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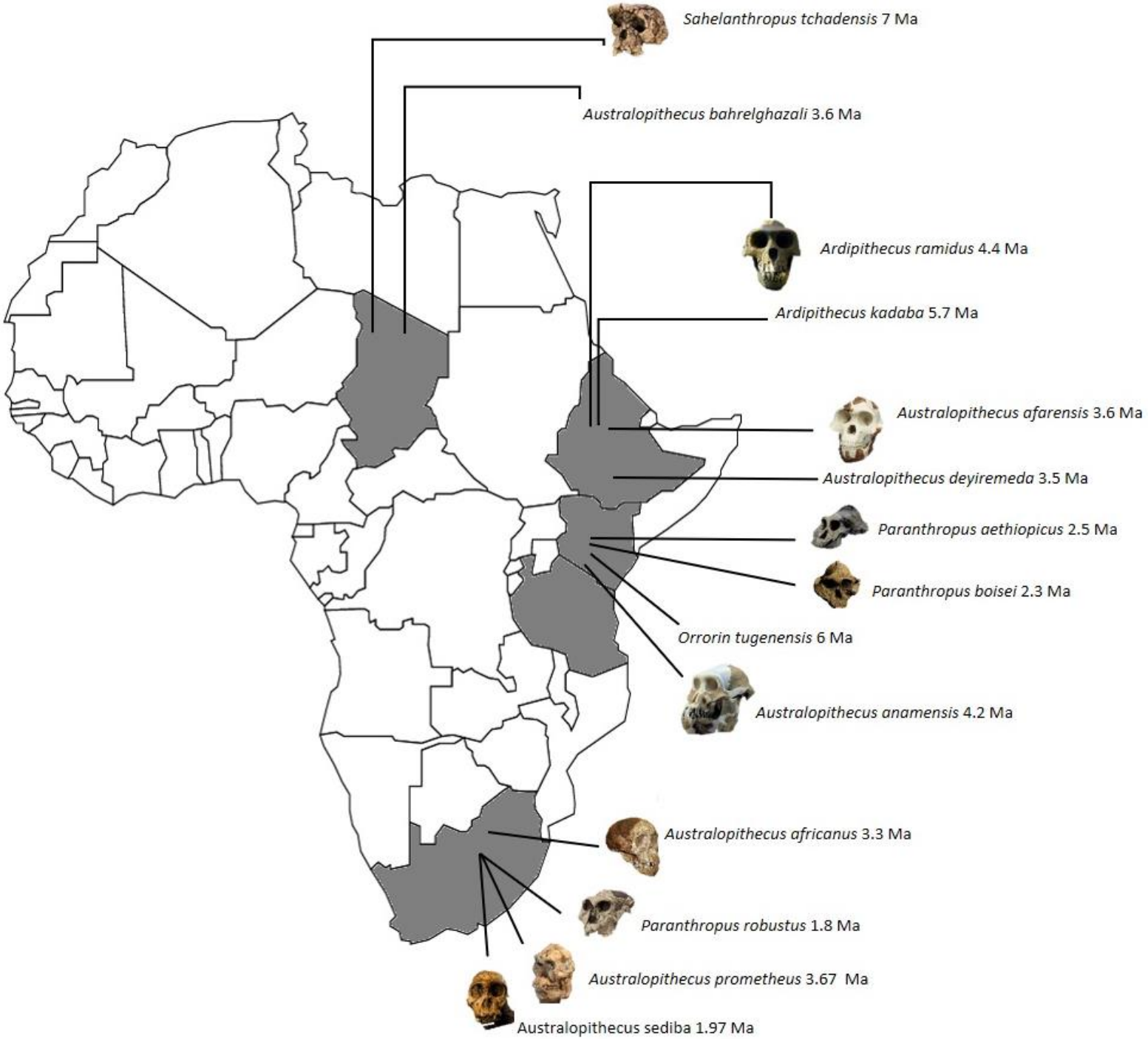
Paleontology with computed tomography

K. Jakata
The European Synchrotron Radiation Facility

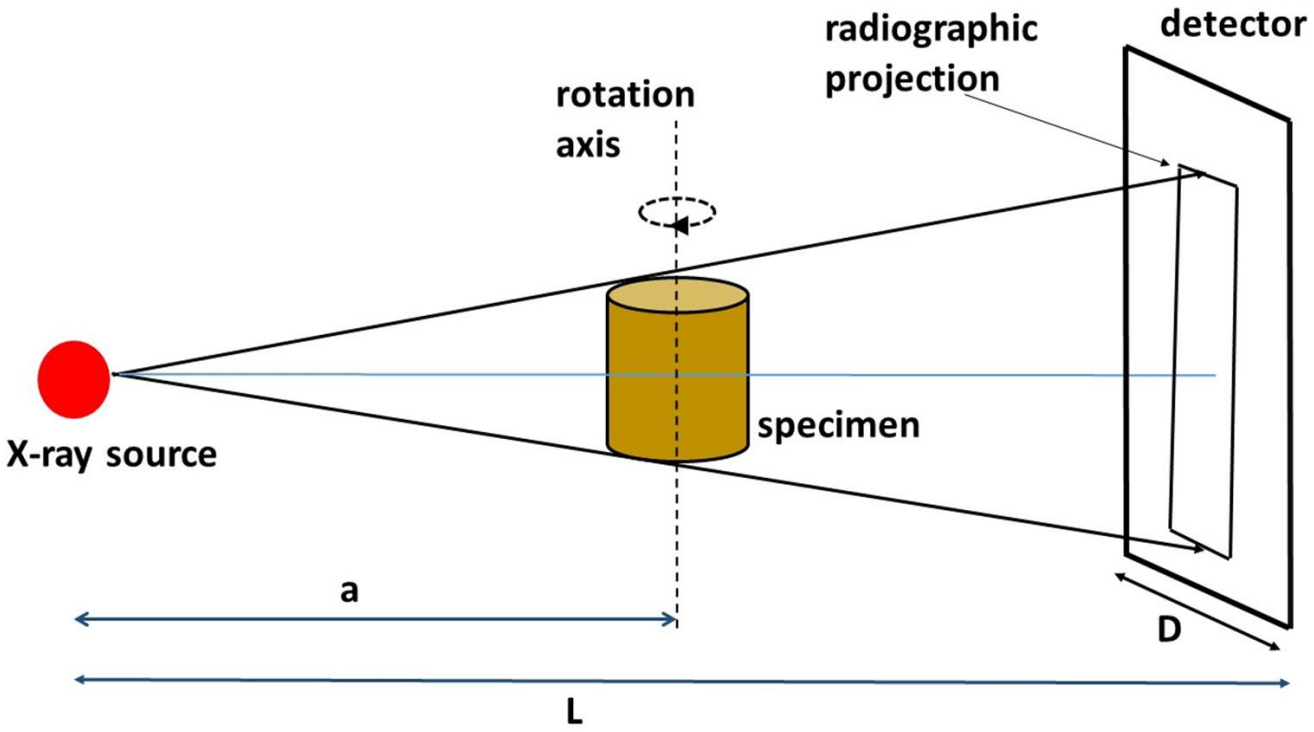
Stromatolites

https://www.megainteresting.com/pictures/gallery/the-most-important-fossils-in-the-world-771573552908/1

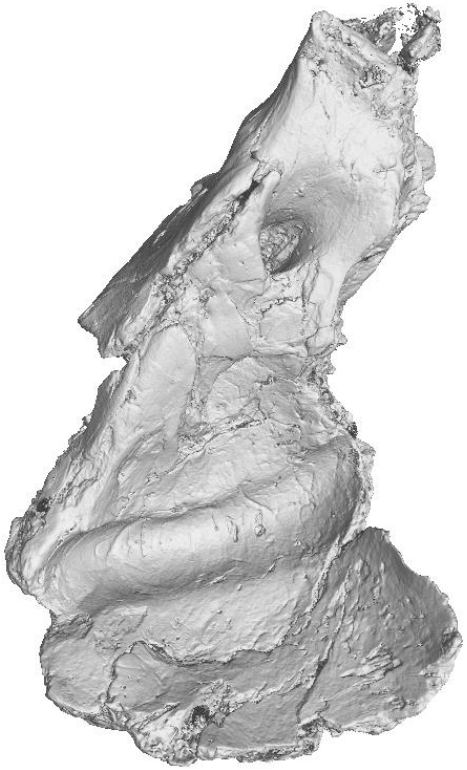
https://www.wits.ac.za/news/latest-news/research-news/2018/2018-06/first-tetrapods-of-africa-lived-within-the-devonian-antarctic-circle.html

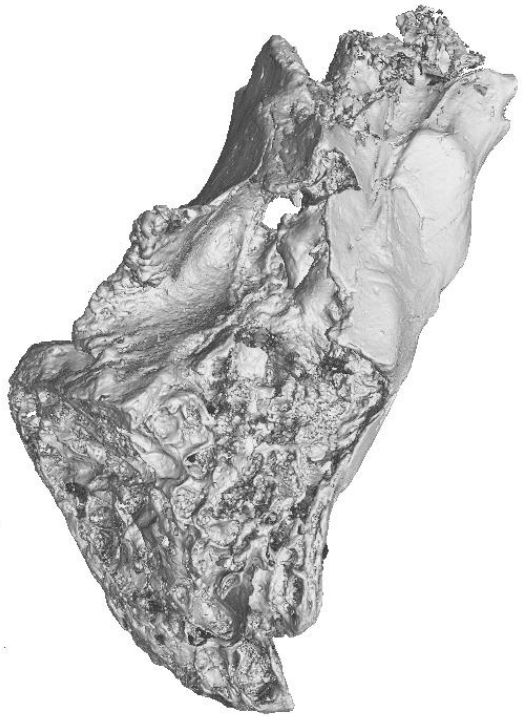


Micro-jack-hammer



Schematic image of cone beam CT





Petrosal bone

LITTLE FOOT

Journal of Human Evolution 127 (2019) 67–80

Contents lists available at ScienceDirect

Journal of Human Evolution

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

The bony labyrinth of StW 573 ("Little Foot"): Implications for early hominin evolution and paleobiology

Amélie Beaudet [a, b, *], Ronald J. Clarke [c], Laurent Bruxelles [a, d, e], Kristian J. Carlson [c, f], Robin Crompton [g, h], Frikkie de Beer [i], Jelle Dhaene [j], Jason L. Heaton [c, k], Kudakwashe Jakata [c], Tea Jashashvili [c, l, m], Kathleen Kuman [a], Juliet McClymont [n], Travis R. Pickering [c, o], Dominic Stratford [a]

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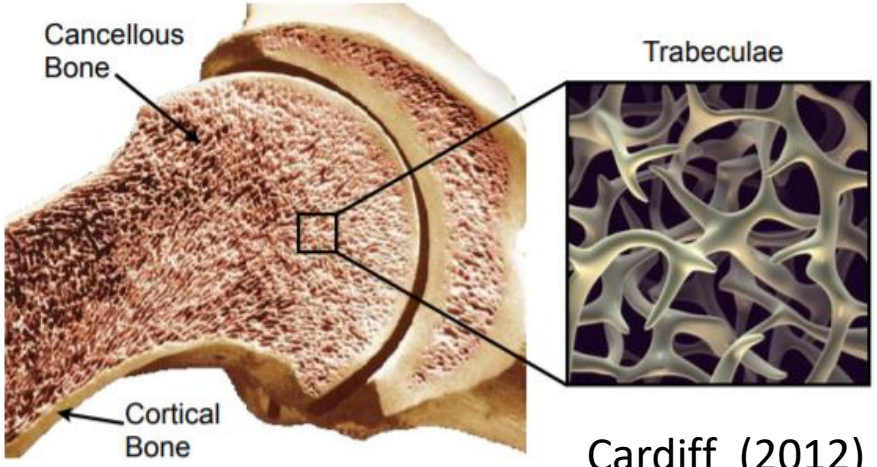
[c] Evolutionary Studies Institute, University of the Witwatersrand, Private Bag 3, Johannesburg, WITS 2050, South Africa
[d] French National Institute for Preventive Archaeological Research (INRAP), Nîmes, France
[e] French Institute of South Africa (IFAS), USR 3336 CNRS, Johannesburg, 2001, South Africa
[f] Department of Integrative Anatomical Sciences, Keck School of Medicine, University of Southern California, Los Angeles, CA, 90033, USA
[g] Department of Musculoskeletal Biology, Institute of Ageing and Chronic Disease, University of Liverpool, Liverpool, L7 8TX, UK
[h] Department of Rheumatology, Aintree University NHS Trust, Hospital NHS Trust, Liverpool, L9 7AL, UK
[i] South African Nuclear Energy Corporation SOC Ltd. (Necsa), Pelindaba, North West Province, South Africa
[j] UGCT Department of Physics and Astronomy, Ghent University, Proeftuinstraat 86/N12, B-9000, Gent, Belgium
[k] Department of Biology, Birmingham-Southern College, Birmingham, AL, 35254, USA
[l] Molecular Imaging Center, Department of Radiology, Keck School of Medicine, University of Southern California, Los Angeles, CA, 90033, USA
[m] Department of Geology and Paleontology, Georgian National Museum, Tbilisi, 0105, Georgia
[n] School of Health Sciences, Aldro Building, University of Brighton, Eastbourne, UK
[o] Department of Anthropology, University of Wisconsin, Madison, WI, 53706, USA

Locomotor and habitat reconstruction of Plio-Pleistocene cercopithecoids: evidence from trabecular bone organization.

Lender (2018)

Trabecular bone



Cardiff (2012)

Quantified parameters: anisotropy (DA density (BV/TV), trabecular bone spacing (Tb.Sp) and trabecular thickness (Tb.Th).

Several studies used CT scan data for locomotor signals in trabecular bone in extant primates (e.g. Ryan and van Rietbergen, 2005; Ryan and Shaw, 2012).

Phase contrast imaging

- Gives much better contrast
- Better sensitivity to sample inhomogeneities

Radiography using propagation phase contrast

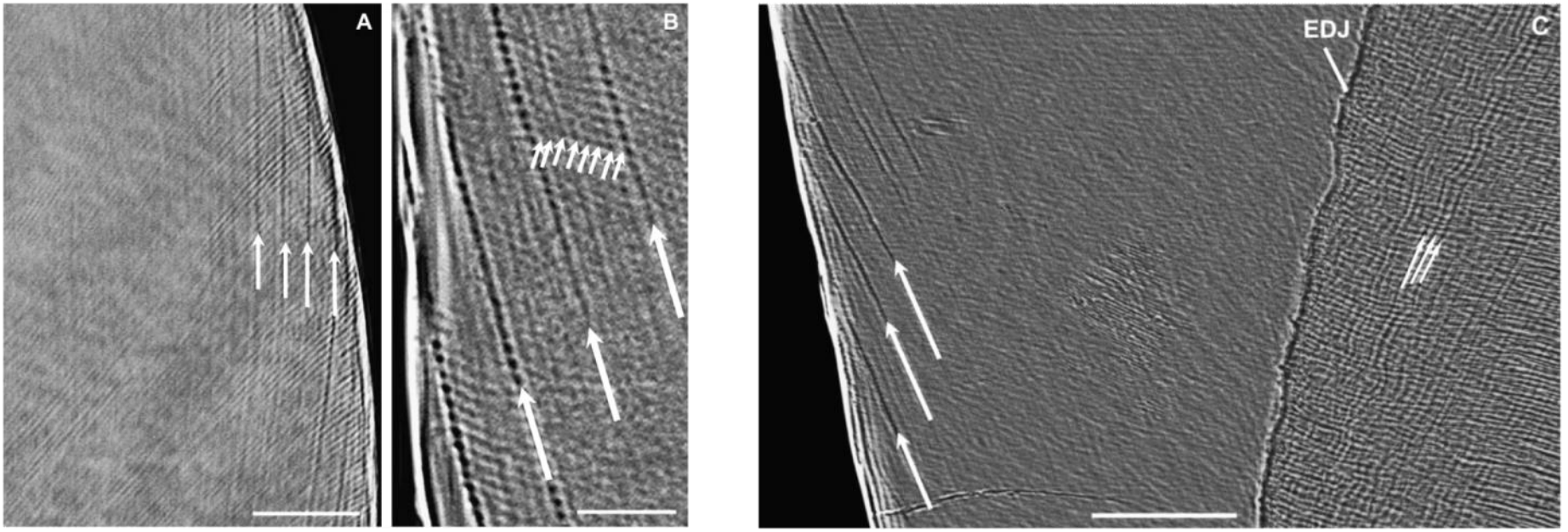
Images from P. Tafforeau (ESRF)

Journal of Human Evolution 54 (2008) 272–278

News and Views

Nondestructive imaging of hominoid dental microstructure using phase contrast X-ray synchrotron microtomography

Paul Tafforeau [a,b,*], Tanya M. Smith [c]



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JHE

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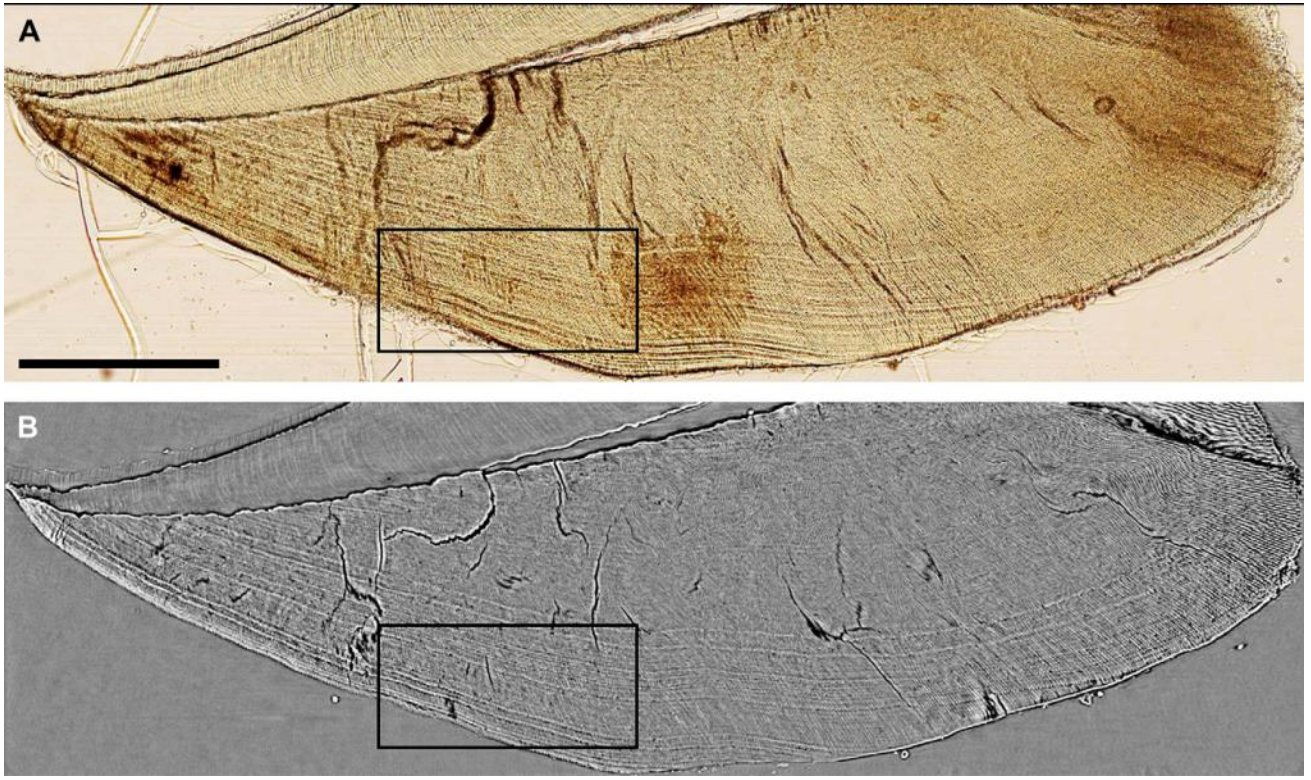

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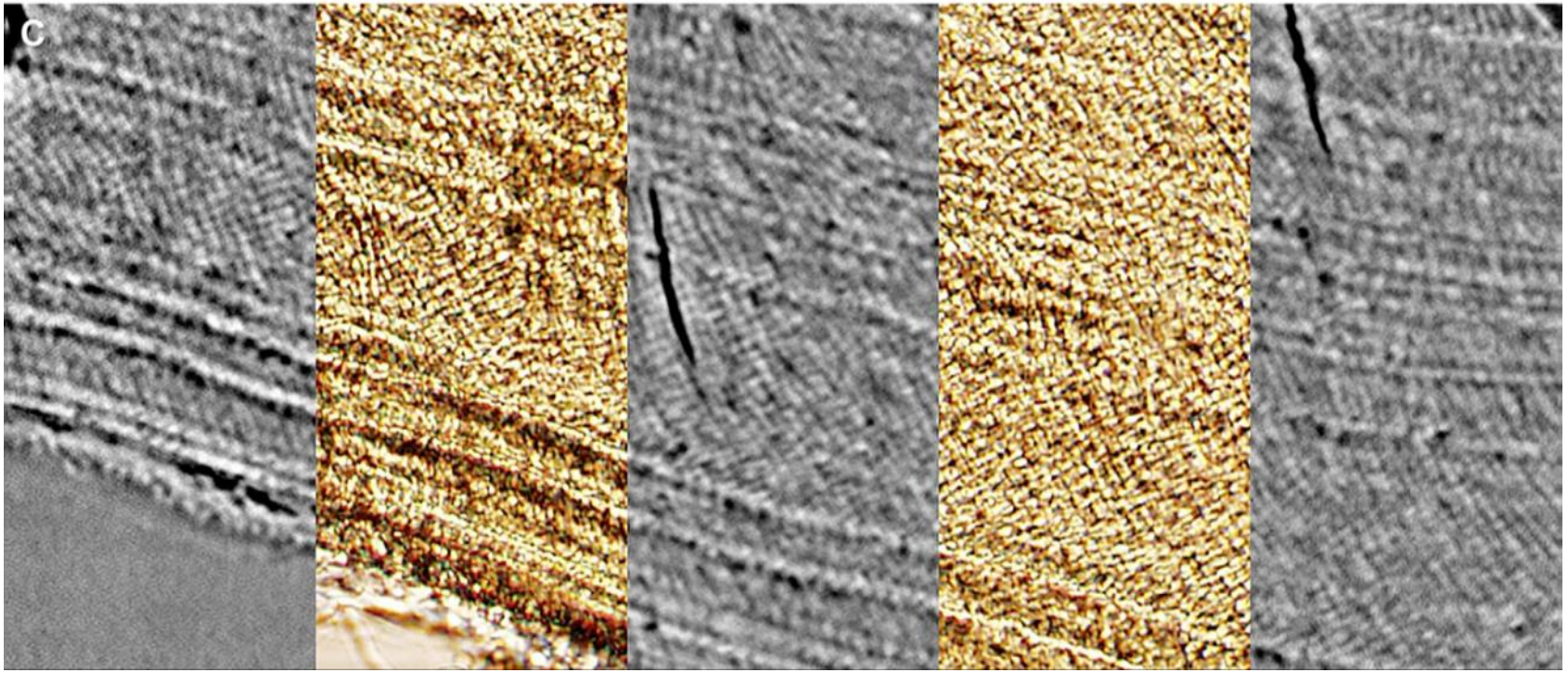
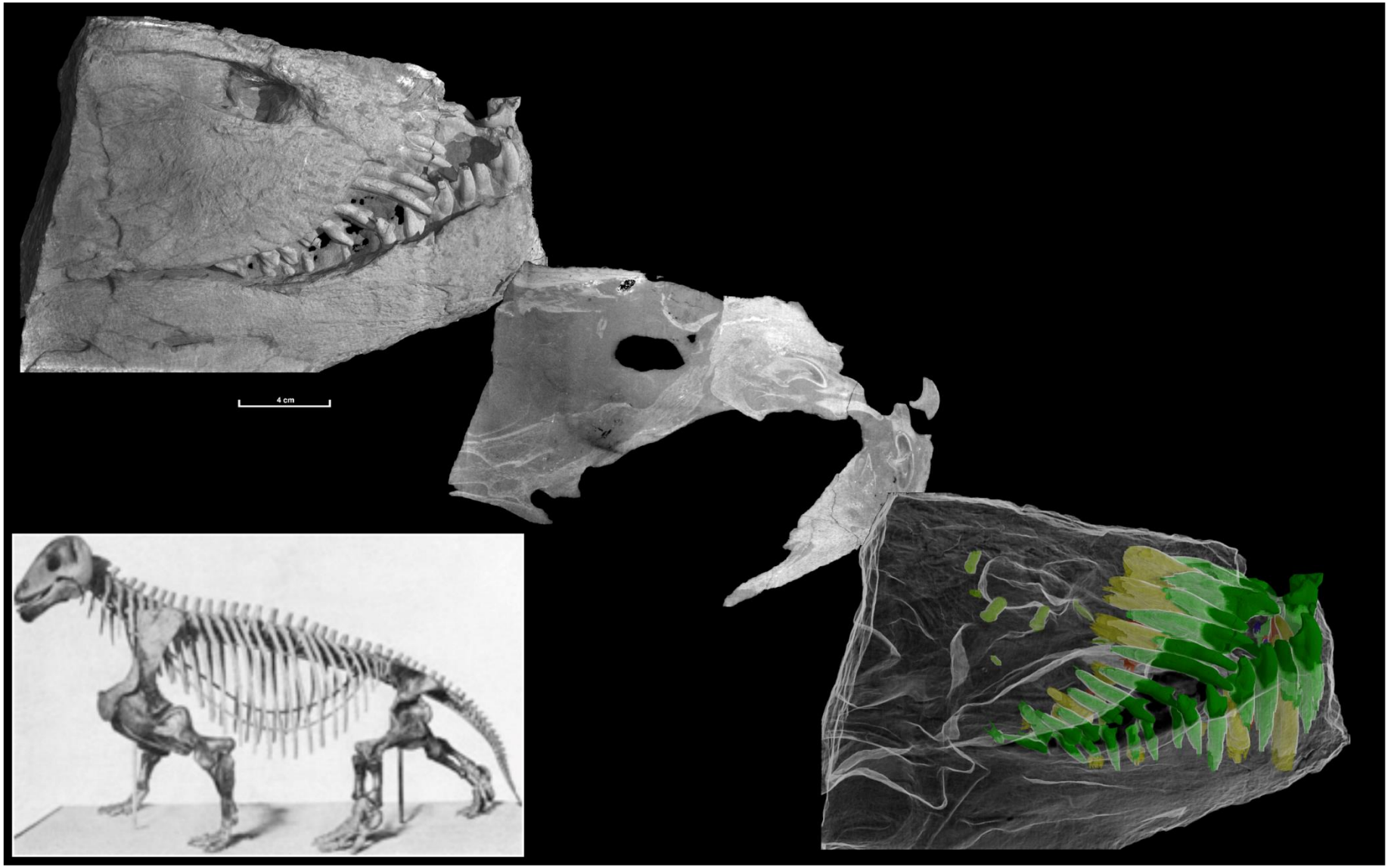


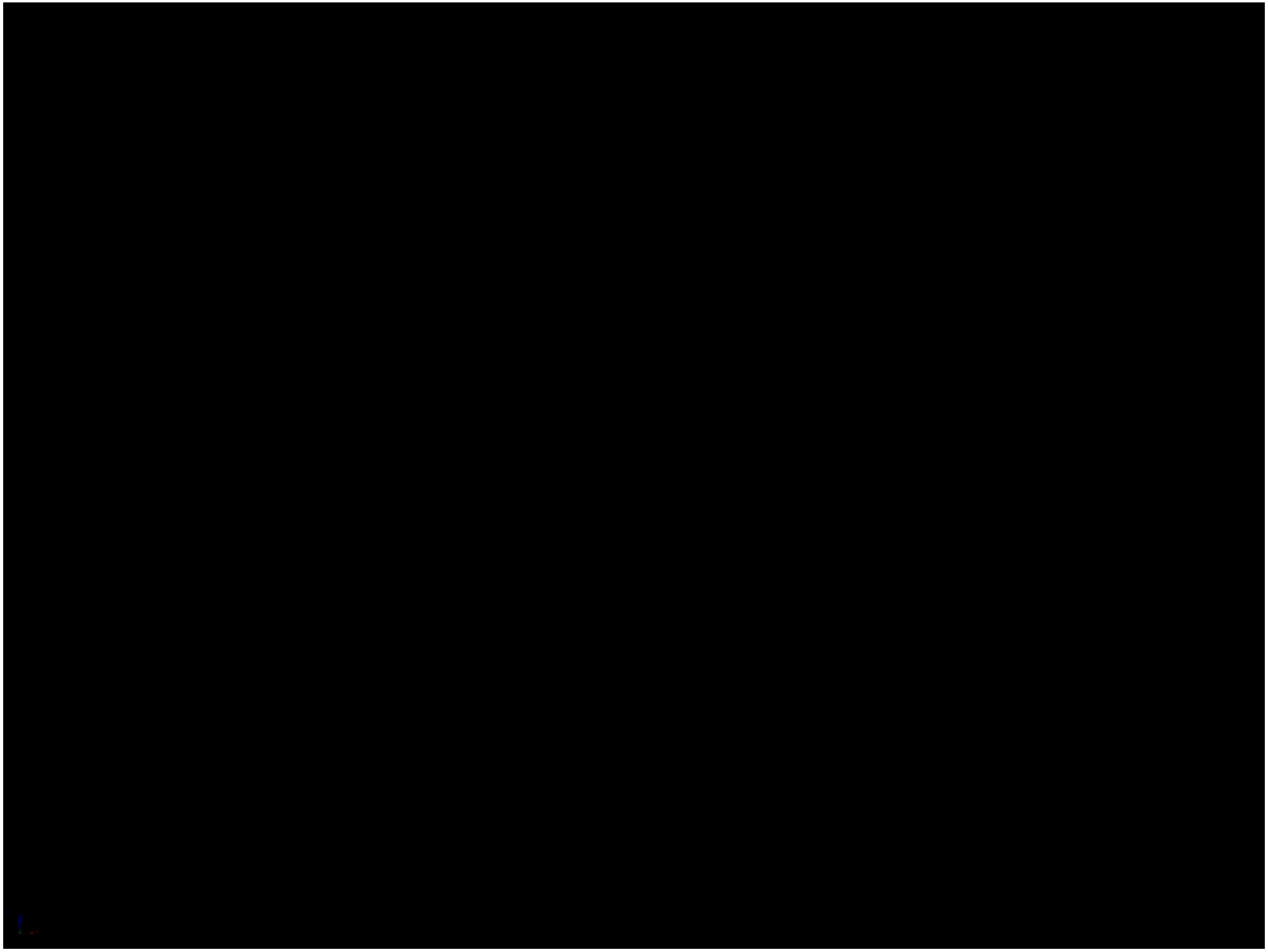
PeerJ

Synchrotron scanning reveals the palaeoneurology of the head-butting *Moschops capensis* (Therapsida, Dinocephalia)

Julien Benoit[1,2,*], Paul R. Manger[2,*], Luke Norton[1,*], Vincent Fernandez[3,*] and Bruce S. Rubidge[1,*]

[1] Evolutionary Institute, School of Geosciences, University of the Witwatersrand, Johannesburg, South Africa
[2] School of Anatomical Sciences, University of the Witwatersrand, Johannesburg, South Africa
[3] Beamline ID19, European Synchrotron Radiation Facility, Grenoble, France
[*] These authors contributed equally to this work.


4 cm

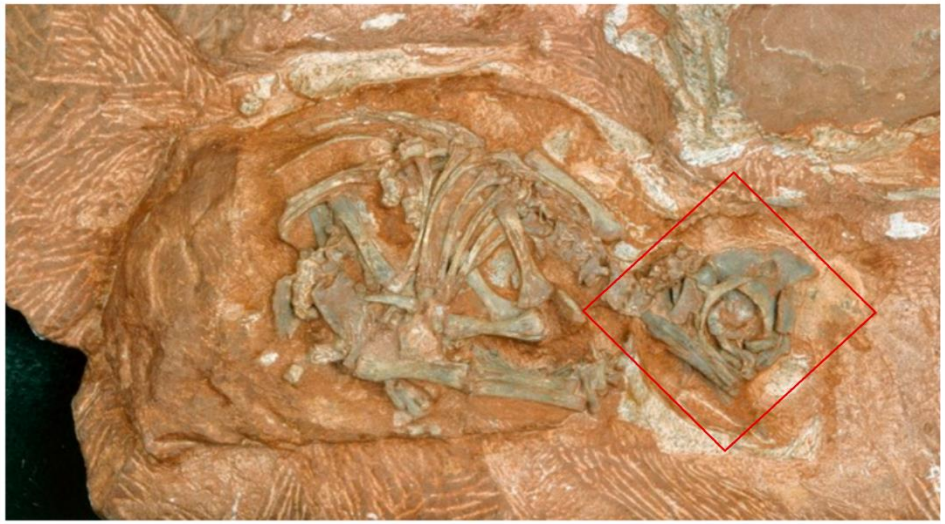


THE CONVERSATION AFRICA PILOT

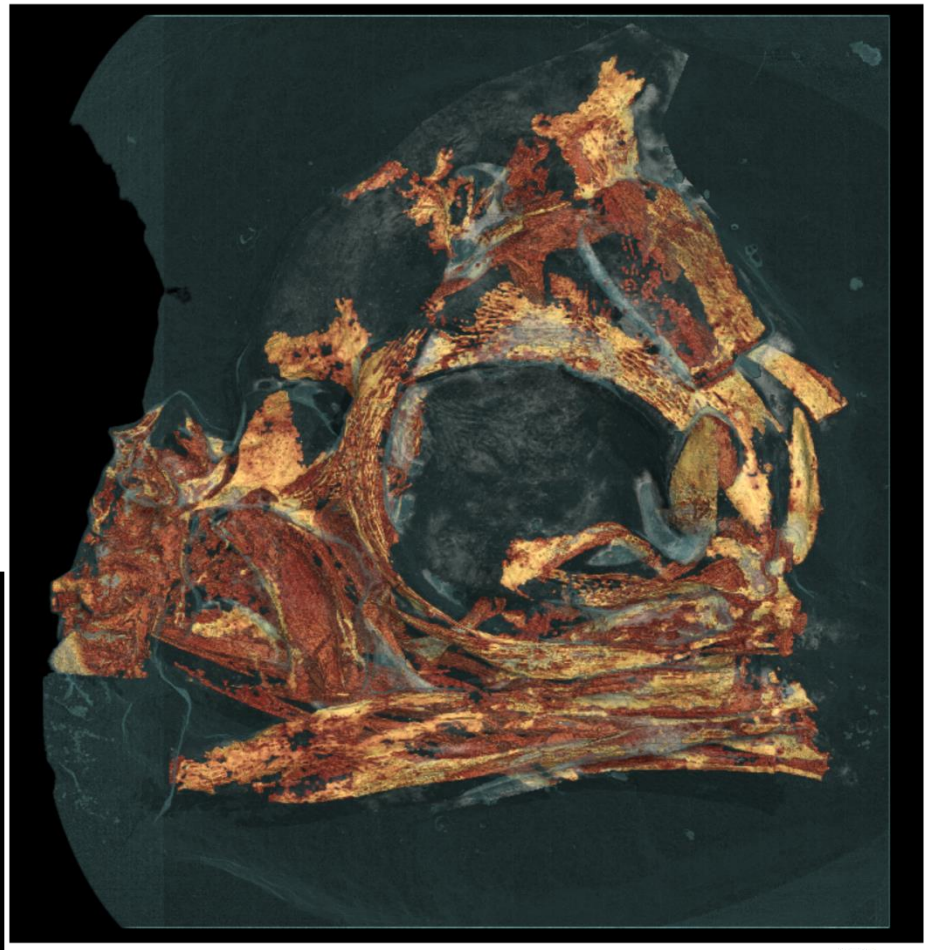
Academic rigour, journalistic flair

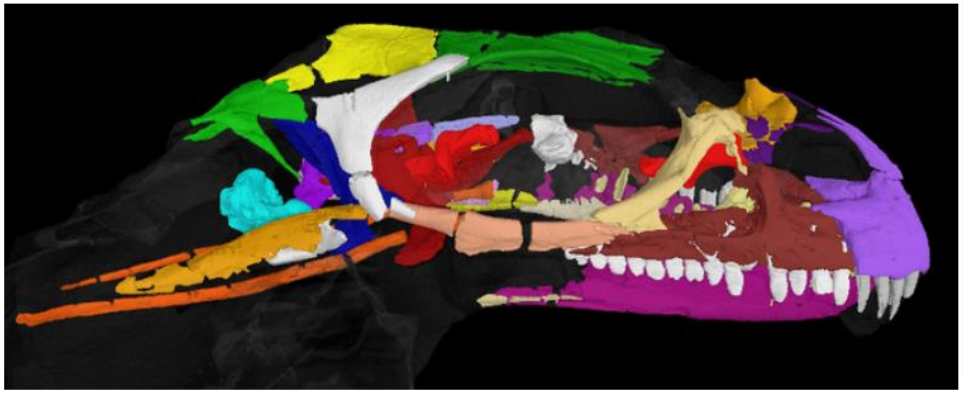
Dinosaur eggs get ready to hatch their secrets – 200 million years later

June 22, 2015 6.46am SAST

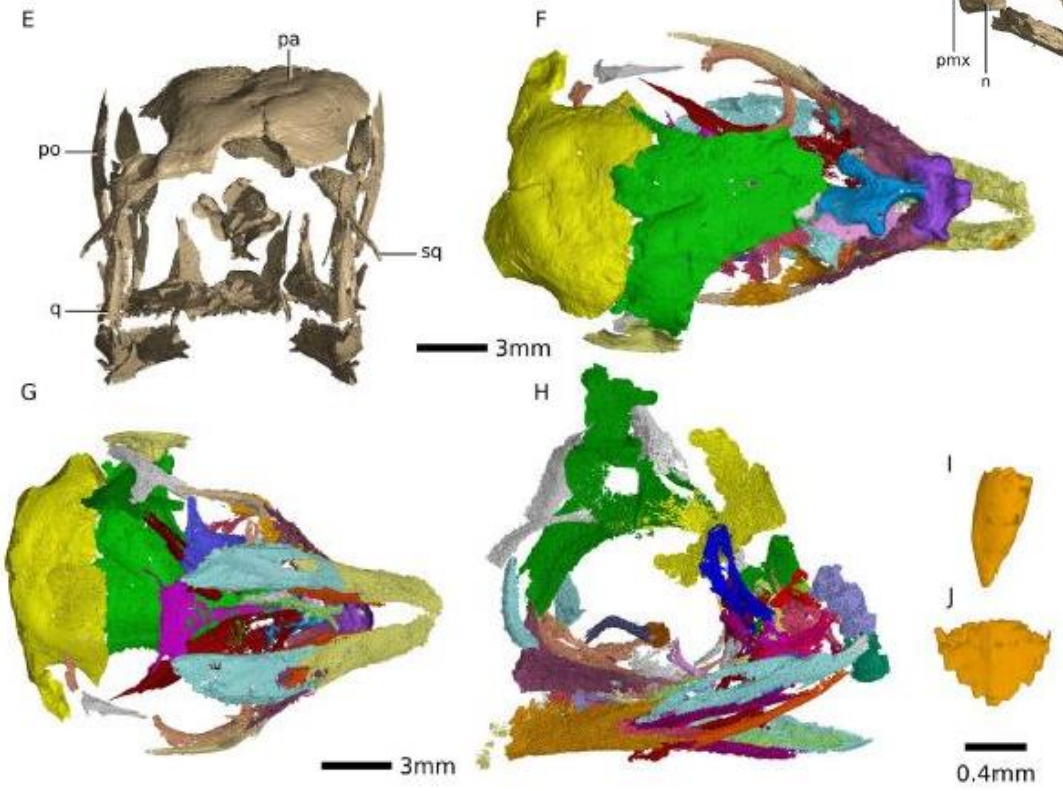


One of Kitching's original find of eggs, after being prepared by Diane Scott. Supplied





Side view of a 3D model of a juvenile Massospondylus produced from CT scans. Kimi Chapelle, MSc candidate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SCIENTIFIC REPORTS

nature research

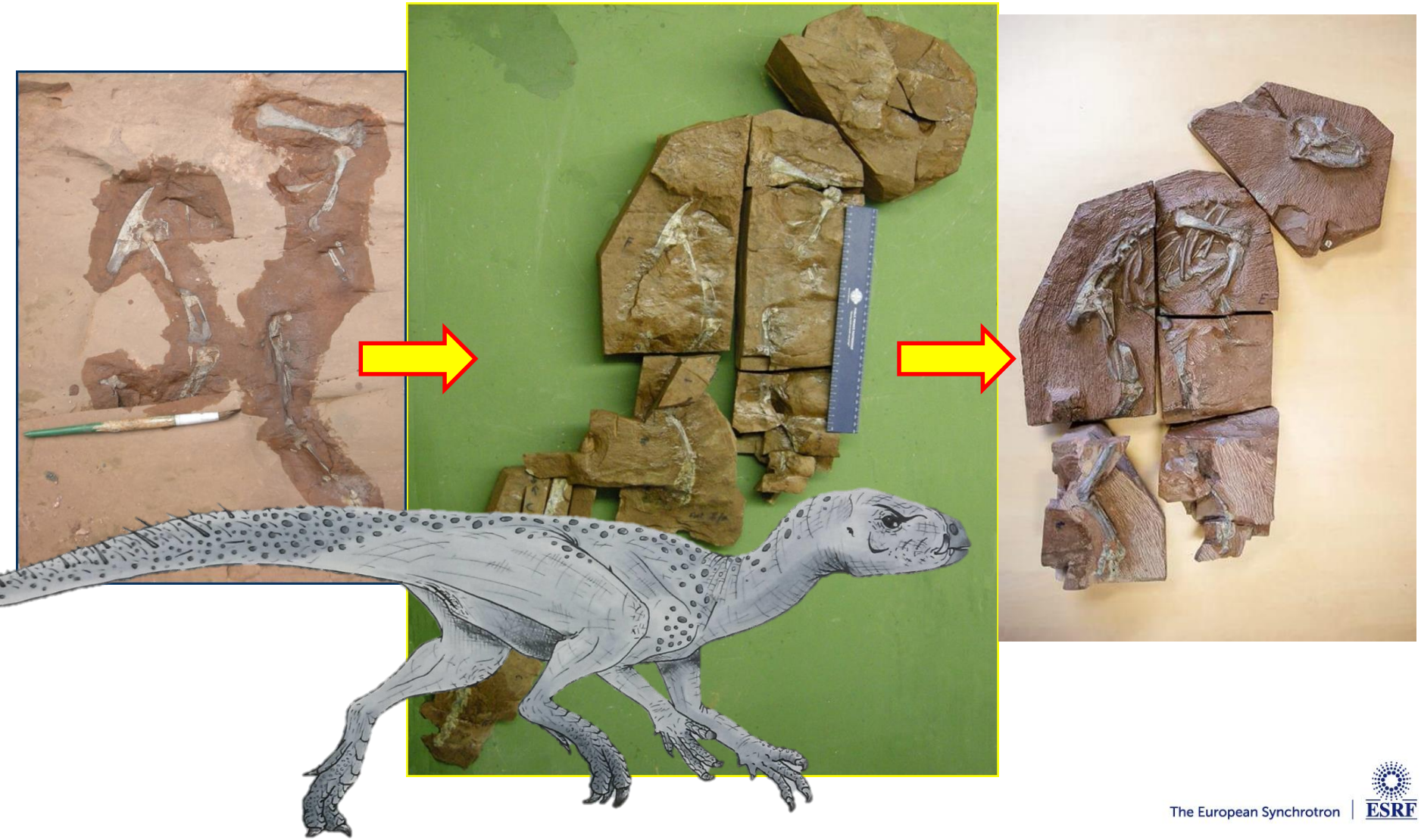
OPEN

Conserved in-ovo cranial ossification sequences of extant saurians allow estimation of embryonic dinosaur developmental stages

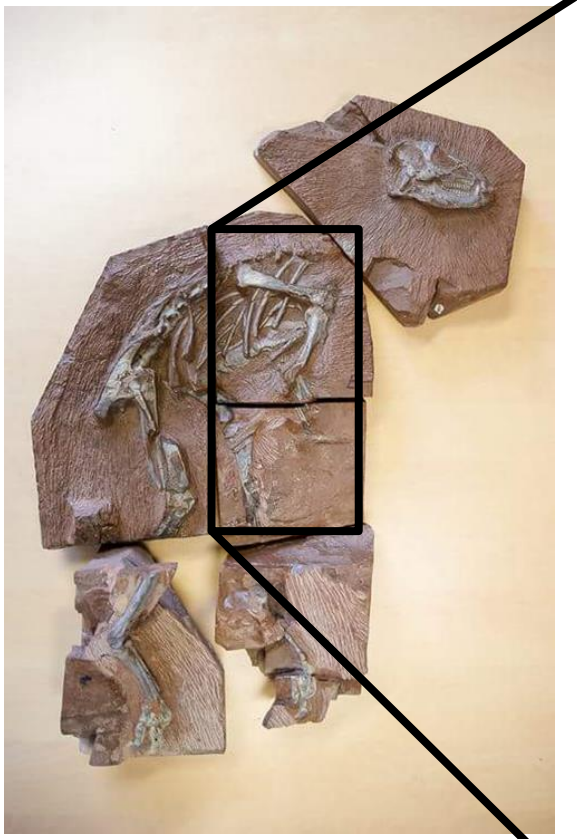
Kimberley E. J. Chapelle[1,2*], Vincent Fernandez[1,3,4] & Jonah N. Choiniere[1]

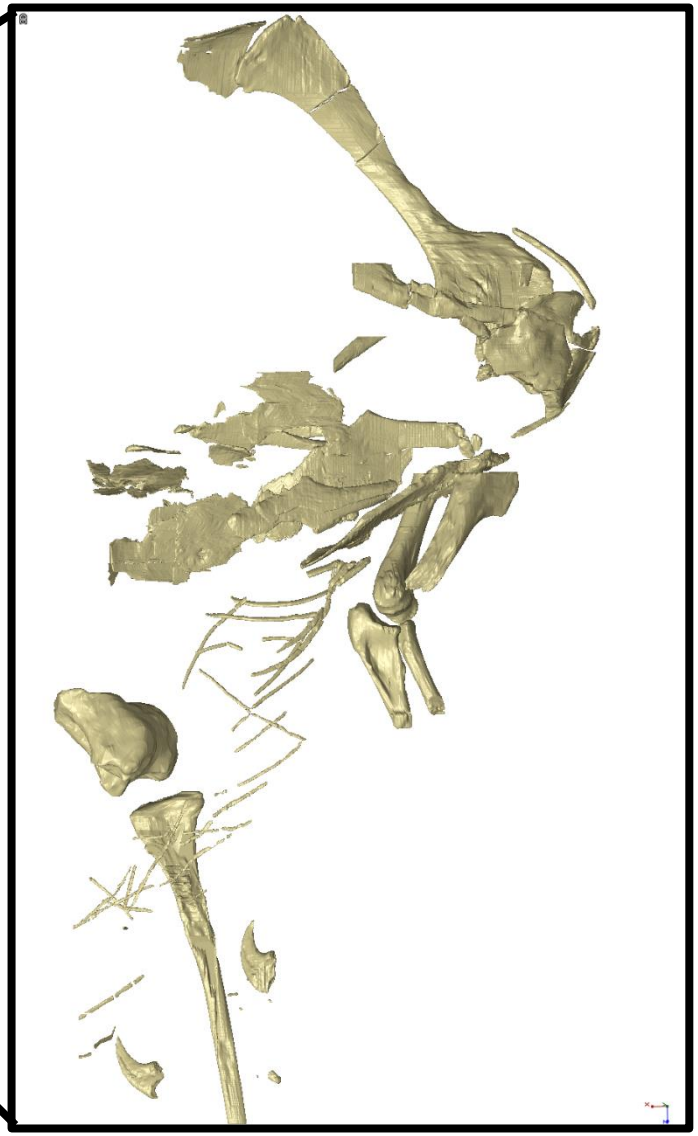
Dinosaur embryos are among the rarest of fossils, yet they provide a unique window into the palaeobiology of these animals. Estimating the developmental stage of dinosaur embryos is hindered by the lack of a quantitative method for age determination, by the scarcity of material, and by the difficulty in visualizing that material. Here we present the results of a broad inquiry, using 3D reconstructions from X-ray computed tomography data, into cranial ossification sequences in extant saurian taxa and in well-preserved embryos of the early branching sauropodomorph dinosaur *Massospondylus carinatus*. Our findings support deep-time conservation of cranial ossification sequences in saurians including dinosaurs, allowing us to develop a new method for estimating the relative developmental percentage of embryos from that clade. We also observe null-generation teeth in the *Massospondylus carinatus* embryos which get resorbed or shed before hatching, similar to those of geckos. These lines of evidence allow us to confidently estimate that the *Massospondylus carinatus* embryos are only approximately 60% through their incubation period, much younger than previously hypothesized. The overall consistency of our results with those of living saurians indicates that they can be generalized to other extinct members of that lineage, and therefore our method provides an independent means of assessing the developmental stage of extinct, in-ovo saurians.

HETERODONTOSAURUS



ESRF REVEALS *NEW* ANATOMY





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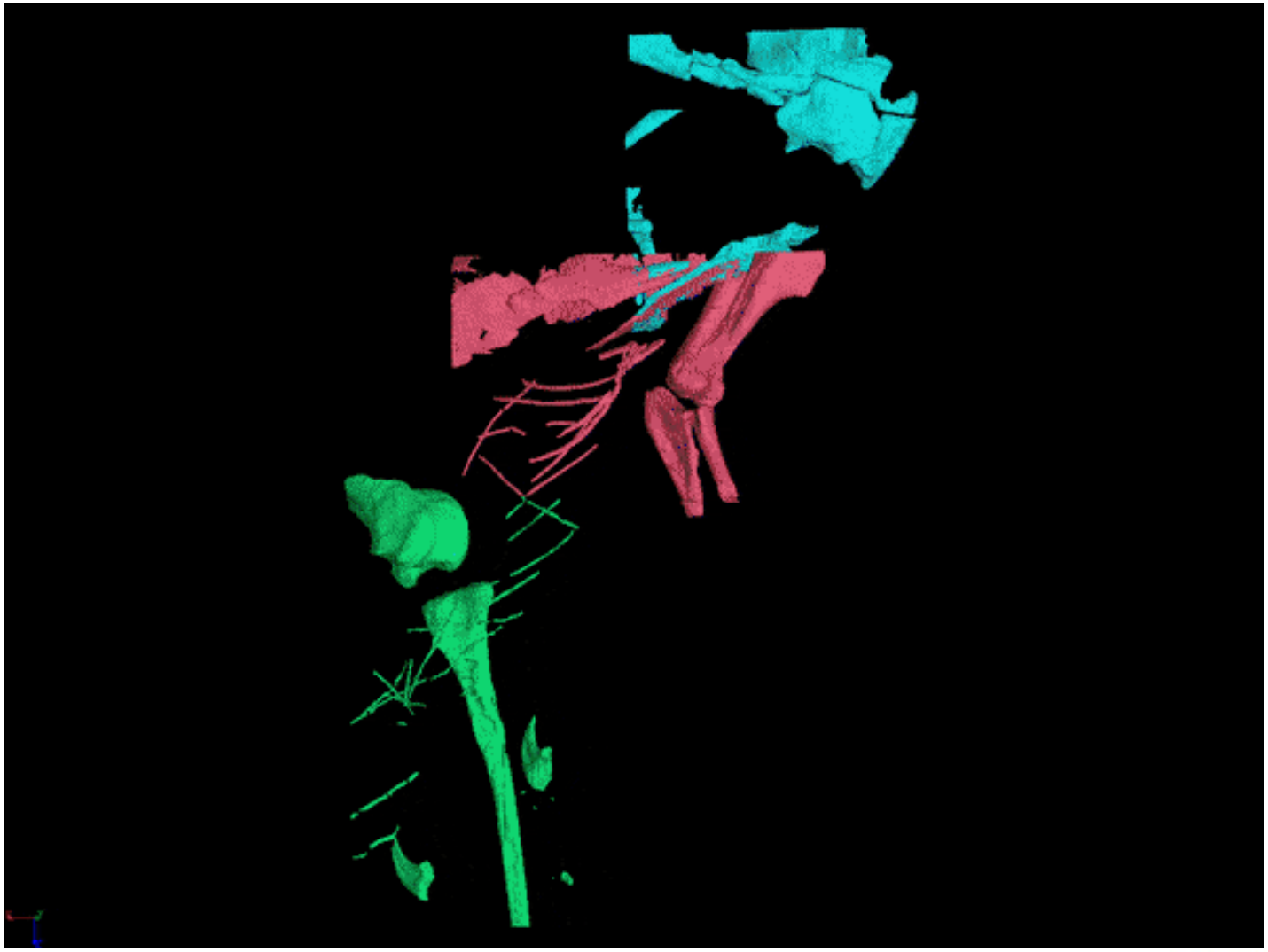
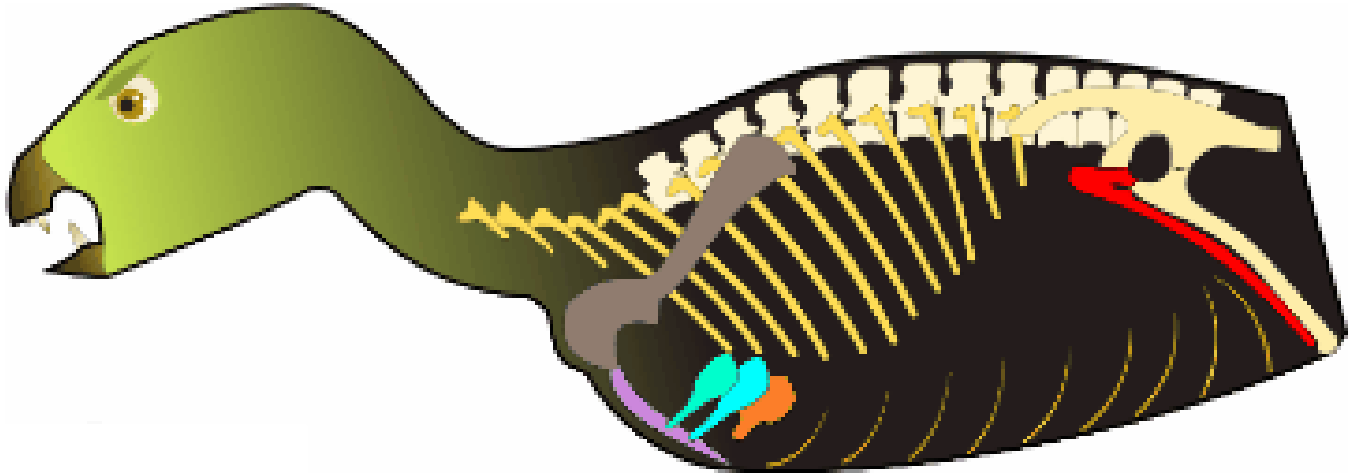
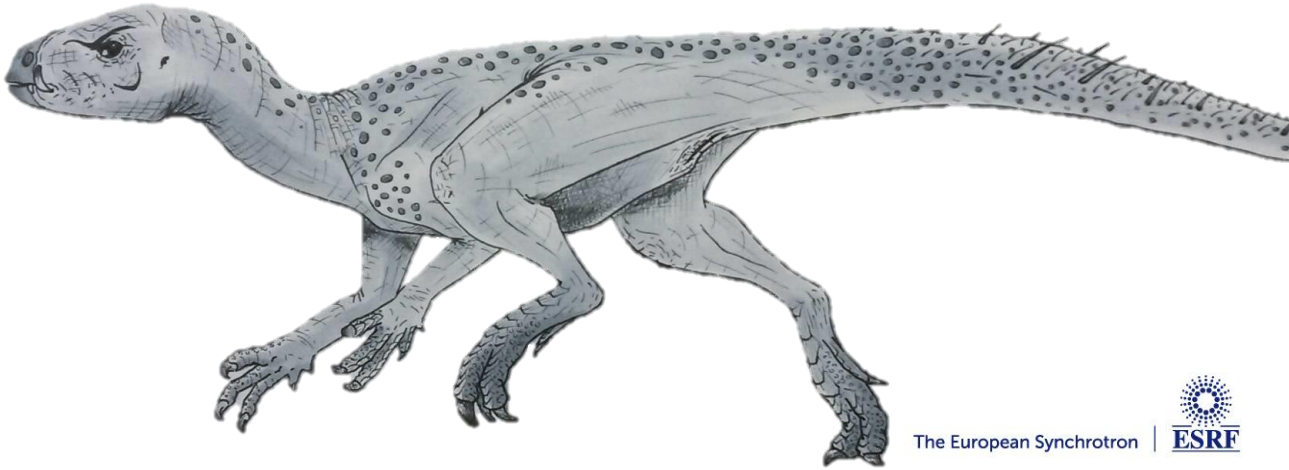
ESRF REVEALS *NEW* ANATOMY



BREATHING LIFE INTO THE DEAD





eLife

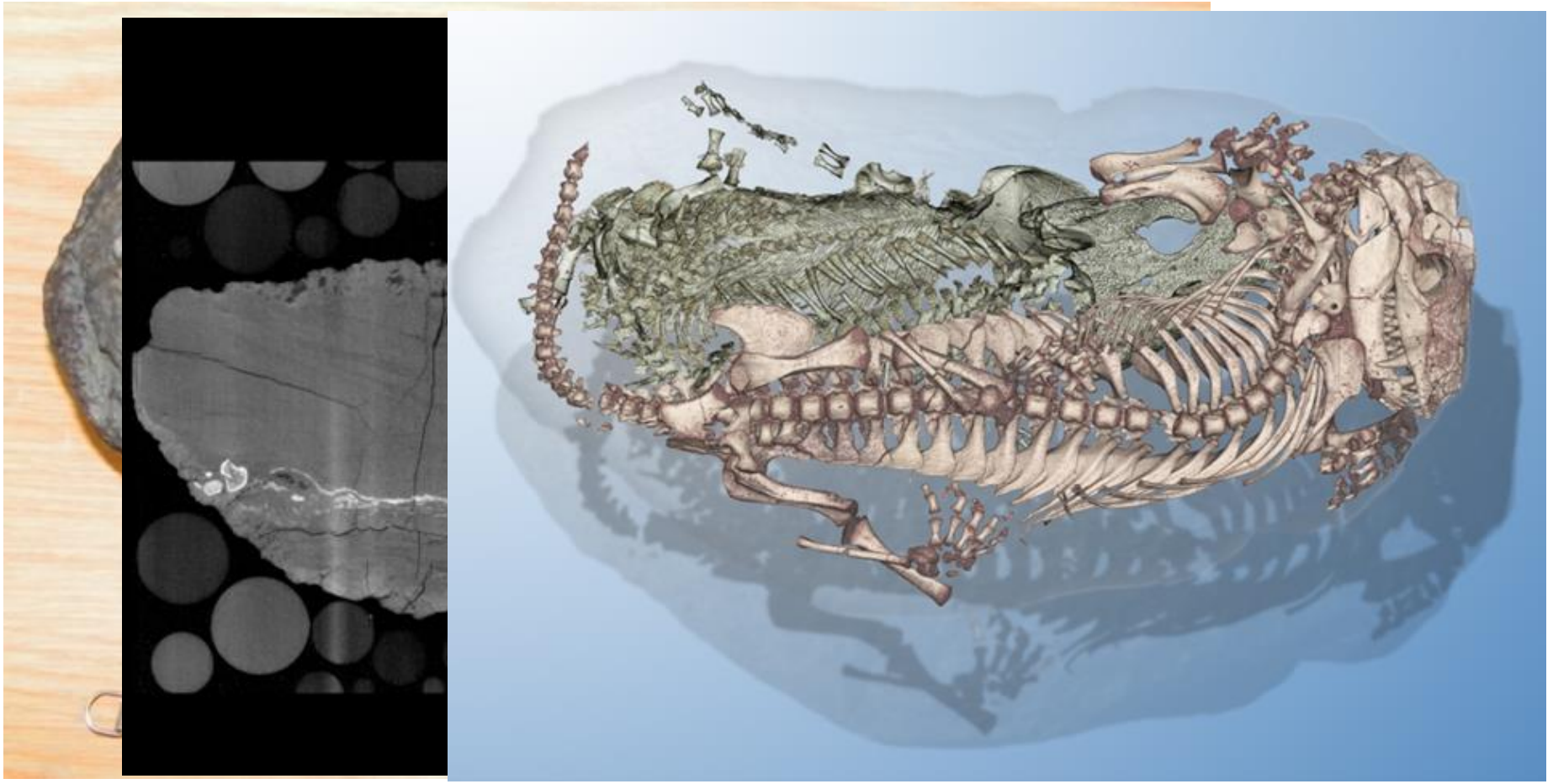
RESEARCH ARTICLE

A new *Heterodontosaurus* specimen elucidates the unique ventilatory macroevolution of ornithischian dinosaurs

Viktor J Radermacher[1,2]*, Vincent Fernandez[1,3,4], Emma R Schachner[5], Richard Butler[1,6], Emese Bordy[7], Michael Naylor Hudgins[8], William J de Klerk[1,9], Kimberley EJ Chapelle[1,10], Jonah N Choiniere[1]

[1]Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa; [2]Department of Earth and Environmental Sciences, University of Minnesota, Minneapolis, United States; [3]European Synchrotron Radiation Facility, Grenoble, France; [4]Natural History Museum, Imaging and Analysis Centre, London, United Kingdom; [5]Department of Cell Biology & Anatomy, School of Medicine, Louisiana State University Health Sciences Center, New Orleans, United States; [6]School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, United Kingdom; [7]Department of Geological Sciences, University of Cape Town, Cape Town, South Africa; [8]Department of Biological Sciences, University of Alberta, Edmonton, Canada; [9]Department of Earth Sciences, Albany Museum, Grahamstown, South Africa; [10]Division of Paleontology, American Museum of Natural History, New York, United States

The fossil burrow



OPEN ACCESS Freely available online

PLOS ONE

Synchrotron Reveals Early Triassic Odd Couple: Injured Amphibian and Aestivating Therapsid Share Burrow

Vincent Fernandez[1]*, Fernando Abdala[1], Kristian J. Carlson[1,2], Della Collins Cook[2], Bruce S. Rubidge[1], Adam Yates[1,3], Paul Tafforeau[4]

1 Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, Gauteng, South Africa, **2** Department of Anthropology, Indiana University, Bloomington, Indiana, United States of America, **3** Museum of Central Australia, Araluen Cultural Precinct, Alice Springs, Northern Territory, Australia, **4** European Synchrotron Radiation Facility, Grenoble, France

Abstract

Fossorialism is a beneficial adaptation for brooding, predator avoidance and protection from extreme climate. The abundance of fossilised burrow casts from the Early Triassic of southern Africa is viewed as a behavioural response by many tetrapods to the harsh conditions following the Permo-Triassic mass-extinction event. However, scarcity of vertebrate remains associated with these burrows leaves many ecological questions unanswered. Synchrotron scanning of a lithified burrow cast from the Early Triassic of the Karoo unveiled a unique mixed-species association: an injured temnospondyl amphibian (*Broomistega*) that sheltered in a burrow occupied by an aestivating therapsid (*Thrinaxodon*). The discovery of this rare rhinesuchid represents the first occurrence in the fossil record of a temnospondyl in a burrow. The amphibian skeleton shows signs of a crushing trauma with partially healed fractures on several consecutive ribs. The presence of a relatively large intruder in what is interpreted to be a *Thrinaxodon* burrow implies that the therapsid tolerated the

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Thank you