
Kindling
the Flame
Cremation and
burnt remains

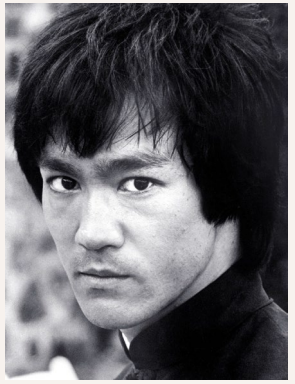
What do these celebrities have in common?

Robin Williams

David Bowie

Leslie Cheung

Alfred Hitchcock

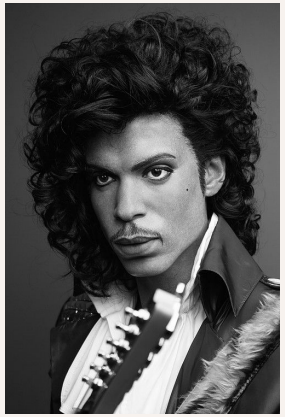


Bruce Lee

Amy Winehouse

John Lennon

Karl Lagerfeld



Prince

They all chose to be cremated

But, what's a cremation?

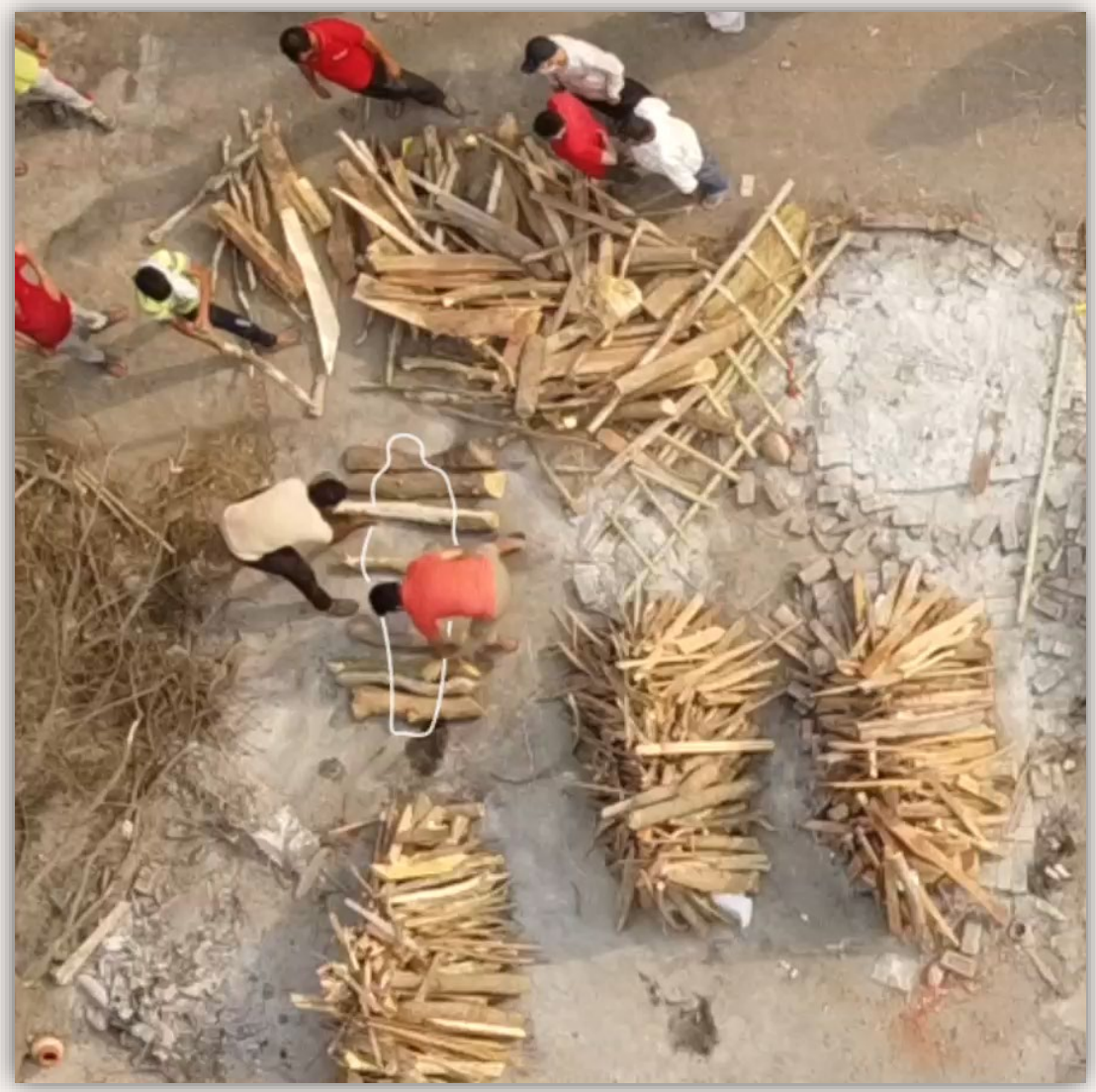
Let's try to define it together!

Definition

‘Cremation’ has two meanings:

1 – the act of burning the dead body (in a funerary context)

2 – the mortuary custom of burning the dead body (including the funeral, rituals, practices, etc.)



https://www.reuters.com/graphics/HEALTH-INDIA/CORONAVIRUS-DEATHS/qzjvqrqaqpx/

Wood stacked for funeral pyres prepared in the carpark of Ghazipur crematorium, Delhi.

Definition

What about the term ‘incineration’?

1 – incineration primarily serves waste management purposes

2 – Latin etymology:
> *incinerāre*: related to *cinis* (“ashes”), meaning “burn to ashes” – *NB: not always true in funerary contexts*
> *cremāre*: from *kerh$_3$- (“heat, fire”), meaning “consume or destroy by fire”

3 – cremation is therefore the more appropriate term for the disposal of the deceased

https://zerowasteeurope.eu/2020/09/no-time-to-waste-incineration-and-waste-to-energy/

Waste management practice involving fire

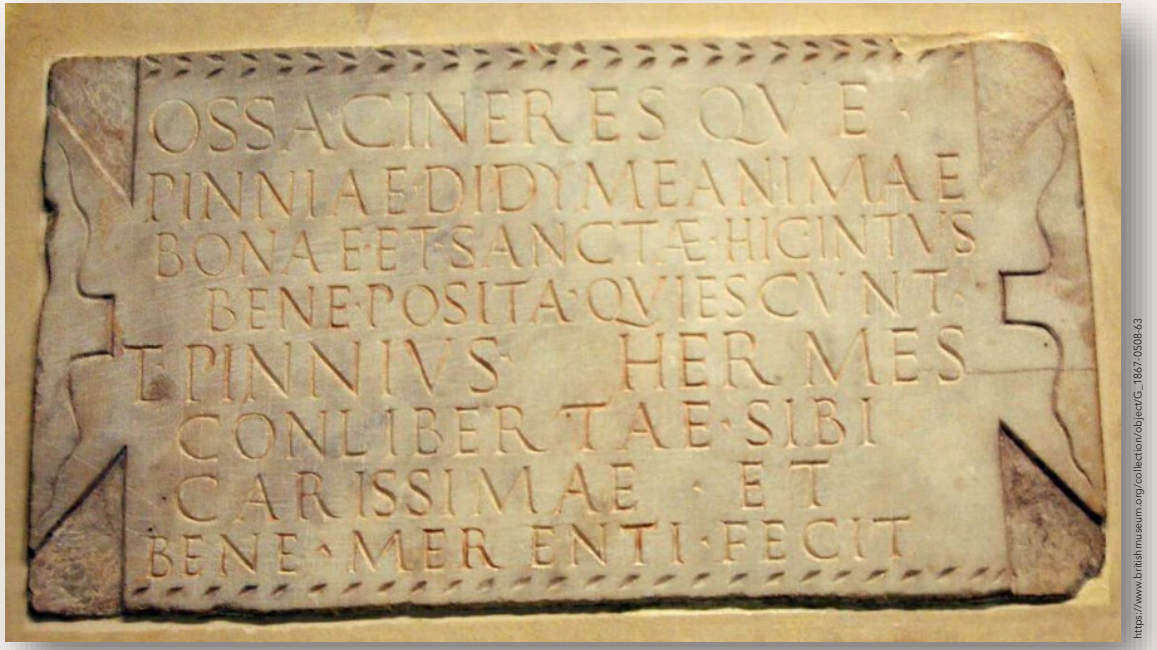
https://www.istockphoto.com/cs/fotky/waste-incineration

Because nothing is simple…

According to David Noy:

The phrase "*ossa et cineres*" is often used by the Romans to describe the residual elements of a cremation, encompassing both bones and ashes

The term "*cineres"* can also stand alone, and when used in that manner, it implies the presence of both bones and ashes



Marble epitaph plaque from a niche in a columbarium on the Appian Way outside Rome (British museum)

Inscription translation: The bones and ashes of Pinnia Didyma, of a good and saintly spirit, rest quietly in here, well placed. Titus Pinnius Hermes made this for his dearest and well-deserving fellow freedwoman.

https://www.jstor.org/stable/826933

Today's undertakers

International Cremation Federation

NGO in status (Roster) with the Economic and Social Council of the United Nations

It is preferable and more respectful to say that a body is being cremated rather than incinerated

The Cremation Society

Rooted in history: committed to the future

MEMBER CANA

Cremation Association of North America

Canadian Cremation Centre

FBCA

Federation of Burial & Cremation Authorities

But also…

Archaeologists
Bioarchaeologists
Biological anthropologists
Forensic anthropologists
Social anthropologists
Etc.
They all agree!


https://soundeffects.fandom.com/wiki/Indiana_Jones_and_the_Temple_of_Doom_(1984)/Image_Gallery

Indiana Jones and the Temple of Doom (1984)


https://cinemorgue.fandom.com/wiki/Nizwar_Karanj

The victim is lowered into lava which burns him to death

Does body turn to ash when cremated?

Just to be clear, there are no ashes obtained as a result of the cremation process. What is really retrieved and returned to you is the person's skeleton

In modern crematorium, the bones are then reduced in size to a granular consistency. The pulverized bones yield a coarse, grayish material with a texture resembling that of fine gravel

The remains of a human that have undergone the process of cremation are commonly referred to as "cremated remains" or "cremains"

Cinerary urn with cremated remains

Are the terms "cremated bones" and "burnt bones" interchangeable?

While both terms refer to bones that have been subjected to the intense heat, "cremated bones" derived primarily from funerary contexts

In contrast, "burnt bones" is a more general term that does not necessarily imply any specific association with funerary practices. For example, burnt bones from forensic contexts

https://www.wistv.com/2020/08/01/sumter-fire-department-investigating-plane-crash/

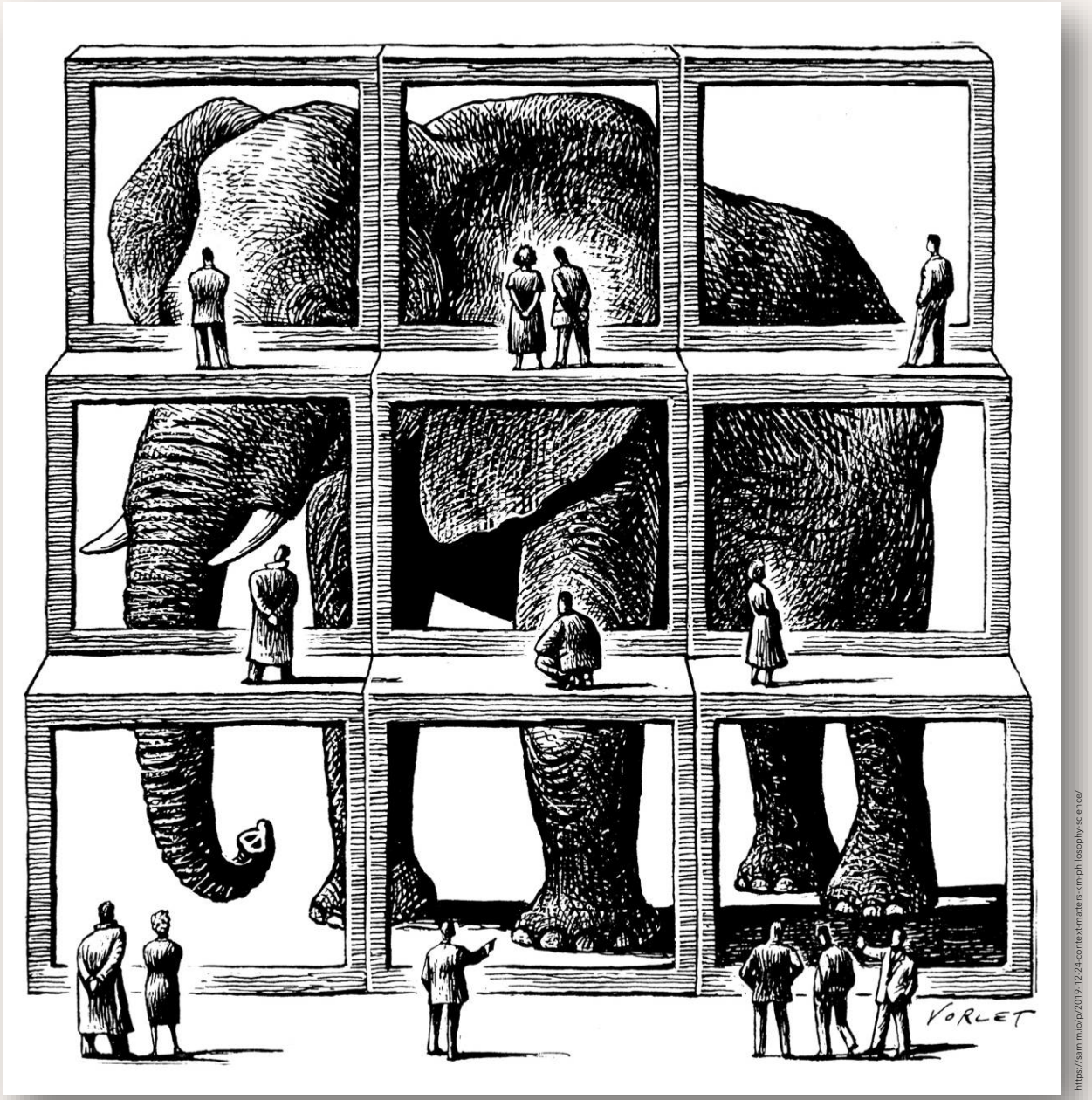
Plane crash in which victims can be burned beyond recognition

Context does matter

All burnt bones look alike

Understanding the details of how, where, and when the bones (and consequently the body) were cremated holds significant importance

Social context
Historical context
Cultural context
Economic context
Etc.



The big picture

The cremation context

Let's go back to your list of keywords
3 key components

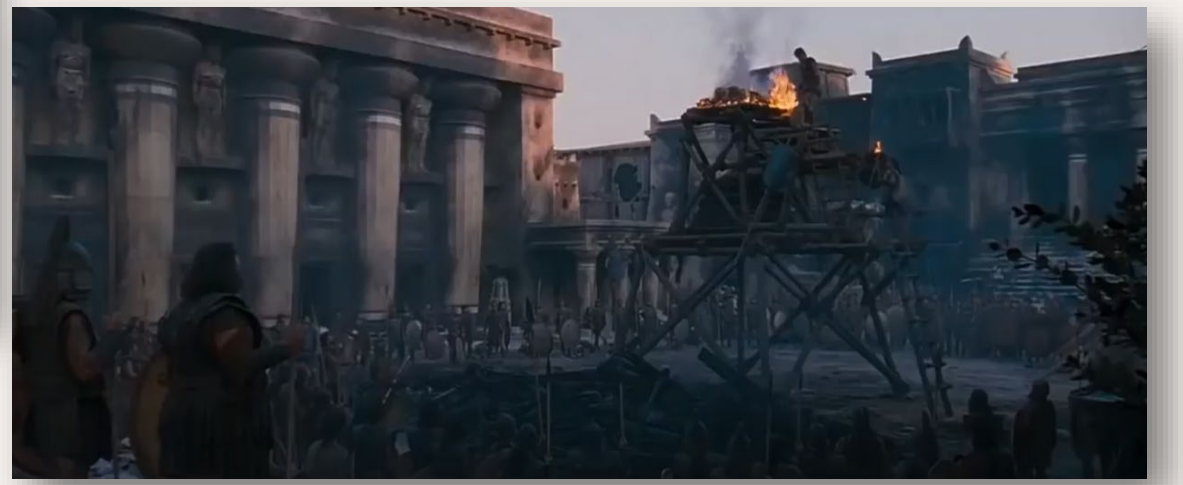
Cremations in the 7th-8th arts

Bronze Age (c. 1200 CE)

The funeral of Achilles in *Troy* (2004)

People

Body



Fire

Achilles was invulnerable in all of his body except for one heel, because when his mother Thetis dipped him in the river Styx as an infant, she held him by one of his heels. The death of Achilles is not presented in the *Iliad* but is known from other sources

Cremations in the 7th-8th arts

Roman period (44 BC)

The funeral of Niobe in *Rome* (S02E01 - 2007)

Interactions with human remains

People

Body

Fire

Vorenus says goodbye to his wife, Niobe, while Rome says goodbye to Caesar

Cremations in the 7th-8th arts

Medieval period (c. 1000 AD)

The funeral of Einar in *The Vikings* (1958)

People

The Vikings tracks the lives of two Viking half brothers, Einar (played by Kirk Douglas) and Eric (Tony Curtis). It was noted for its efforts to be an authentic portrayal of Viking life, especially the cremation scene

Body

Fire

Cremations in the 7th-8th arts

Pre-WWI (c. 1900's)

Gypsy funerals in *Peaky Blinders* (S04E02 - 2017)

People

The scene depicts a cremation practiced by a minority group in the early 20th century

Body

Fire

Cremations in the 7th-8th arts

Post-WWI (c. 1960's)

The Cremator (Czech: Spalovač mrtvol) is a 1969 Czechoslovak dark comedy horror film directed by Juraj Herz, featuring Rudolf Hrušínský, one of the most popular Czech actors

The Cremator is often considered to be one of the best movies ever made in Czechoslovakia. It has also gathered a prominent cult following

The Cremator is available on (Czech) Netflix

https://www.csfd.cz/film/4244-spalovac-mrtvol/galerie/plakaty/

Cremations in the 7th-8th arts

Medieval Fantasy

The funerals of the Night's Watch in *Game of Thrones* (S08-E04)

People

Mass cremation conducted following a war event

Body

Fire

Cremations in the 7th-8th arts

Science Fiction

Qui Gon's Funeral in *Star Wars: The Phantom Menace* (1999)

People

The funeral of Qui-Gon Jinn took place on the planet Naboo. A traditional Jedi funeral was held in his honor, including a cremation

Body

Fire

Cremations in the 9th art

Video game (as movie scene)

The Funeral Pyre Of April Ryan*: Dreamfall Chapters* (2014)

People

Body

Fire

The funeral of April Ryan is conducted on a boat over water, evoking (supposedly) Viking funeral traditions

Cremations in the 9th art

Video game (partially playable)

Vesemir's Funeral*: The Witcher 3* (2016)

People

Body

Fire

This quest begins with the funeral of Vesemir. One of the few video games that allows you to control a character during a cremation

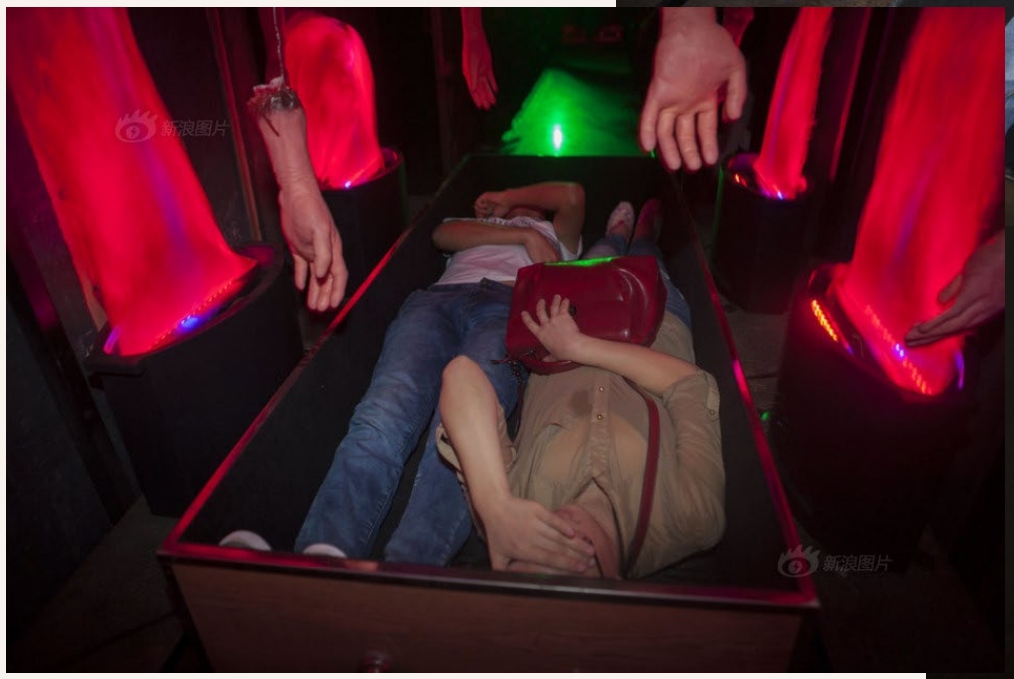
Cremations in the 9th art

Video games (fully playable)

Both differ from the previous examples (no people or no fire).

Simulated cremation!

Creepy “4D death simulator” allows people to experience being cremated (Shanghai, China)



The oven itself, however, isn't fired; it merely raises the temperature to about 40 degrees using heat fans.

https://www.thatsmags.com/shenzhen/post/7172/shenzhen-theme-park-offers-cremation-simulator

What can we learn from these scenes?

Regardless of whether it is in films, literature, video games, or historical sources

Cremation is an intricate process that entails a multitude of ritual sequences, characterized by strict codes and standards, occasionally transcending time and geographical boundaries

Nonetheless, there exists a certain level of freedom in the execution of these rituals. Every culture is permeated with variations, encompassing diverse attitudes towards the deceased (signs of respect or affection, family traditions, etc.)

https://envietnamplus.vn/thailand-royal-cremation-exhibition-extended-to-dec-31/122786.vnp

Royal cremation ceremony in Thailand in 2017

Cremation genesis – Australia

Published: 20 February 2003

New ages for human occupation and climatic change at Lake Mungo, Australia

James M. Bowler, Harvey Johnston, Jon M. Olley, John R. Prescott, Richard G. Roberts, Wilfred Shawcross & Nigel A. Spooner

Nature **421**, 837–840 (2003) | Cite this article

https://doi.org/10.1038/nature01383

Archaeological records indicate that cremation has a history dating back at least 44000 years, exemplified by the discovery of the Mungo Lady at Mungo Lake, Australia

World Heritage Mungo National Park

Archaeologist John Mulvaney (right) at Lake Mungo, 1974

Cremation genesis – America

ACADEMIC PRESS

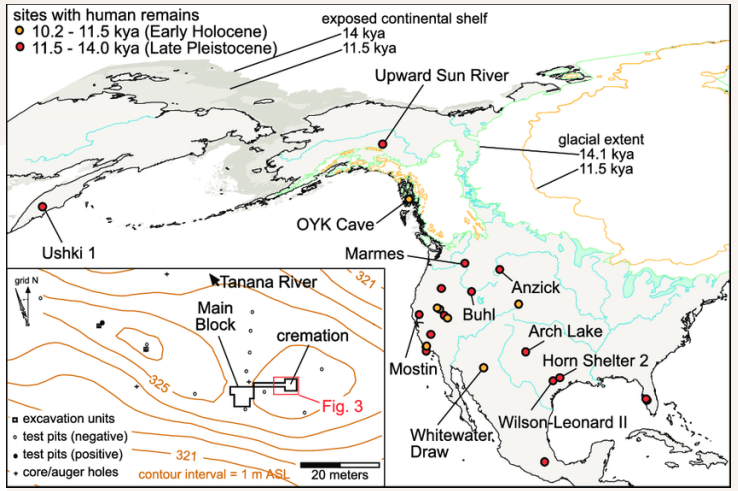
The Analysis of Burned Human Remains (Second Edition)

2015, Pages 295-306

Chapter 16 - An 11,500-Year-Old Human Cremation from Eastern Beringia (Central Alaska)

Joel D. Irish Ph.D. [1 2], Ben A. Potter Ph.D. [2], Joshua D. Reuther Ph.D. [3]

https://doi.org/10.1016/B978-0-12-800451-7.00016-4



The cremated human remains from the Upward Sun River (USR) site, in Alaska are the earliest known for the entire Arctic/Subarctic of North America and date from 9500 BC

https://www.ancient-origins.net/ancient-places-americas/children-upward-sun-river-11500-year-old-remains-shed-light-alaska-s-021109

Burying scene at Upward Sun River site

Cremation genesis – Asia

PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Emergence of corpse cremation during the Pre-Pottery Neolithic of the Southern Levant: A multidisciplinary study of a pyre-pit burial

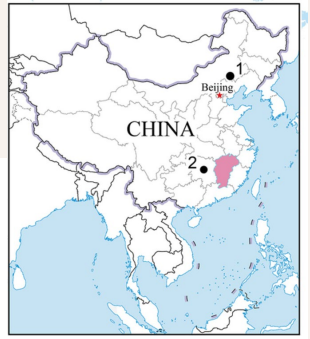
Fanny Bocquentin, Marie Anton, Francesco Berna, Arlene Rosen, Hamoudi Khalaily, Harris Greenberg, Thomas C. Hart, Omri Lernau, Liora Kolska Horwitz

Published: August 12, 2020 • https://doi.org/10.1371/journal.pone.0235386

https://doi.org/10.1371/journal.pone.0235386

The oldest known cremation in Western Asia dates to 7000 BC at the Neolithic site of Beisamoun (Israel).

The oldest Neolithic cremation tomb in Eastern Asia, found at Laohudun, China, dates back to 2800-2500 BC



International Journal of Osteoarchaeology

RESEARCH ARTICLE | Full Access

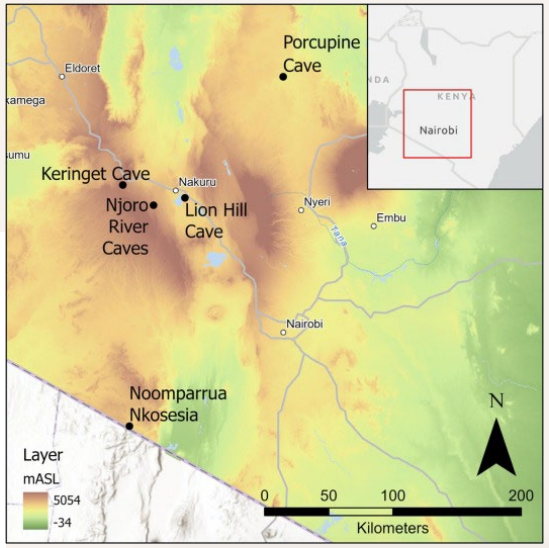
Determining the earliest directly dated cremation tombs in Neolithic China via multidisciplinary approaches: A case study at Laohudun site

Yuqian Yan, Wei Ge, Yile Wang, Changqing Xu, Yuanfei Wu, Tao Cui

First published: 23 June 2022 | https://doi.org/10.1002/oa.3139 | Citations: 1

https://doi.org/10.1002/oa.3139

Cremation genesis – Africa



Journal of Anthropological Archaeology
Volume 71, September 2023, 101523

Revisiting cremation practices of the Pastoral Neolithic in Kenya

Lorraine W. Hu

https://doi.org/10.1016/j.jaa.2023.101523

The oldest cremation from Africa is from the Njoro River Cave and dates from 1500-1100 BC

Archaeological Sites Njoro River Cave Magical Nakuru.

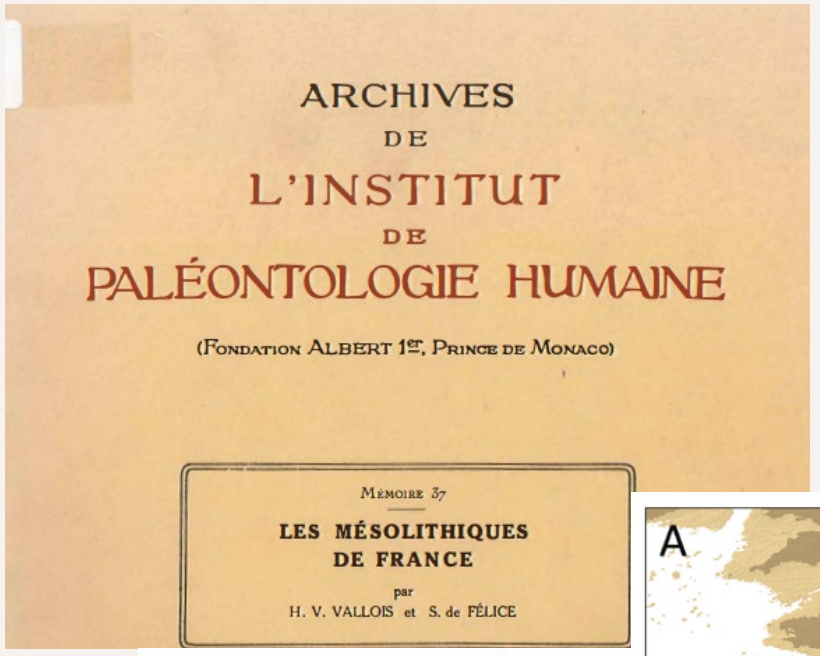
Cremation genesis – Europe

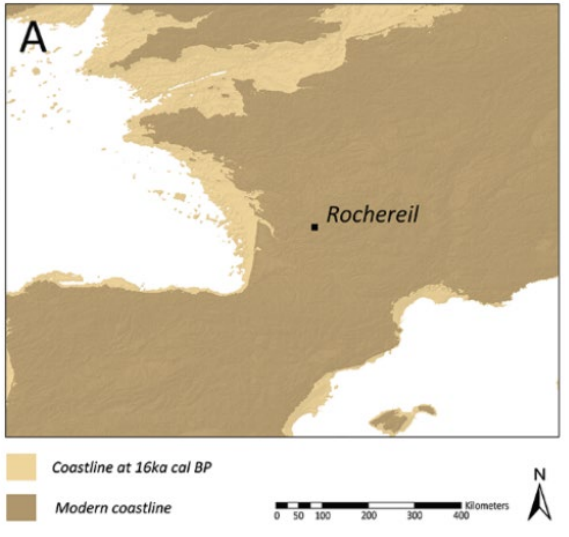
The oldest European cremation is thought to have been found in France, at the Rochereil site, and may date back to 14,000 BC. Its dating is uncertain, however, as no cremation for the Late Palaeolithic is otherwise known; it is probably Mesolithic in age (Azilian)

In Europe, cremation was practiced during the early and late Mesolithic periods (8000-4000 BC) across Scandinavia, the Netherlands, Belgium, northern France, and Ireland

However, there is an undeniable necessity to precisely establish the dating of these cremated remains in order to gain a more profound insight into their chronological distribution across Europe

Vallois and Félice 1977





https://doi.org/10.24072/pcjournal.185

Cremation through time in Europe

In the early Neolithic period (7000-5000 BC), cremation as a funerary rite grew, leading to the establishment of large bi-ritual cemeteries and, occasionally, dedicated cremation cemeteries

The Late Bronze Age Urnfield Period in Central Europe (c. 1300-800 BC) is characterized by the dominance of cremation as a burial rite

In Classical Antiquity (8th c. BC-5th c. AD), Greeks and Romans underwent cycles where cremation or inhumation served as the prevailing funerary rite, occasionally coexisting simultaneously

With the arrival of Christianity, cremation vanished as a funeral rite, except for rare cases in England (5th-7th c. AD), the Low Countries (5th-9th c. AD), and Poland (12th-13th c. AD)

A bone story

Cremated remains

Burnt bones are the most tangible by-product of cremation

They come in two forms: charred or burnt.

Bones that have experienced various stages of heat-induced transformations, leading to alterations in their structure, the depletion of water and organic components, and different coloration (black vs white).

The burning

However, our knowledge about the specific methods employed for cremating bodies in the past remains quite limited

The **ephemerality** of the moment, the **taphonomic vulnerability** of the pyre locations, the **choices** made by the funerary ritual attendants, and the unpredictable **contingencies** inherent to the burning process (e.g. pyre collapse) are all variables that make each cremation **a unique event predestined to vanish.**

Why is it so rare and random to find pyre sites?

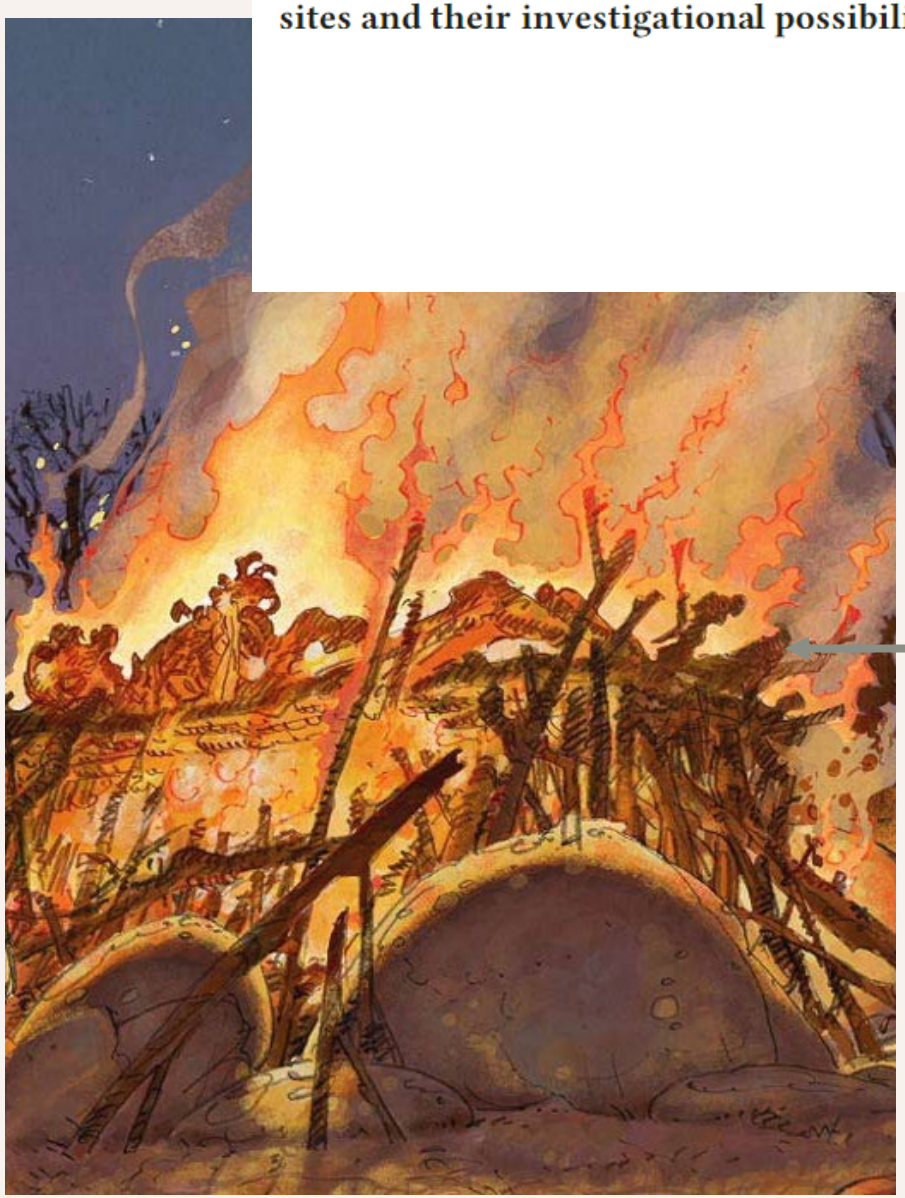
Two cremation experiments to understand the characteristics of pyre sites and their investigational possibilities

2018

KRISTÓF FÜLÖP

Institute of Archaeological Sciences
Eötvös Loránd University

fulopkr14@gmail.com



Funeral pyre

The Julius Caesar's pyre

Probably one of the most famous pyres ever

Following the assassination of Julius Caesar, it is said that the crowd desired to burn his body in the Forum.

https://www.flickr.com/photos/seanblinn/5530881410

https://justmovingaround.com/2018/03/15/the-grave-of-caesar-roman-forum-rome/

Temple and altar of Julius Caesar

The tall funeral pyre of Julius Caesar. Engraving drawn by A Houbraken & engraved by M Pool (19th c.).

https://www.bridgemanimages.com/en/noartistknown/caesar-s-pyre-houbraken/engraving/asset/6882963

The fervor of the people led to the swift construction of an altar and temple dedicated to Caesar's memory

However, this contravened the XII Tables' prohibition of carrying out a cremation within the city

The pyre shape – Oldest Greek depictions

By what means do we acquire knowledge about the configuration of pyres from bygone eras?

Iconography plays a crucial role in revealing the shape of past pyres

One of the oldest and most impressive depictions of a pyre is this Attic red figure amphora, featuring Croesus at the stake as described in Book I of Herodotus

Note: the logs have an irregular shape, and the operator lights the pyre from the top

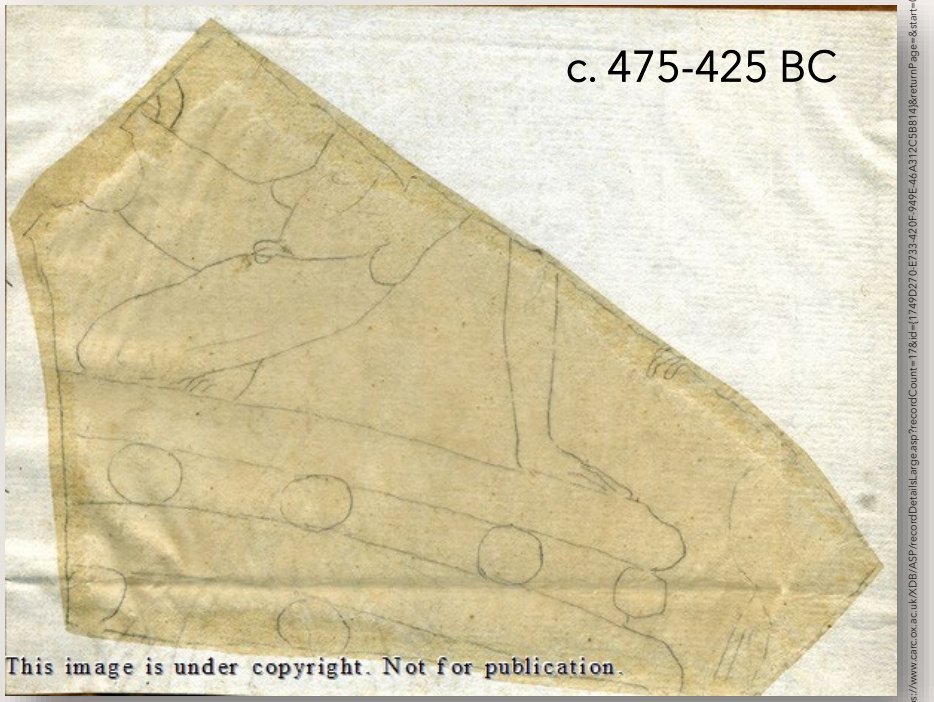
c. 500-490 BC

https://www.carc.ox.ac.uk/carc/resources/introduction-to-Greek-Pottery/Keypieces/redfigure/myson

The pyre shape – Greek depictions

Among the earliest depictions of pyres, these two Greek representations stand out.

Although less well-preserved, we note that the pyres are built with layers of logs, each layer being laid at right-angles to the previous one.



https://www.carc.ox.ac.uk/XDB/ASP/recordDetailsLarge.asp?recordCount=17&id={1749D270-E733-4220F-949E-46A312C5B814}&returnPage=8&start=0

Note: Man seated on a pyre

https://www.carc.ox.ac.uk/XDB/ASP/recordDetails.asp?recordCount=9&start=0

Note: Herakles lying on his belly on a pyre

The pyre shape – Greek style

The same pyre shape is used, with offset logs

360-320 BC

https://www.carc.ox.ac.uk/carc/resources/Introduction-to-Greek-Pottery/Keypieces/Paestan/python

Alcmena is seated upon a pyre. Amphitryon placed his wife on the pyre to test the veracity of her claim that Zeus had stolen her virginity in the guise of her new husband. The god quenched the flames, saving her life and verifying her claims.

In the middle of the middle row is the pyre for Patroclus with helmet and two breastplates. In front of the pyre kneels a youthful Trojan with his hands tied behind his back; Achilles has grabbed his head with his left hand and points his sword against it with his right.

https://www.pedicinimages.com/index.php?hpag=https://www.pedicinimages.com/ecom_ita/ricerca_detail.php?id_prodotto=41582

340-330 BC

The pyre shape – Other Greek depictions

Burning pyres were also depicted

410 BC

400-300 BC

In agony, Heracles requested his friends to build a towering wooden pyre on Mount Oeta. Upon laying himself on the pyre, he instructed them to set it ablaze. As the flames engulfed him, the gods observed from Olympus. Recognizing Heracles' immense suffering, Zeus intervened, prompting Athena to rescue him and transport him to Olympus.

Pyres, though occasionally arranged differently, consistently adhere to a square configuration

400-300 BC

A Satyrs attacking a maenad sleeping on a pyre

The pyre shape – Roman depiction

End of 2nd c. AD

As the Greeks, the Romans used a similar iconography, with square, well-organized pyres made of several layers of logs.

Relief belonging to a funerary monument depicting Hercules on the stake

The pyre shape – Roman funeral

Terracotta lid of a sarcophagus. In the center is the funeral pyre. The body of the Meleager, accompanied by a wailing Meleagride, is carried onto it from the left. Two other wailing girls and Althaia are also depicted. The latter sinks to her knees and kills herself. Meleager is carried to the funeral pyre

Again, the same pyre shape

3rd c. AD

https://livyarrow.org/2020/11/11/woman-and-funeral-pyre/

NB: It is worth noting that this is the depiction of a deceased body, as all other representations portray individuals in a state of being alive

The pyre – Written sources

Although Roman written sources are more informative than their Greek counterparts, they ultimately do not provide significantly greater insights compared to the iconography

A must-read

Antichthon

Building a Roman Funeral Pyre

Published online by Cambridge University Press: **08 May 2015**

David Noy

Article | Metrics

Get access | Share | Cite | Rights & Permissions

https://doi.org/10.1017/S0066477400001167

1st c. AD

https://sarahemilybond.com/2015/09/25/good-mourning-roman-clothing-courtrooms-and-the-psychology-of-color/

Relief of a Roman funeral procession

Likewise, our knowledge regarding the positioning of the deceased on the pyre or if the cremation was always tended is notably scarce (at the bottom, within, upon, funeral bier, etc.)

And this information is, of course, non-existent for even earlier periods

Ethnographic examples

Ethnographic instances, particularly observed in Central Asia where open-air cremations are still practiced, demonstrate that there exist numerous diverse methods for the cremation of a body

https://www.loe.org/shows/segments.html?programID=13-P13-00027&segmentID=7

Pyre in India next to the Ganges

Cremation ceremony in Bali

https://authentic-indonesia.com/blog/cremation-ceremony-in-bali-ngaben/

https://www.aa.com.tr/en/pg/photo-gallery/mass-cremation-for-covid-19-victims-in-new-delhi/0

Mass cremation for Covid-19 victims in New Delhi

Experimental archaeology

Experimental burnings are unparalleled when it comes to gaining a comprehensive understanding of the intricacies and challenges associated with cremation

https://twitter.com/EArchaeol/status/893792770934091776

UCD Roman cremation pyre to investigate destruction & appearance of her ceramic lamps

The significance of archaeological evidence

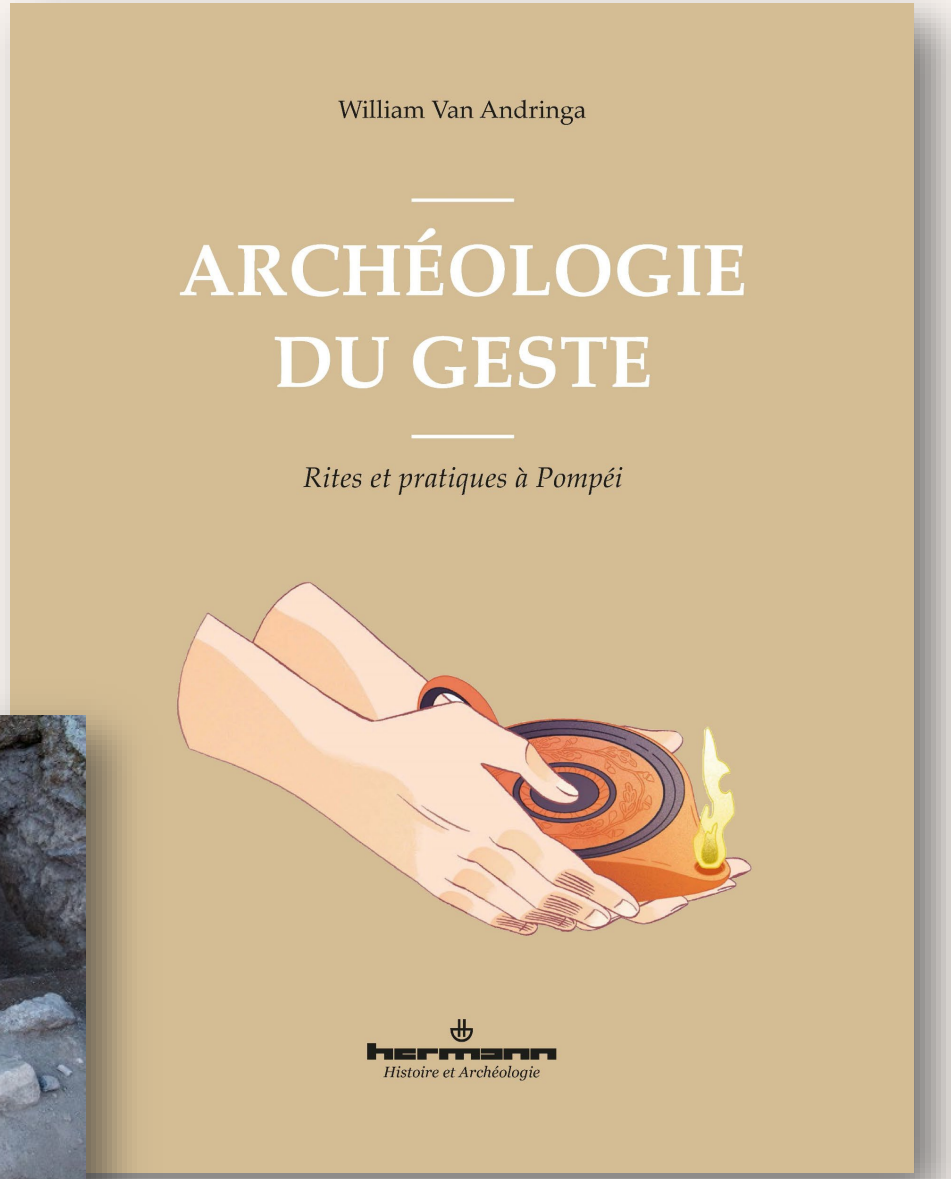
Cremation encompasses also pre- and post-burning rituals that often leave minimal traces, yet in certain contexts, such as Pompeii, these practices become detectable

https://journals.openedition.org/cefr/1942?lang=es

The recontextualization of cremated remains is key!

https://eveha-international.com/?tag=pompei-porta-nocera&lang=en

Necropolis of Porta Nocera in Pompeii



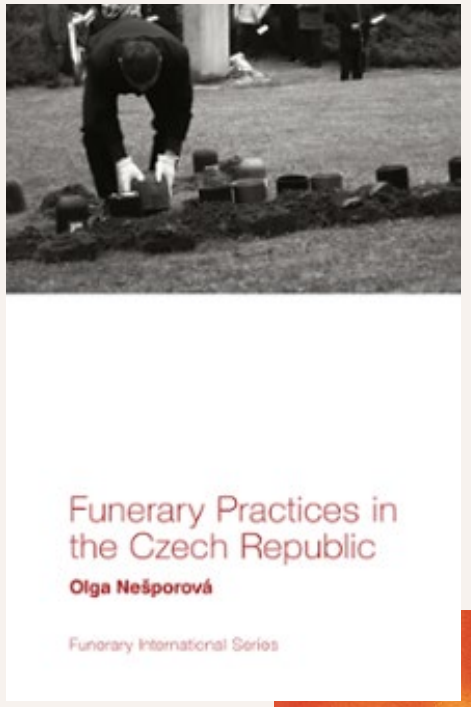
Van Andringa 2021

Insights from social anthropology

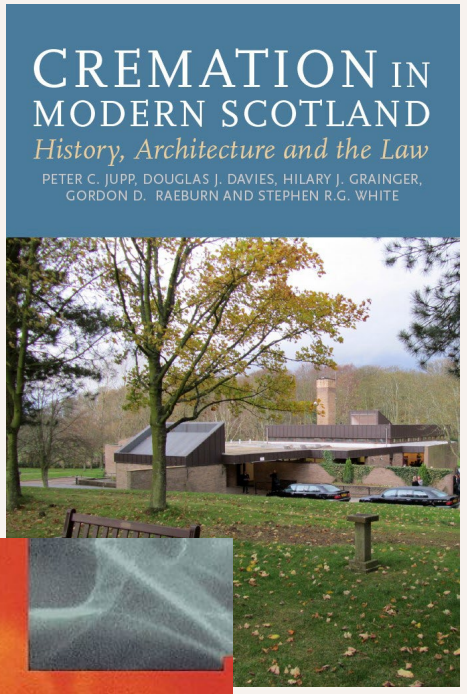
Across cultures and time, individuals are emotionally and spiritually impacted by death

The response to the loss of a loved one varies greatly from person to person and from culture to culture, yet remains profoundly personal

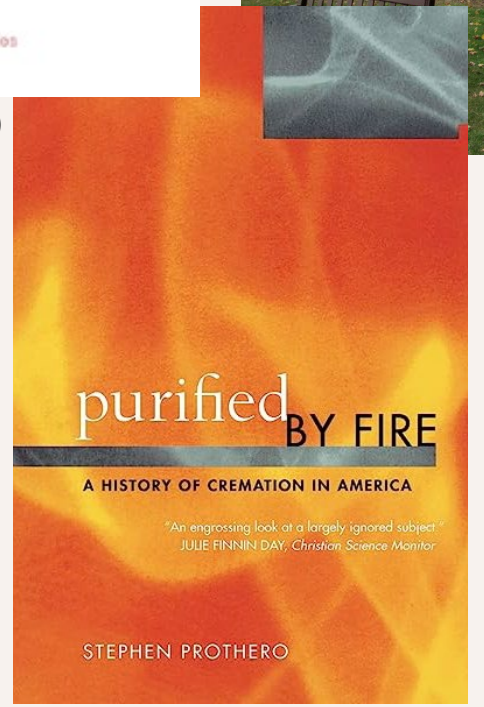
Social anthropology plays an invaluable role in capturing these dimensions that archaeology often struggles to comprehend



Nešporová 2020



Jupp et al. 2016



Prothero 2001

Cremation in crematorium

Nowadays, the process of transforming the deceased through fire is predominantly mechanized and carried out in crematoria

There is a disconnection in the ritual sequences, with relatives nowadays not actively participating in the act of burning the deceased as they did in the past

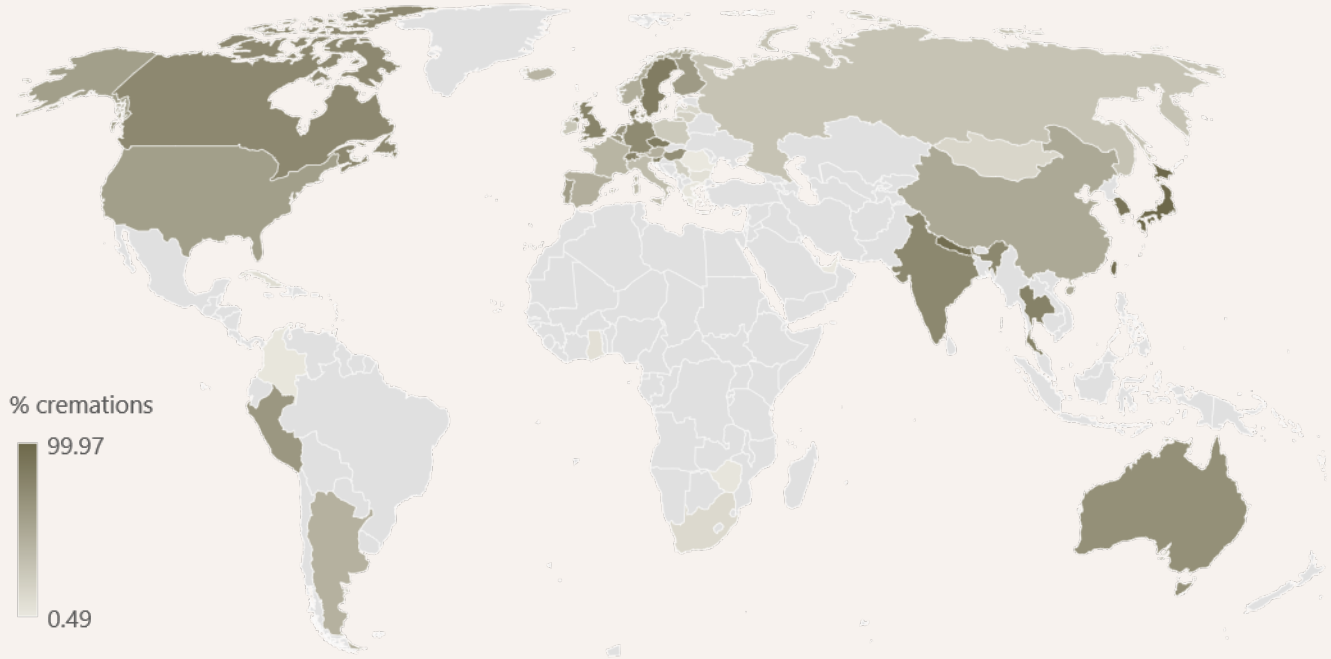
This approach also reflects the contemporary societal view of death and the process of cremation

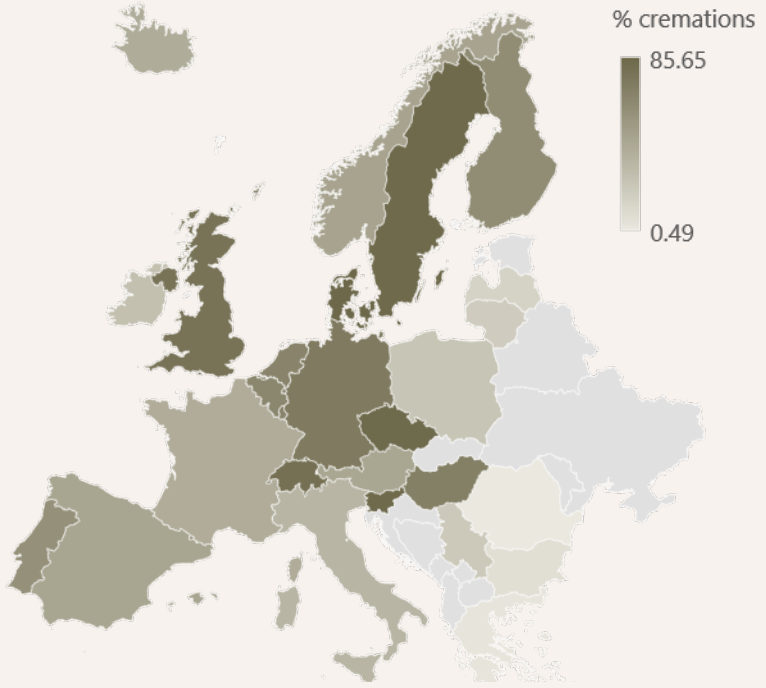
Crematorium's furnaces

Cremations around the world

Nations where cremation rates exceed 80%
- Europe: Switzerland, Sweden, Slovenia, Czechia, Denmark
- Asia: Thailand, Singapore, South Korea, Hong Kong, Nepal, Taiwan, Japan

International Statistics 2021





European Statistics 2021

Nations with cremation rates below 5%
- United Arab Emirates, Colombia, Zimbabwe, Greece

Source: The cremation society
https://www.cremation.org.uk/International-cremation-statistics-2021

Cremations not only for humans

Pet crematorium

https://www.pet-crematorium.co.uk/about-us.html

The objective of the pet crematorium is to provide a dignified farewell to cherished pets, emphasizing the evolving significance of animals

The facilities, furnaces and ritual sequences are eerily similar to those used for human beings

Hong Kong pet funerals

https://www.reuters.com/world/asia-pacific/hong-kong-pet-funerals-aim-respectful-farewell-rather-than-landfill-waste-2021-09-06/

Funny cases

The man responsible for the modern Frisbee design and the "Father of Disc Golf" was cremated and had his ashes molded into Frisbees to give to friends and family

https://www.todayifoundout.com/index.php/2012/09/the-man-responsible-for-the-modern-frisbee-design-and-the-father-of-disc-golf-was-cremated-and-had-his-ashes-molded-into-frisbees/

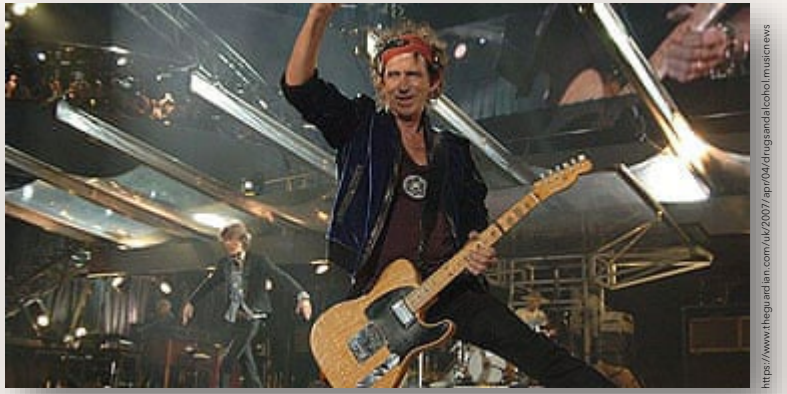
Ashes of man who designed Pringles packaging buried in crisp can

https://www.onlyinyourstate.com/ohio/cincinnati/pringles-grave-cincinnati/

Dispose of your ashes with care!
The big Lebowski (1998)

http://alittlegray.blogspot.com/2013/02/film-petit-7-big-lebowski.html

Keith Richards from the *Rolling Stones* tells of snorting his dad's ashes with cocaine



https://www.theguardian.com/uk/2007/apr/04/drugsandalcohol.musicnews

Osteology!

What do bones from a cremation deposit look like?

Well-cremated remains of complete adult (after Little et al. 2017).

https://www.cambridge.org/core/journals/antiquity/article/harp-investigating-mesolithic-landscapes-of-life-and-death-at-the-western-edge-of-europe/8E64BC66B12F5E3D952C3254AE48852F

A waste of time…

"I would straight away place on record my considered opinion, based on experience, that cremated remains of human bones in burial urns are almost always devoid of any anthropological interest … From an anthropological point of view, therefore, these bones are of no scientific value, and I consider that nothing is lost if they are neither submitted to nor preserved in the Museum."

Prof. C.M. Furst,
Chief Inspector of Antiquities in Stockholm, 1930s

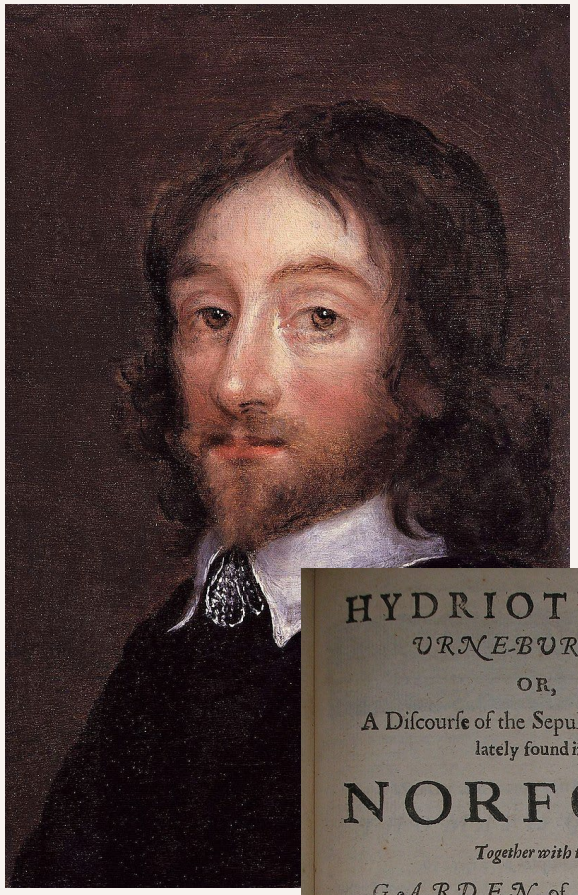
https://tenor.com/fr/search/waste-of-time-gifs

Some pioneers

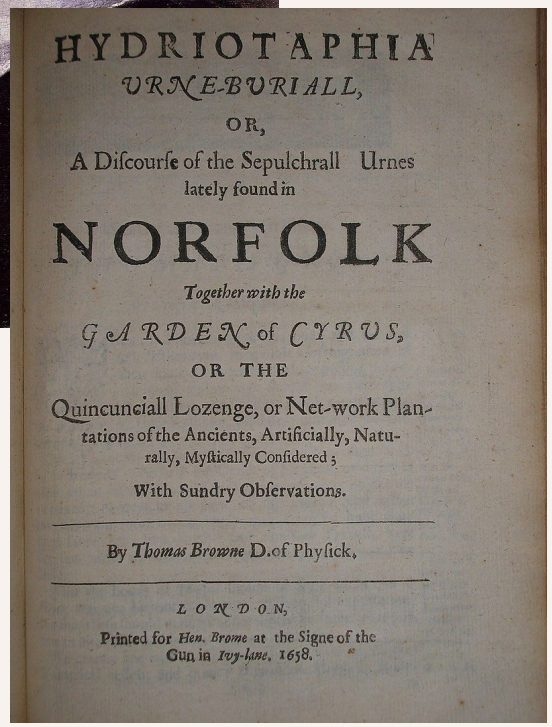
Certainly, the first and more comprehensive description of the skeletal remains found in a cremation burial:

In a field of Old Walsingham, not many months past, were digged up between forty and fifty urns, deposited in a dry and sandy soil, not a yard deep, nor far from one another. Not all strictly of one figure, but most answering these described: some containing two pounds of bones, distinguishable in skulls, ribs, jaws, thigh bones, and teeth, with fresh impressions of their combustion; besides the extraneous substances, like pieces of small boxes, or combs handsomely wrought, handles of small brass instruments, brazen nippers, and in one some kind of opal.

Sir Thomas Browne (1605-1682),
Hydriotaphia. Urn Burial, or, a Discourse of the Sepulchral Urns lately found in Norfolk, 1658



https://en.wikipedia.org/wiki/Thomas_Browne



HYDRIOTAPHIA
URNE-BURIALL,
OR,
A Diſcourſe of the Sepulchrall Urnes
lately found in
NORFOLK
Together with the
GARDEN of CYRUS,
OR THE
Quincunciall Lozenge, or Net-work Plantations of the Ancients, Artificially, Naturally, Myſtically Conſidered;
With Sundry Obſervations.
By Thomas Browne D. of Phyſick.
LONDON,
Printed for Hen. Brome at the Signe of the Gun in Ivy-lane, 1658.

https://en.wikipedia.org/wiki/Hydriotaphia,_Urn_Burial

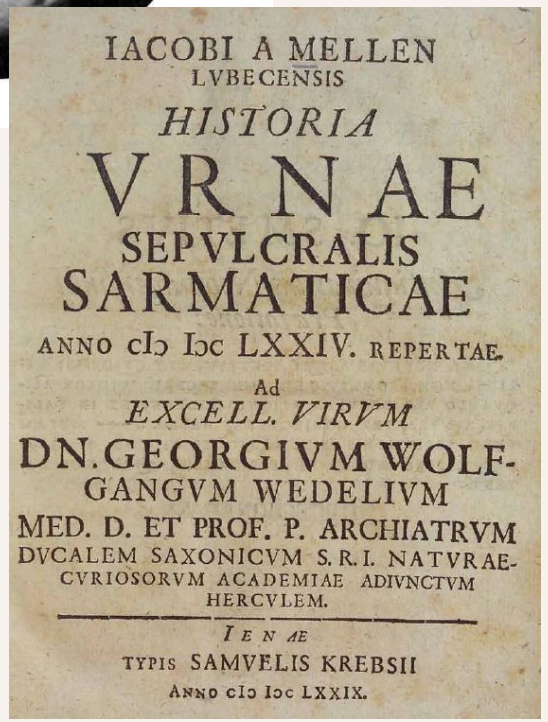
Some pioneers

One of the first and more in-depth osteological analysis of the remains found in a cremation burial:

I now refer to the bones which I have stated are the first snow-white, later partly yellowish and shriveled, although a few still keep their original whiteness. Additionally, one should notice the corpse's bones, such as the skull, lower jaw, vertebrae, and certain others with which, when more urns are found, skilled men ought to be able to assemble into a whole skeleton. Yet it is strange that one single urn not only contains the bone of just one person, but even of several; this is proved by the larger and smaller skulls, which are found in one and the same vessel.

Jacob von Mellen (1659-1743),
Historia urnae sepulcralis Sarmaticae, 1679

https://de.wikipedia.org/wiki/Jacob_von_Melle


IACOBI A MELLEN
LVBECENSIS
HISTORIA
VRNAE
SEPVLCRALIS
SARMATICAE
ANNO cIↃ IↃc LXXIV. REPERTAE.
Ad
EXCELL. VIRVM
DN. GEORGIVM WOLF-
GANGVM WEDELIVM
MED. D. ET PROF. P. ARCHIATRVM
DVCALEM SAXONICVM S. R. I. NATVRAE-
CVRIOSORVM ACADEMIAE ADIVNCTVM
HERCVLEM.
IENAE
TYPIS SAMVELIS KREBSII
ANNO cIↃ IↃc LXXIX.

http://diglib.hab.de/wdb.php?dir=drucke/qun-292-2

Initial phase of the field

Although demonstrating the always present interest for cremated human remains among scholars, these investigations cannot be assessed as a systematic approach to the topic.

This situation remained the same for many decades.

Up to the 1930s, in Europe, archaeological cremation burials were commonly not excavated at all, or only the urns, accessory vessels and burial goods were taken along for archaeological investigations, and the cremated human remains were left behind.

Systematic anthropological investigations of cremations were rare, and each of them a pioneering effort.

https://www.popsci.com/science/bronze-age-cremation-archeology/

A Late Bronze Age urn from Austria in roughly 1400-1300 BCE, containing cremated human remains.

Initial phase of the field

This changed in the 1960s and 1970s, when almost annually new investigations and methods were developed.

Among these new methods, which filled the field of cremation investigations with a fully new life, for example, the reports by Nils-Gustaf Gejvall, Milan Dokládal, Bernd Herrmann, Gerrit N. van Vark, Joachim Wahl, or Jaqueline McKinley are all outstanding.

chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www2.med.muni.cz/biomedjournal/pdf/2004/05/03_306.pdf

Profesor MUDr. Milan Dokládal, CSc. (1928-2004)
Section of Medical Anthropology
Department of Anatomy, MUNI

Challenges!

Dealing with burnt human remains is notably challenging.

Human remains can undergo cremation or burning in various scenarios, and the specifics of these situations, including factors like fire temperature, oxygen availability, burning duration, and human actions, are significant determinants.

The changes resulting from exposure to heat encompass shrinkage, loss of mass, warping, fragmentation, fracturing, and alterations in color.

Standard morphological methods are generally found to be of limited practicality.

https://www.bbc.com/news/uk-england-wiltshire-35461309

Some 45kg (99lbs) of bone fragments were recovered in Stonehenge

Heat-induced changes in bone

The four stages of heat-induced transformation in bone

Stage of transformation	Evidence	Existing temperature range (°C)	Revised temperature range (°C)
Dehydration	Fracture patterns; weight loss	100–600	100–600
Decomposition	Colour change; weight loss; reduction in mechanical strength; changes in porosity	500–600	300–800
Inversion	Increase in crystal size	700–1100	500–1100
Fusion	Increase in mechanical strength; reduction in dimensions; increase in crystal size; changes in porosity	1000+	700+

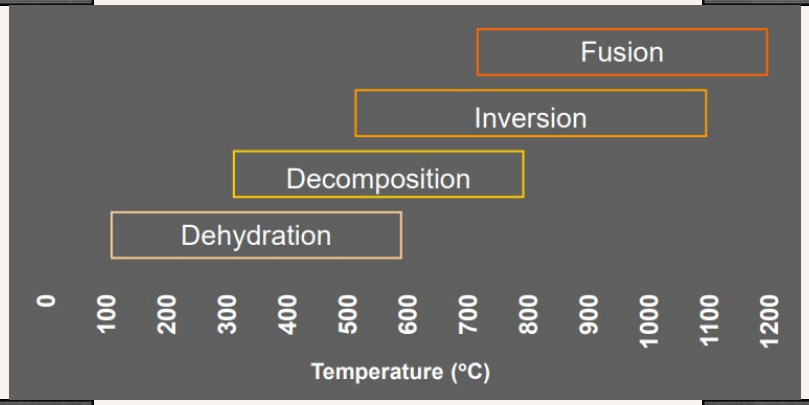
Thompson, 2004
https://doi.org/10.1016/j.forsciint.2004.09.063

Thompson, 2004
https://doi.org/10.1016/j.forsciint.2004.09.063

Heat-induced changes in bone

These two stages cause an increase in porosity (small holes) in the bone, which leads to increased fracturing, fragmentation and breakage.

Dehydration (100-600°C)
Moisture evaporating in response to the heat



Dehydration (300-800°C)
Organic component of the bone is lost

Inversion (500-1100°C)
Changes to the inorganic part of the bone

Fusion (>700°C)
Crystals start to melt and coalesce together

These two stages result in a reorganisation of the mineral structure of the bone, which leads to shrinkage, reduced porosity, increased crystallinity and a conversion to a more ceramic-like material.

https://www.futurelearn.com/info/courses/forensic-archaeology-and-anthropology/0/steps/67911

Heat-induced changes on techniques

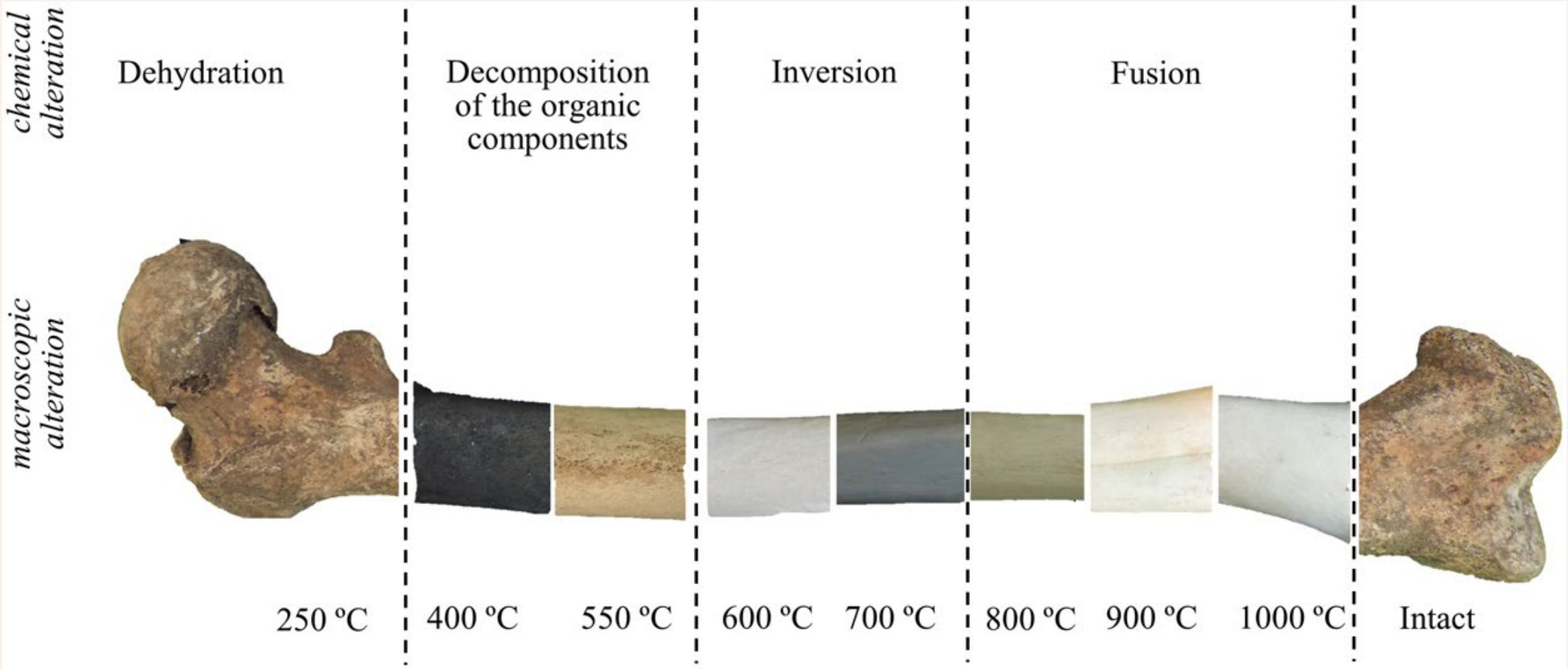
The influence of heat-induced change on anthropological techniques

Heat-induced change	Technique affected	Cause of effect
Colour change	Metric	*Indirectly*: colour change implies loss of organics, which causes shrinkage
Weight loss	Metric	*Indirectly*: weight loss implies loss of organics, which causes shrinkage
Fracture formation	Morphological and metric	*Directly*: increased fragmentation reduces likelihood of technique application
Changes in Strength	Morphological and metric	*Indirectly*: weaker bone increases fragmentation, which reduces likelihood of technique application
Recrystallisation	Morphological and metric	*Directly*: changes in microstructure may affect shape and will affect dimensions.
Porosity change	Metric	*Indirectly*: implies loss of organics and reorganisation of microstructure.
Dimensional change	Morphological and metric	*Directly*: differential size changes may affect shape and will affect dimensions.

Thompson, 2004
https://doi.org/10.1016/j.forsciint.2004.09.063

Colors change in bone...!

Schematic representation of the several stages of bone combustion.



Marques et al., 2018
https://doi.org/10.1038/s41598-018-34376-w

https://doi.org/10.1016/j.forsciint.2023.111608
Peer and Sarig, 2023

Colors change in bone... and tooth!

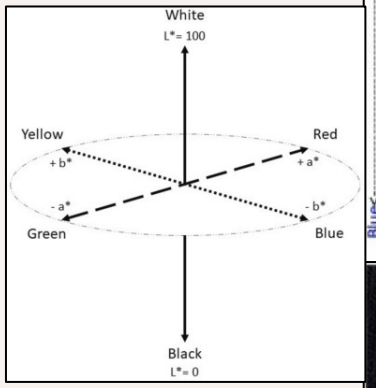
While it has been studied for decades, color modifications are one of the least understood phenomena in bone

A variety of factors affect bones' heat-induced color

There is a lack of uniformization regarding the methods to determine the exact colorations and nomenclature

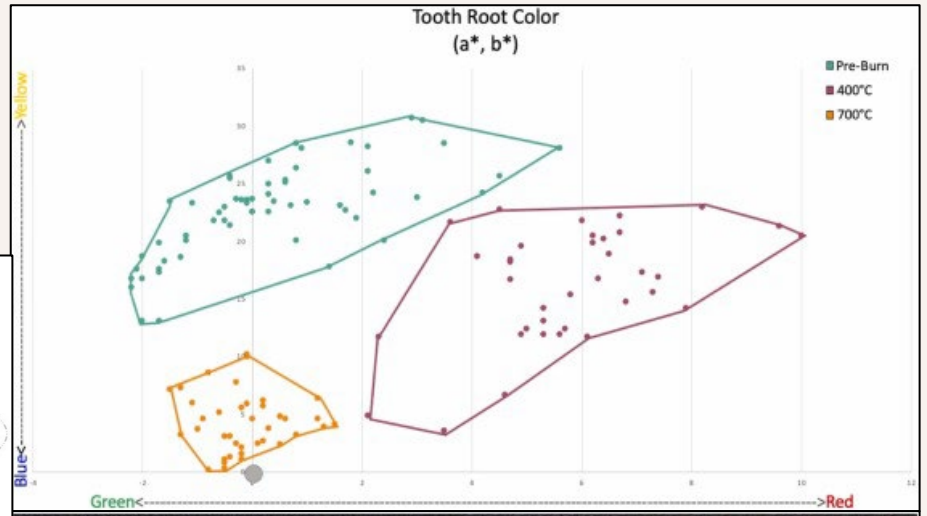
Pantone Matching System or the Munsell Charts could become a standard practice in this field

Or even better, the electronic spectrophotometers and imaging software (for photos with controlled lighting), should become a standard practice



CIEL*a*b* color space.

The color of teeth on an a* (x) by b* (y) scatter plot, comparing the dentin of pre-burned teeth and teeth burned at 400 °C and 700 °C.



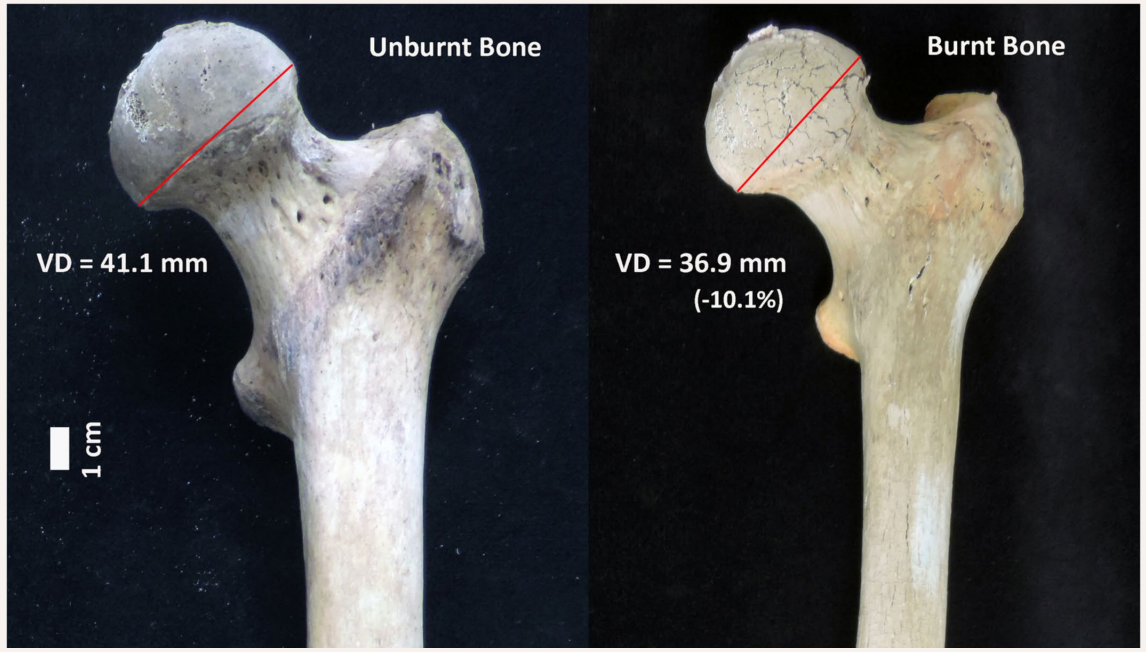
Images of teeth burned at 400 °C (left) and 700 °C (right).

Rosa et al., 2023
https://doi.org/10.1016/j.scijus.2023.07.002

https://doi.org/10.1002/ajpa.24104
Gonçalves et al., 2020

Dimensions change!

Osteometric measurements exhibit their most significant changes when bones are completely calcined (generally between 10-12%)



Shrinkage of a femur

Shrinkage of a humerus

https://doi.org/10.1002/ajpa.24104
Gonçalves et al., 2020

Statures is impacted, but...!

Bone heat-induced changes complicate osteometric stature estimation of human remains

To assess how precise are stature estimations, 3 approaches were used (i) Rösing's (1977) method, (ii) a 10% shrinkage correction factor (Strzałko et al. 1972), and (iii) chemosteometry (Gonçalves et al. 2020)

Chemosteometry delivered the most precise stature estimations (vs pre-burned bone estimates)

Chemosteometry uses regression models including osteometric and chemometric (ATR-FTIR) measurements

However, the alternative methods still offered reasonably dependable estimations, although they necessitate the verification of bone calcination

	Humerus (*N* = 15)	Radius (*N* = 15)	Femur (*N* = 16)
Rösing method			
Abs mean diff (cm)	1.72 (SD: 2.02)	1.92 (SD: 1.42)	2.45 (SD: 1.97)
Min diff (cm)	0.01	0.00	0.01
Max diff (cm)	5.75	5.16	6.21
%TEM	1.16	1.02	1.24
10% shrinkage correction factor			
Abs mean diff (cm)	2.16 (SD: 1.04)	2.18 (SD: 1.45)	2.31 (SD: 1.29)
Min diff (cm)	0.38	0.43	0.15
Max diff (cm)	3.98	6.11	3.93
%TEM	1.06	1.12	1.02
Chemosteometry			
Abs mean diff (cm)	1.70 (SD: 1.27)	1.32 (SD: 1.08)	1.42 (SD: 1.14)
Min diff (cm)	0.02	0.10	0.00
Max diff (cm)	3.69	4.04	3.80
%TEM	0.94	0.73	0.69

Wolska et al., 2022
https://doi.org/10.1111/1556-4029.15175

Sex changes! Feminization

Have a look at the color!

Bone heat-induced changes interfere with both metric and morphological sex estimations

Feminization of some traits

Heat-induced feminization of the great sciatic notch of the os coxa according to the recommendations of Buikstra and Ubelaker (1994)

Left: right unburnt os coxa. Right: left os coxa burnt to 500 °C during 75 min. Red dots delineate the outline of the unburnt greater sciatic notch.

Examples!

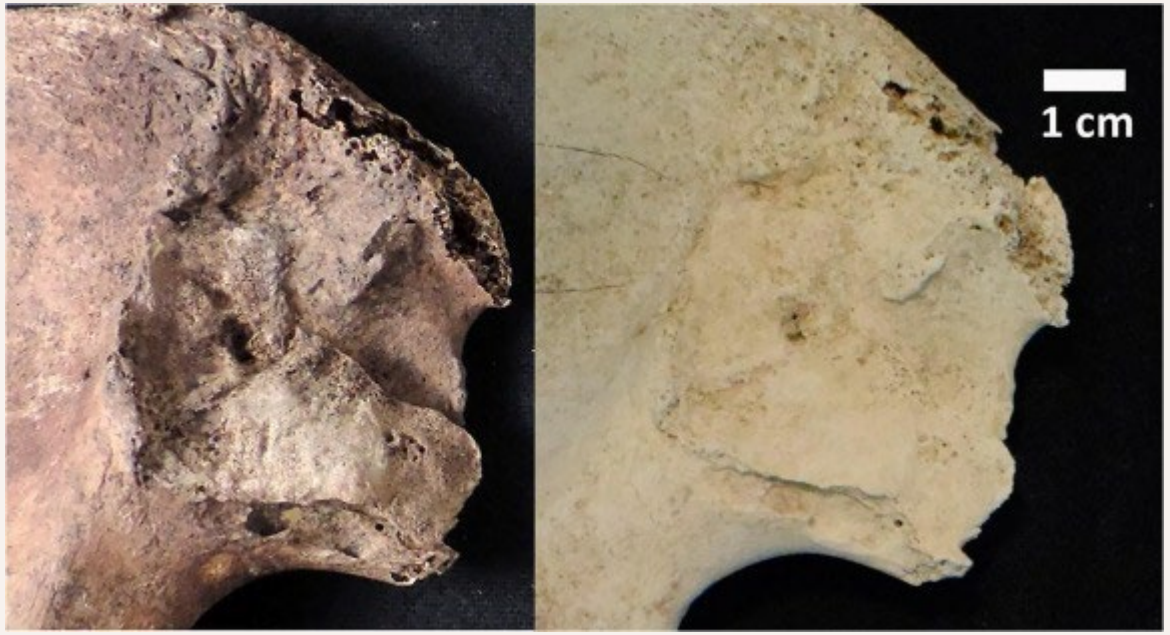
Rodrigues et al., 2021
https://doi.org/10.1016/j.scijus.2020.09.007

Sex changes! Masculinization

Have a look at the color!

Bone heat-induced changes interfere with both metric and morphological sex estimations

Masculinization of some traits



Toward a heat-induced masculinization of the preauricular sulcus becoming less pronounced and with less relief based on the recommendations of Buikstra and Ubelaker (1994)

Left: right unburnt os coxa. Right: right os coxa burnt to 1000 °C during 120 min.

Examples!

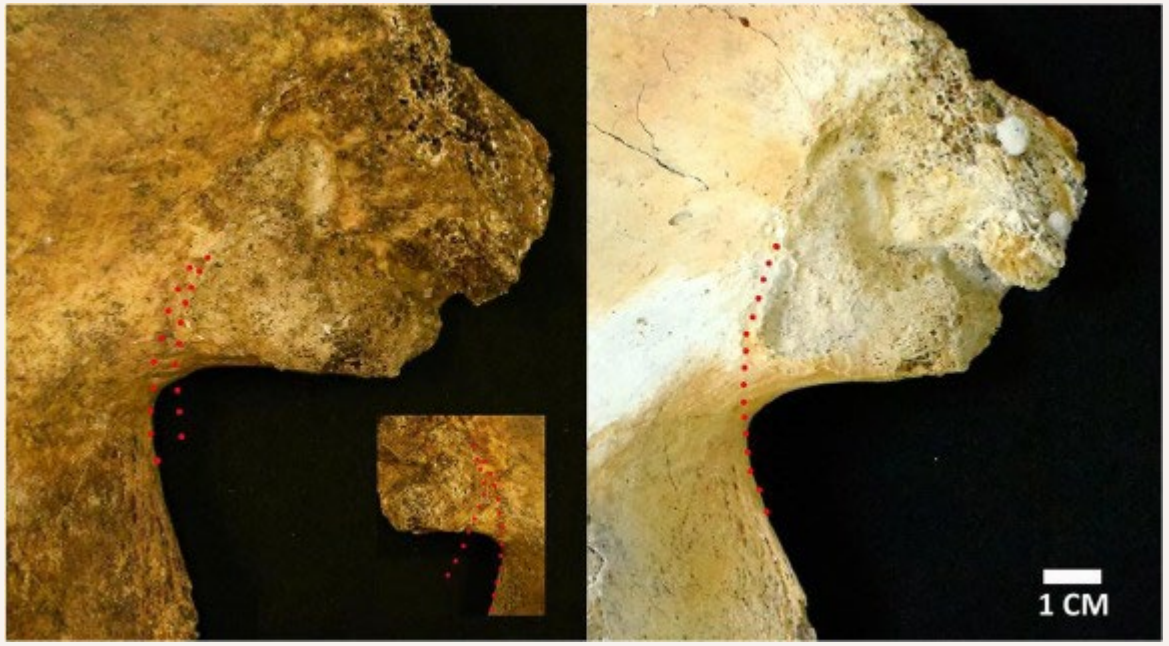
Rodrigues et al., 2021
https://doi.org/10.1016/j.scijus.2020.09.007

Sex changes! Masculinization

Have a look at the color!

Bone heat-induced changes interfere with both metric and morphological sex estimations

Masculinization of some traits



Masculinization observed on the outline of the composite arc according to Bruzek (2002)

Left: right unburnt os coxa. Right: left os coxa burnt to 700 °C for 125 min. he composite arc of the right unburnt antimere is also given because the double arc is easier to detect on it.

Examples!

Rodrigues et al., 2021
https://doi.org/10.1016/j.scijus.2020.09.007

Sex changes! Mitigation

Have a look at the color!

Bone heat-induced changes interfere with both metric and morphological sex estimations

Feminization of some traits

Mitigation of the female trait on the burnt pubis with the ventral arc somewhat disguised by heat-induced changes and the feature mistakenly scored as being absent according to the recommendations of Buikstra and Ubelaker (1994)

Left: right unburnt os coxa. Right: left os coxa burnt to 500 °C during 75 min. Red dots delineate the outline of the unburnt greater sciatic notch.

Examples!

Rodrigues et al., 2021
https://doi.org/10.1016/j.scijus.2020.09.007

Sex changes! Or not...

Have a look at the color!

Bone heat-induced changes interfere with both metric and morphological sex estimations

No effect on some traits

No heat-induced changes relevant enough to change the scoring of the features of subpubic region according to Buikstra and Ubelaker (1994) or Bruzek (2002)

Left: unburnt left os coxa mirrored as if it was the right antimere for easier comparison with right os coxa; Right: right os coxa burnt to 800 °C for 110 min.

Examples!

Rodrigues et al., 2021
https://doi.org/10.1016/j.scijus.2020.09.007

https://doi.org/10.1016/j.scijus.2020.09.007
Rodrigues et al., 2021

This is the way!

Recommendations from Rodrigues et al. (2021) according to the consistency of the methods between pre- and post-burnt observations on a Portuguese (!) reference collection

For low to medium intensity burnt bones:

1) **Bruzek (2002) and Curate et al. (2016) (ex-aequo)** – hip bone and femur
2) **Wasterlain (2000)** – humerus, femur, calcaneus and talus
3) **Buikstra and Ubelaker (1994)** – hip bone

For high intensity burnt bones:

1) **Bruzek (2002)** – hip bone
2) **Gonçalves et al. (2013)** – humerus, femur, calcaneus and talus
3) **Curate et al. (2016)** – femur
4) **Buikstra and Ubelaker (1994)** – hip bone
5) **Wasterlain (2000)** – humerus, femur, calcaneus and talus

Age-at-death changes!

Bone heat-induced changes interfere with age-at-death estimations

Unburnt (left) and burnt (right) pubic symphysis of the right os coxae (800°C/110 min) .

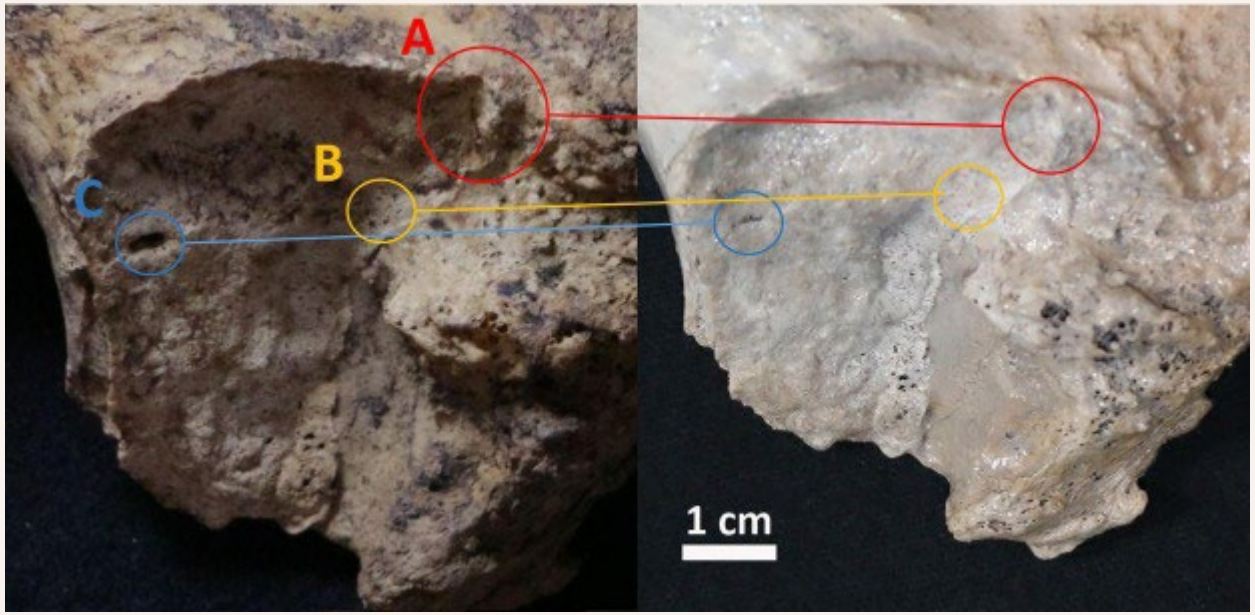
The symphyseal face of the unburnt bone also seem to be more irregular and display more pits and pores than the burnt counterpart

All these changes led to a shift in score from phase VI to phase V according to Brooks and Suchey (1990)

Rodrigues et al., 2022
https://doi.org/10.1016/j.scijus.2022.07.005

Age-at-death changes!

Bone heat-induced changes interfere with age-at-death estimations



A) a post-burnt mitigation of age-related degeneration;
B) a post-burnt loss of porosity;
C) the almost complete erasure of a cavity.

Overall texture and transverse organization also appear to have acquired different appearances after heat exposure.

Unburnt (left) and burnt (right) auricular surface of the right os coxae (600°C/120 min)

Rodrigues et al., 2022
https://doi.org/10.1016/j.scijus.2022.07.005

https://doi.org/10.1016/j.scijus.2022.07.005
Rodrigues et al., 2022

This is the way!

Recommendations from Rodrigues et al. (2022) according to the agreement between pre-burning and post-burning observations of age features on a Portuguese (!) reference collection composed of old (61-93 yo)(!) individuals

In the order:

1) **Brooks and Suchey (1990)** – pubic symphysis of the hip bone
2) **Buckberry and Chamberlain (2002)** – auricular surface of the hip bone
3) **Veselka et al (2021)** – sternal end of the clavicle

However, it is clear that heat-induced changes affected both methods regardless of heat intensity since both calcined bones and bones burnt at lower intensities often showed less than perfect agreement

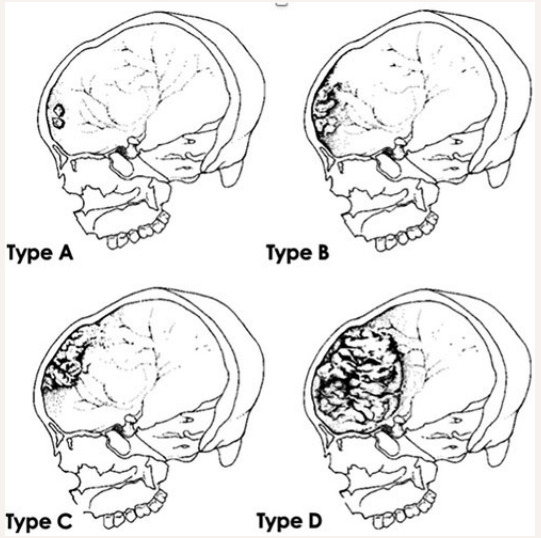
Sex- and age-related pathology!

Hyperostosis frontalis interna (HFI) is a benign bone lesion and is manifested by the accretion of bone on the endocranial surface of the frontal bone

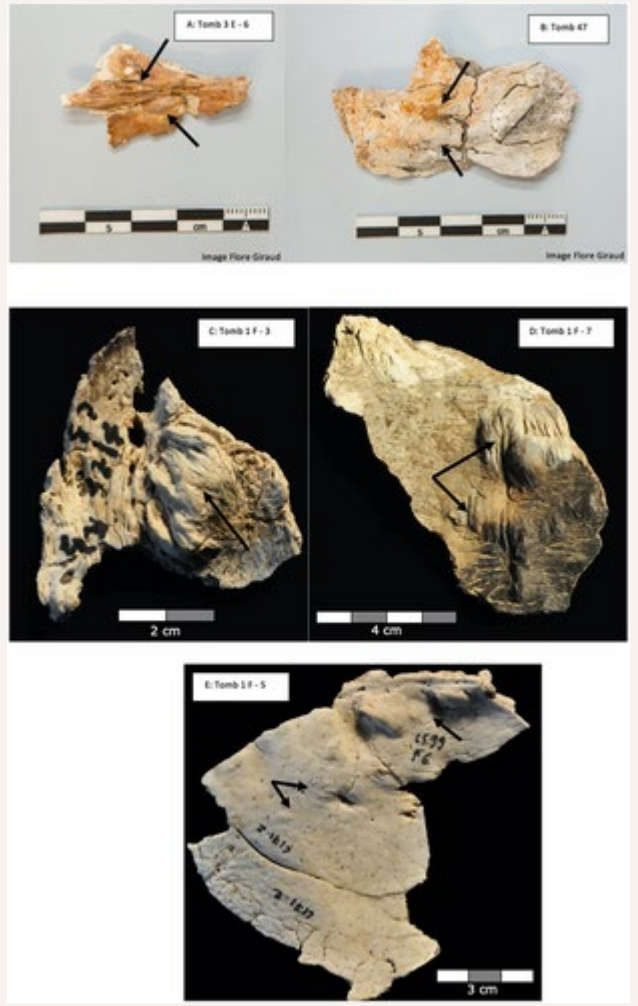
While no consensus has been reached regarding its cause, it's widely acknowledged that hormones, potentially accounting for the disorder's prevalence among older and postmenopausal women

Among the cremated individuals from the Roman Porta Nocera necropolis in Pompeii, there were no instances of HFI found in individuals previously identified as male

A noteworthy 90.9% of the individuals exhibited degenerative conditions alongside HFI, indicating a strong and statistically significant correlation between this lesion and the effects of aging



Schematic representation of the four types of hyperostosis frontalis interna according to Hershkovitz et al. (1999).



Different types of hyperostosis frontalis interna (HFI) disorder at Porta Nocera, macroscopic observations.

Du Fayet de la Tour et al., 2022
https://doi.org/10.1016/j.scijus.2020.09.007

Gonçalves et al., 2013
https://doi.org/10.1111/1556-4029.12167

Wait... what about the weight?

Weight is often one of the few recoverable data when analyzing cremated human remains, but references are still rare, especially for European populations

Males are generally heavier than females, and age has a powerful effect in female skeletal weight

Weight references may, in some cases, help estimating the minimum numberof individuals, the completeness of the skeletal assemblage, and the sex of an unknown individual

Skeletal weights (g) of the sample of Portugese skeletons according to sex.

	Without <2-mm Fraction		With <2-mm Fraction	
	Female	Males	Female	Males
n	49	39	49	39
Mean	1440.6	1967.4	1803.6	2313.5
Standard deviation	395.5	397.6	497.1	435.6
Minimum	688.3	1245.1	856.9	1389.0
Maximum	2263.2	2644.1	2882.5	3160.4

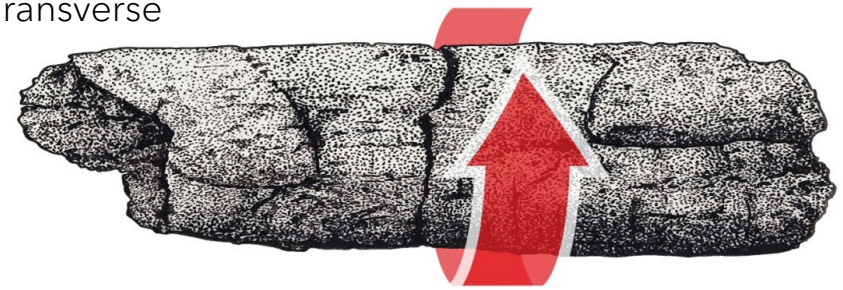
Current weight references for burned human skeletal remains.

	Cremation Parameters		Females			Males		
Author	Temperature (°C)	Duration	g	*n*	Age	g	*n*	Age
Malinowski and Porawski (20)	±1000	–	1540	–	45–65	2004	–	45–65
Herrmann (21)	–	–	1700	226	76.2	1842	167	72.8
McKinley (10)—no 2-mm fraction	–	–	1272	6	81.6	1862	9	77.3
McKinley (10)—with 2-mm fraction	–	–	1616	6	81.6	2284	9	77.3
Sonek (in Bass and Jantz [22])	–	–	1875	63	75.7	2801	76	64.1
Warren and Maples (23)	>830	73–207′	1840	40	74.1	2893	51	66.3
Bass and Jantz (22)	871–982	120–180′	2350	155	70.7	3379	151	62.8
Chirachariyavej et al. (25)	850–1200	60–90′	2120	55	73.3	2680	55	63.5
Van Deest et al. (24)	871–927	120′	2238	363	76.1	3233	365	71.4

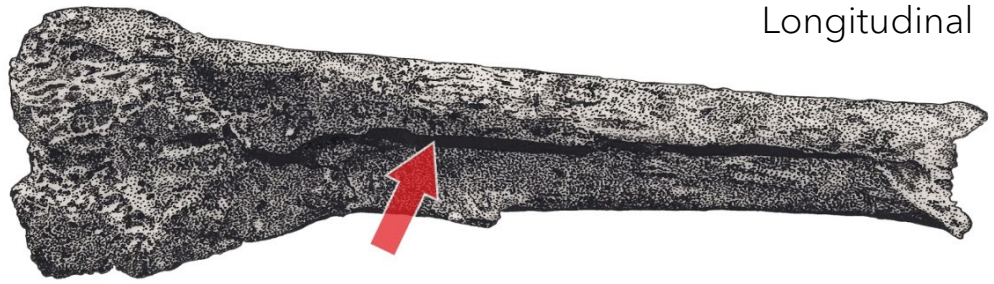
Fracture patterns

Anthropologists have studied thermal fractures for more than a century (Krogman, 1939,1943a,b; Baby, 1954; Binford, 1963; Mayne, 1990; Symeset al., 1996)

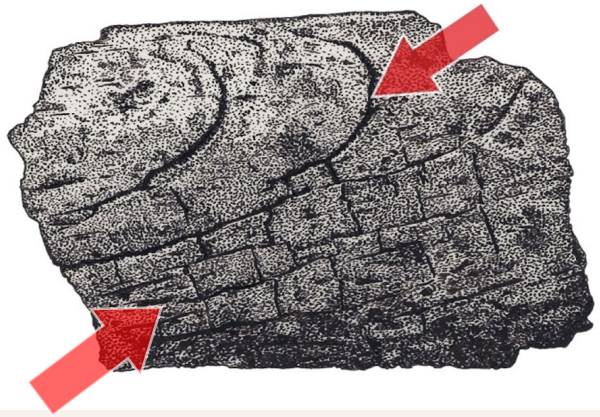
Transverse



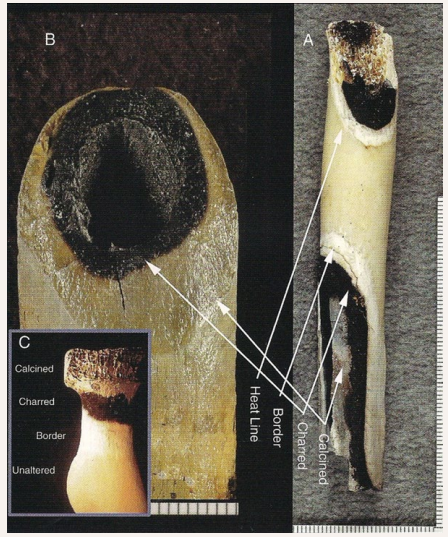
Longitudinal



Curve transverse or thumbnail

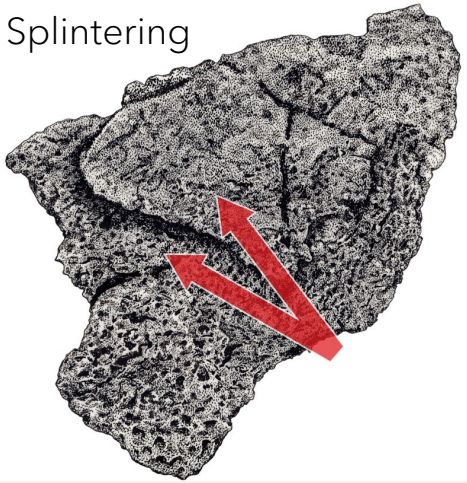


Step or grid-like

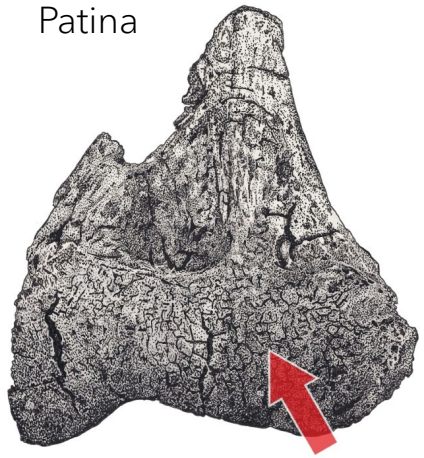


Burn line

Splintering



Patina

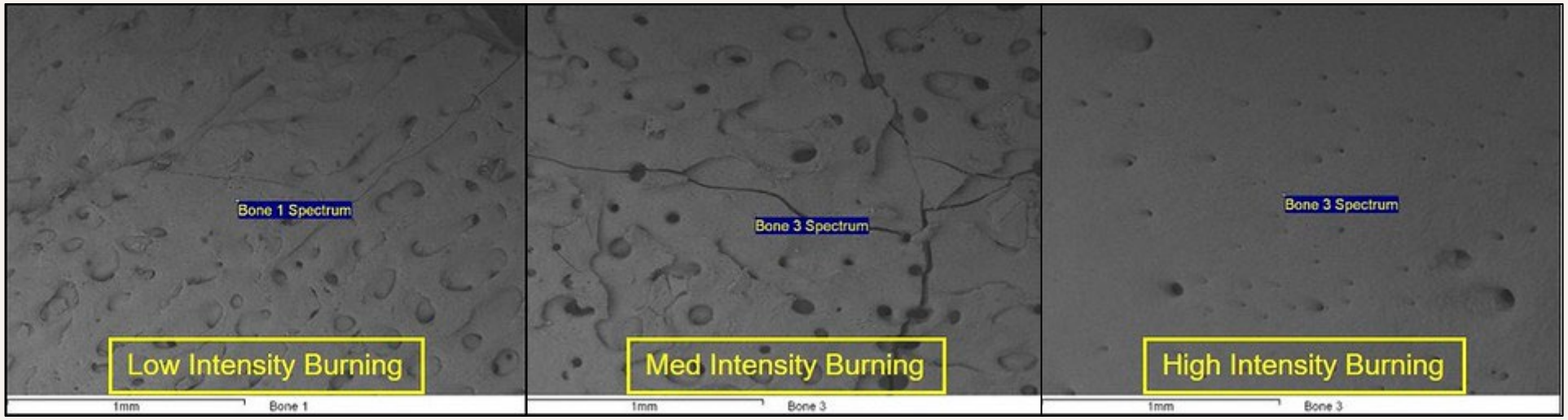


Symes et al., 2008: https://doi.org/10.1016/B978-012372510-3.50004-6
Owens, 2010: https://ir.ua.edu/handle/123456789/857

Thompson, 2004
https://doi.org/10.1016/j.forsciint.2004.09.063

Reorganization of the mineral structure

Calcination results in decreased porosity and increased crystallinity. These features can be investigated by advanced analytical techniques such FTIR spectroscopy, X-ray diffraction, porosimetry, SEM-EDX, (p)XRF, etc.



https://www.futurelearn.com/info/courses/forensic-archaeology-and-anthropology/0/steps/67911

SEM images of burnt bones

Bone burned at a high intensity can actually preserve much better in the ground than bone burned at a low intensity because of this change to a more ceramic-type crystal structure

A whole new world... with isotopes!

Life history information

Cremation environment characterization

Position of the burnt body

Dating

https://www.vogue.com.au/beauty/news/mac-to-launch-a-whole-new-world-of-beauty-with-a-disney-aladdin-collection/news-story/305b3a29d874d8b2a4c93776ef9f6a04

To delve deeper into the subject,
consider enrolling in the Bi2727 course!

Tomorrow activity!

How do we deal with burnt bones in an osteo lab?


Thank you and goodbye