins and routes of transmission of the Black Death.<sup>40</sup> The genome of the pathogen identified in individuals from selected plague cemeteries in Great Britain (Fig. 4), France and Germany showed close links to plague strains found in Asia. This provides the first unambiguous scientific evidence in support of the theory that the plague was indeed transmitted from Eastern and Central Asia via the Silk Roads.

A second devastating disease event history which historic sources connect to travel and trade along the silk road is the “Antonine Plague” which de-populated large parts of the Roman Empire between 165–180 AD.<sup>41</sup> Named after the Roman Emperor Marcus Aurelius Antoninus who was reported to be amongst the plague’s victims, the epidemic severely affected the social, economic and political stability of the Roman Empire.<sup>42</sup> It is assumed that the disease was carried by Chinese traders first to Parthia. During the Roman-Parthian wars of the 2<sup>nd</sup> century AD, Roman soldiers would have contracted the disease and carried it back to Roman heartlands. The cause of the disease is yet unclear but based on contemporary descriptions it seems most likely that it would have been smallpox. Smallpox had most likely been introduced into China by the Huns in the 3<sup>rd</sup> century BC where it caused several large scale epidemics in the following centuries.<sup>43</sup> Nevertheless, the first unambiguous medical description of smallpox in China only dates to the 5<sup>th</sup> century AD. Consequently, the cause of many of these earlier epidemics including the Antonine plague still remains debated. Again, archaeological human remains and bioarchaeological studies could help to resolve this case. Unfortunately, the main problem up until now is that isolating DNA of the smallpox virus from archaeological human remains has so far only very rarely been achieved,<sup>44</sup> which may be due to the fact that the viral DNA is very small and thus subject to easy degradation. However, science

39 Raoult et al. 2000; Drancourt et al. 2007; Haensch et al. 2010

40 Haensch et al. 2010

41 Duncan-Jones 1996

42 Fears 2004

43 Finer 2010: 19

44 E.g. Biagini et al. 2012



Figure 5 Hygiene sticks preserving eggs of intestinal parasites recovered from a latrine at the Silk Road relay station Xuanquanzhi. Photo: Courtesy of I. Hui-yuan Yeh, reproduced from Yeh et al. 2016 with permission of the author.

is progressing very fast at the moment, and it is anticipated that a few years from now smallpox will be readily identifiable in the archaeological record.

Transmission of diseases also worked in the other direction. Contrary to earlier theories attributing the spread of Leprosy, a contagious, chronic infectious disease caused by the pathogen *Mycobacterium leprae*, to migration from India around 500 BC,<sup>45</sup> new biomolecular research draws a different picture. Using genomic information from ancient and modern DNA samples of the bacteria, the phylogeographic analysis indicates spread of the disease from the Eastern Mediterranean via Iran into China and then onwards to Korea and Japan.<sup>46</sup> The Silk Roads appear to be the most likely route of transmission and spread of the disease. There is tentative paleopathological evidence with skeletal signs of leprosy in human remains from several Central Asian and Chinese sites,<sup>47</sup> and it is possible that biomolecular research of these individuals will help shedding further light on the spread and transmission of leprosy in antiquity.

Another example of disease transmission along the Silk Roads and how these processes can be detected by new bioarchaeological methods are the findings of endo-parasites from the Silk Road relay station at Xuanquanzhi in Gansu Province (III BC –

45 Monot et al. 2005

46 Monot et al. 2009

47 C. A. Roberts, pers. comm. 2016