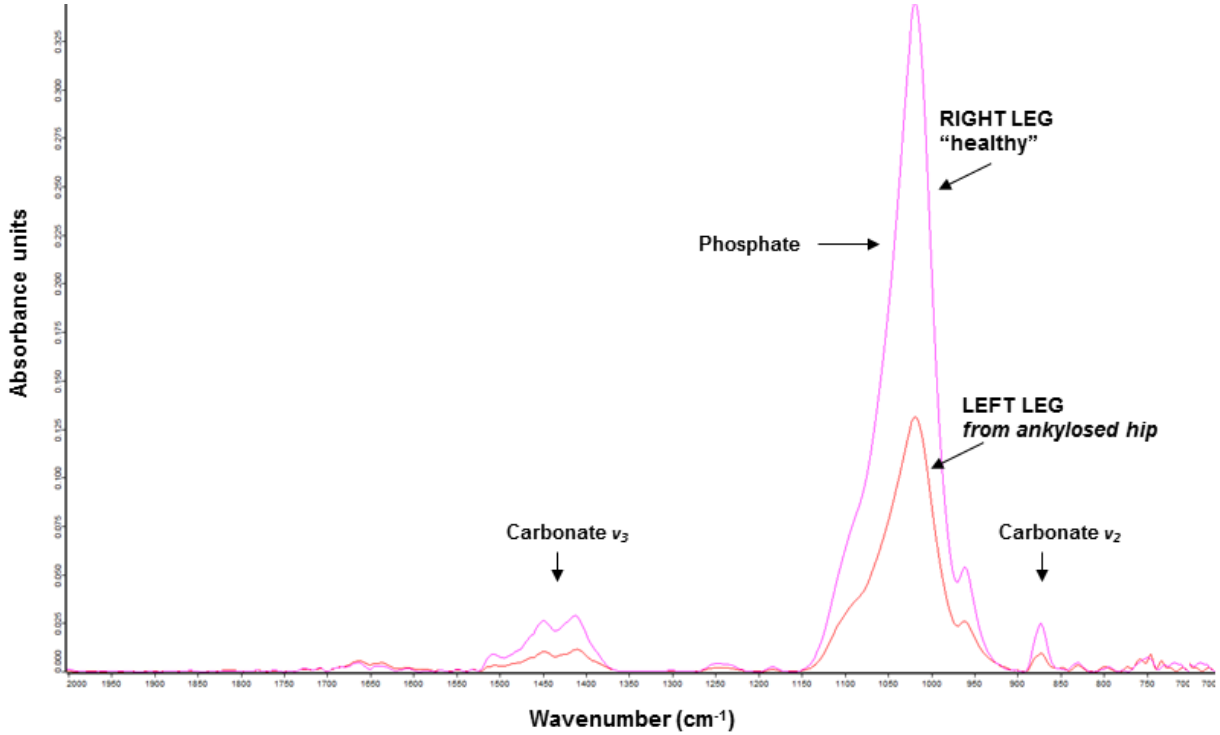
Australian National University



Using sFTIRM data from archaeological human bone to reconstruct health and disease in our recent past

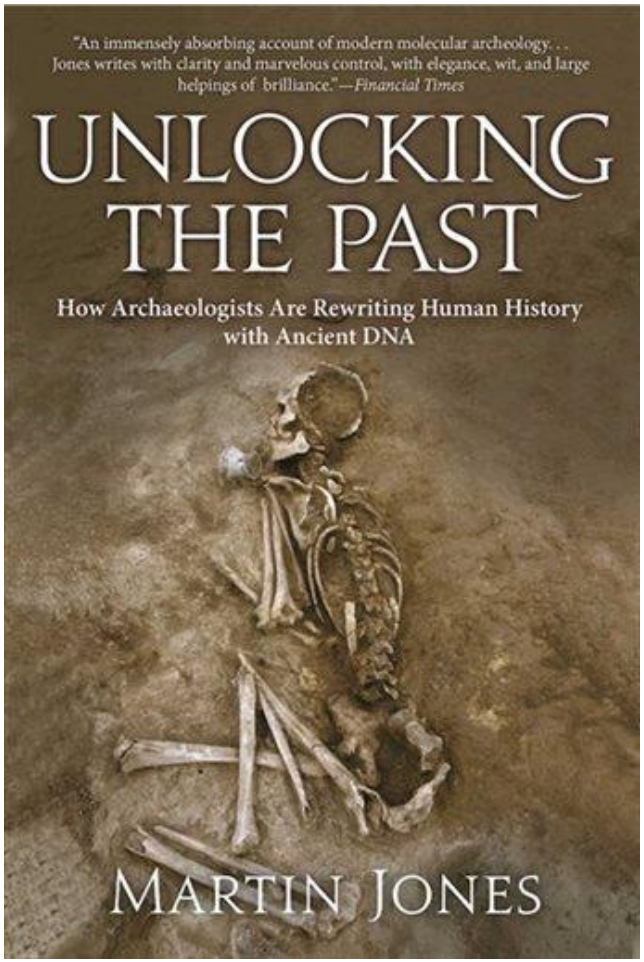
Justyna Miszkiewicz, PhD

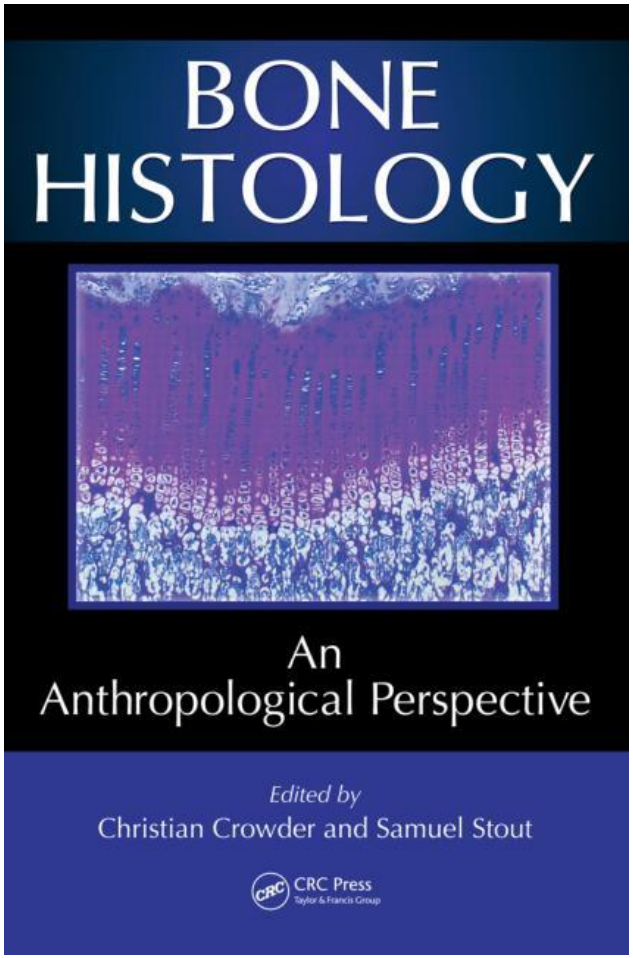
Australian National University

Justyna.Miszkiewicz@anu.edu.au

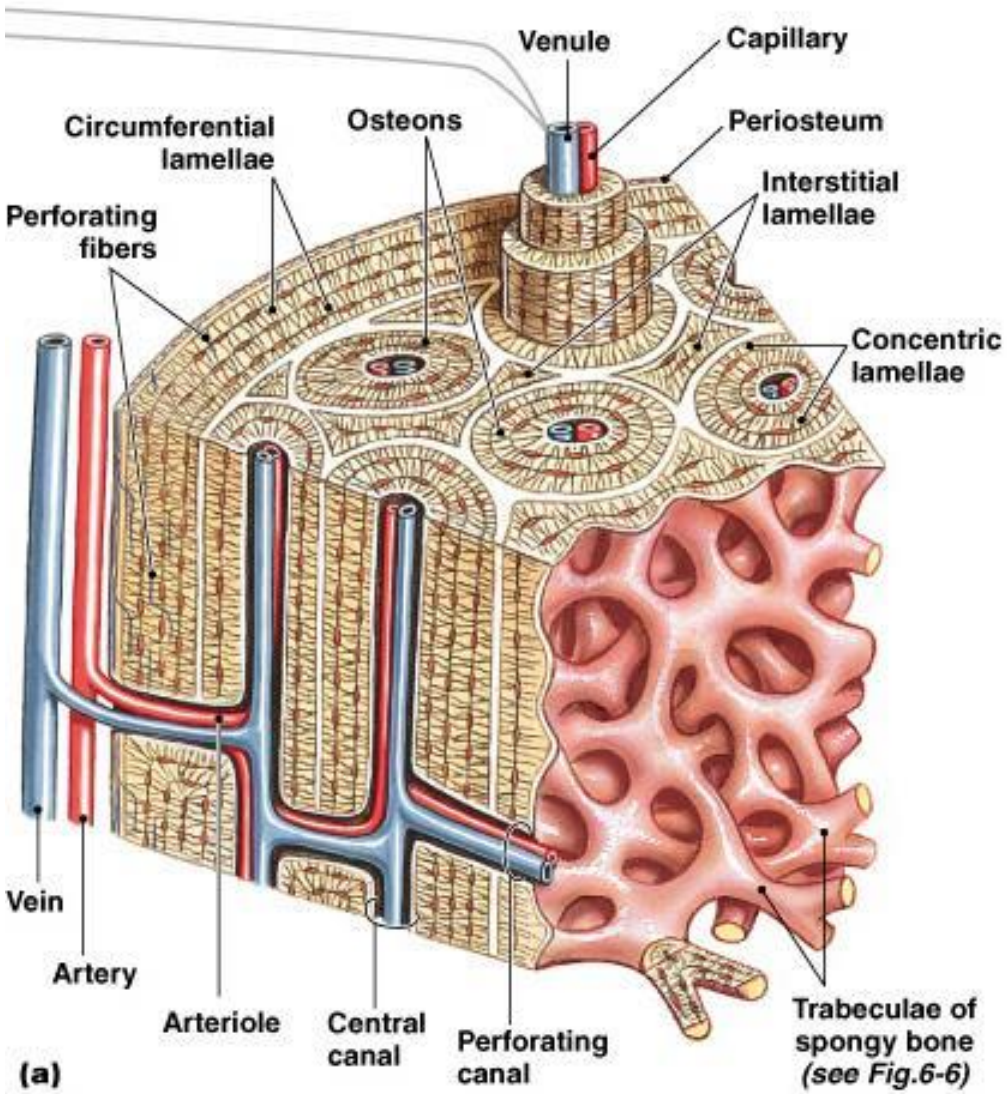
This presentation contains images of human remains

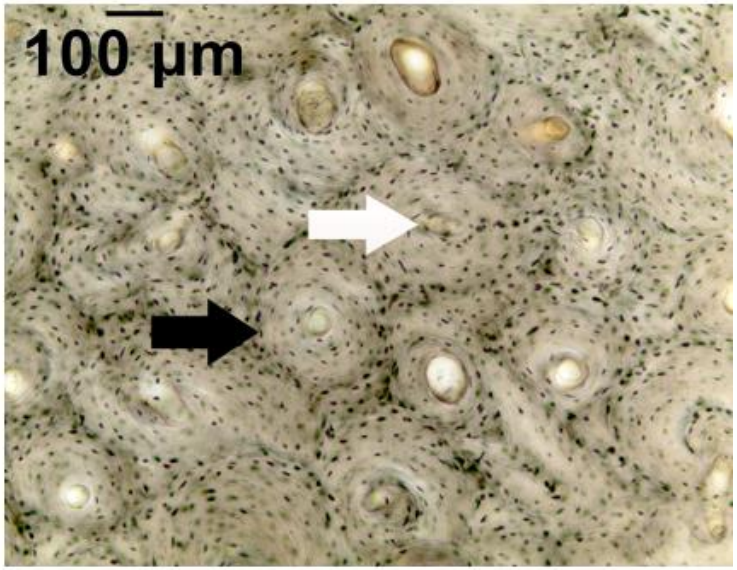
Bioarchaeology

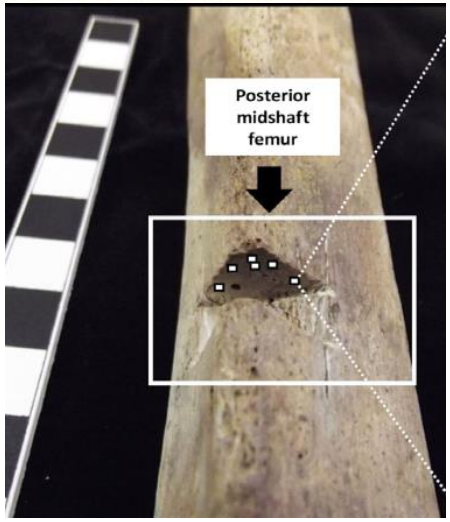




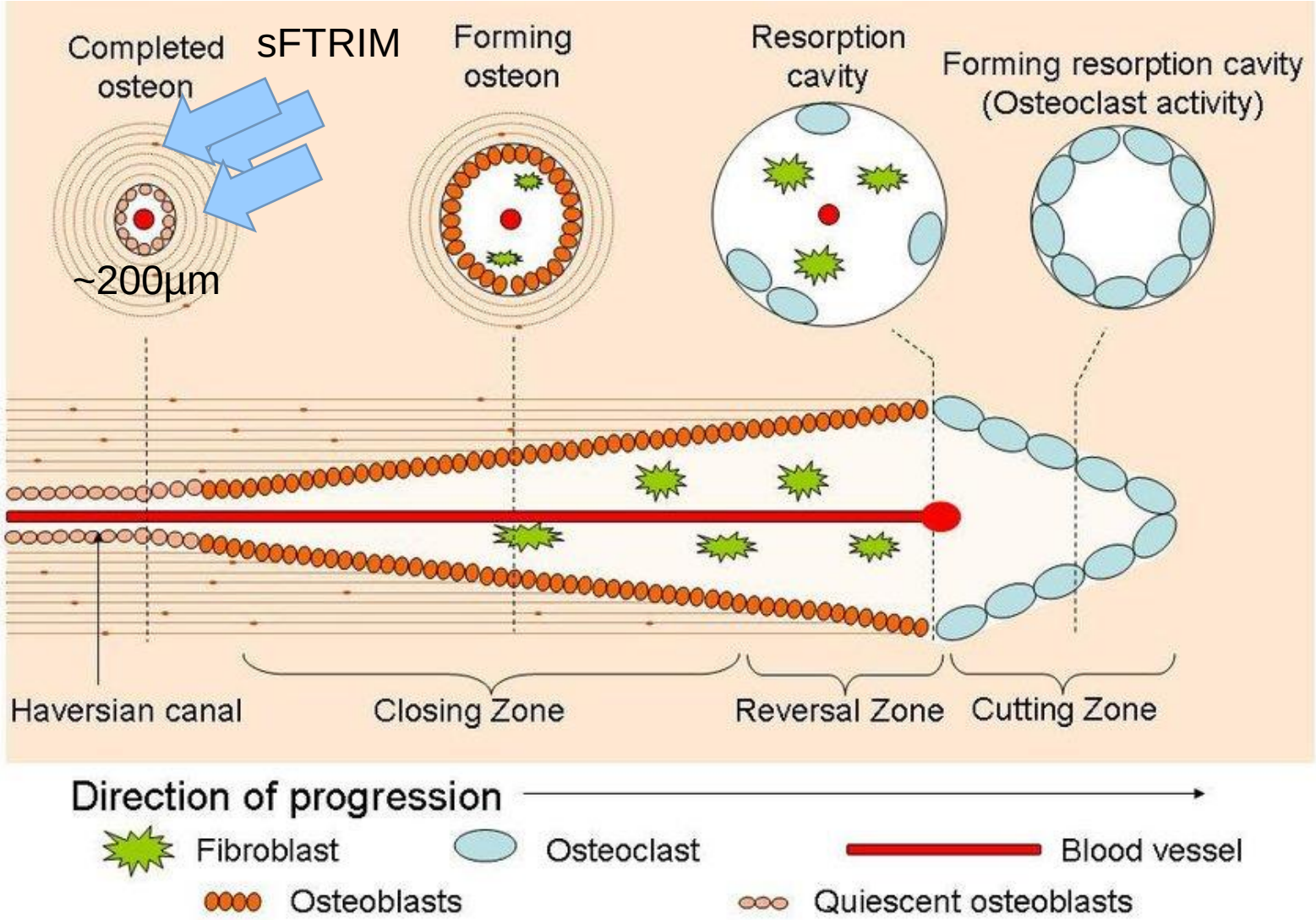
Miszkiewicz & Mahoney, 2017: 40



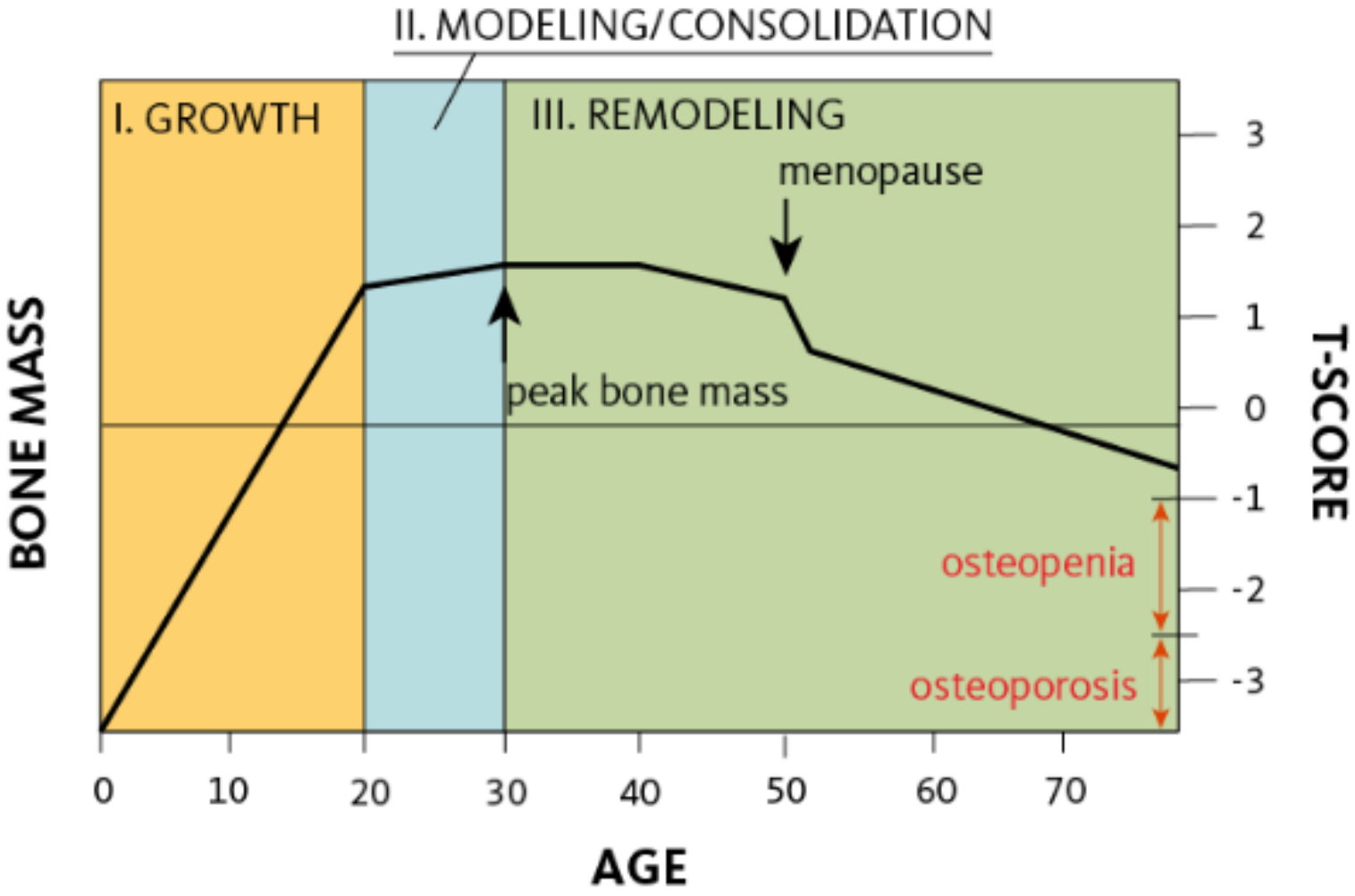




mineral, carbonate substitution into hydroxyapatite



Holland JC. 2012. Bone microstructure, turnover and peri-articular osteopathies (PhD thesis, Royal College of Surgeons in Ireland).



Heaney RP et al. 2000. Osteoporosis international 11(12):985.

International Journal of Paleopathology 31 (2020) 14–22

Contents lists available at ScienceDirect

International Journal of Paleopathology

journal homepage: www.elsevier.com/locate/ijpp

Asymmetric midshaft femur remodeling in an adult male with left sided hip joint ankylosis, Metal Period Nagsabaran, Philippines

Justyna J. Miszkiewicz [a,*], Claire Rider [a], Shimona Kealy [b,c], Christina Vrahnas [d,e,f], Natalie A. Sims [d,e], Jitraporn Vongsvivut [g], Mark J. Tobin [g], Mary Jane Louise A. Bolunia [h], Alexandra S. De Leon [h], Antonio L. Peñalosa [h], Pablo S. Pagulayan [h], Adan V. Soriano [h], Ruth Page [a], Marc F. Oxenham [a,i]

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[c] ARC Centre of Excellence for Australian Biodiversity and Heritage, Australian National University, Canberra, ACT, 0200, Australia
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[e] Department of Medicine, The University of Melbourne, St. Vincent's Hospital, Melbourne, VIC, 3065, Australia
[f] MRC Protein Phosphorylation and Ubiquitylation Unit, James Black Centre, University of Dundee, Dundee, DD1 4HN, United Kingdom
[g] Infrared Microspectroscopy (IRM) Beamline, ANSTO – Australian Synchrotron, 800 Blackburn Road, Clayton, VIC 3168, Australia
[h] Archaeology Division, National Museum of the Philippines, P. Burgos St., Manila, 1000, Philippines
[i] Department of Archaeology, University of Aberdeen, St. Mary's, Elphinstone Road, Aberdeen, AB24 3UF, Scotland, United Kingdom

International Journal of Osteoarchaeology, Vol. 3: 19–28 (1993)

Effects of a Nineteenth Century Below-knee Amputation and Prosthesis on Femoral Morphology

RICHARD A. LAZENBY[1] AND SUSAN K. PFEIFFER[2,*]
[1]Dept. of Anthropology, McMaster University, Hamilton, Ontario L8S 4L9, Canada; and
[2]School of Human Biology, University of Guelph, Guelph, Ontario N1G 2W1, Canada

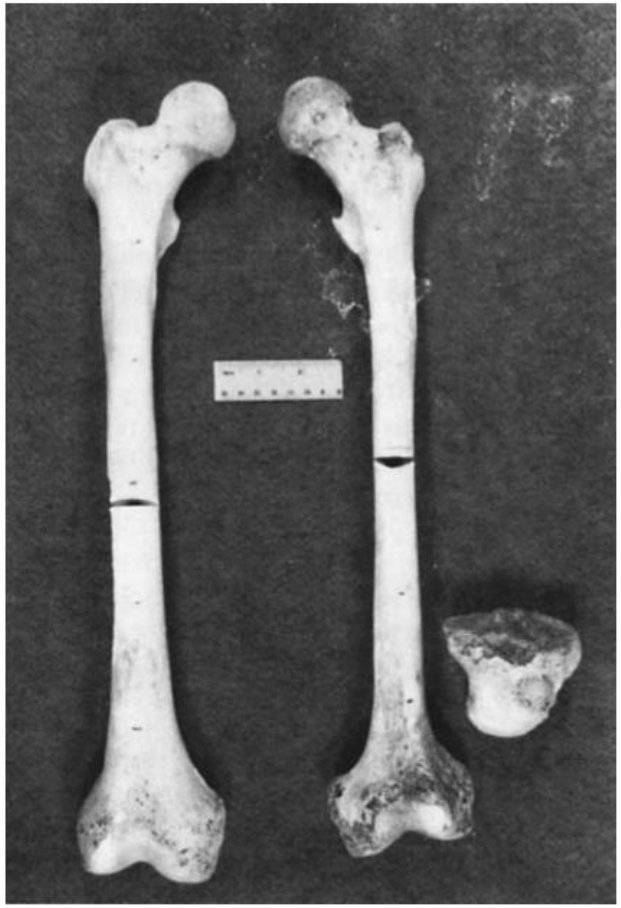


Figure 4. The femora of Madie Brown, showing the visible difference in size. (A wedge of bone has been removed at midshaft from the anterior surface, for preparing the histological section.)

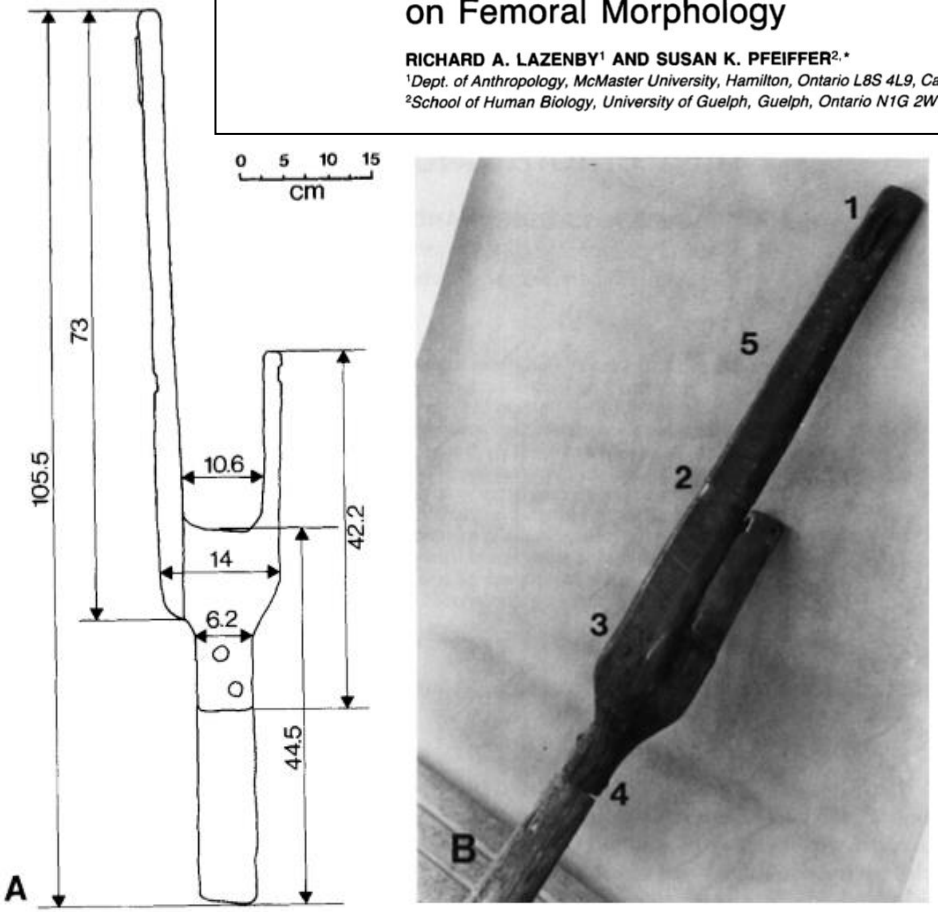
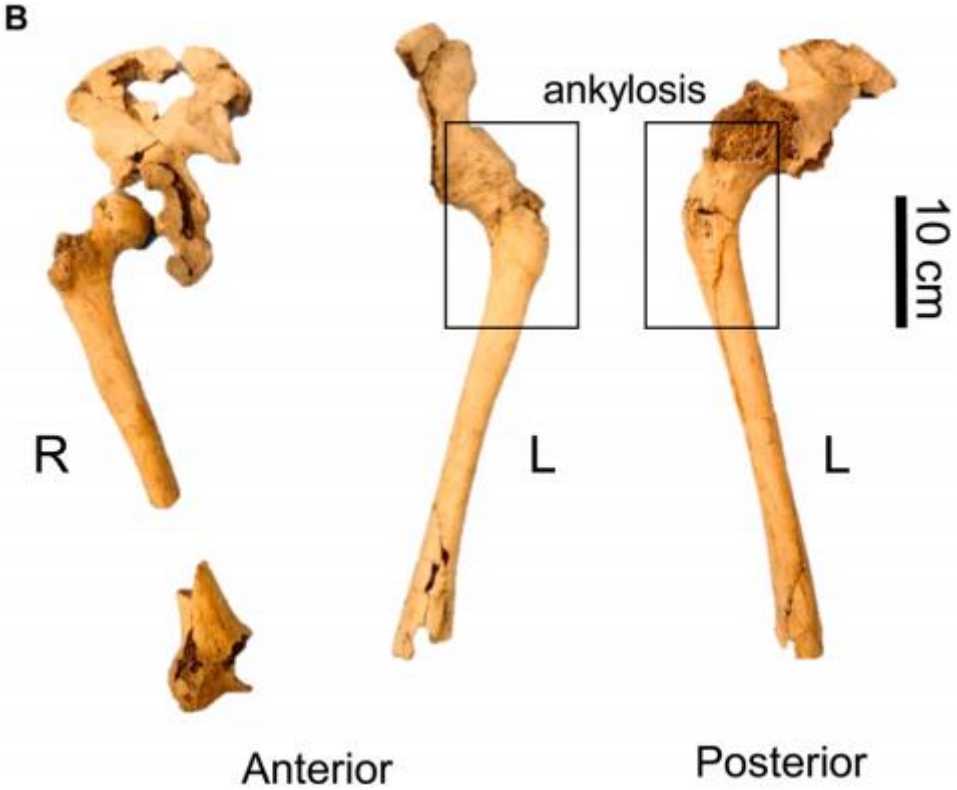


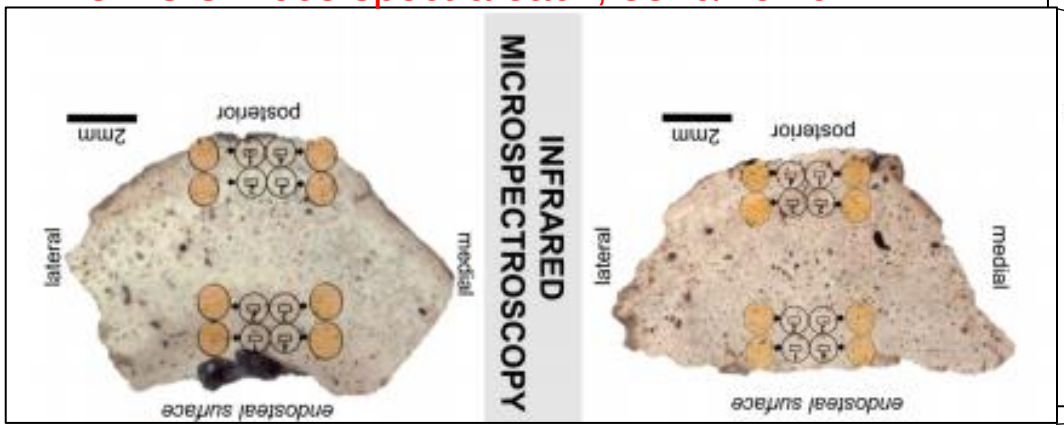
Figure 1. (a) A schematic anterior view of the wooden prosthesis worn by Madie Brown at the time of his execution, showing the various components and dimensions (all in cm). (b) An anterolateral view of the prosthesis showing: 1, the leather loop for the waist strap; 2, the carved notches for the thigh strap; 3, the nails attaching the lateral stabilizer to the base; 4, the straight rabbet joint and comparatively poor fit between the base and peg; 5, saw marks on the lateral stabilizer.

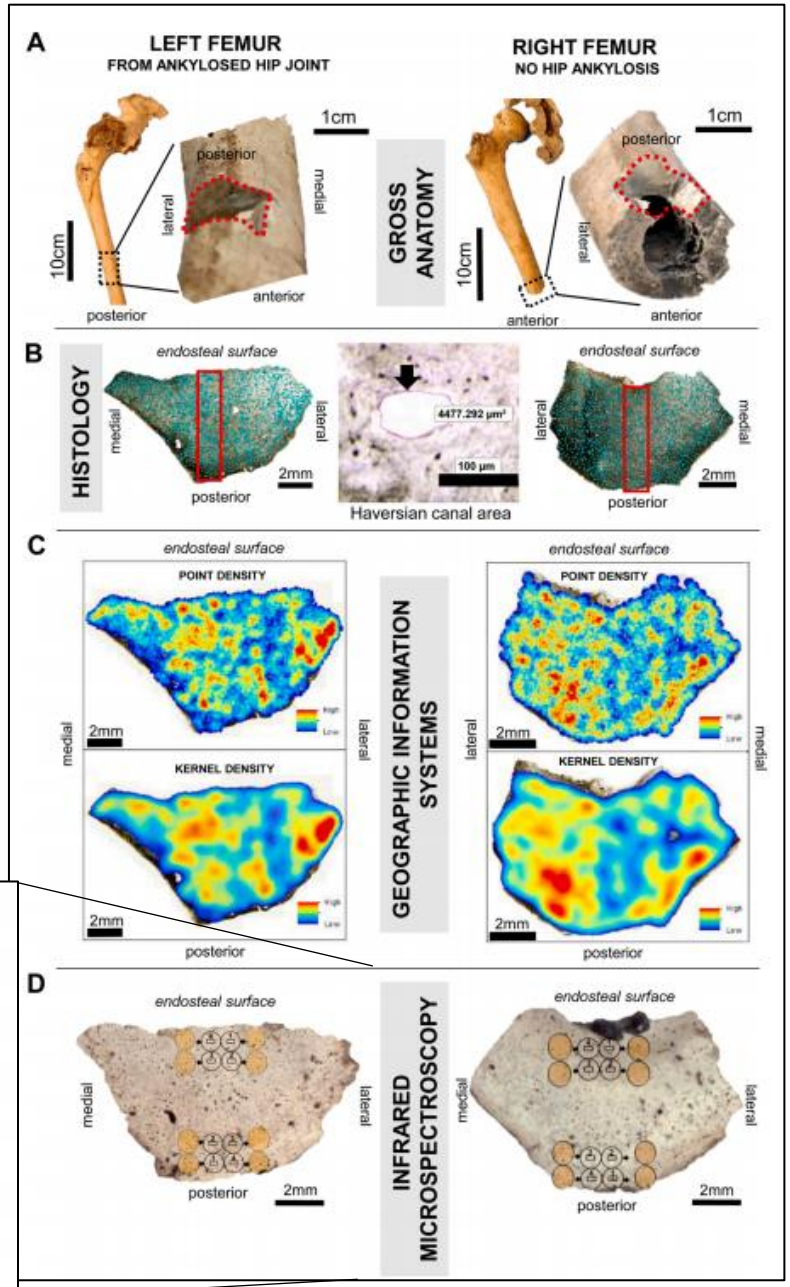
Lazenby & Pfeiffer, 1993, p. 20

Miszkiewicz et al. 2020, p. 15.



ATR accessory – Vonsgvivut et al. 2019
8 ROIs = 665 spectra each, 5320/ femur



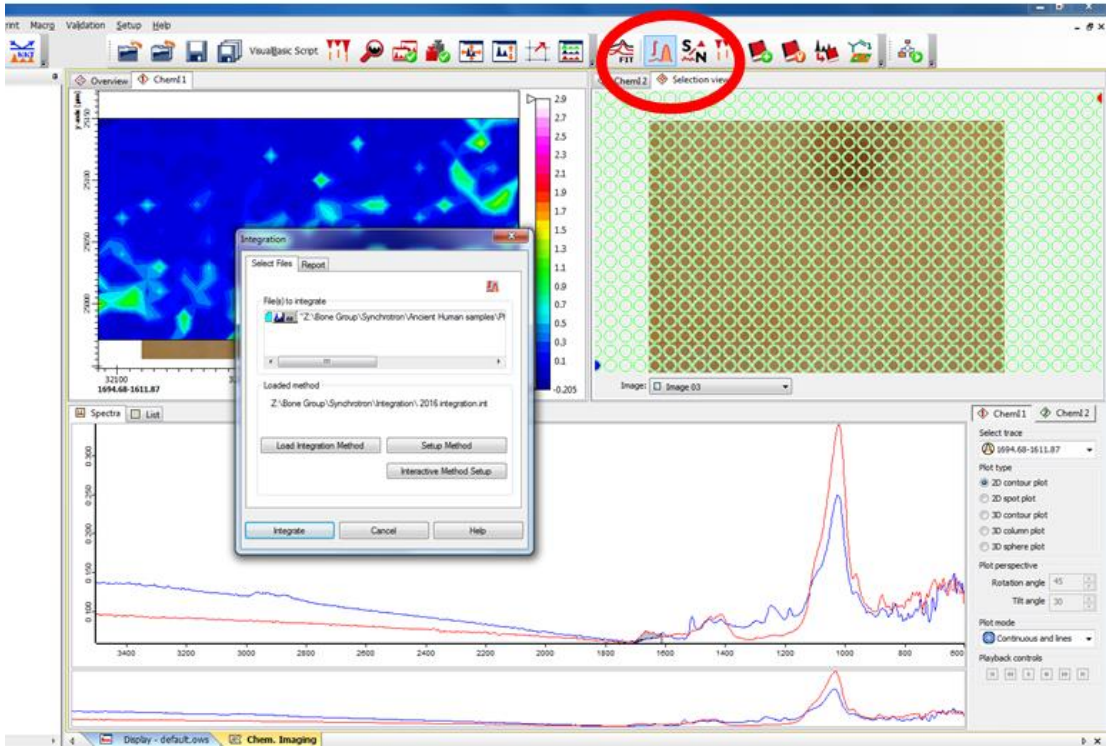


Miszkiewicz et al. 2020, p. 17.

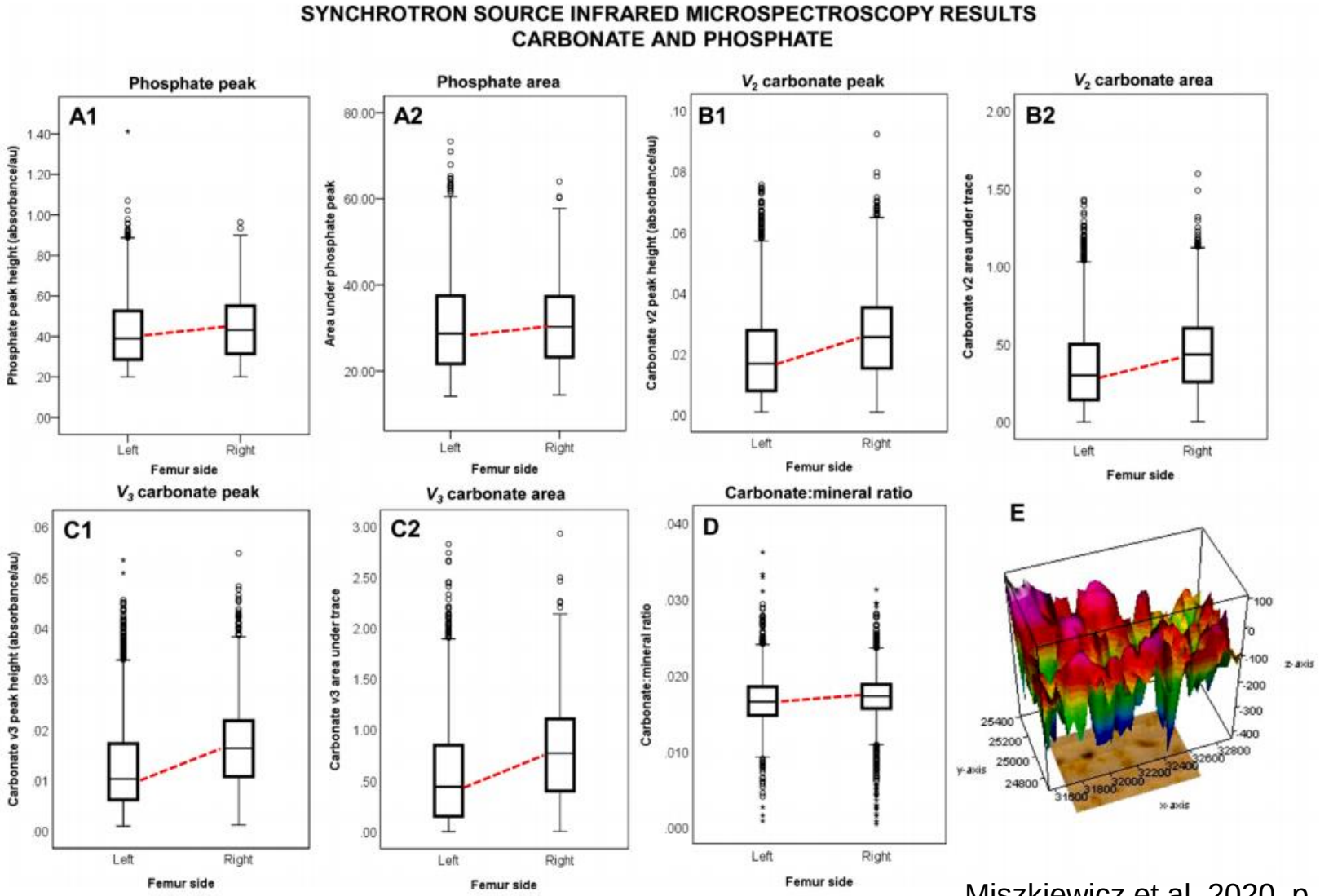
Miszkiewicz et al. 2020. International Journal of Paleopathology 31:14-22.
Vongsvivut, J. et al. 2019 Analyst 144: 3226–3238.

Thousands of spectra!

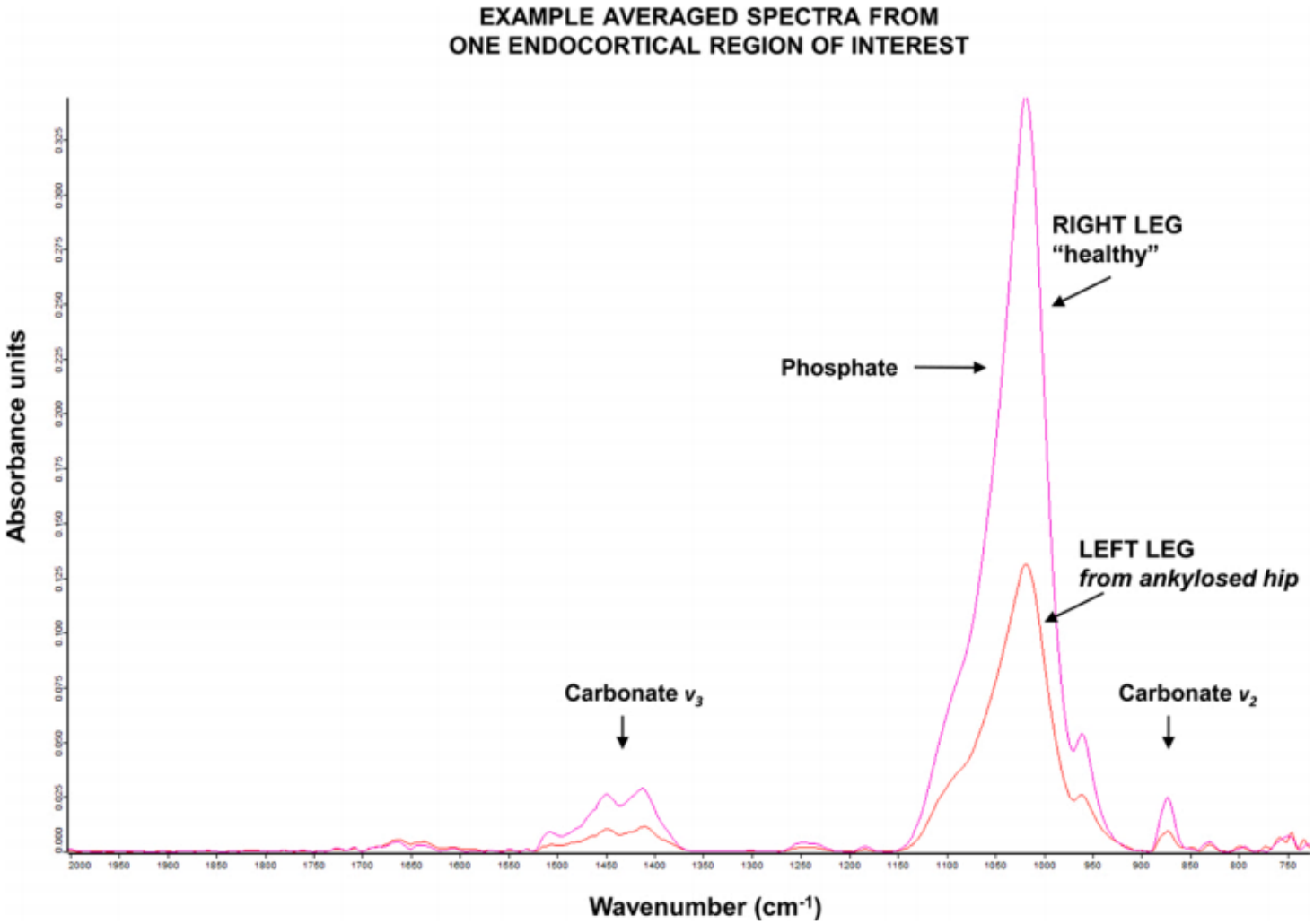
- Integration files - extract peak height and area under the trace. Summarise and compare descriptively.
- Carbonates v_2 (890− 850 cm^{-1}), v_3 (1500− 1400 cm^{-1}), phosphate (1180–916 cm^{-1}), v_2:phosphate ratios (e.g. Ou-Yang et al., 2001; Madupalli et al., 2017).
- Min. 2605, max. 5170 in left femur, and 3893 min and 5128 max right femur.



Madupalli et al. 2017. Journal of Solid State Chemistry 255: 27-35.
Ou-Yang et al., 2001. Journal of Bone and Mineral Research 16(5), 893-900.



Miszkiewicz et al. 2020, p. 20.



Miszkiewicz et al. 2020, p. 20.

Ca. 2000 year old male with ankylosed hip joint…

- Compromised bone in left femur.
- Bone functional adaptation paradigms of remodeling to pathological and biomechanical changes.
- Reconstruction of his lifestyle in the lead up to death.

Miszkiewicz et al. 2020, p. 15.

scientific reports

Check for updates

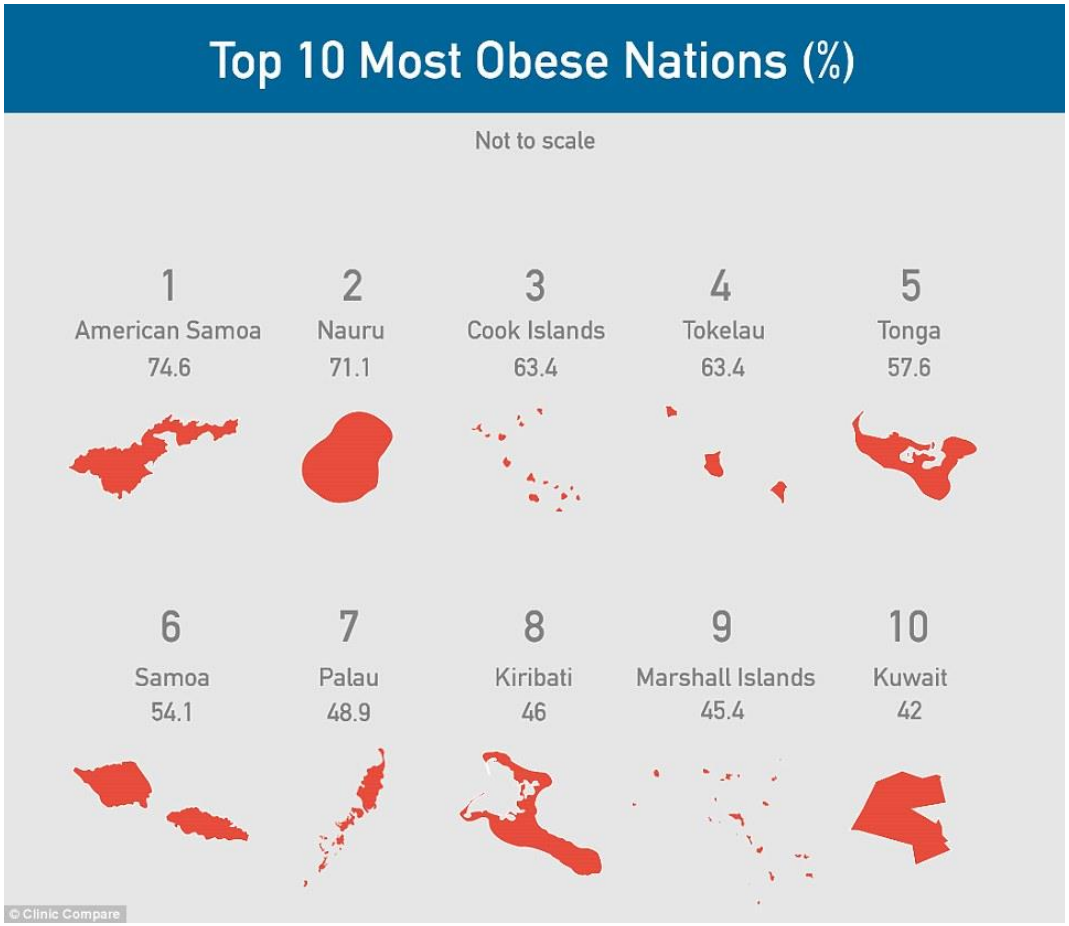
OPEN

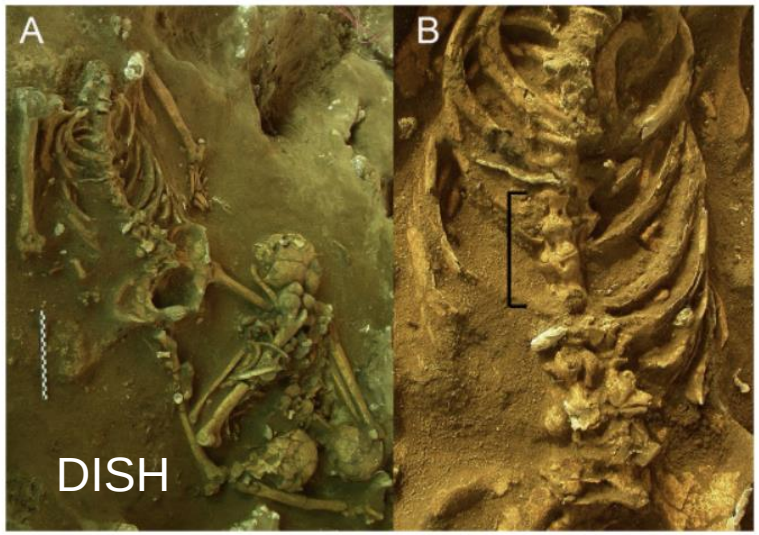
Bone loss markers in the earliest Pacific Islanders

Justyna J. Miszkiewicz[1], Frédérique Valentin[2,3], Christina Vrahnas[4,5,6], Natalie A. Sims[5,6], Jitraporn Vongsvivut[7], Mark J. Tobin[7] & Geoffrey Clark[3]

Kingdom of Tonga in Polynesia is one of the most obese nations where metabolic conditions, sedentary lifestyles, and poor quality diet are widespread. These factors can lead to poor musculoskeletal health. However, whether metabolic abnormalities such as osteoporosis occurred in archaeological populations of Tonga is unknown. We employed a microscopic investigation of femur samples to establish whether bone loss afflicted humans in this Pacific region approximately 3000 years ago. Histology, laser confocal microscopy, and synchrotron Fourier-transform infrared microspectroscopy were used to measure bone vascular canal densities, bone porosity, and carbonate and phosphate content of bone composition in eight samples extracted from adult Talasiu males and females dated to 2650 BP. Compared to males, samples from females had fewer vascular canals, lower carbonate and phosphate content, and higher bone porosity. Although both sexes showed evidence of trabecularised cortical bone, it was more widespread in females (35.5%) than males (15.8%). Our data suggest experiences of advanced bone resorption, possibly as a result of osteoporosis. This provides first evidence for microscopic bone loss in a sample of archaeological humans from a Pacific population widely afflicted by metabolic conditions today.

Why Pacific?



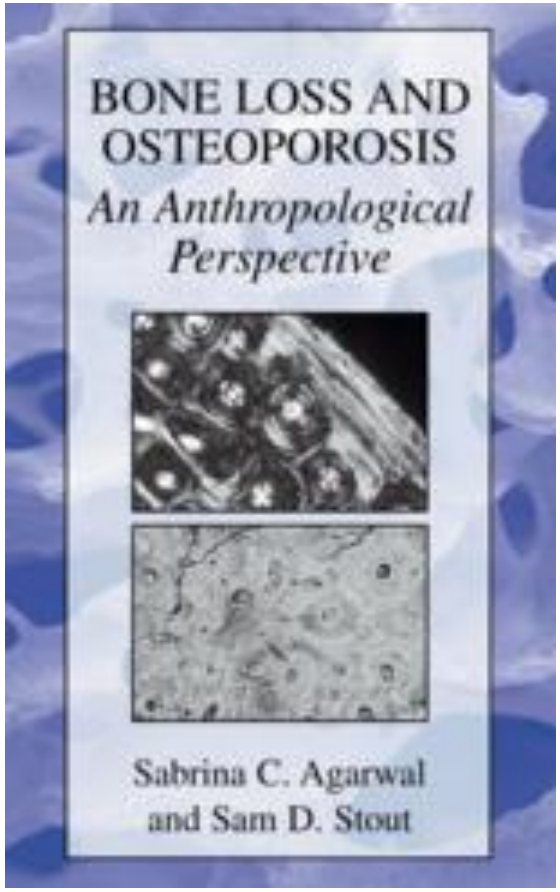


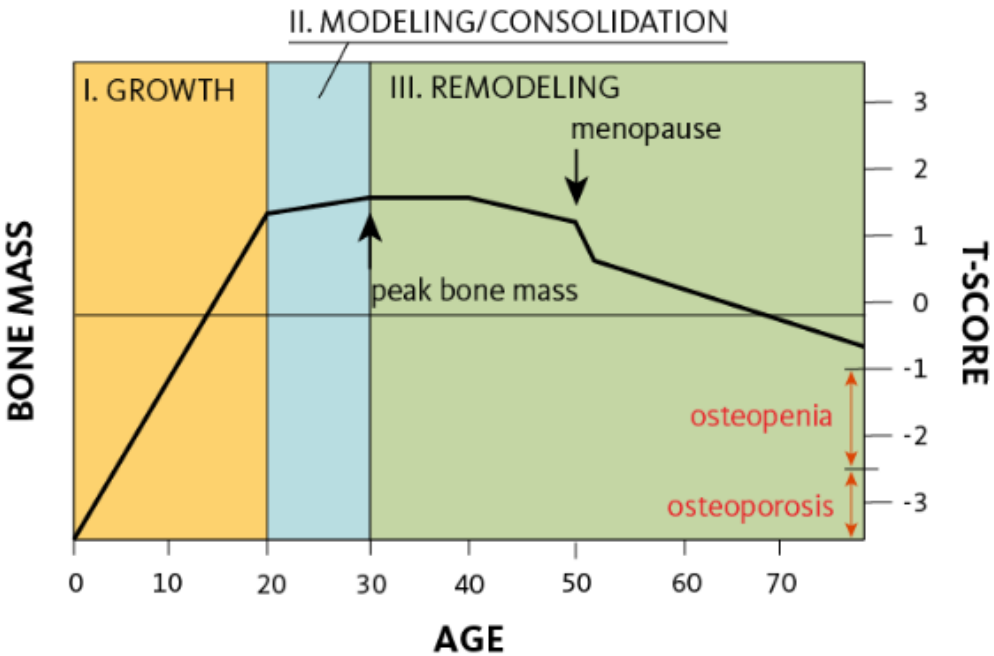
Foster et al. 2018 p. 413

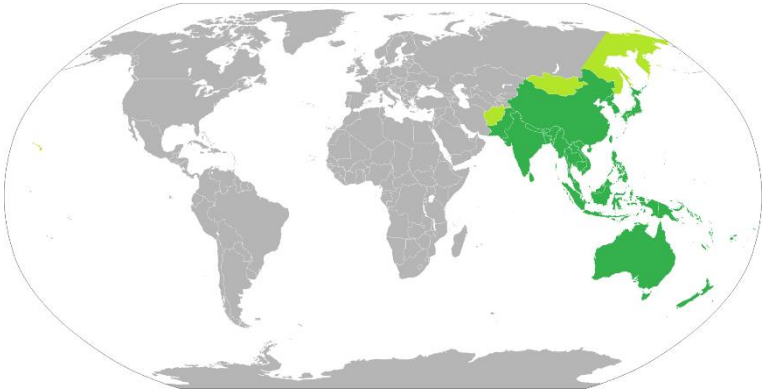
Buckley 2007 p. 744

Buckley 2007. Current Anthropology 48(5):741-9.

Foster et al. 2018. Journal of Archaeological Science: Reports 18:408-19.

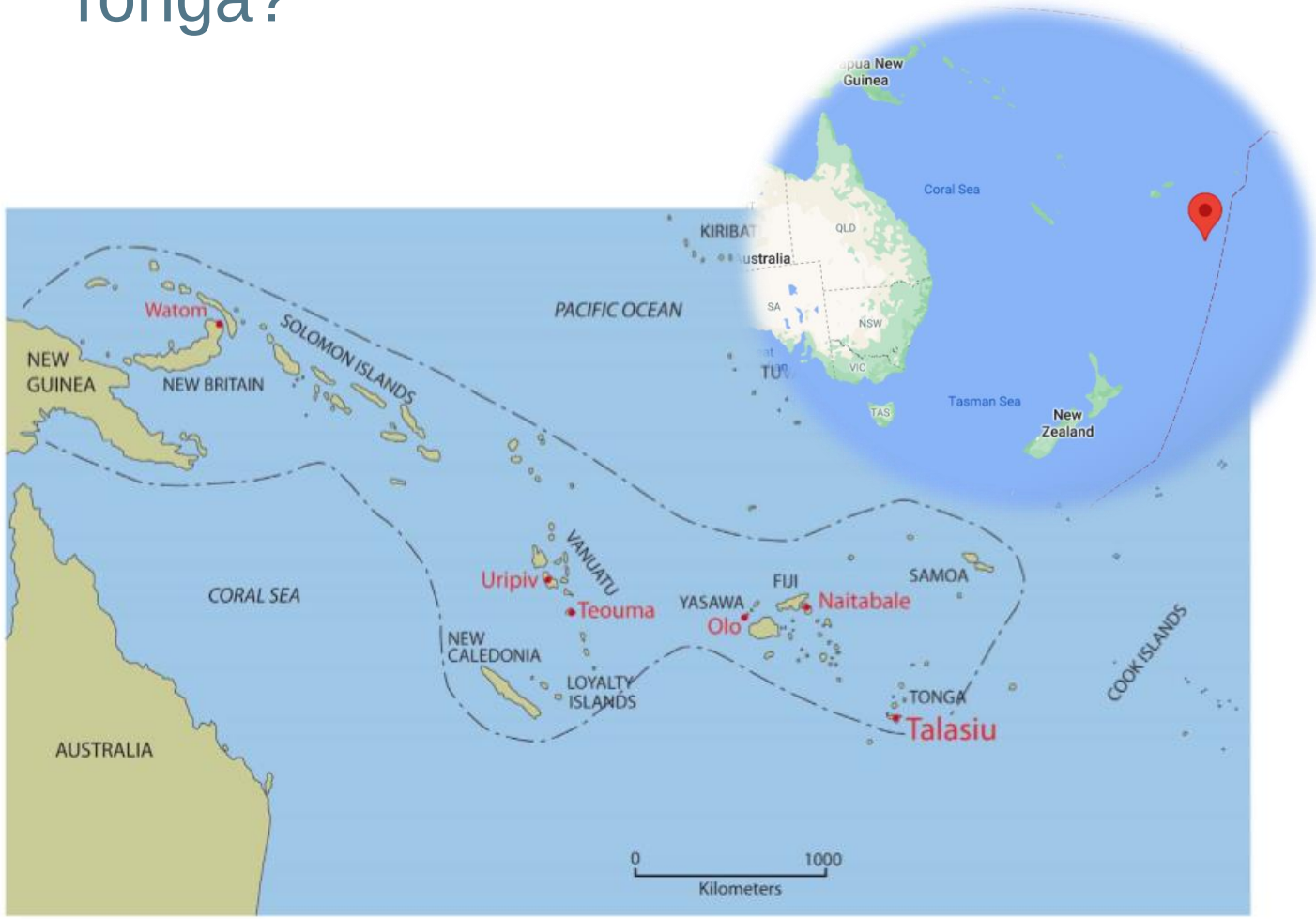






Heaney RP et al. 2000. Osteoporosis international 11(12):985.

Increased bone fragility in Talasiu, Kingdom of Tonga?

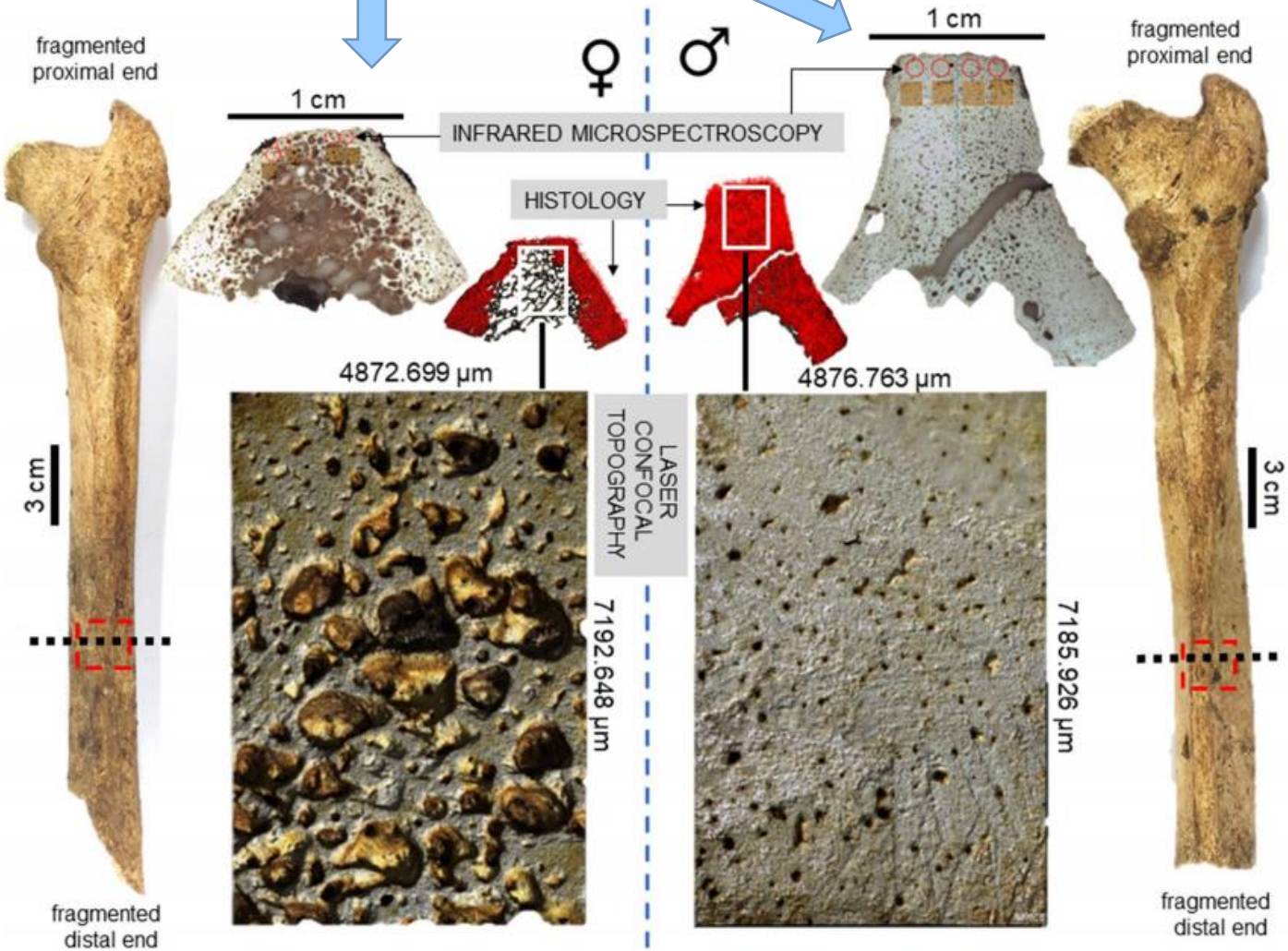


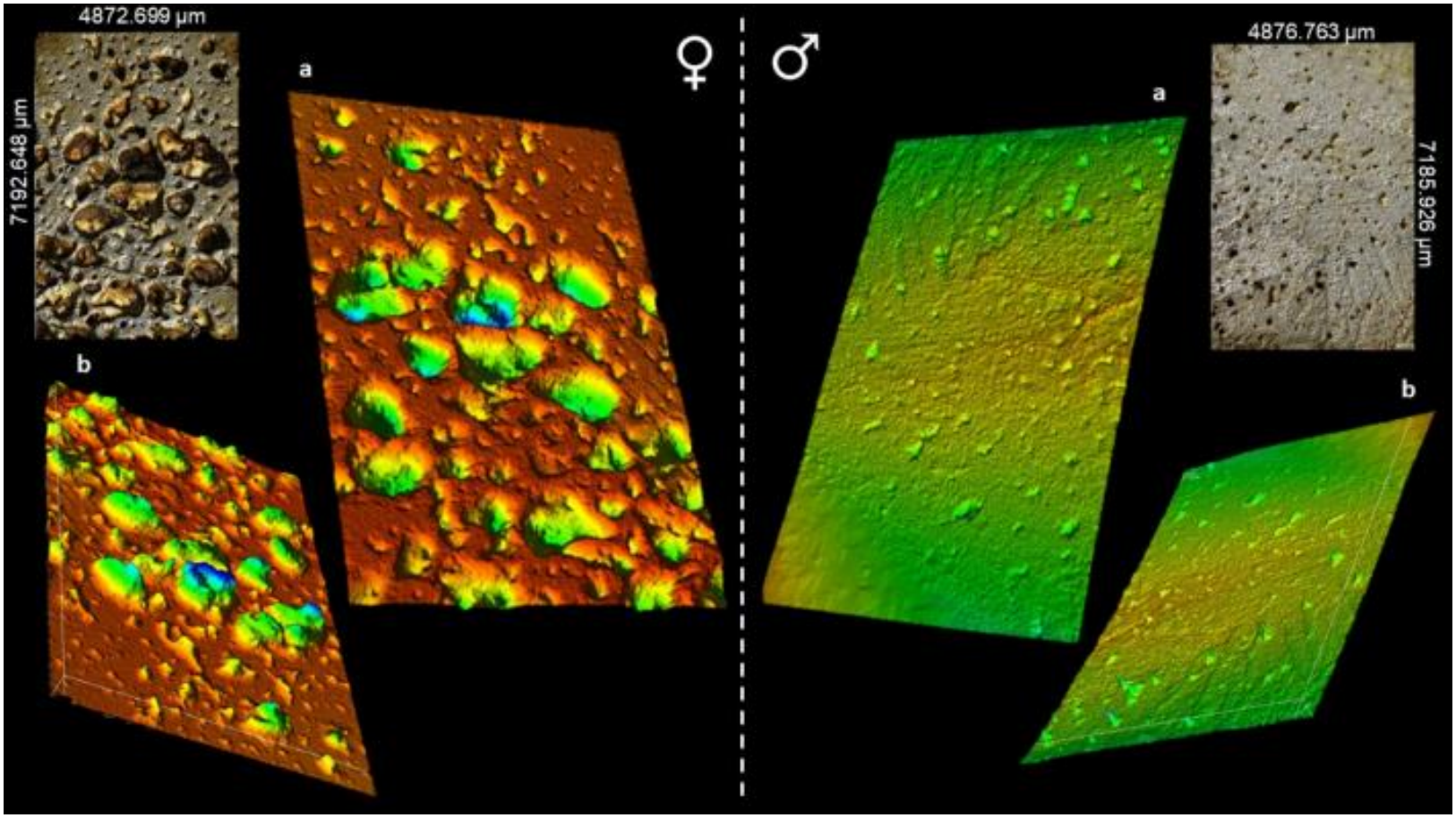
2650 BP
"old", femur histology, confocal microscopy, sFTIRM

n = 8

Herrscher et al. 2018 p. 309

4 ROIs = 220 spectra/sample, 7040 in total



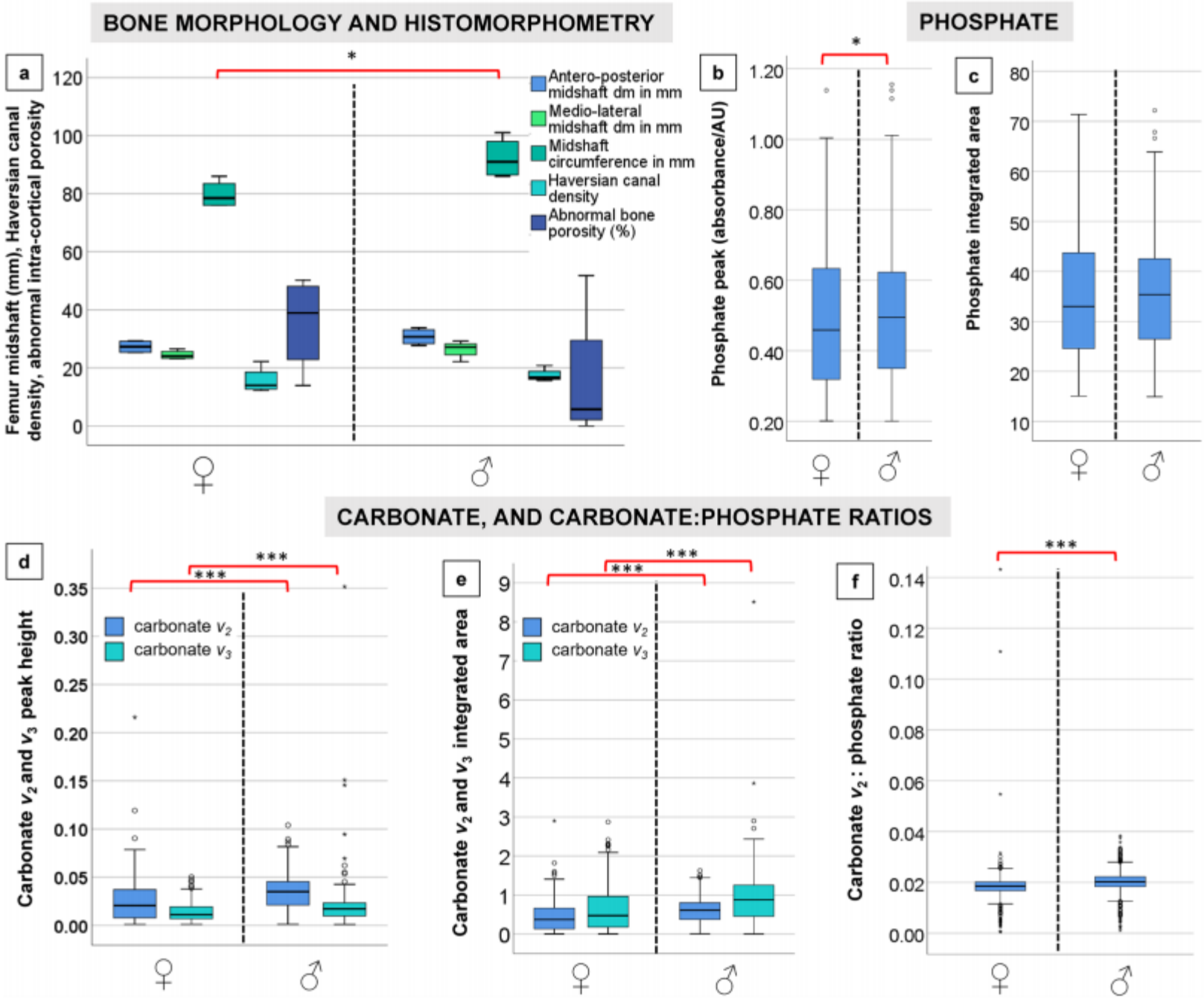


Following inspection of spectra:

phosphate = 3344 in males, 844 in females

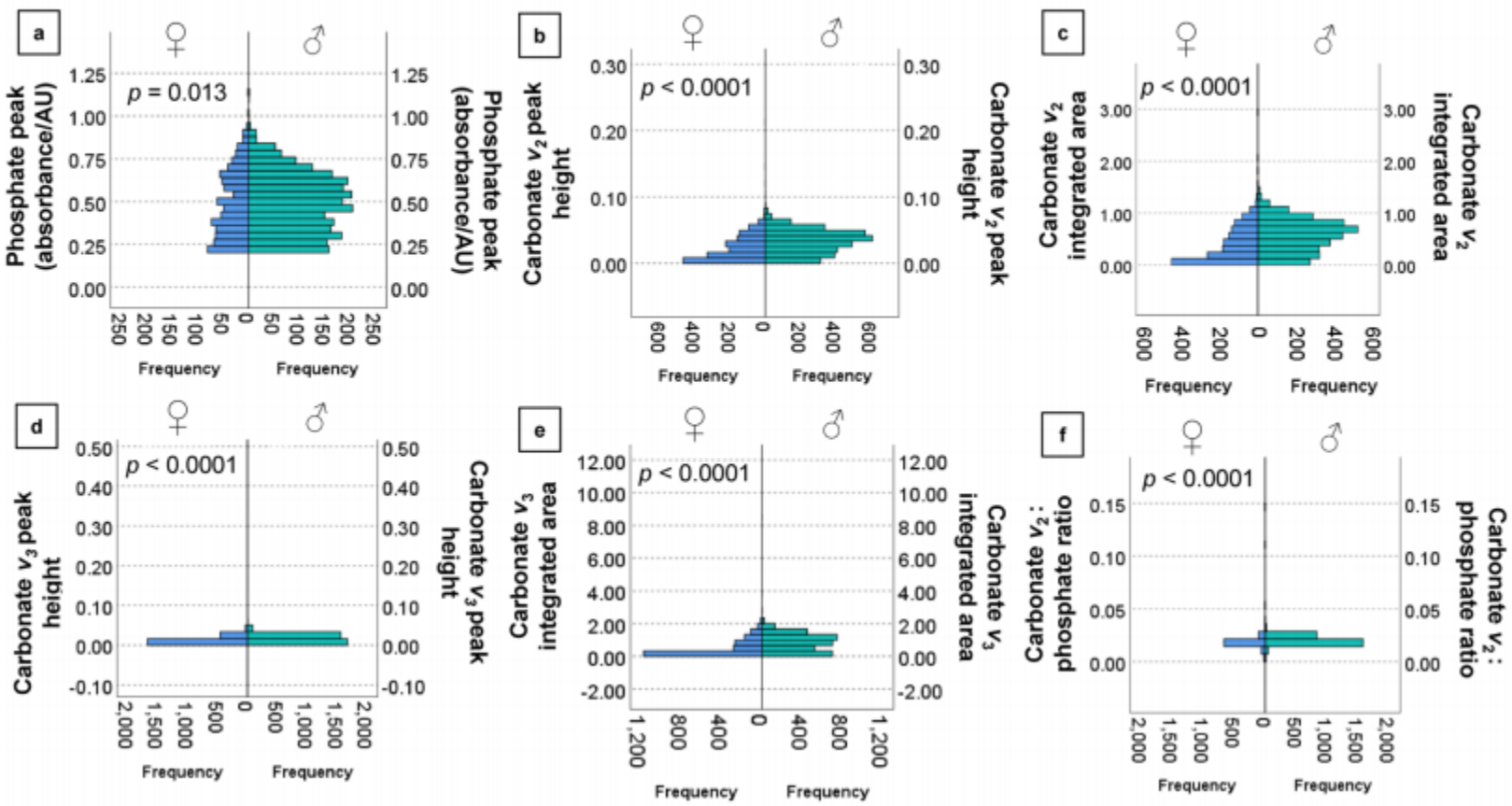
carbonate min 1676 (v_2) and 2159 (v_3) in females, and 3339 (v_2) and 3329 (v_3) in males

carbonate v_2 :phosphate ratios: 846 in females and 2495 in males



Miszkiewicz et al., 2021 Scientific Reports 11(1):1-6.

PHOSPHATE AND CARBONATES, AND THEIR RATIOS



Ca. 3000 Tongans

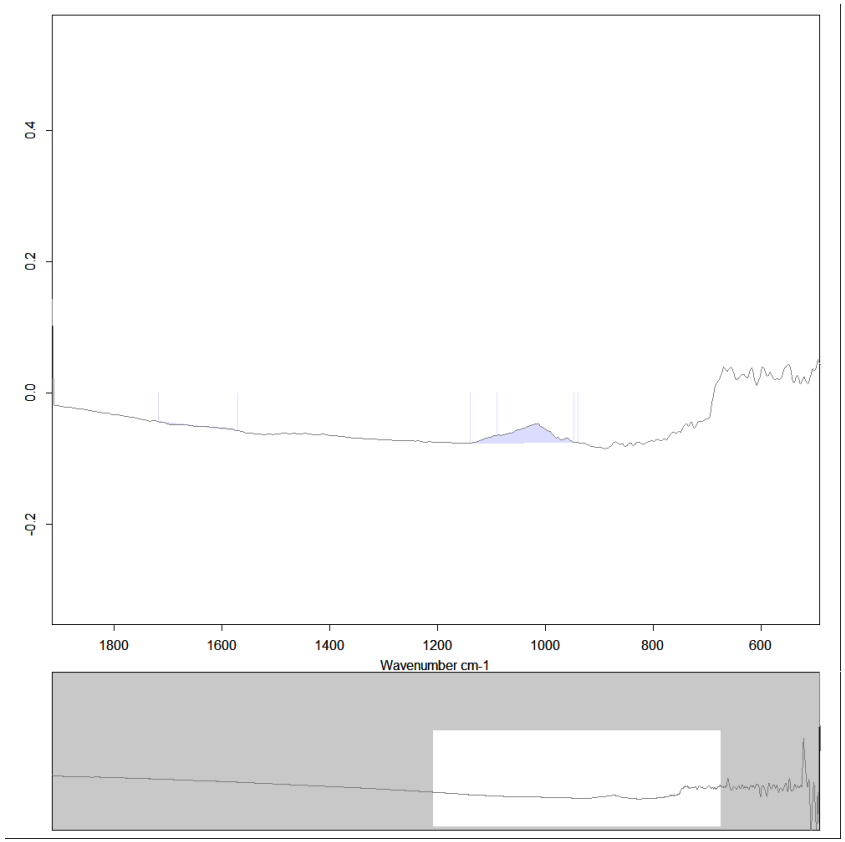
- Lifestyle contributions to accelerated bone remodelling?
- Lifespan longer than previously thought with females possibly experiencing menopause related bone loss?

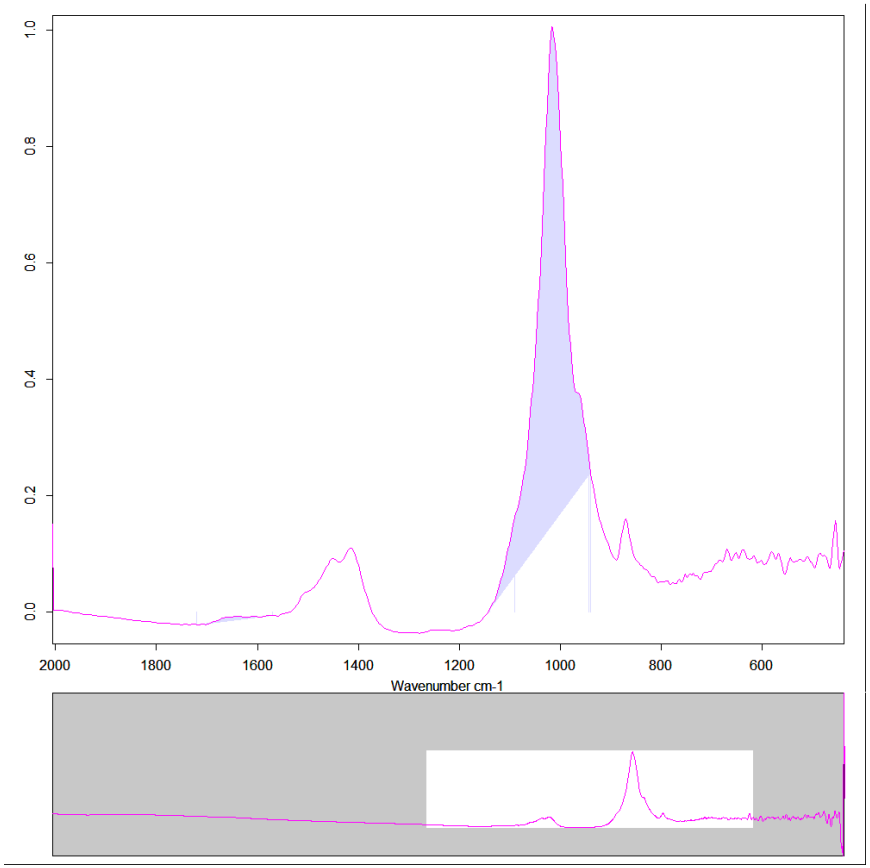
Afia-Too-Ca, a burying place on the Island of Amsterdam, © Indian Ocean Iconographic Collections

Technical challenges

- **ATR attachment** not making contact with all bone regions, uneven? (sample ~100µm)
- **Biodegradation post-mortem** - not all spectra suitable for analysis -- diagenetic calcite deposited post-mortem can contribute to carbonate sites of spectra

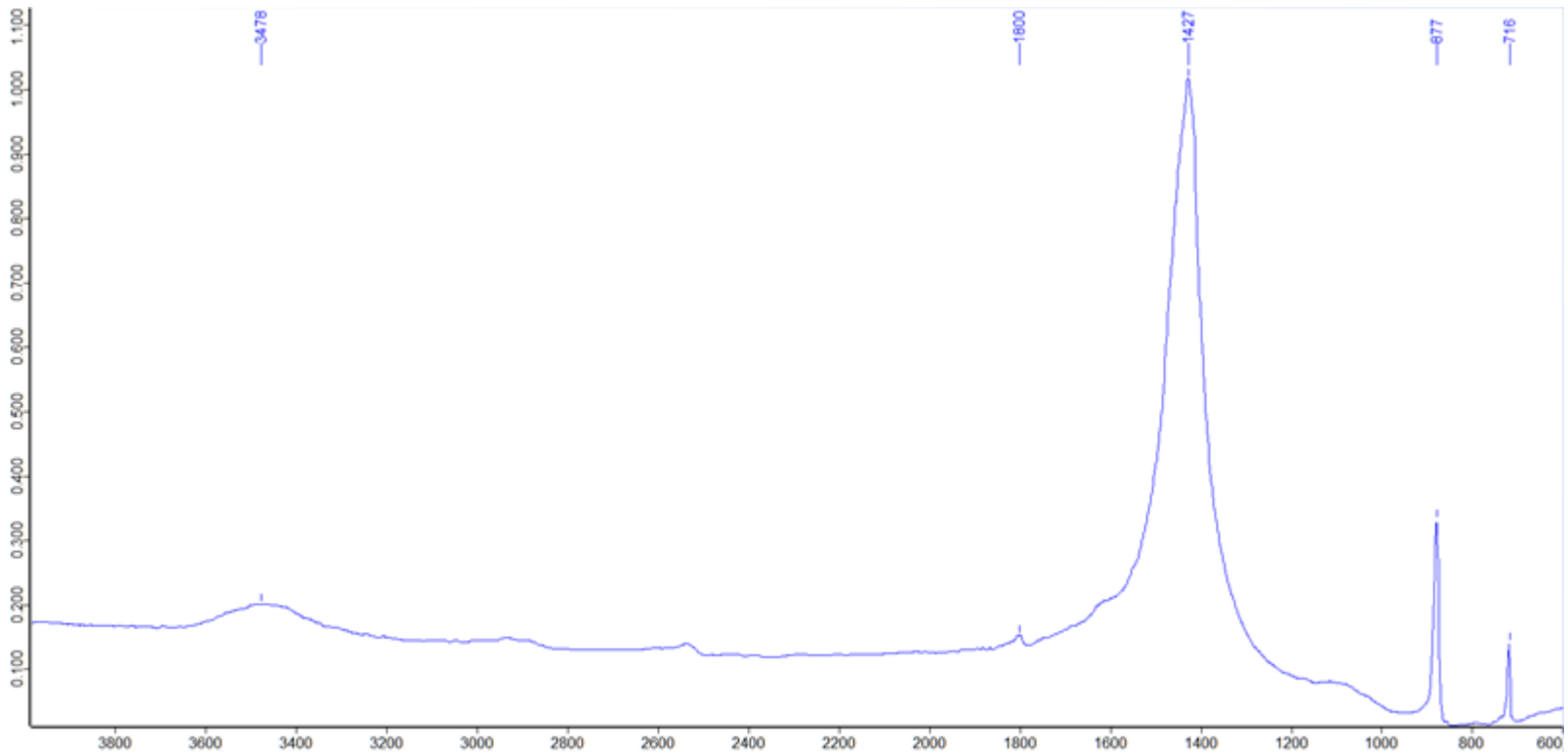
Image courtesy of Pimm!



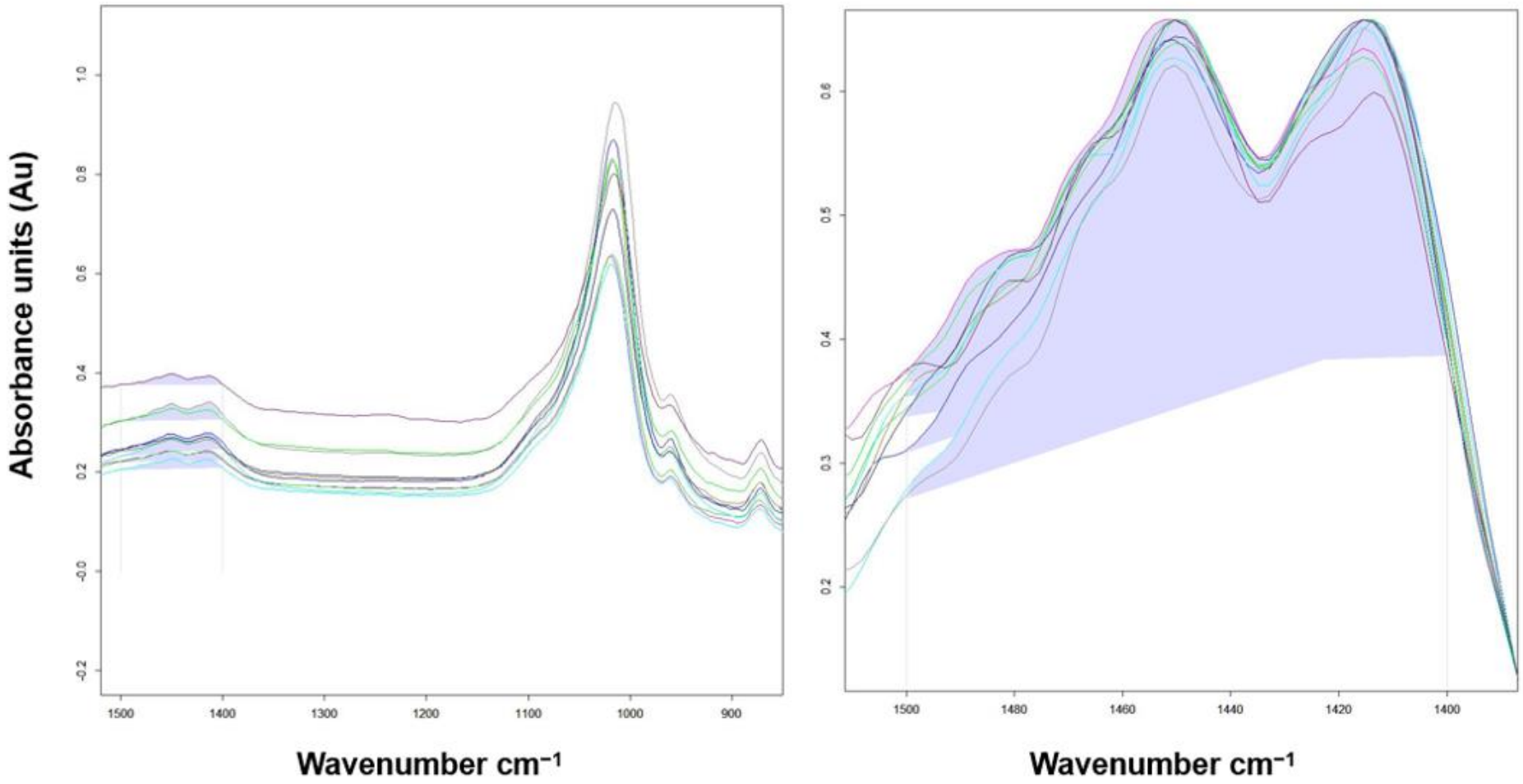


1. Remove unsuitable spectra/ phosphate, carbonate values; **2.** Perform statistical correlations to check carbonate v_2 and v_3 data alignment – remove where random scatter. **3.** Manually examine sites of v_3 for a strong peak at 1427 cm^{-1} indicating presence of calcite.

Calcite - strong and distinct peak at 1427 cm^{-1}

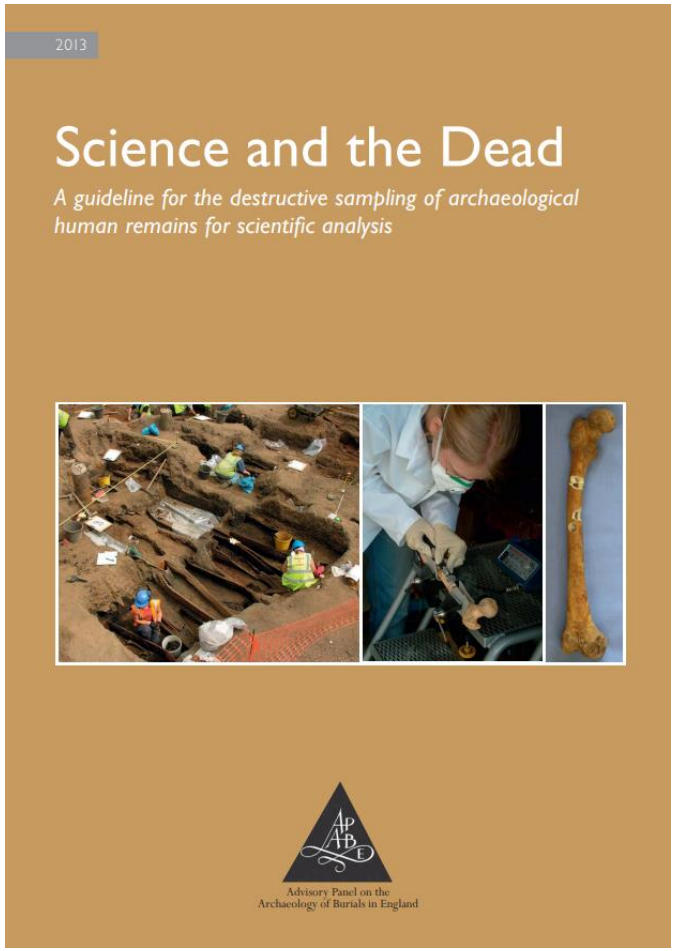


Courtesy of Pimm!


Absorbance units (Au)
1.0
0.8
0.6
0.4
0.2
-0.0
-0.2
1500
1400
1300
1200
1100
1000
900
Wavenumber cm⁻¹
0.6
0.5
0.4
0.3
0.2
1500
1480
1460
1440
1420
1400
Wavenumber cm⁻¹

…method still rarely applied in bioarchaeology

- Destructive sampling.
- Haven't been able to apply modern bone approaches (Vrahnas et al. 2016, e.g. collagen molecular compaction via amide I, II).



Mays et al., 2013

Mays et al 2013. *English Heritage with the Advisory Panel on the Archaeology of Burials in England.*

Vrahnas, C. et al. 2016. Bone 93: 146–154.

Acknowledgements

Australian Government
Australian Research Council

Thank you!

Dr Christina Vrahnas, Prof Natalie Sims, Dr Frederique Valentin, Prof Geoff Clark, Dr Pimm Vongsvivut, Dr Mark Tobin, David McGregor, Prof Marc Oxenham, Dr Shimona Kealy, Claire Rider, Ruth Page, The Lapaha Community and Nobles (His Serene Highness Prince Kalaniuvalu Fotofili, Her Serene Highness Princess Marcella Taumoepeau Tupou Kalaniuvalu Fotofili, and Her Royal Highness Mele Siu'ilikutapu Kalaniuvalu Fotofili) and the Ministry of Internal Affairs (Government of Tonga), team at the National Museum of the Philippines.

Funding:

ARC DE190100068, ANU MEG grant 2018, ANU CASS Research Hub Grant 2017, ANU RSHA Travel Grant 2017