XVI International Conference on Science, Arts and Culture
INTERNATIONAL CONFERENCE ON SESAME
In honour of Paolo Budinich

Veli Lošinj, Croatia, 29th August - 2nd September 2016

X-rays for cultural heritage and archaeology at ICTP

Federico Bernardini

EXACT Project

Elemental **X**-ray **A**nalysis and **C**omputed **T**omography

- **Micro-Tomography**
- **Portable X-ray system**

Multidisciplinary Laboratory, ICTP
F. Bernardini, I. Birri, A. Cicuttin, M. Crespo, C. Kwasi Nuviadenu, A. Mendoza Cuevas, C. Zanolli

Elettra Sincrotrone Trieste
D. Dreossi, A. Gianoncelli, L. Mancini, N. Sodini, G. Tromba, F. Zanini

Coordinator: C. Tuniz

Euro 600,000.00 from **Friuli Venezia-Giulia Region**

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Museo Storico della Fisica e
Centro Studi e Ricerche Enrico Fermi

Fermi Centre Interdisciplinary Research Projects

Centro Fermi – Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi

Microtomography for Archaeology and Paleoanthropology (2014-2016)

S.A.P.I.E.N.S
Scienze per l'Archeologia e la Paleoantropologia: InterpretareE la Nostra Storia (2017-?)

The cone-beam mCT station at ICTP

The **mCT** has been designed by **ICTP** and **Sincrotrone Trieste**.

This mCT system has been specifically designed for the investigation of large objects (with dimensions up to 20 cm and a weight up to 15 kg) at 40-50 micron resolution. Smaller objects can be also studied with spatial resolution of the order of 5-10 micron.

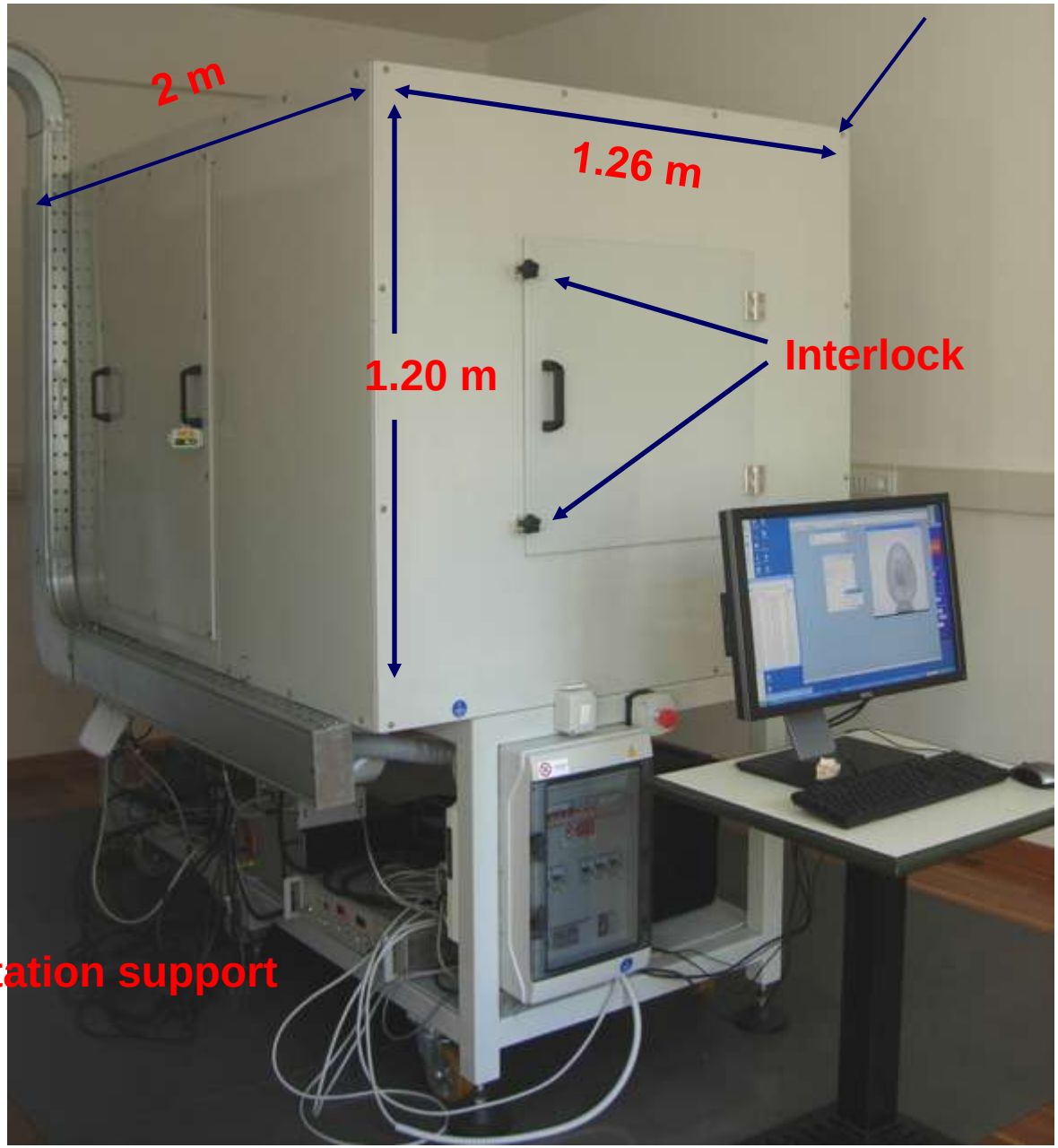
Main Components

- **Tube**: X-rays are produced by a Hamamatsu microfocus X-ray source (150 kV max. voltage, 500 µA max. current, 5 µm min. focal spot size).

- **Detector**: is a Hamamatsu flat panel sensor coupled to a fiber optic plate under the GOS scintillator. It is a large-area device with small pixel size (50x50 µm) and high efficiency in the radiation conversion.

- **Sample positioning system**: Aerotech high-performance mechanical components with two linear translation axes and rotation stage.

Desktop mCT station



Inside the facility

New flat panel Teledyne Dalsa

X-RAY
SPECTROMETRY

Published online in Wiley Online Library

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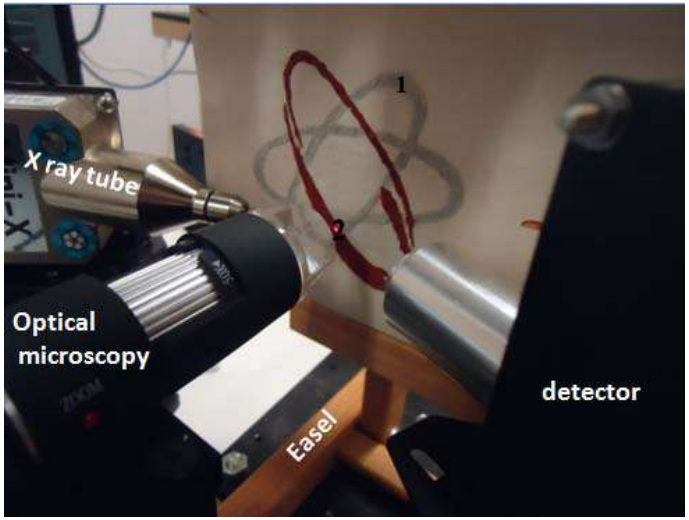
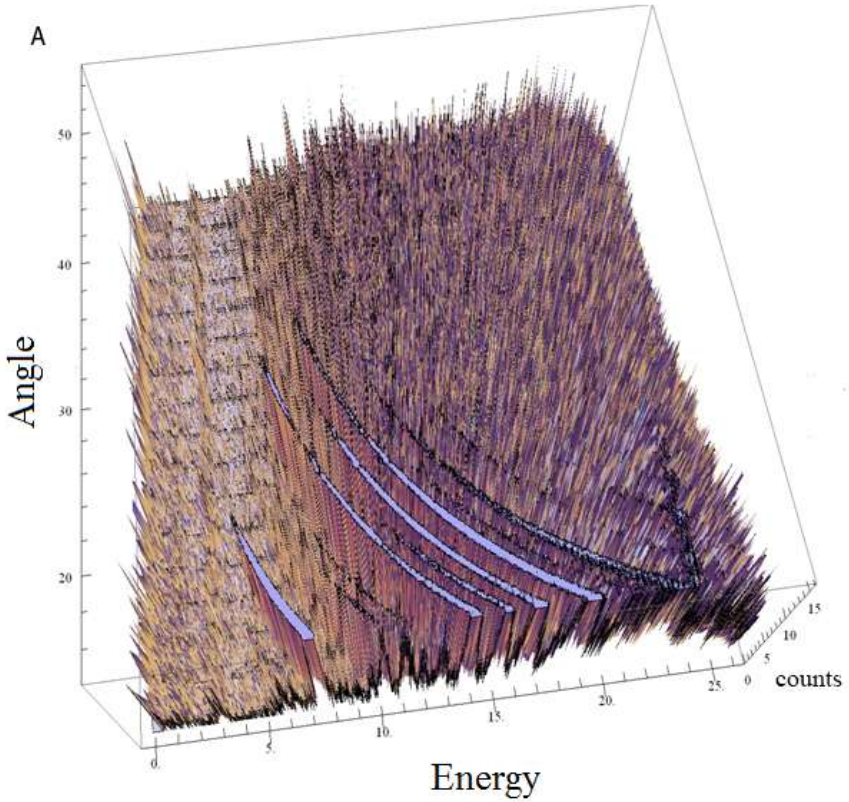
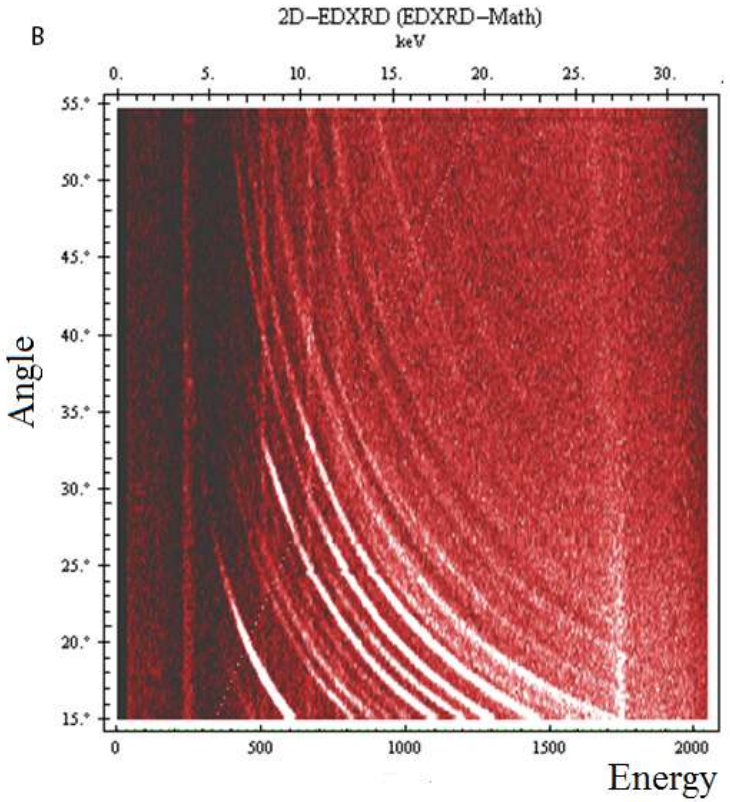
Energy dispersive X-ray diffraction and fluorescence portable system for cultural heritage applications

Ariadna Mendoza Cuevas, Federico Bernardini, Alessandra Gianoncelli and Claudio Tuniz








Kinder

Paleontology

PLOS ONE

RESEARCH ARTICLE

A Reappraisal of the Purported Gastric Pellet with Pterosaurian Bones from the Upper Triassic of Italy

Borja Holgado[1,2]*, Fabio Marco Dalla Vecchia[1], Josep Fortuny[1], Federico Bernardini[3,4], Claudio Tuniz[3,4,5]

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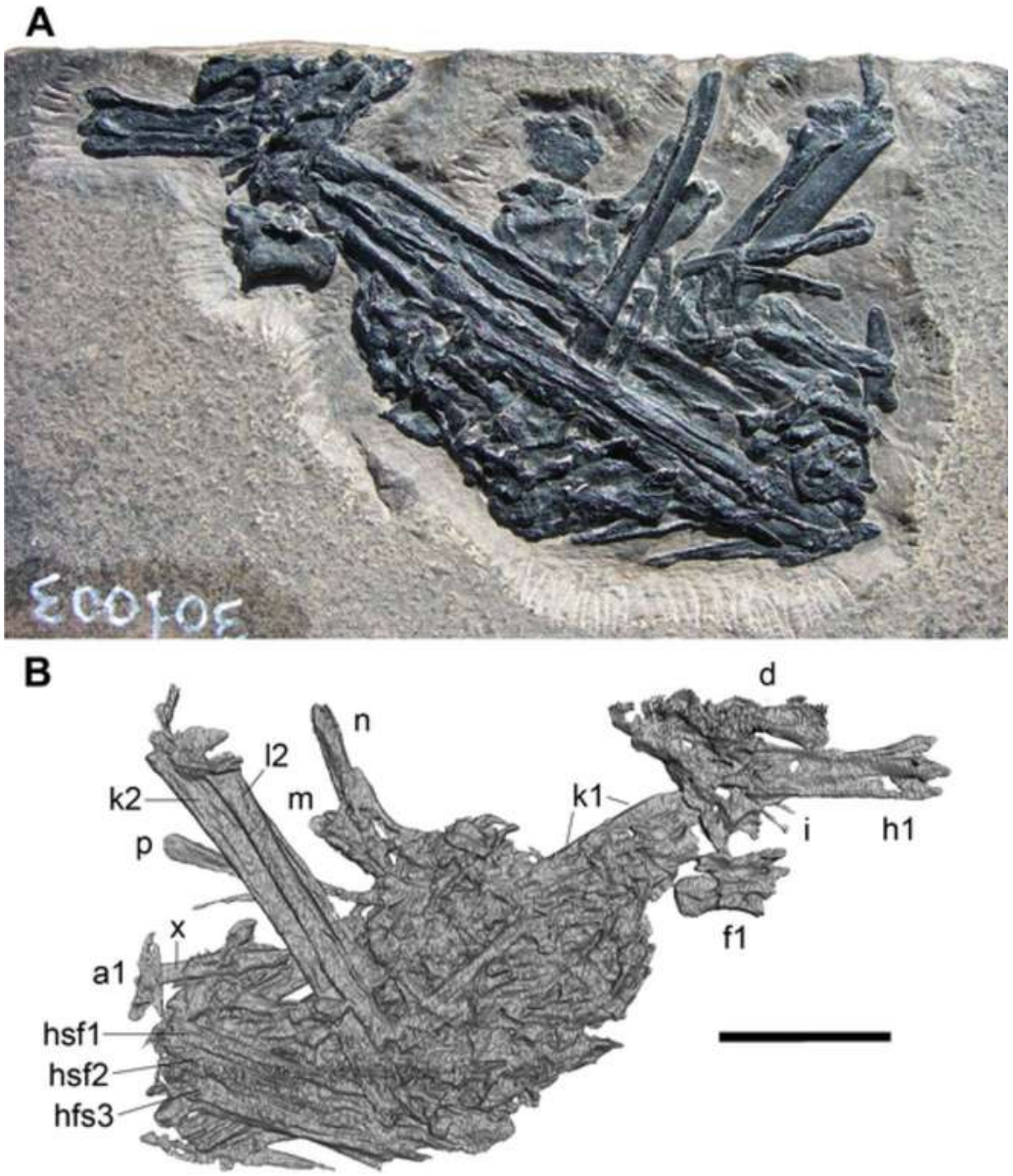
Abstract

A small accumulation of bones from the Norian (Upper Triassic) of the Seazza Brook Valley (Carnic Prealps, Northern Italy) was originally (1989) identified as a gastric pellet made of pterosaur skeletal elements. The specimen has been reported in literature as one of the very few cases of gastric ejecta containing pterosaur bones since then. However, the detailed analysis of the bones preserved in the pellet, their study by X-ray microCT, and the comparison with those of basal pterosaurs do not support a referral to the Pterosauria. Comparison with the osteology of a large sample of Middle-Late Triassic reptiles shows some affinity with the protorosaurians, mainly with *Langobardisaurus pandolfii* that was found in the same formation as the pellet. However, differences with this species suggest that the bones belong to a similar but distinct taxon. The interpretation as a gastric pellet is confirmed.


A
B
d
n
l2
k2
m
k1
p
i
h1
x
f1
a1
hsf1
hsf2
hfs3
g
k2
p
a1
x
o
s
h2
a2
l2
f3
m
j
b
n
q
r
n
f2
f4
k1
e
f5
l1
f1
d
i
h1

Contents lists available at ScienceDirect

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General Palaeontology, Systematics and Evolution (Vertebrate Palaeontology)

New remains of *Diplocynodon* (Crocodylia: Diplocynodontidae) from the Early Miocene of the Iberian Peninsula

Nouveaux restes de Diplocynodon *(Crocodylia : Diplocynodontidae) du Miocène inférieur de la péninsule Ibérique*

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Diplocynodon ratelii
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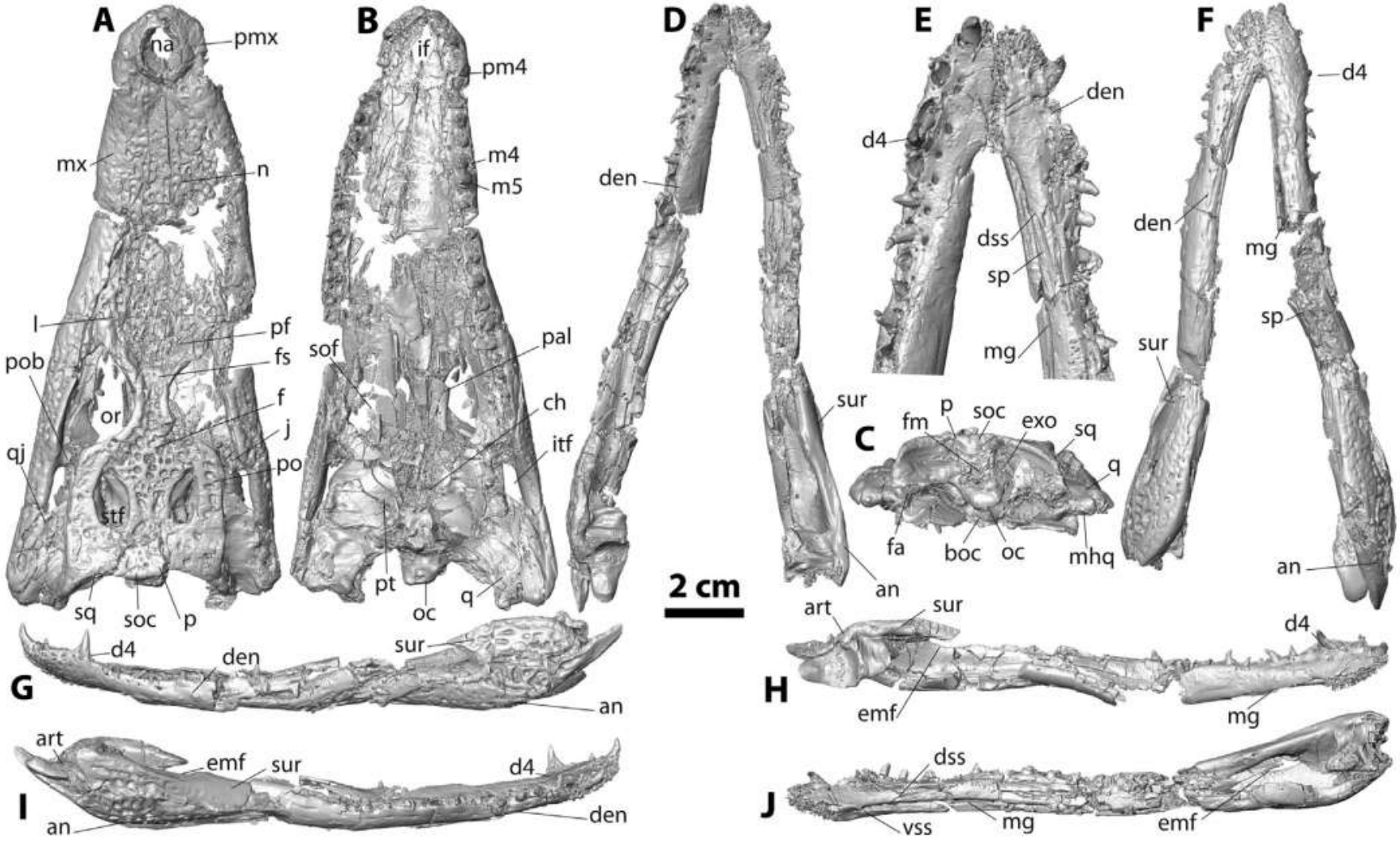
Catalonia
Spain

ABSTRACT

We describe crocodylian remains from the Early Miocene (MN4) site of Els Casots (Subirats, Vallès-Penedès Basin, NE of the Iberian Peninsula). Referral to *Diplocynodon* (Alligatoroidea: Diplocynodontidae) is justified by several cranial and postcranial features, including: (1) the subequal and confluent alveoli of the maxilla (fourth and fifth) and dentary (third and fourth); (2) the position of the foramen aëreum on the quadrate; (3) the small and ventrally reflected medial hemicondyle of the quadrate; (4) the distinct dorsoventral step on the frontal; and (5) the bipartite ventral osteoderms. Multiple morphological features are consistent with an attribution to *Diplocynodon ratelii*, previously known from the Early Miocene (MN2) of France, and discount an alternative attribution to other species of the genus, including *Diplocynodon ungeri* from the Middle Miocene (MN5) of Austria. The described material from Els Casots is smaller in size than the French material of *D. ratelii*, possibly reflecting an earlier ontogenetic stage. The described remains constitute the first report of *D. ratelii* and the youngest record of *Diplocynodon* in the Iberian Peninsula, where only *Diplocynodon muelleri* and *Diplocynodon tormis* have been previously reported. The presence of *Diplocynodon* further supports the lacustrine depositional environment previously inferred for Els Casots and also indicates a relatively high temperature.


A
na
pmx
mx
n
l
pf
pob
fs
or
f
j
qj
po
stf
sq
soc
p
B
if
pm4
m4
m5
sof
pal
ch
itf
pt
oc
q
D
den
sur
an
E
den
d4
dss
sp
mg
F
d4
den
mg
sp
sur
an
C
fm
p
soc
exo
sq
q
fa
boc
oc
mhq
2 cm
G
d4
den
sur
an
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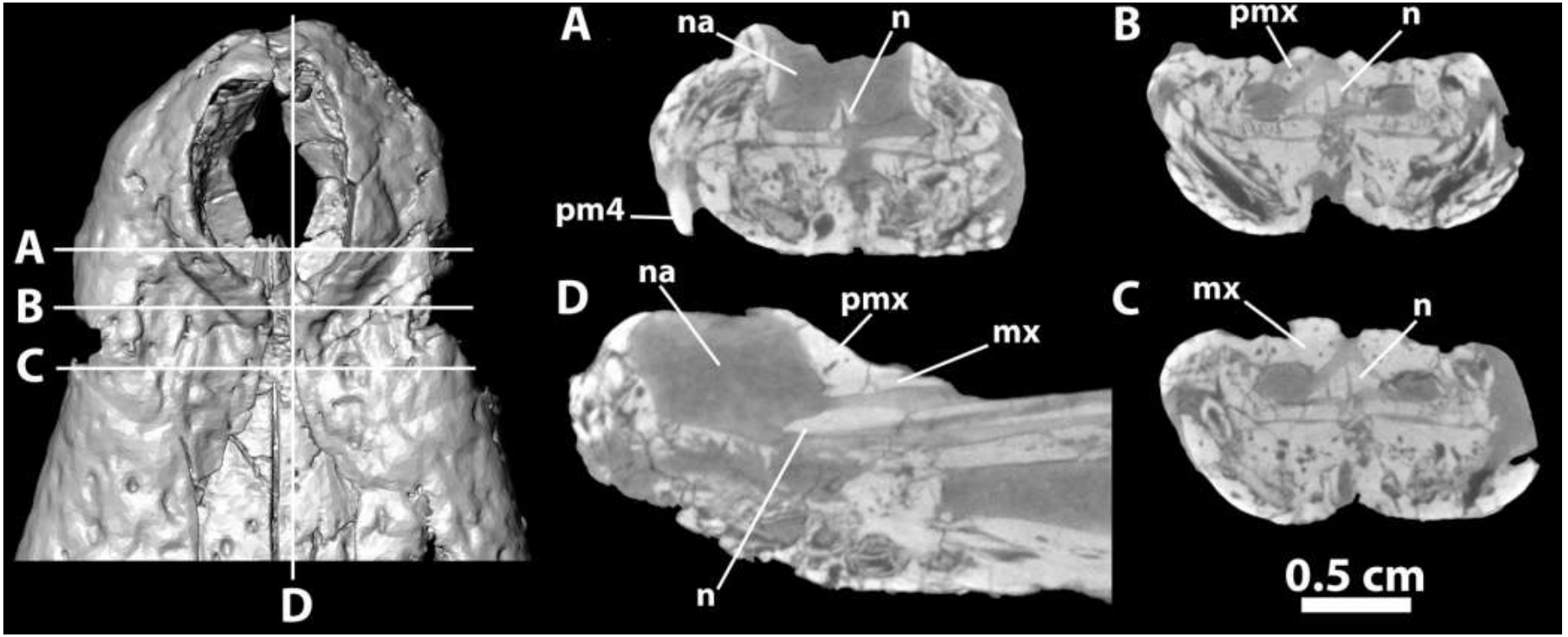
d4
an
den
J
dss
vss
mg
emf


A
B
C
D
A
na
n
pm4
B
pmx
n
D
na
pmx
mx
n
C
mx
n
0.5 cm

Paleoathropology

The immature Neanderthal Archi mandible

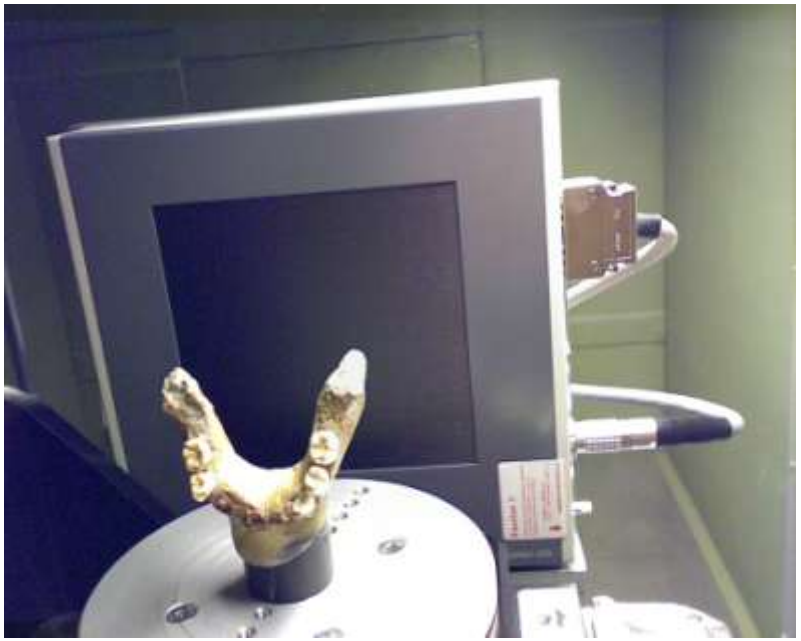
UMR 5199 PACEA, Université de Bordeaux 1, Bordeaux, France (P. Bayle)

Museo Nazionale Preistorico Etnografico 'L. Pigorini', Roma, Italy (L. Bondioli)

Sincrotrone Trieste S.C.p.A, Trieste, Italy (L. Mancini, D. Dreossi)

Dipartimento di Biologia Ambientale, Sapienza Università di Roma, Italy (A. Coppa)

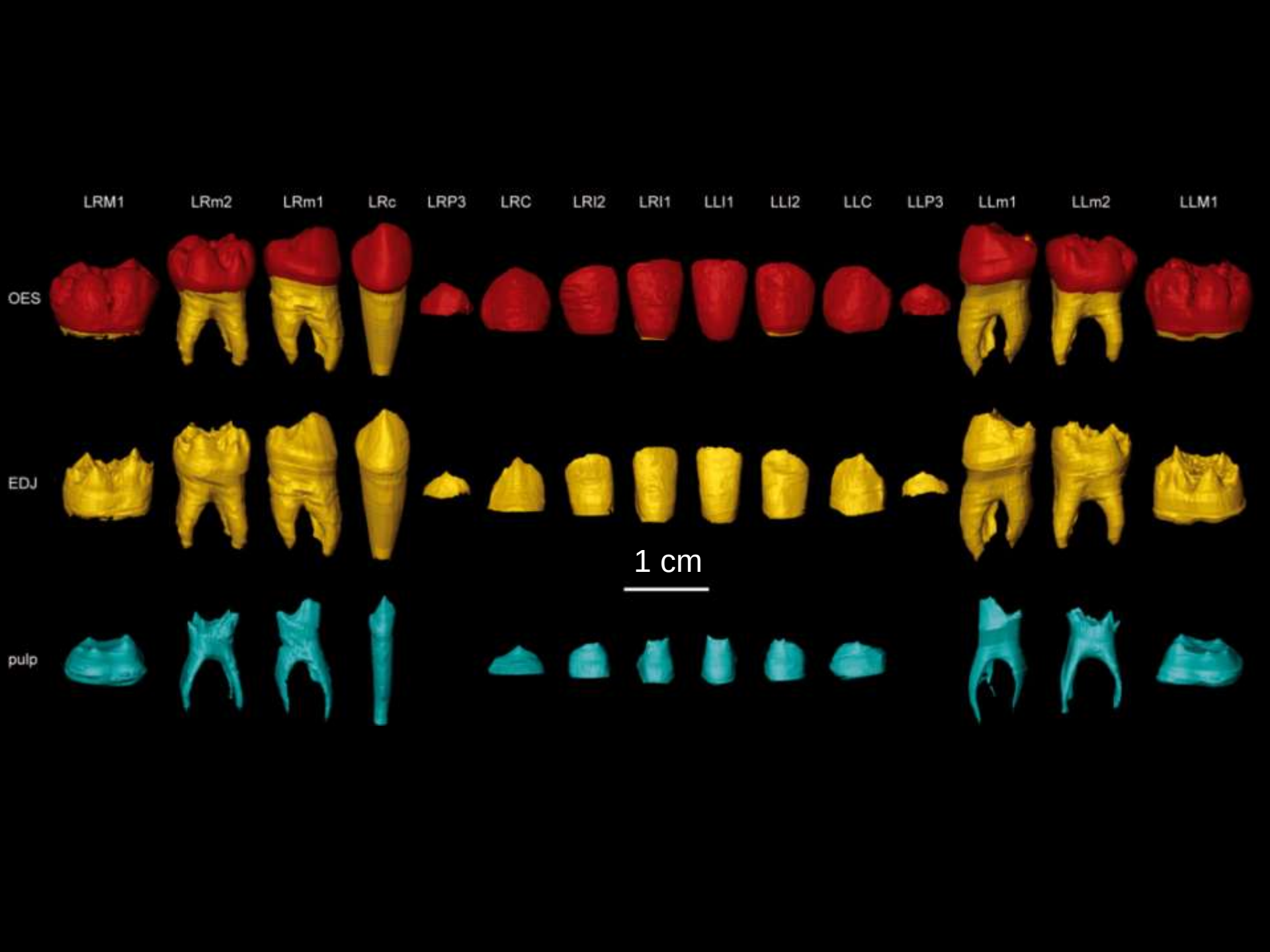
Département Géosciences, Université de Poitiers, Poitiers, France (R. Macchiarelli)

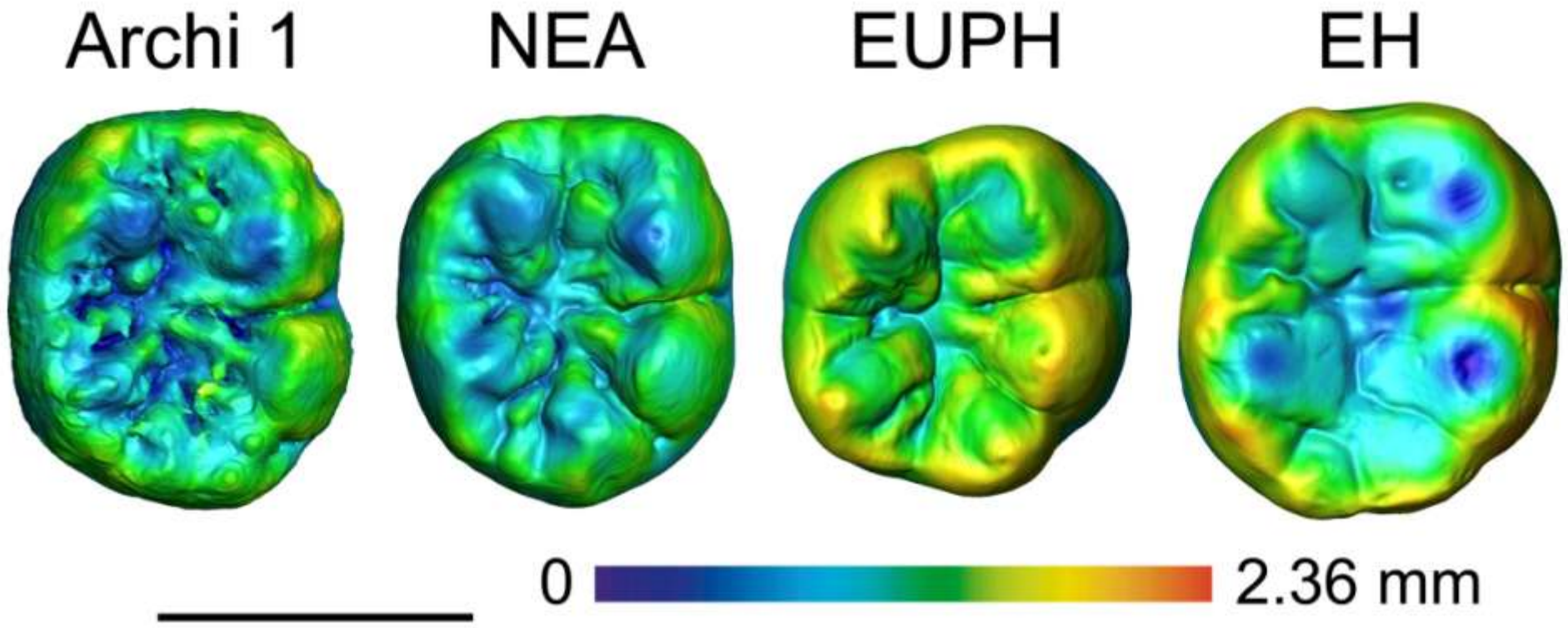


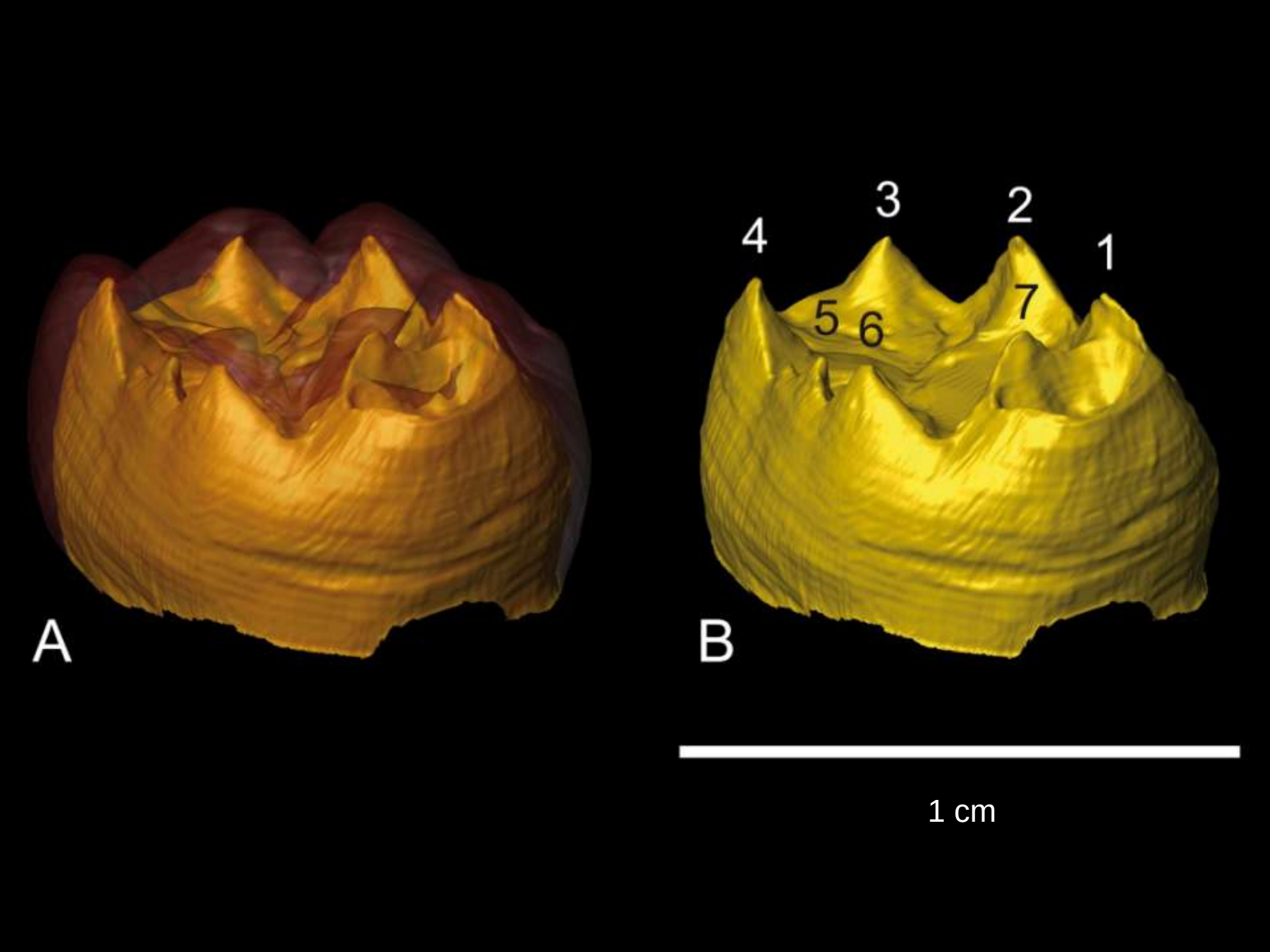
In order to investigate its inner structural morphology, in 2012 Archi 1 Neanderthal mandible has been imaged using X-ray microtomography according to the following parameters: 120 kV voltage, 80 µA current, 2400 projections over 360°. The final volume rendering was reconstructed using DigiXCT in 16-bit format, at an isotropic voxel size of 25 µm.

Bernardini F. et al 2013, Microtomographic-based structural analysis of the Neanderthal child mandible from Archi, Southern Italy. *Proceedings of the European Society for Human Evolution* 2: 44.


A
B
C
D
1 cm


LRM1
LRm2
LRm1
LRc
LRP3
LRC
LRI2
LRI1
LLI1
LLI2
LLC
LLP3
LLm1
LLm2
LLM1
OES
EDJ
1 cm
pulp


Archi 1
NEA
EUPH
EH
0
2.36 mm


A
B
4
3
2
1
5
6
7
1 cm

The Ceprano calvarium

The Ceprano calvarium was found in 1994 at Campogrande (southern Latium, Italy). At the time of its discovery and according to its stratigraphic position, an age of about 800-900 ky was suggested. However, recent studies point to a possible time range between 430 and 385 ky.

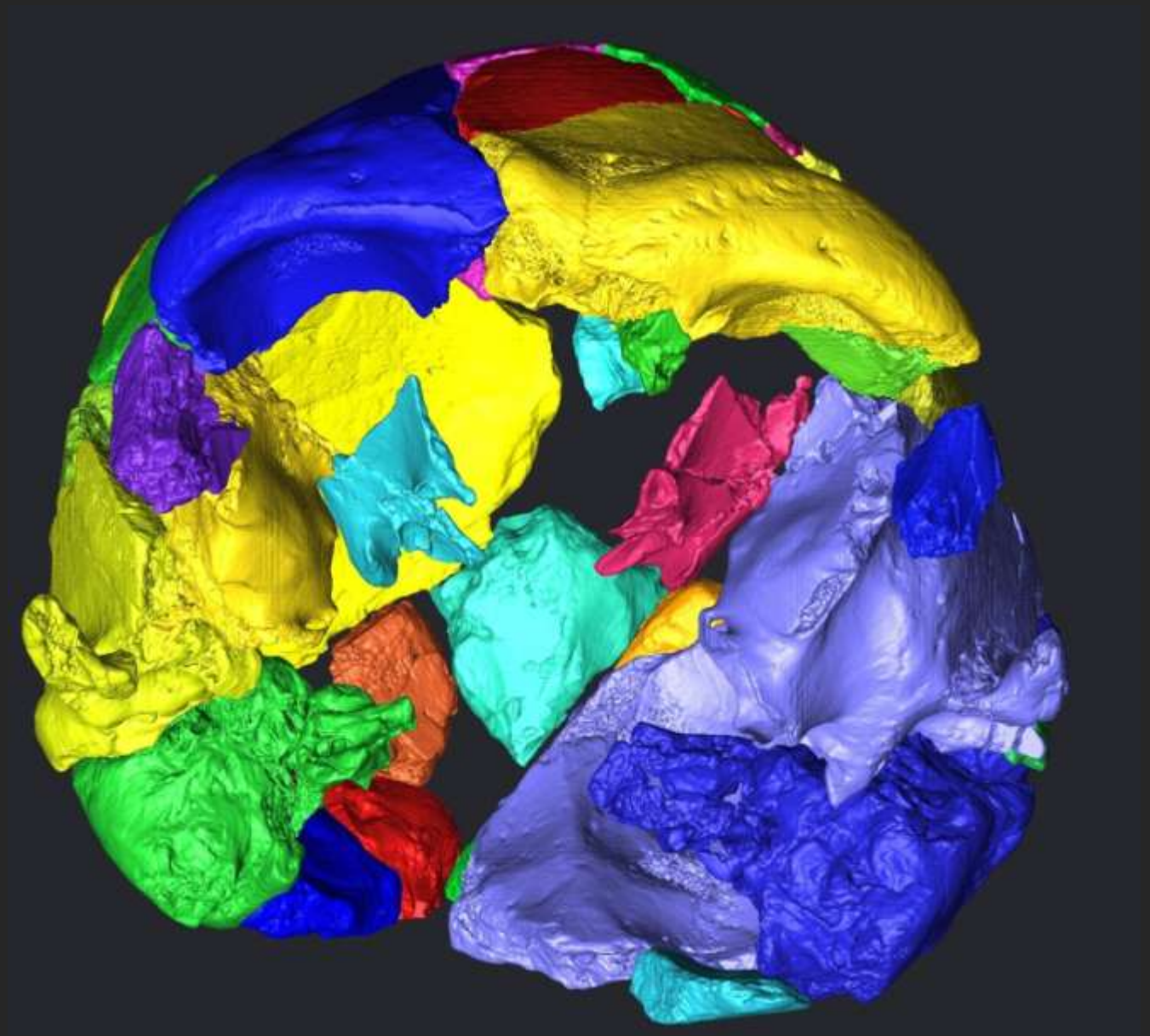
Dipartimento di Biologia Ambientale, Sapienza Università di Roma (G. Manzi, F. Di Vincenzo, A. Profico)

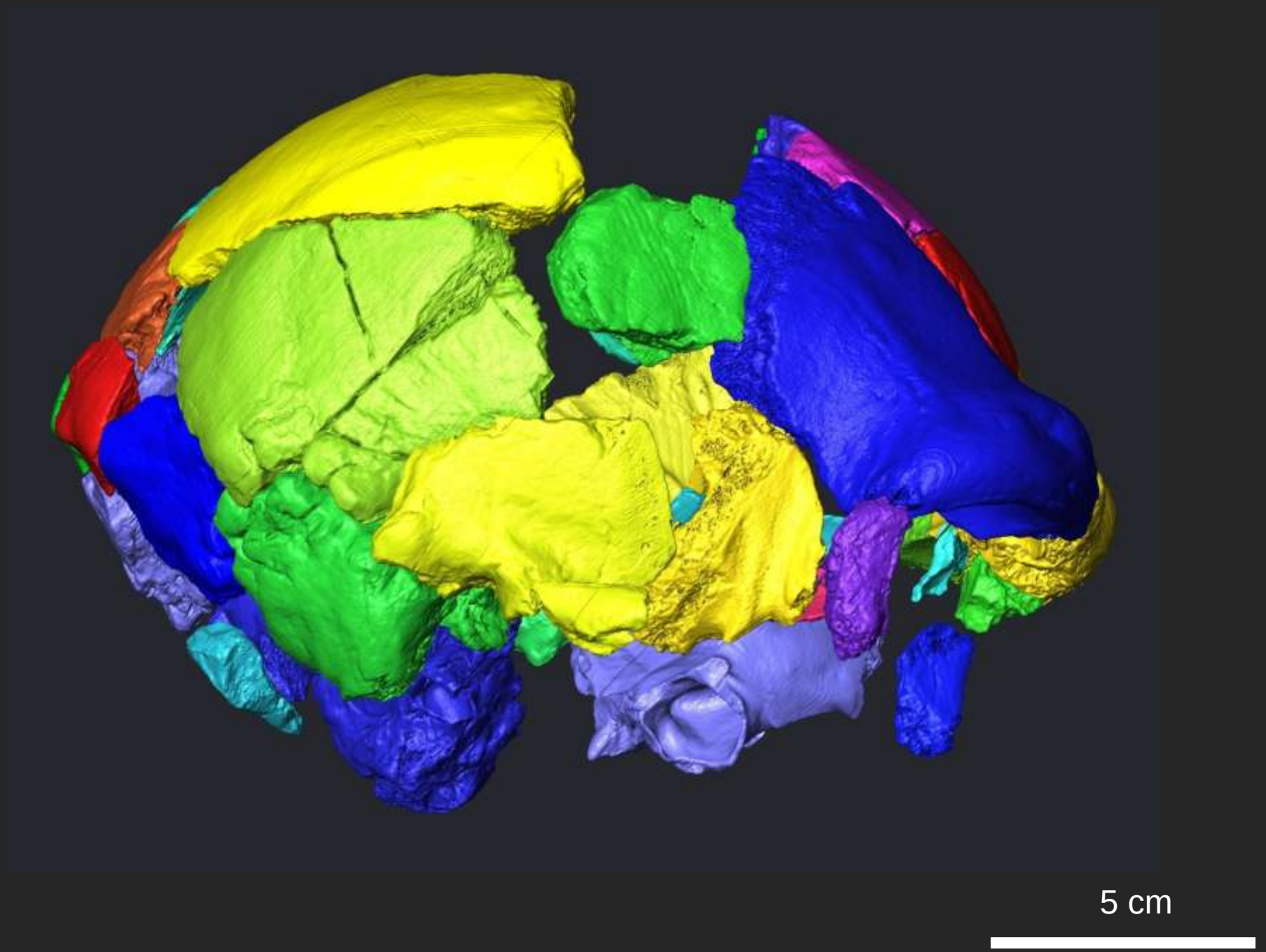
Istituto Italiano di Paleontologia Umana (IsIPU), Roma (I. Bidittu)

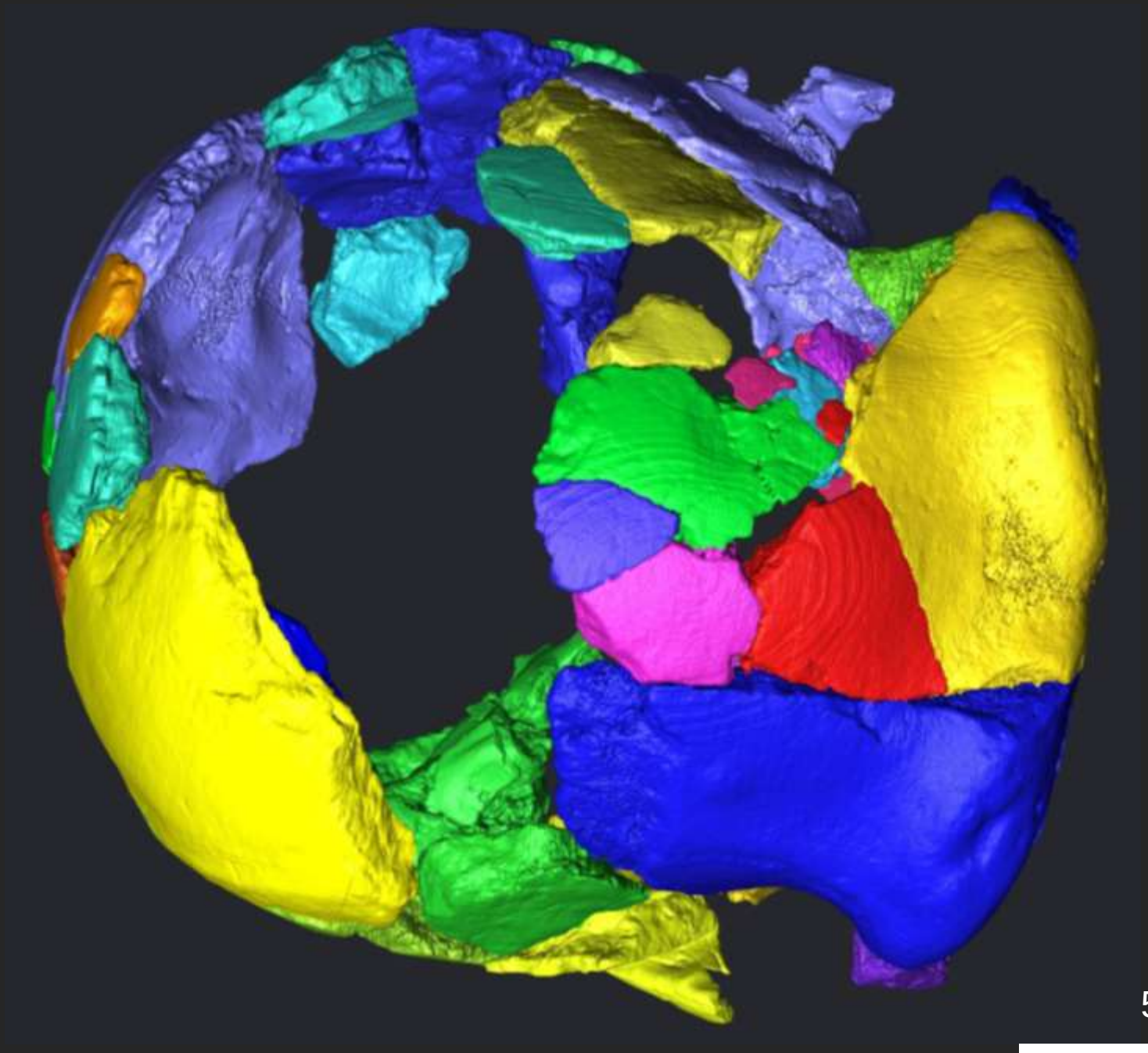
Soprintendenza Archeologica del Lazio, Roma (P. Zaio, M. Rubini)

The calvarium was affected by diagenetic deformation, requiring an accurate restoration in view of more suitable comparative analysis. Several attempts to recompose the puzzle of its original morphology were carried out over time. With the aim of digitally removing any plaster residuals from previous interventions, all the human material from Campogrande has been recorded by X-ray microtomography (µCT) with an isotropic voxel size of 40 µm.

Di Vincenzo F. et al 2014, The Ceprano calvarium, twenty years after. A new generation of (digital) studies. *Proceedings of the European Society for Human Evolution* 3: 61.


5 cm


5 cm

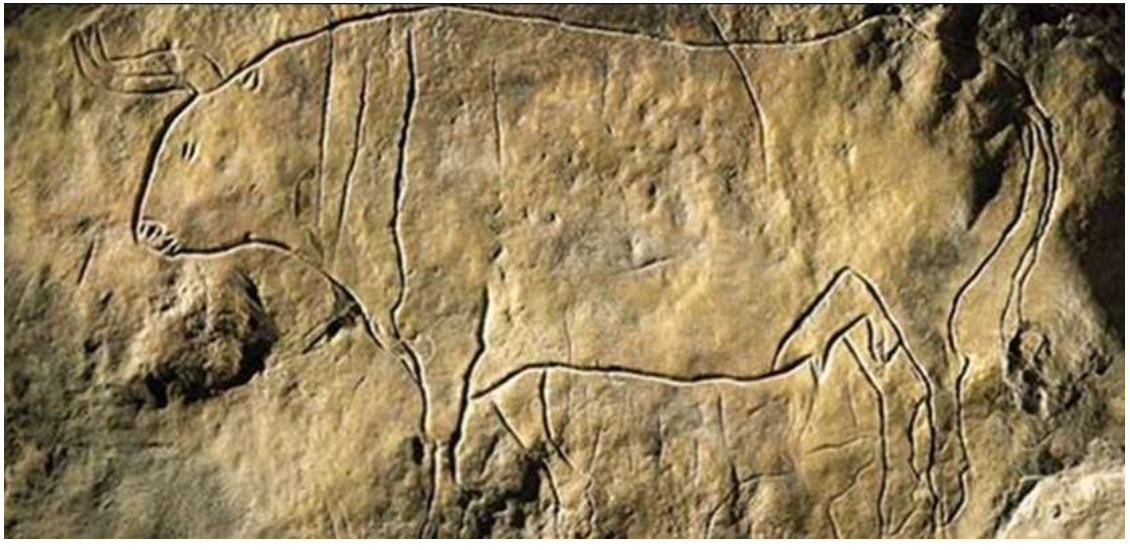

5 cm

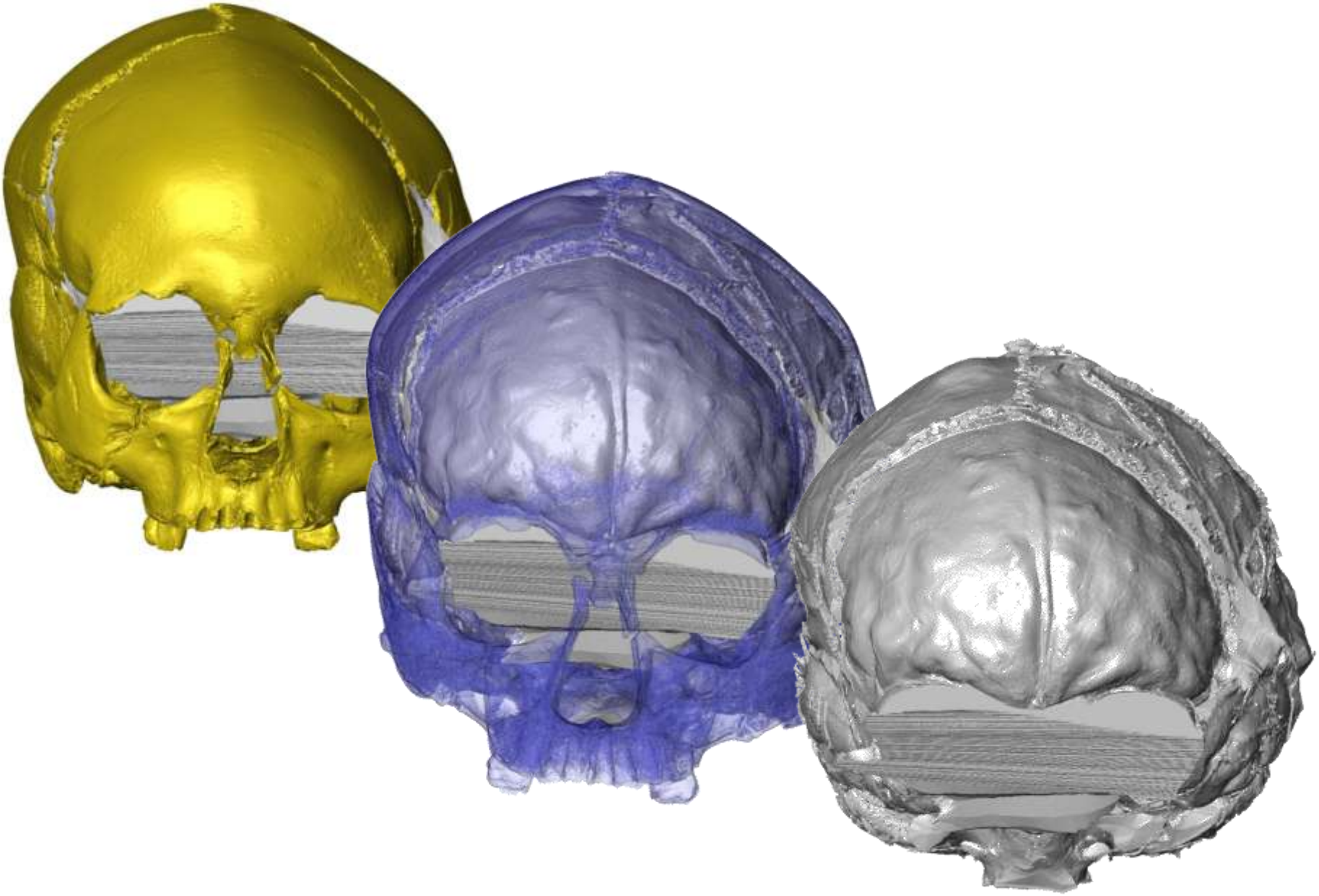
The Romito 9 skull

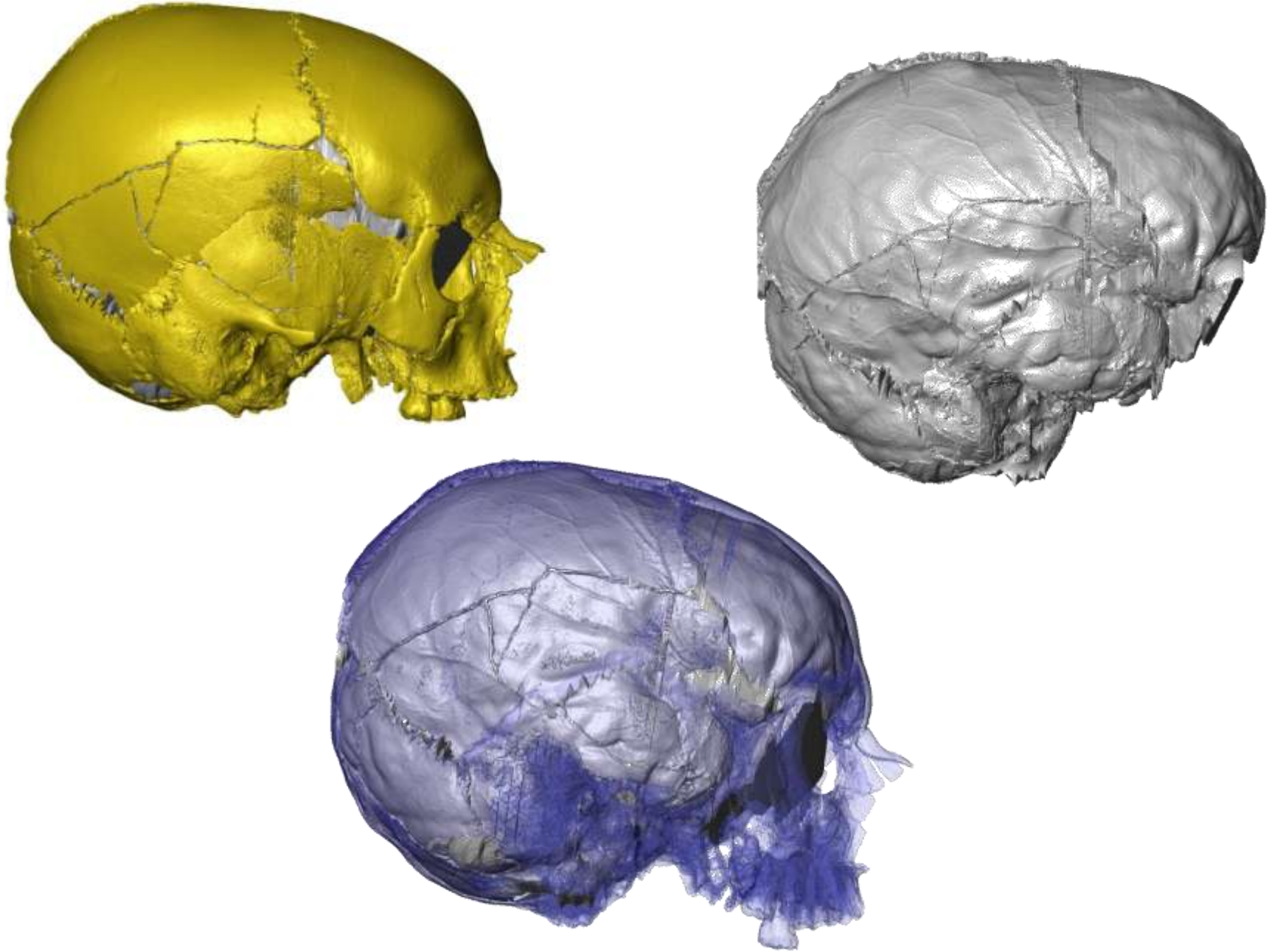
The skull, dated to17 ky, is part of a Epigravettian burial recently discovered in the famous Romito cave in Calabria.

In order to produce a virtual endocast, it has been recently imaged by X-ray microtomography (µCT), according to the following parameters: 145 kV voltage, 200 µA current, and a projection each 0.075°. The final volumes were reconstructed with an isotropic voxel size of 41 µm.

Università di Firenze, Italy
University of California, Irvine, USA
Università di Roma Tor Vergata, Italy
Università del Salento, Italy
Soprintendenza Archeologica della Calabria, Italy

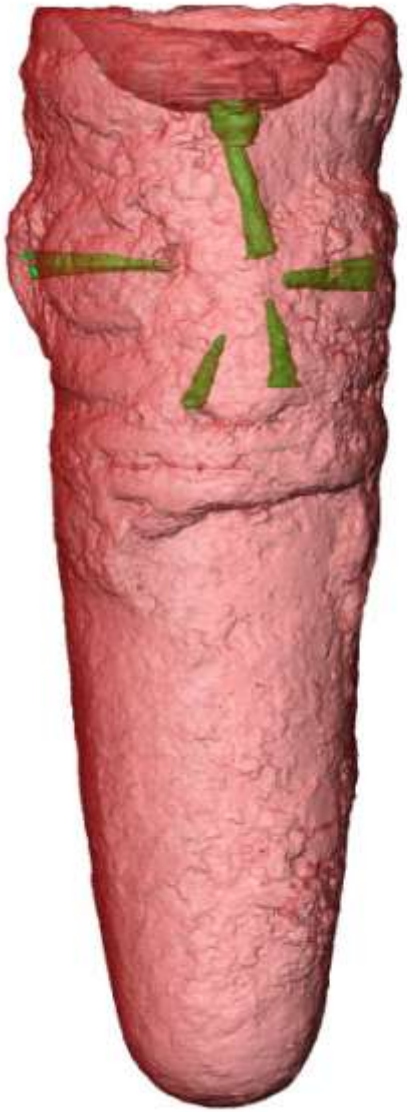






Archaeology

Ghana clay figurines (about 1ky BP)



microCT revealed hidden channels within the objects which could have a medicinal function, used for liquid ritual offerings.

Contents lists available at ScienceDirect

Microchemical Journal

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

Neolithic pottery from the Trieste Karst (northeastern Italy): A multi-analytical study☆

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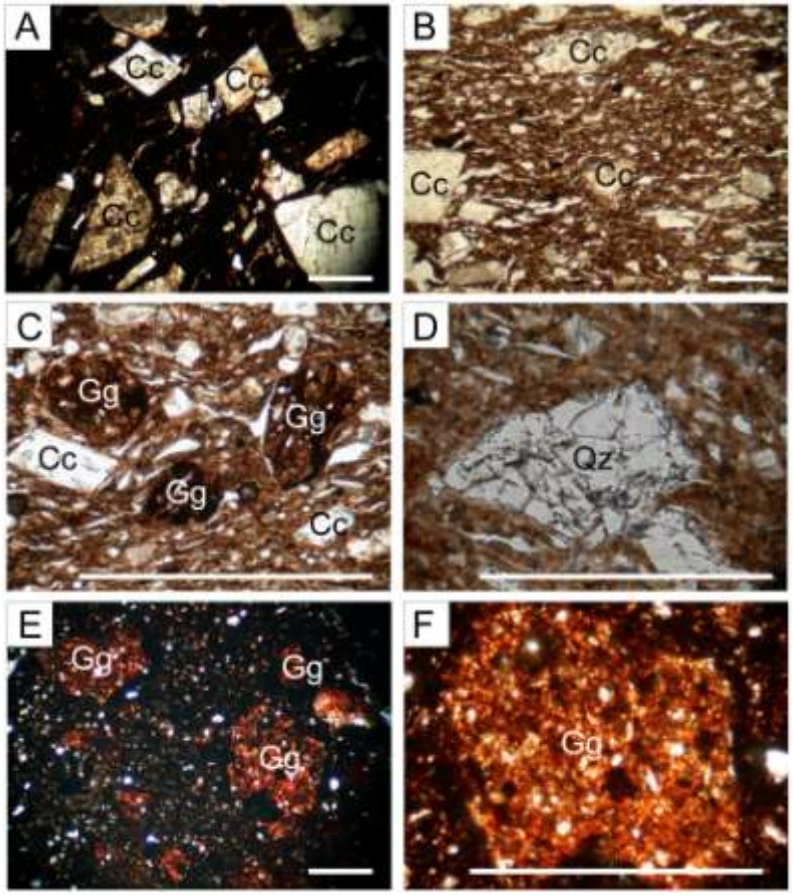
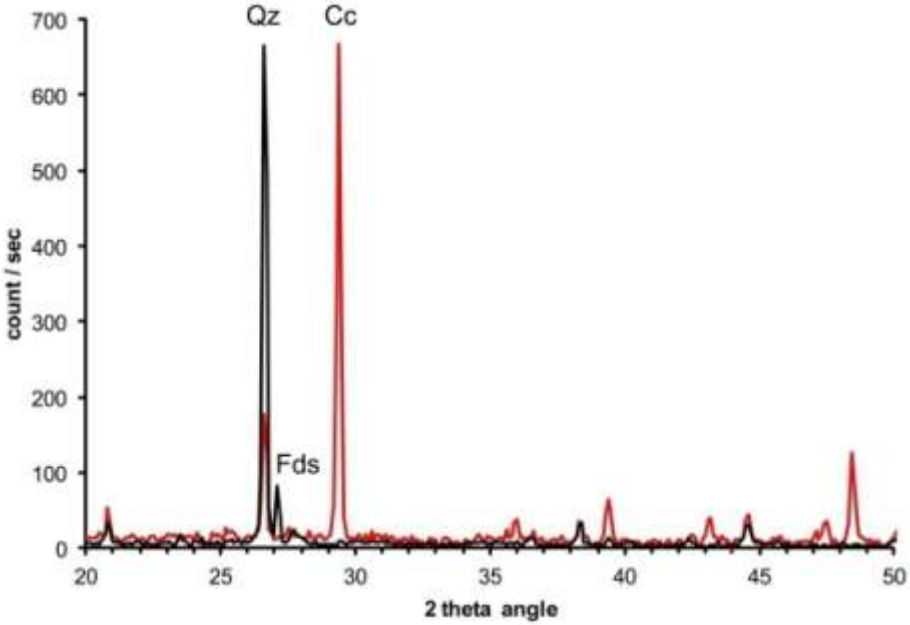
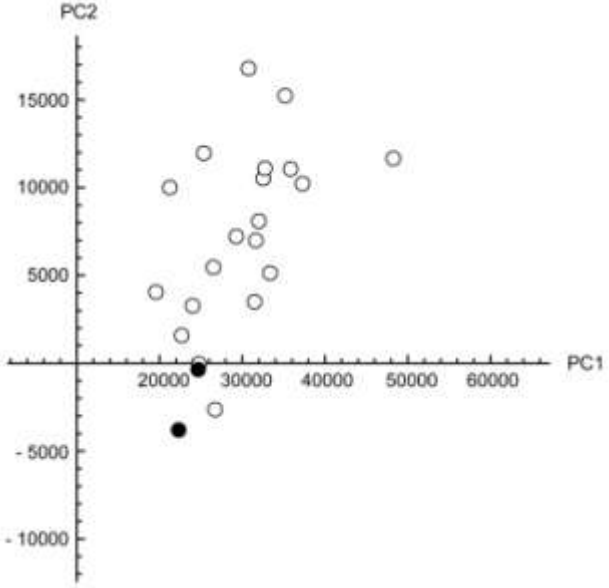
Multi-analytical approach
Production technology
Provenance

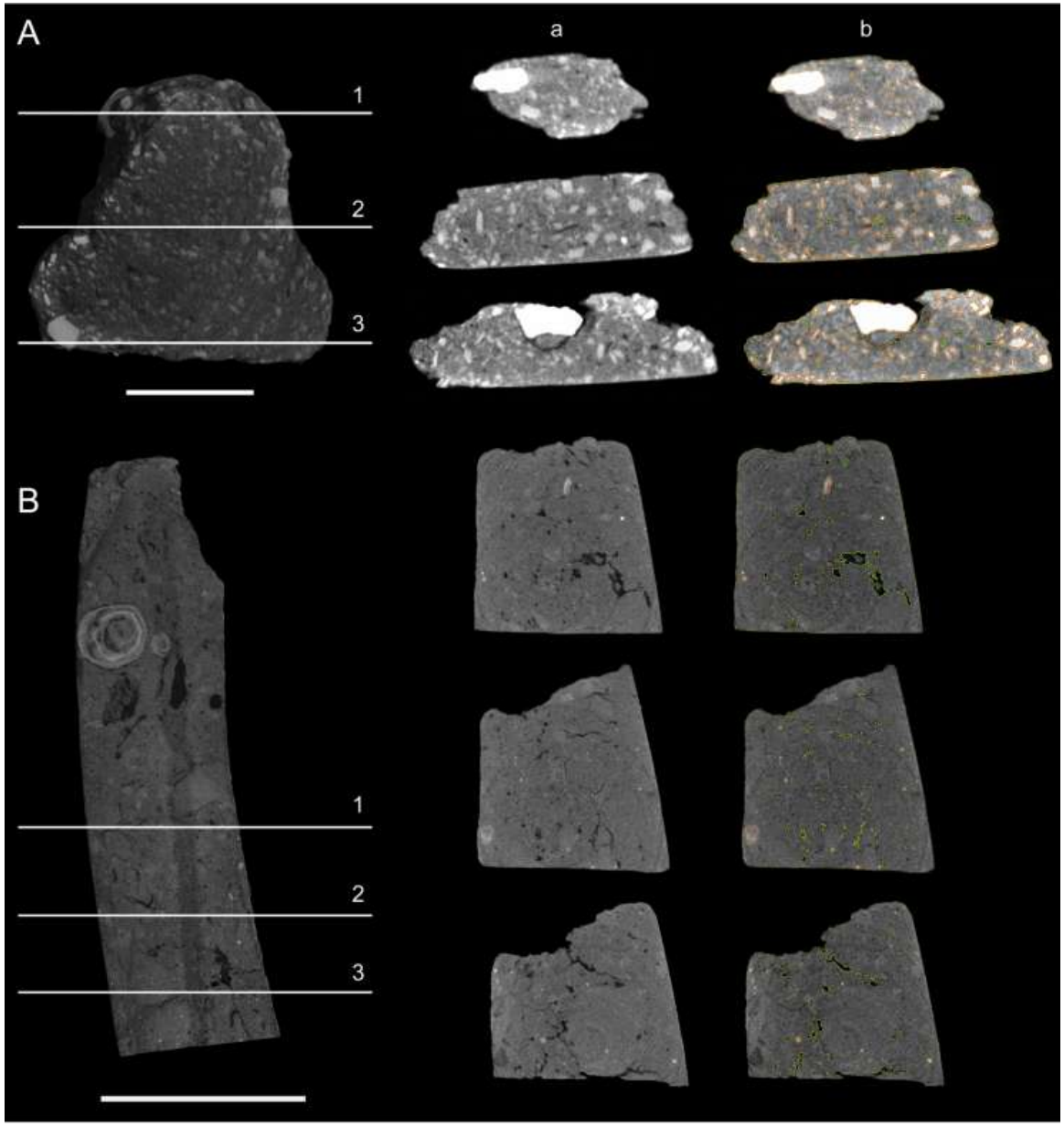
ABSTRACT

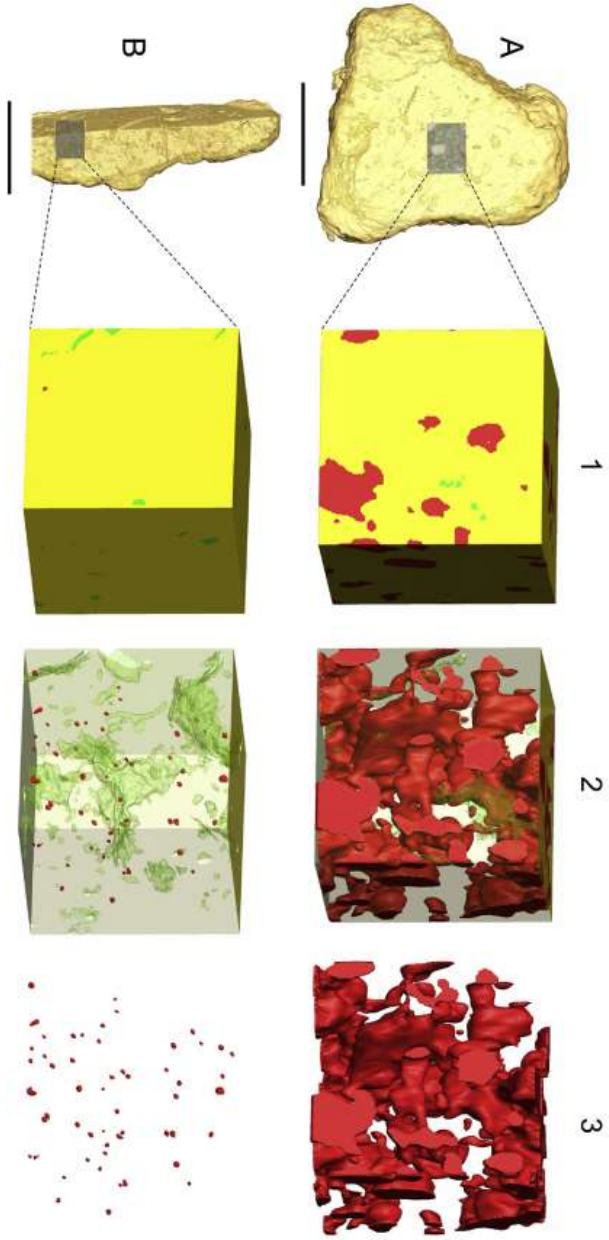
A group of Neolithic potsherds from caves of the Trieste Karst (northeastern Italy) belonging to the Vlaška Group has been studied through a multi-analytical approach mainly based on non-destructive X-ray computed microtomography (μCT) and portable X-ray fluorescence (XRF), combined with X-ray diffraction (XRD) and optical microscopy (OM) to investigate both manufacture technology and provenance of the vases. Most samples, probably produced using a modelling technique, were made using clay-silt size paste containing quartz inclusions, tempered with the addition of abundant calcite and some limestone fragments. Calcite minerals, very common in the karstic environment, were probably obtained by grinding speleothems. This peculiar paste seems to be typical of the Karst area since prehistoric times. One single sample (5880), characterized by an unusual shape recalling those of the Fiorano culture (present in Emilia-Romagna and Veneto), shows a fine-grained fabric with numerous grog fragments, quartz, minor feldspar but without calcite. The 2D and 3D μCT-derived fabric parameters, reflecting the manufacture technology, are also quite different from those of the local vases. These features suggest that sample 5880 was manufactured elsewhere and later reached the Karst, directly or indirectly. The combined use of conventional techniques and non-destructive XRF and μCT, which allows the quantification of clay material, lithic inclusions and porosity, has proved to be an effective approach to investigate both technology and provenance of ceramic materials.

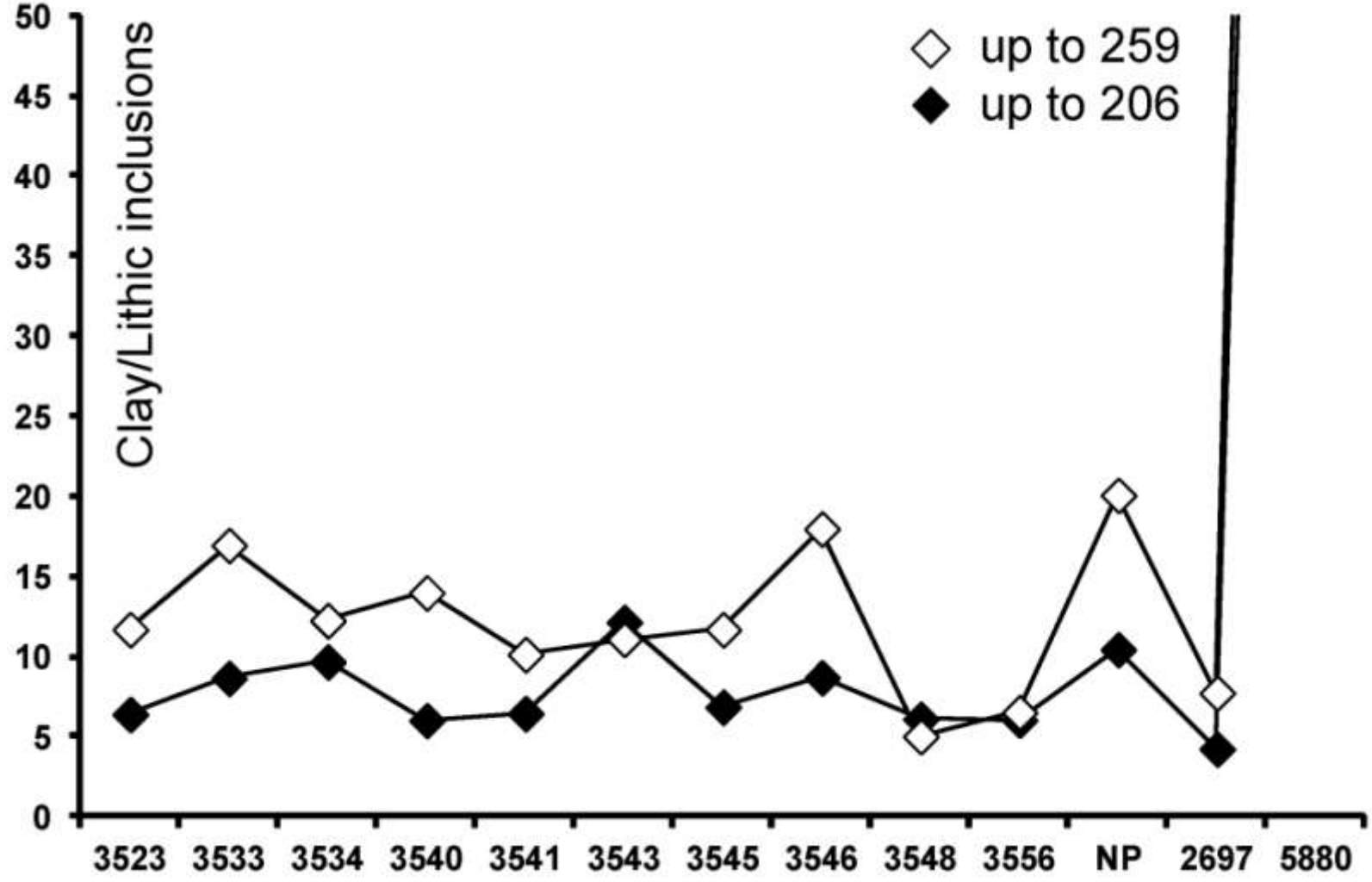

A
Cc
Cc
Cc
Cc
B
Cc
Cc
Cc
C
Gg
Gg
Cc
Gg
Cc
D
Qz
E
Gg
Gg
Gg
F
Gg

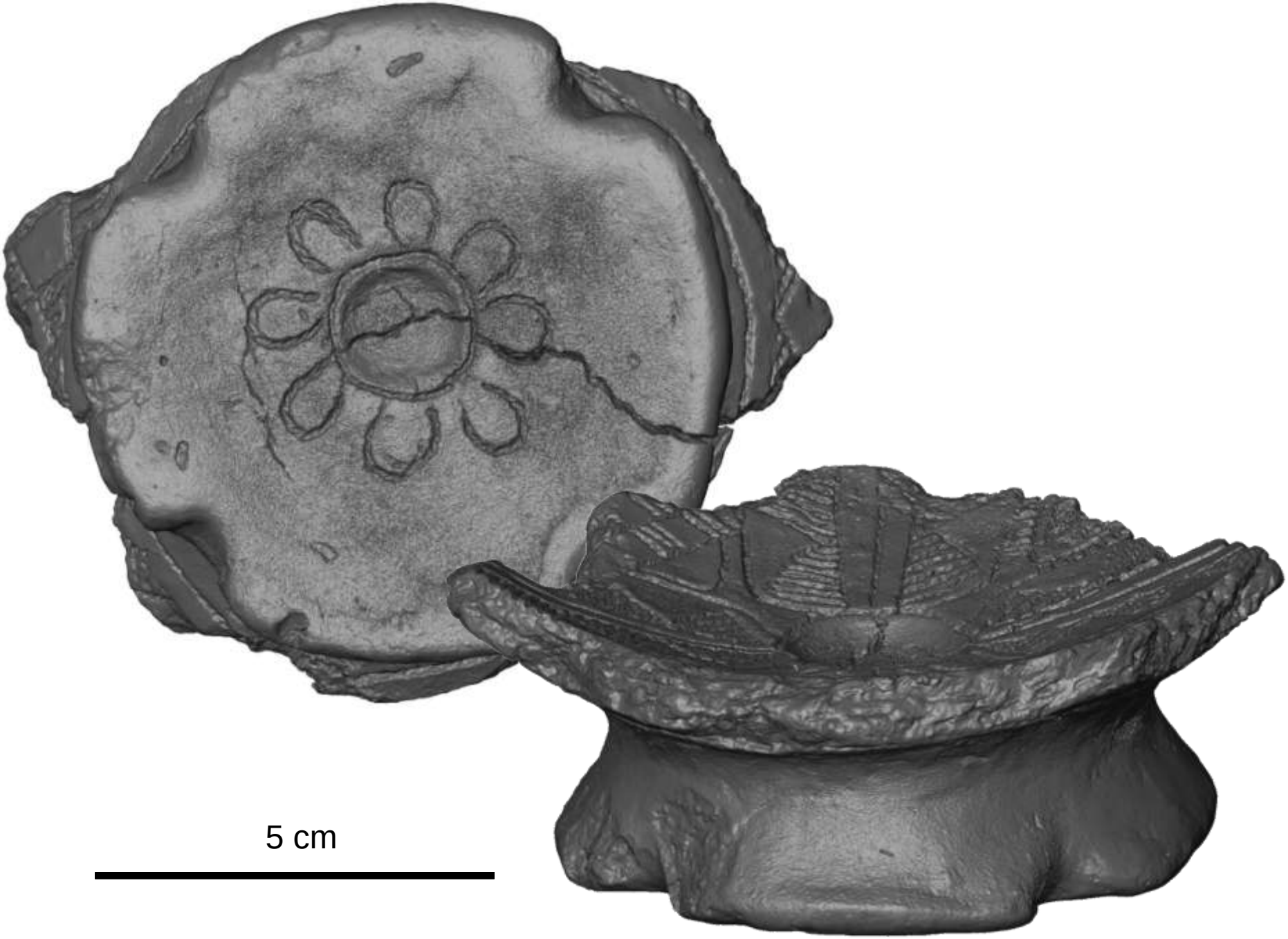

Qz
Cc
Fds
count / sec
2 theta angle
700
600
500
400
300
200
100
0
20
25
30
35
40
45
50

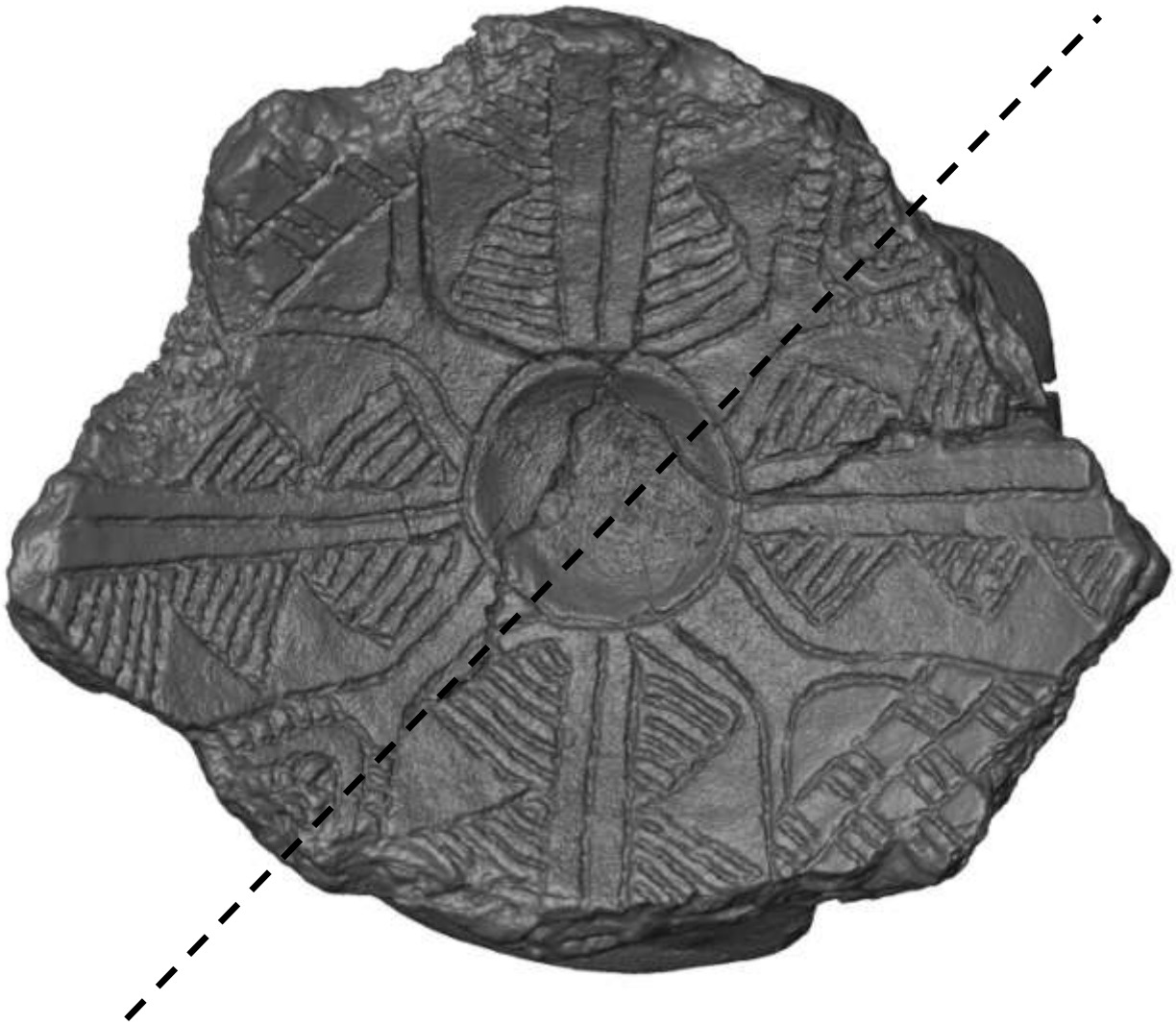

PC2
PC1
15000
10000
5000
- 5000
- 10000
20000
30000
40000
50000
60000

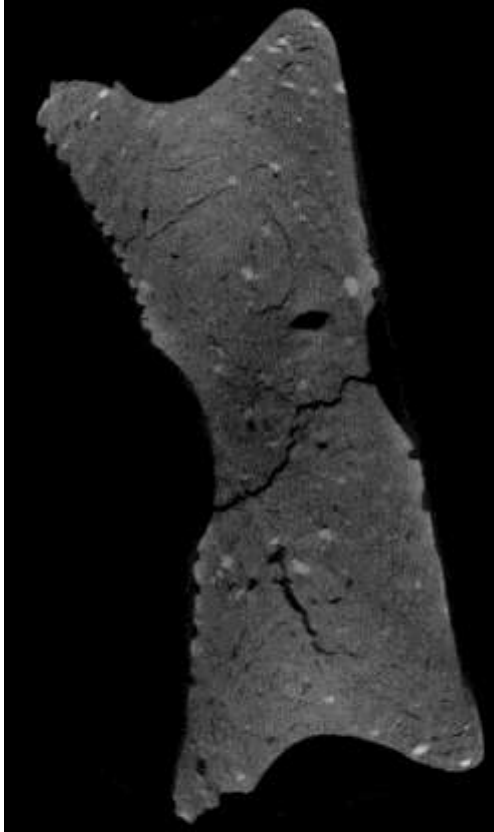

A
a
b
1
2
3
B
1
2
3


B
A
1
2
3


Clay/Lithic inclusions
50
45
40
35
30
25
20
15
10
5
0
up to 259
up to 206
3523
3533
3534
3540
3541
3543
3545
3546
3548
3556
NP
2697
5880

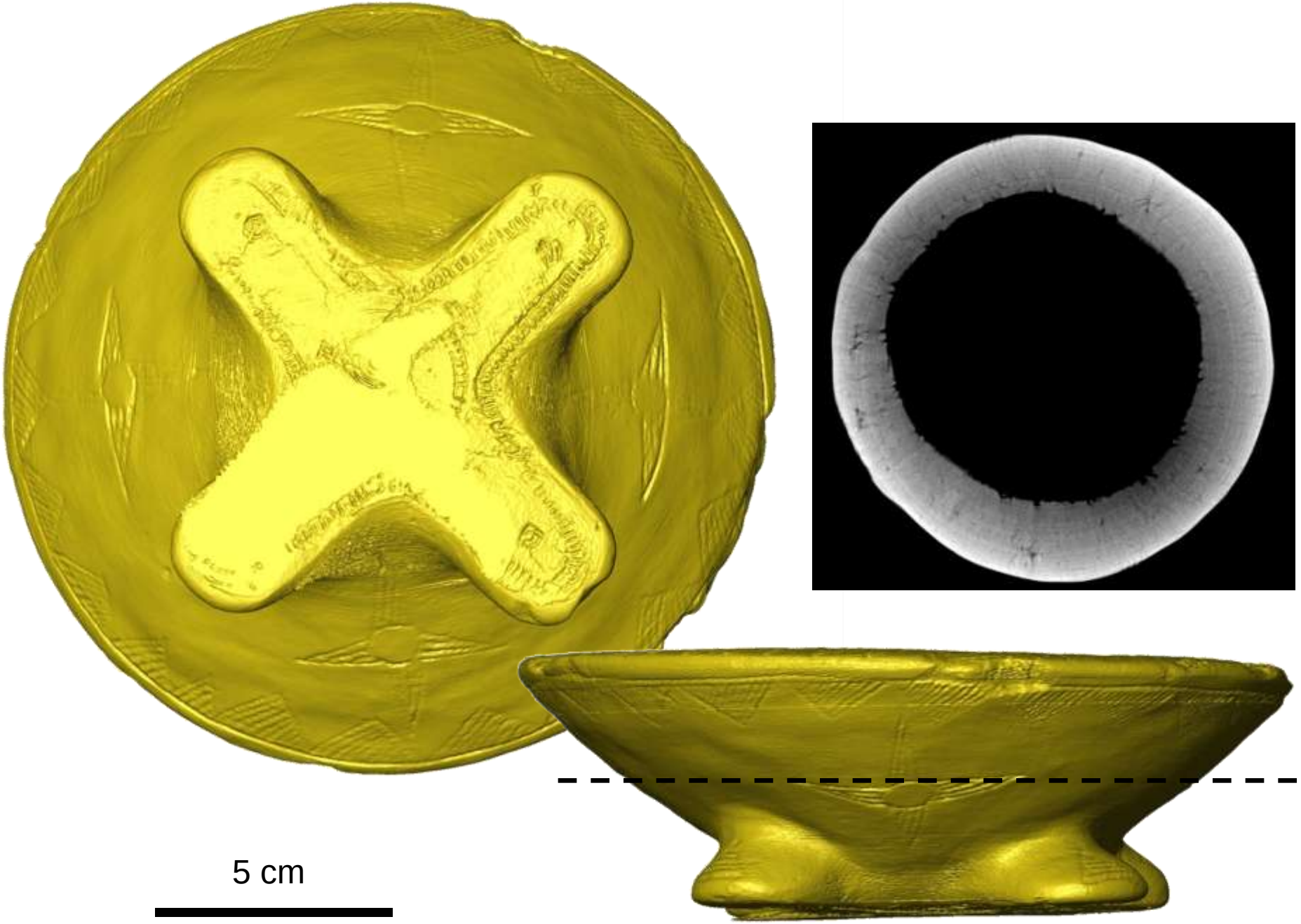

5 cm





5 cm


5 cm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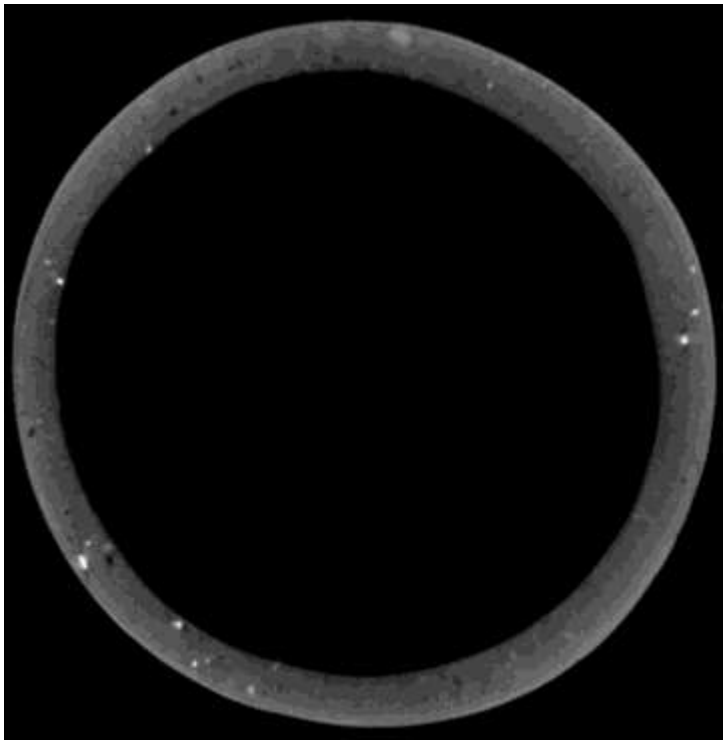
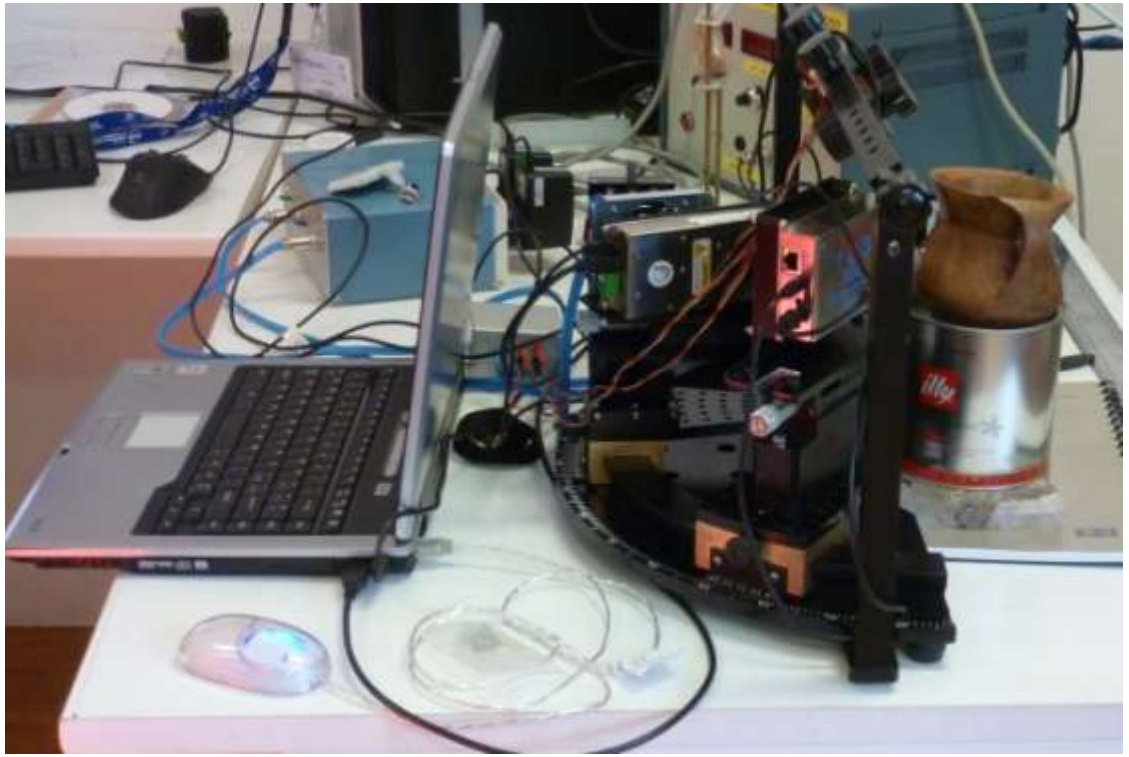


3 cm

3 cm



PNAS PLUS

Early Roman military fortifications and the origin of Trieste, Italy

Federico Bernardini[a,b,1], Giacomo Vinci[c], Jana Horvat[d], Angelo De Min[e], Emanuele Forte[e], Stefano Furlani[e], Davide Lenaz[e], Michele Pipan[e], Wenke Zhao[e], Alessandro Sgambati[f], Michele Potleca[g], Roberto Micheli[h], Andrea Fragiacomo[i], and Claudio Tuniz[a,b,j]

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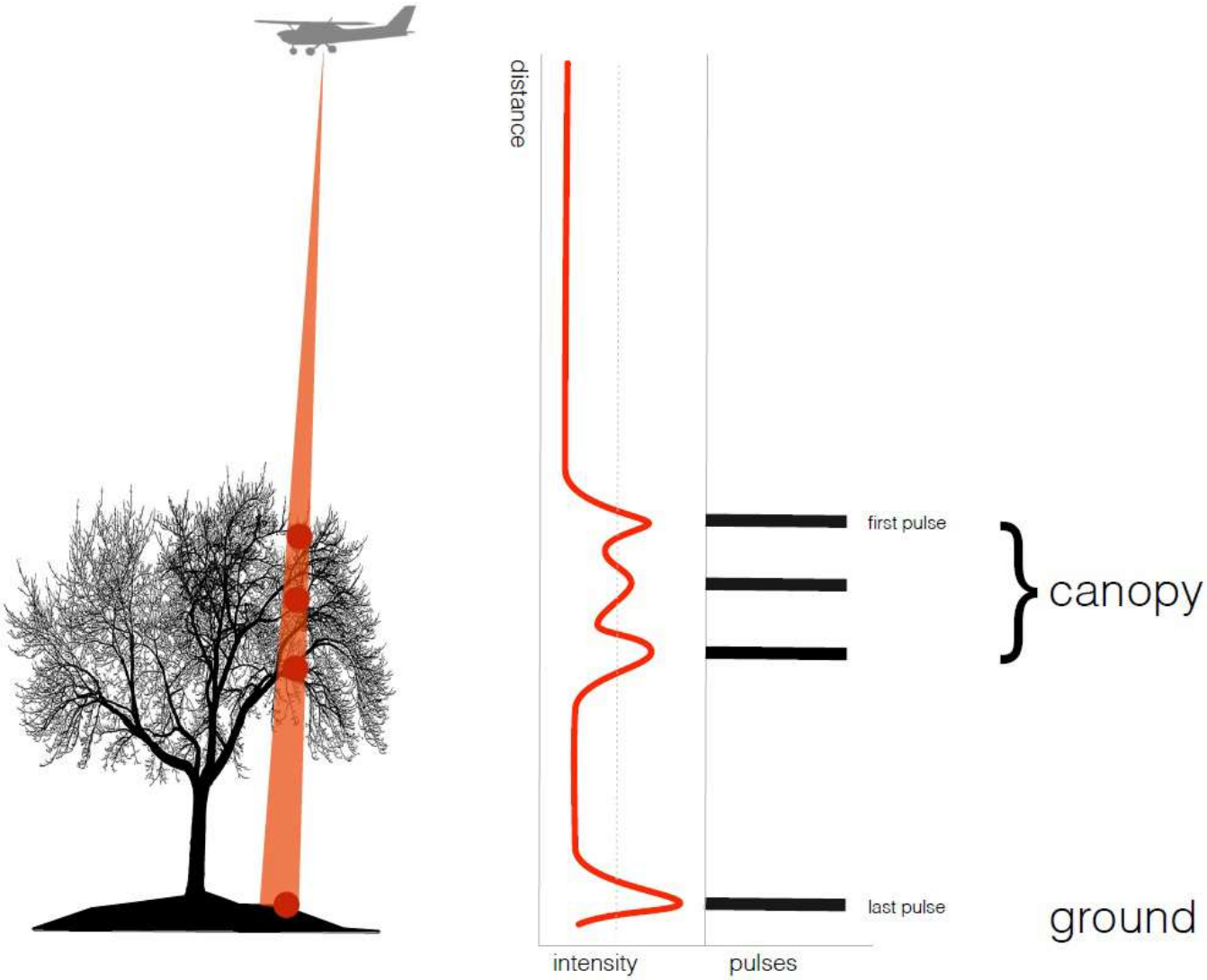
Edited by Mike Dobson, University of Exeter, Exeter, United Kingdom, and accepted by the Editorial Board February 17, 2015 (received for review October 6, 2014)

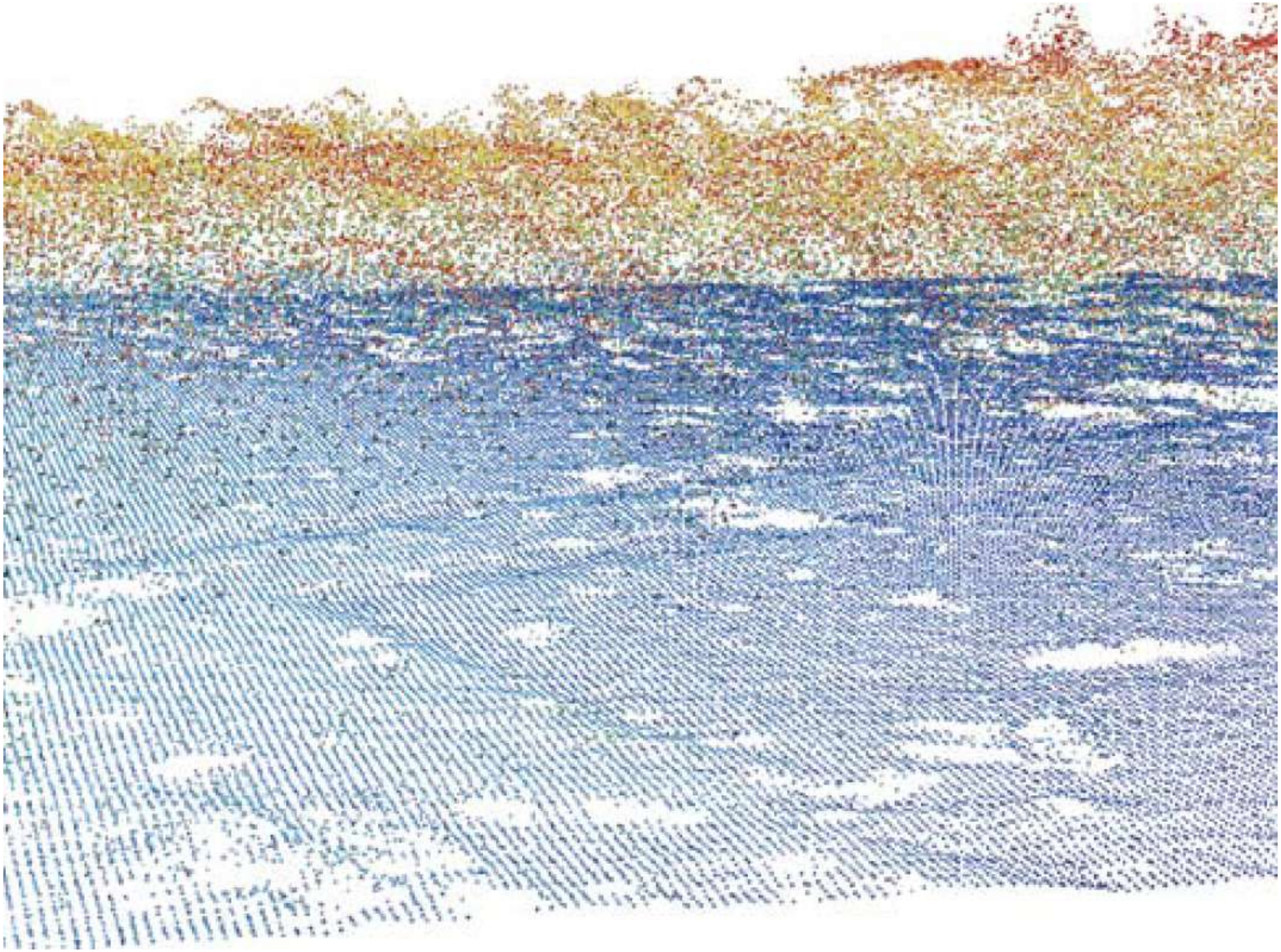
An interdisciplinary study of the archaeological landscape of the Trieste area (northeastern Italy), mainly based on airborne light detection and ranging (LiDAR), ground penetrating radar (GPR), and archaeological surveys, has led to the discovery of an early Roman fortification system, composed of a big central camp (San Rocco) flanked by two minor forts. The most ancient archaeological findings, including a Greco–Italic amphora rim produced in Latium or Campania, provide a relative chronology for the first installation of the structures between the end of the third century B.C. and the first decades of the second century B.C. whereas other materials, such as Lamboglia 2 amphorae and a military footwear hobnail (type D of Alesia), indicate that they maintained a strategic role at least up to the mid first century B.C. According to archaeological data and literary sources, the sites were probably established in connection with the Roman conquest of the Istria peninsula in 178–177 B.C. They were in use, perhaps not continuously, at least until the foundation of Tergeste, the ancestor of Trieste, in the mid first century B.C. The San Rocco site, with its exceptional size and imposing fortifications, is the main known Roman evidence of the Trieste area during this phase and could correspond to the location of the first settlement of Tergeste preceding the colony foundation. This hypothesis would also be supported by literary sources that describe it as a *phrourion* (Strabo, V, 1, 9, C 215), a term used by ancient writers to designate the fortifications of the Roman army.

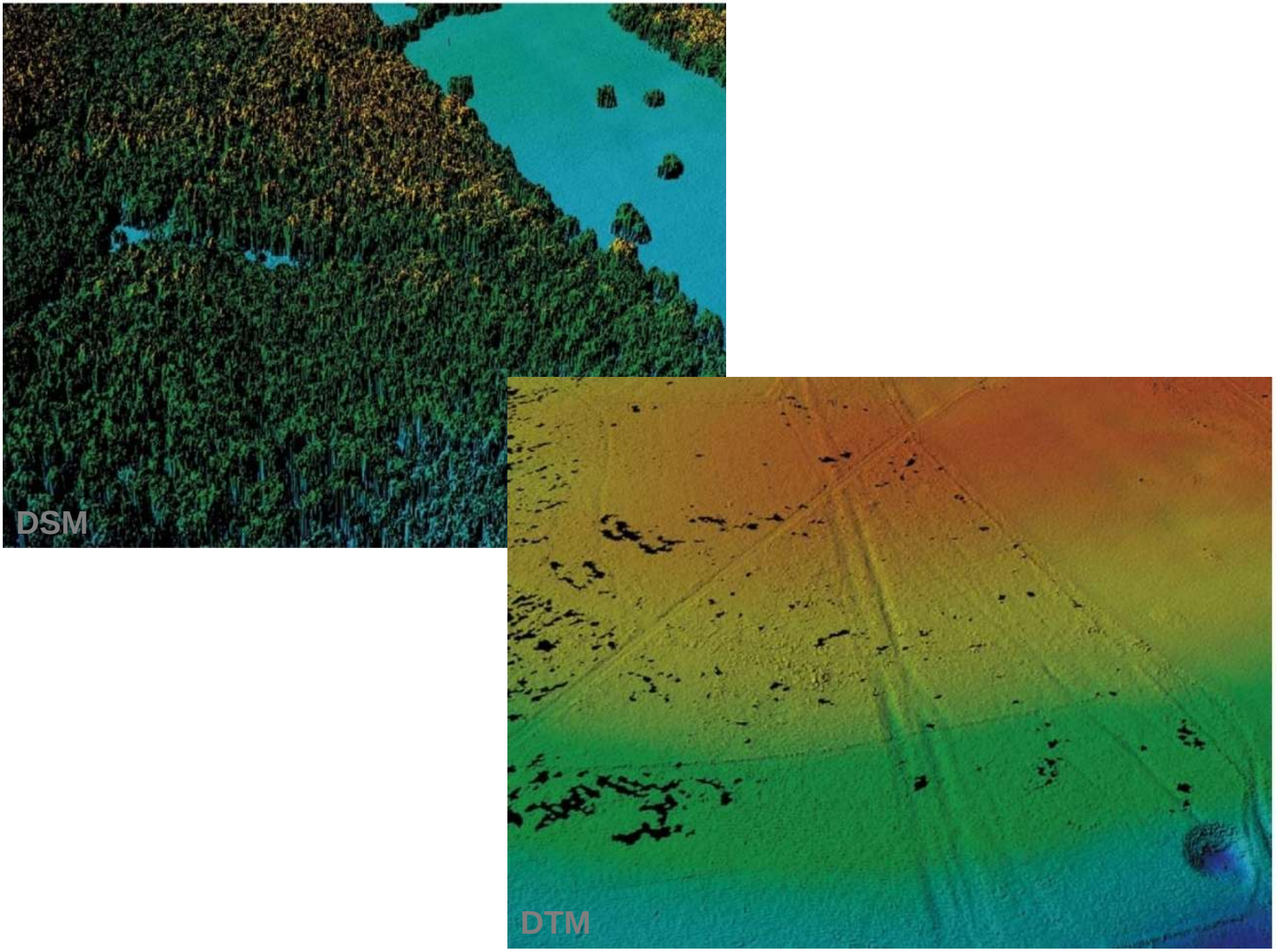
Surprisingly enough, not a single Roman military fortification had been discovered in Italy until the recent identification of the Mt. Grociana piccola fort in the northeastern part of the peninsula close to Trieste (12). Further research, mainly based on LiDAR (light detection and ranging) remote sensing, ground penetrating radar (GPR), and archaeological surveys, has shown that the Mt. Grociana structures are just part of a Republican fortification system, which includes two additional sites. Here, we present the plan of emerging and buried identified structures, their spatial relationship, and the associated archaeological materials to define their chronology and historical significance.

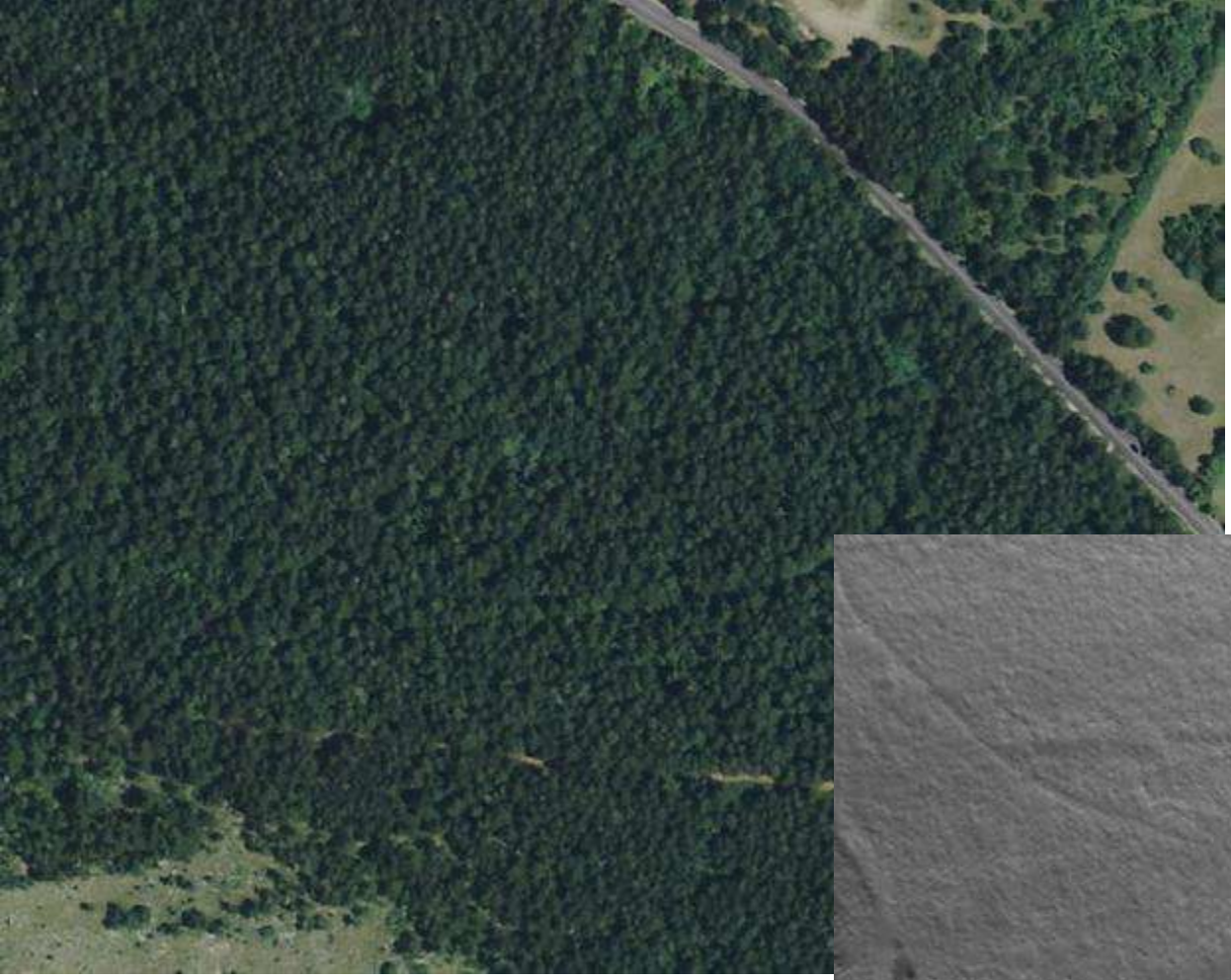
According to ancient sources, the Latin words used to define the fortifications of the Roman army are *castra* (in Greek, *stratopedon*) and its diminutive *castellum* (in Greek, *phrourion*), which have been generally translated by British archaeologists as "fortress/camp" and "fort," respectively (1, 13). Following this conventional terminology, we use here the terms "camp" or "fortress" to designate sites larger than 10 ha, and the term "fort" to indicate the smaller fortifications, independently of the building techniques and possible permanent or temporary functions.

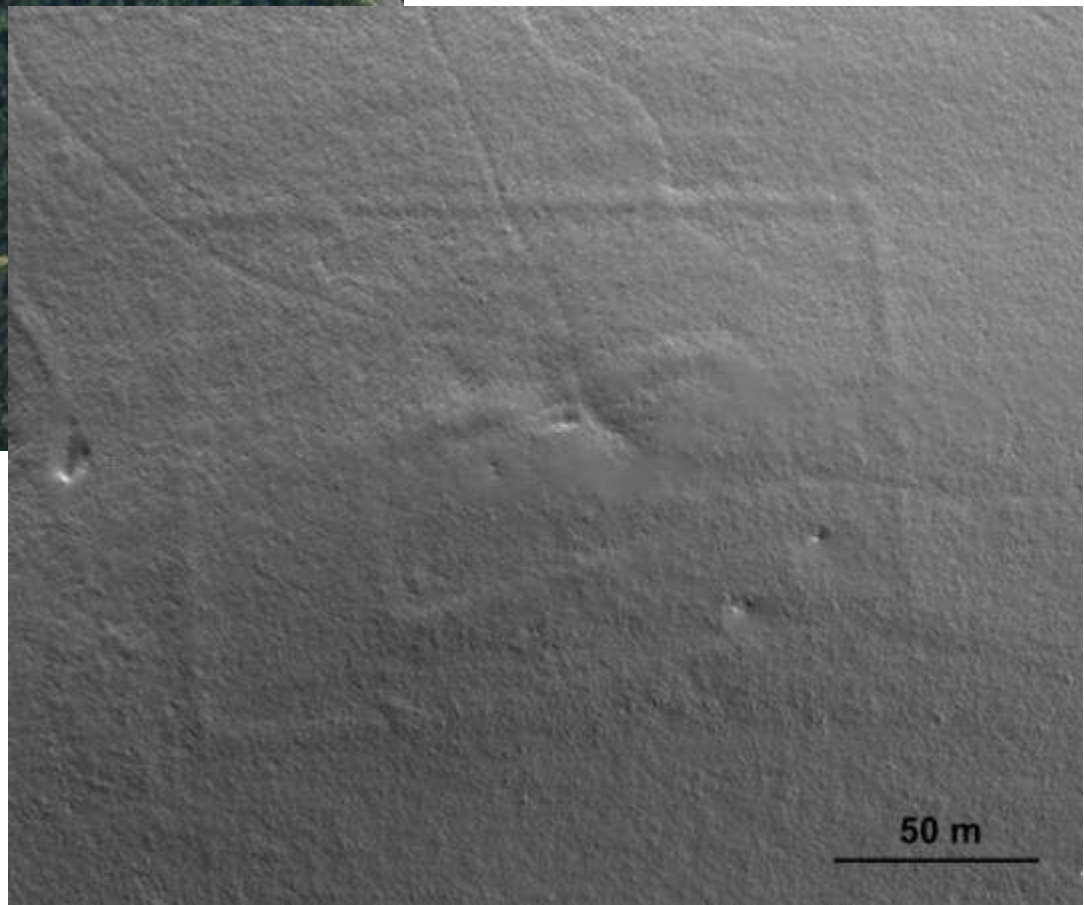
Airborne Laser Scanning





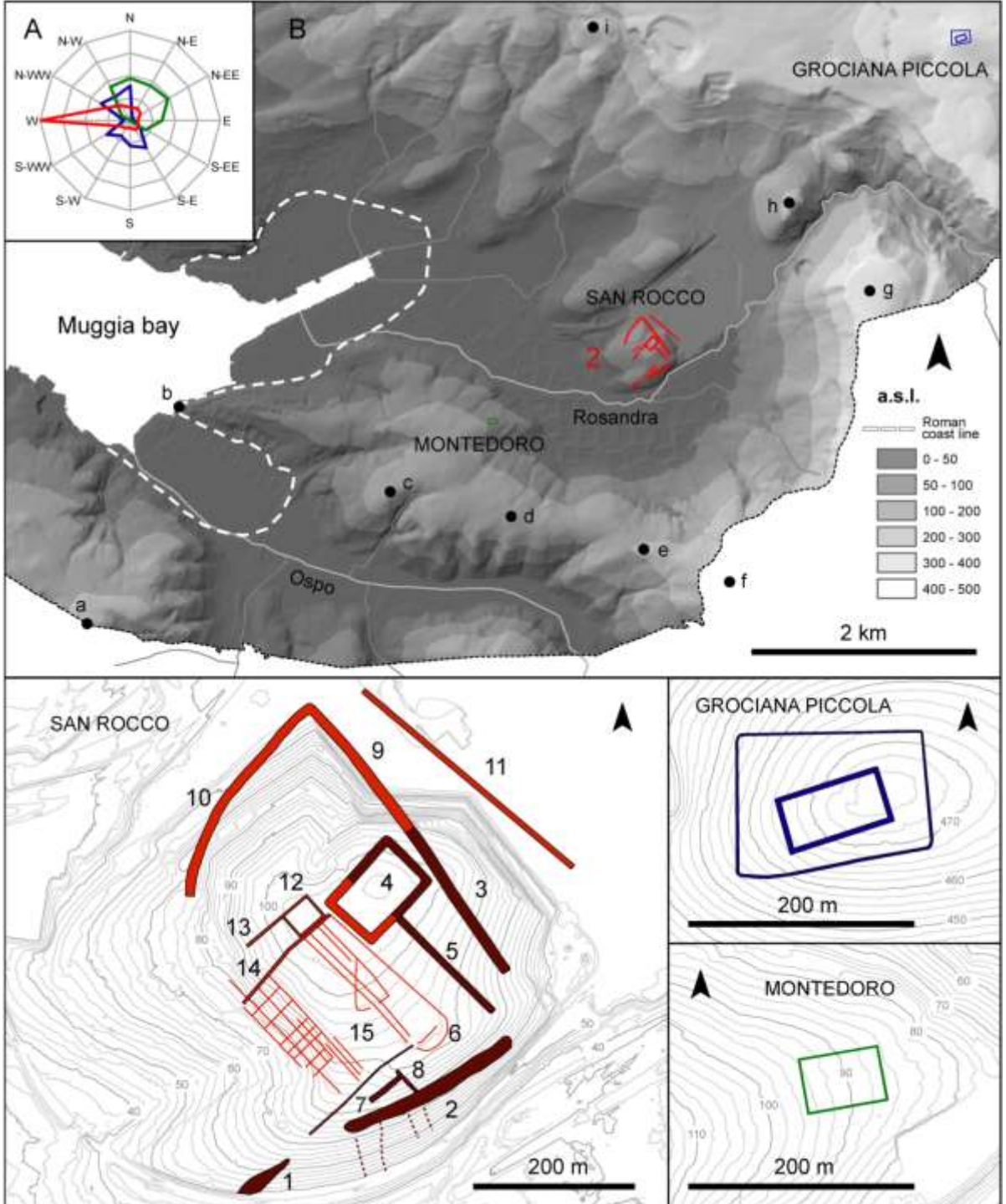

DSM
DTM

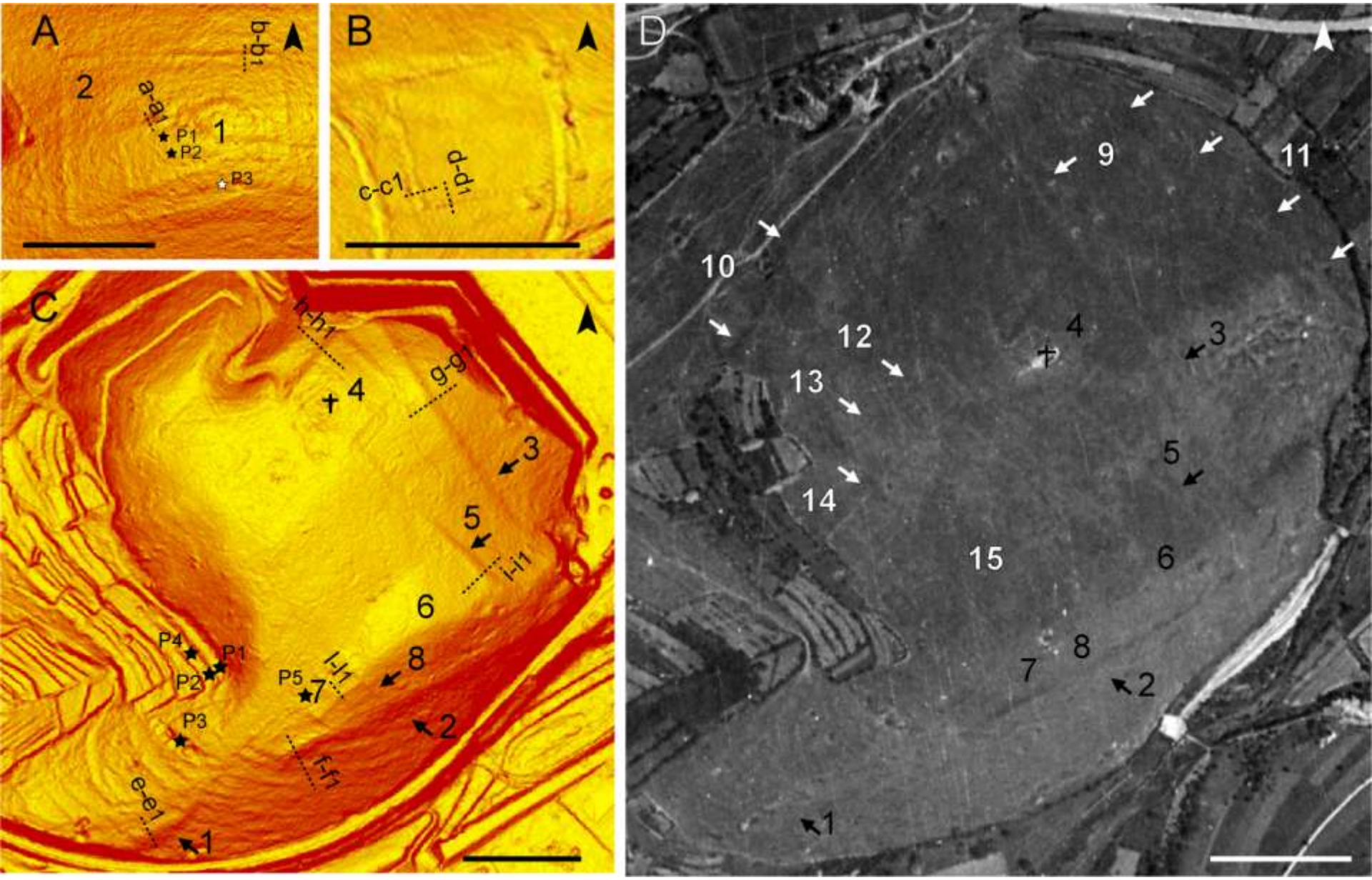




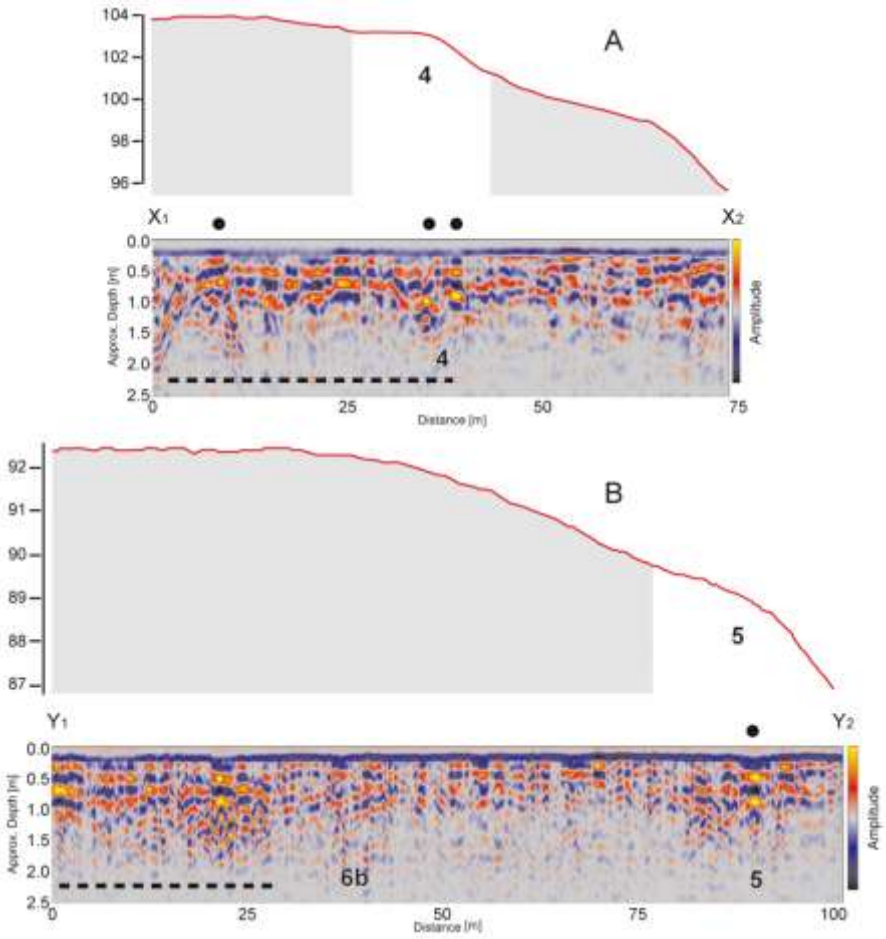
Bernardini F. et al 2013, Airborne LiDAR application to karstic areas: the example of Trieste province (north-eastern Italy) from prehistoric sites to Roman forts. *Journal of Archaeological Science* 40: 2152-2160.

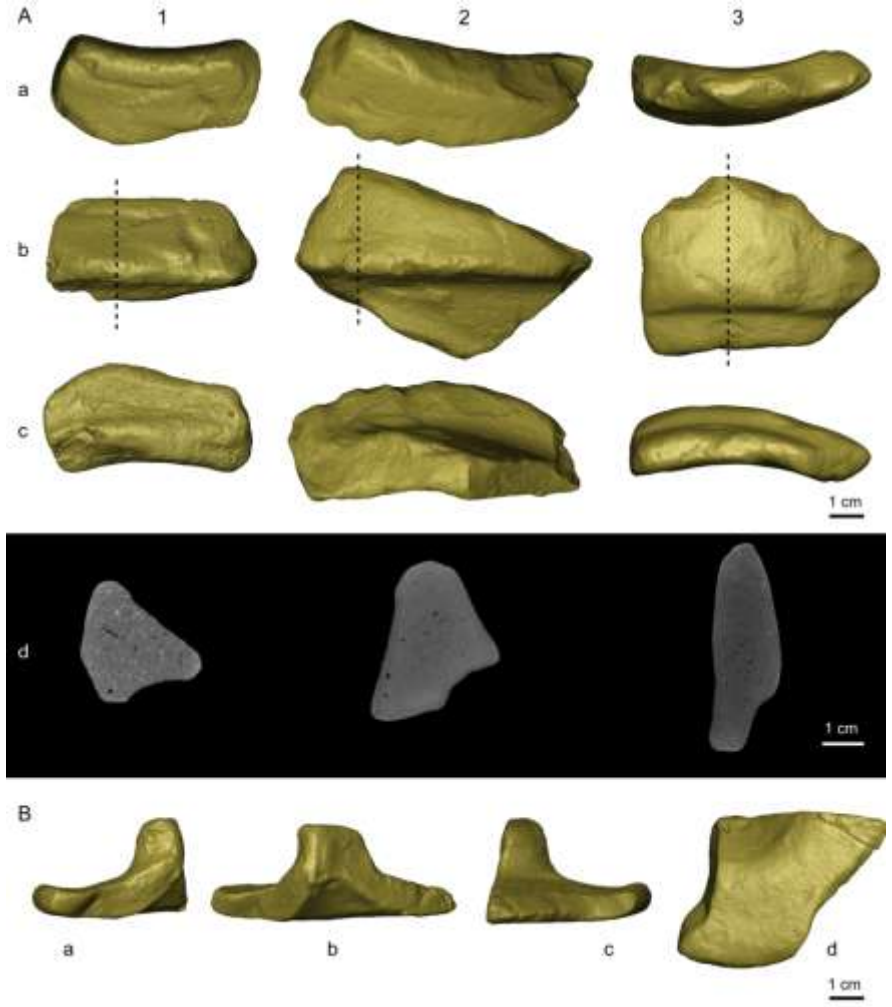
Roman shoe hobnail

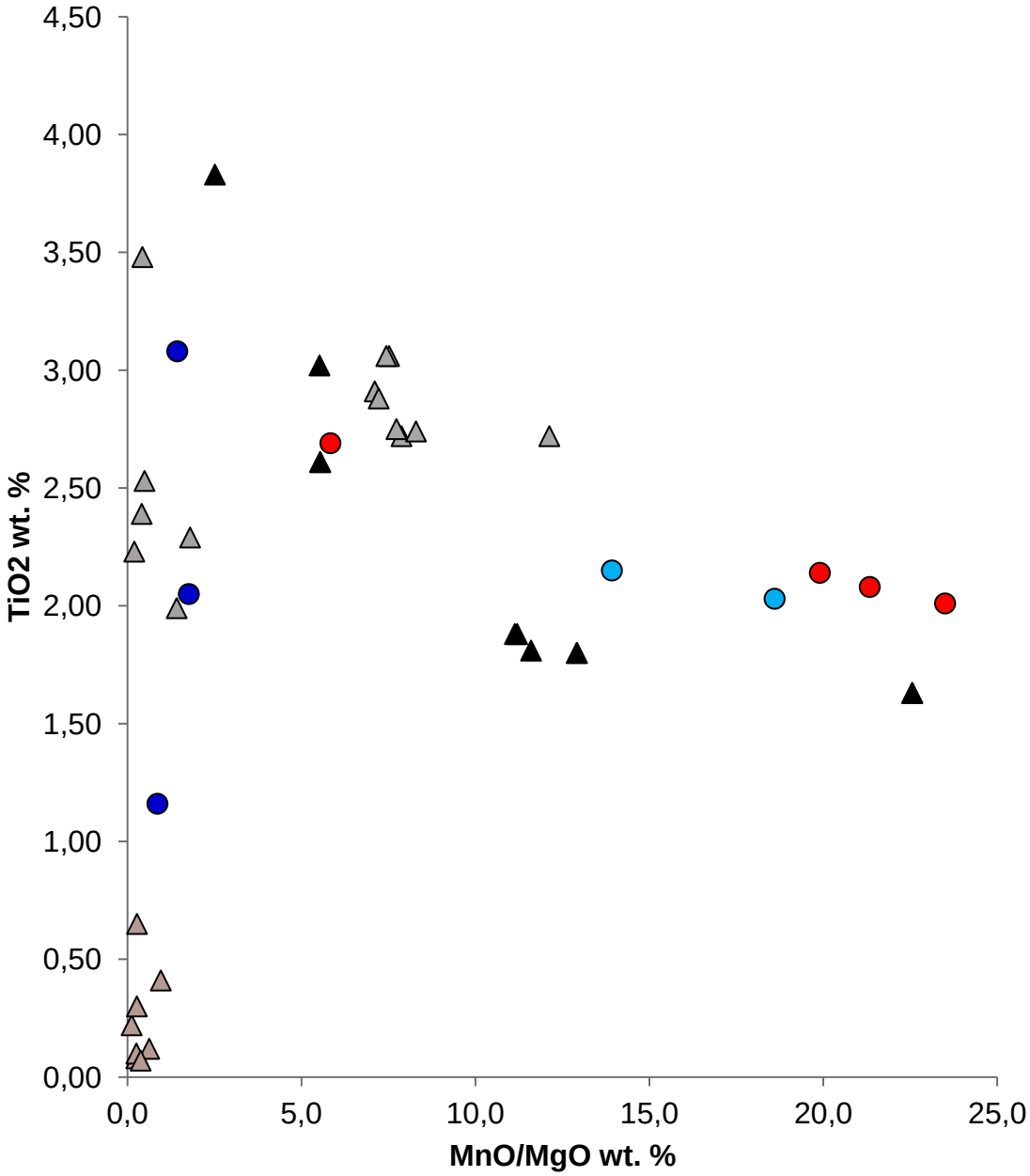

A
N
N-NW
N-NE
N-WW
N-EE
W
E
S-WW
S-EE
S-W
S-E
S
B
GROCIANA PICCOLA
SAN ROCCO
Muggia bay
Rosandra
MONTEDORO
Ospo
a
b
c
d
e
f
g
h
i
a.s.l.
Roman coast line
0 - 50
50 - 100
100 - 200
200 - 300
300 - 400
400 - 500
2 km
SAN ROCCO
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
200 m
GROCIANA PICCOLA
200 m
MONTEDORO
200 m


A
B
C
D
a-a1
b-b1
c-c1
d-d1
e-e1
f-f1
g-g1
h-h1
i-i1
l-l1
P1
P2
P3
P4
P5
B3
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

G. Zanettini


A
4
X1
X2
Approx. Depth [m]
Amplitude
Distance [m]
B
5
6b
Y1
Y2


A
1
2
3
a
b
c
d
1 cm
B


4,50
4,00
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
TiO2 wt. %
0,0
5,0
10,0
15,0
20,0
25,0
MnO/MgO wt. %

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PLOS ONE

Beeswax as Dental Filling on a Neolithic Human Tooth

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Abstract

Evidence of prehistoric dentistry has been limited to a few cases, the most ancient dating back to the Neolithic. Here we report a 6500-year-old human mandible from Slovenia whose left canine crown bears the traces of a filling with beeswax. The use of different analytical techniques, including synchrotron radiation computed micro-tomography (micro-CT), Accelerator Mass Spectrometry (AMS) radiocarbon dating, Infrared (IR) Spectroscopy and Scanning Electron Microscopy (SEM), has shown that the exposed area of dentine resulting from occlusal wear and the upper part of a vertical crack affecting enamel and dentin tissues were filled with beeswax shortly before or after the individual's death. If the filling was done when the person was still alive, the intervention was likely aimed to relieve tooth sensitivity derived from either exposed dentine and/or the pain resulting from chewing on a cracked tooth: this would provide the earliest known direct evidence of therapeutic-palliative dental filling.

Citation: Bernardini F, Tuniz C, Coppa A, Mancini L, Dreossi D, et al. (2012) Beeswax as Dental Filling on a Neolithic Human Tooth. PLoS ONE 7(9): e44904. doi:10.1371/journal.pone.0044904

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Competing Interests: The authors have declared that no competing interests exist.

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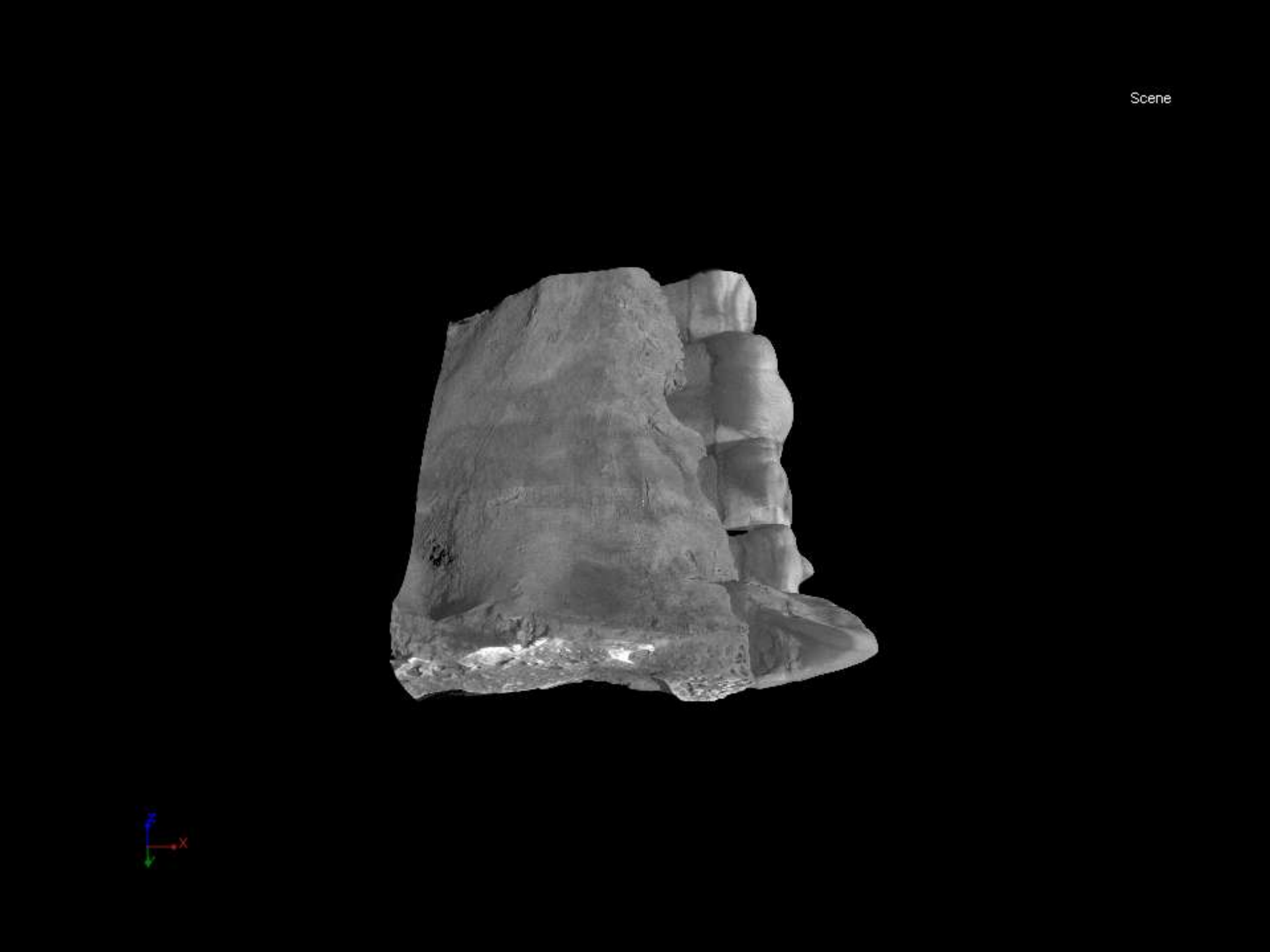
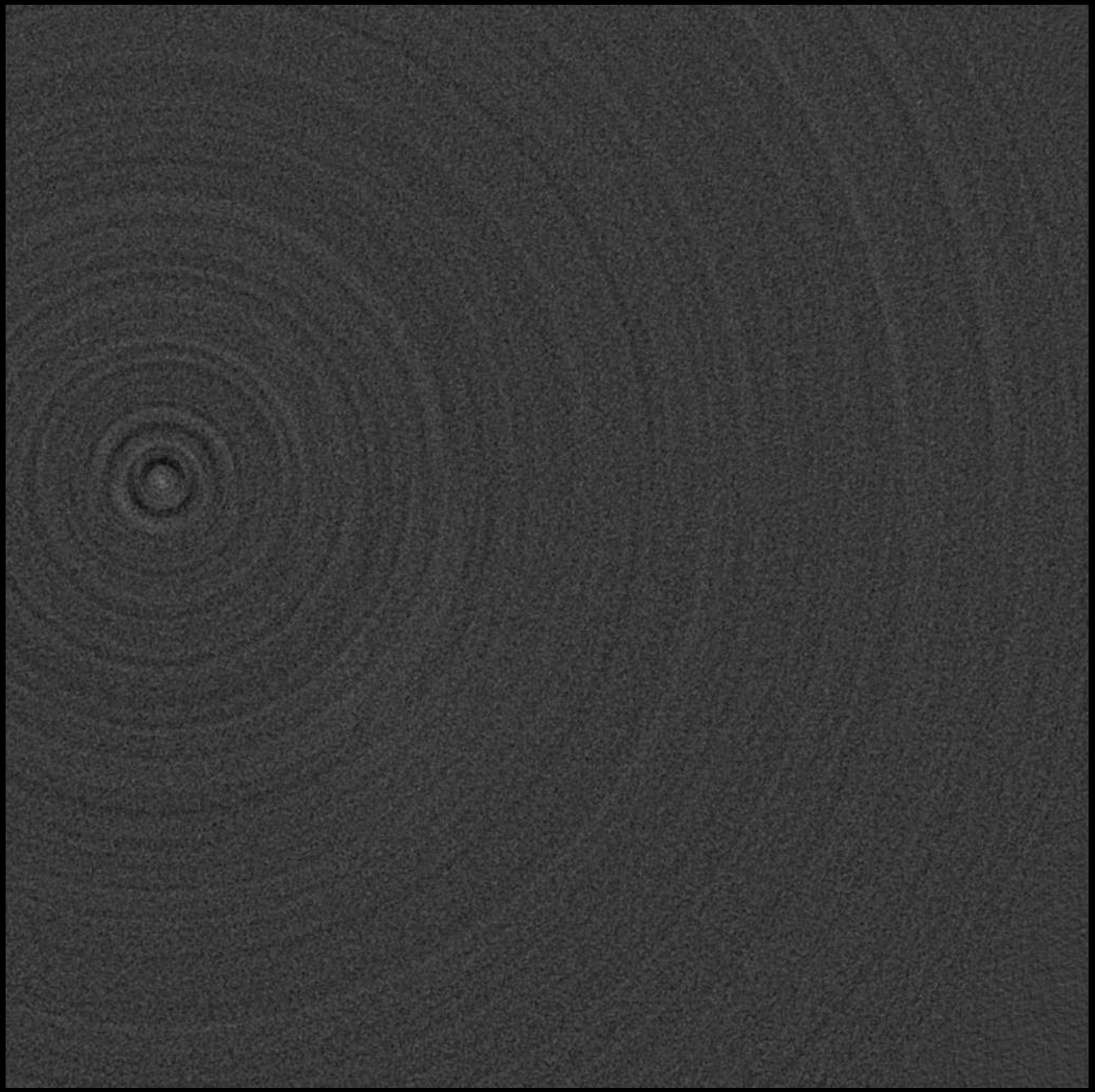
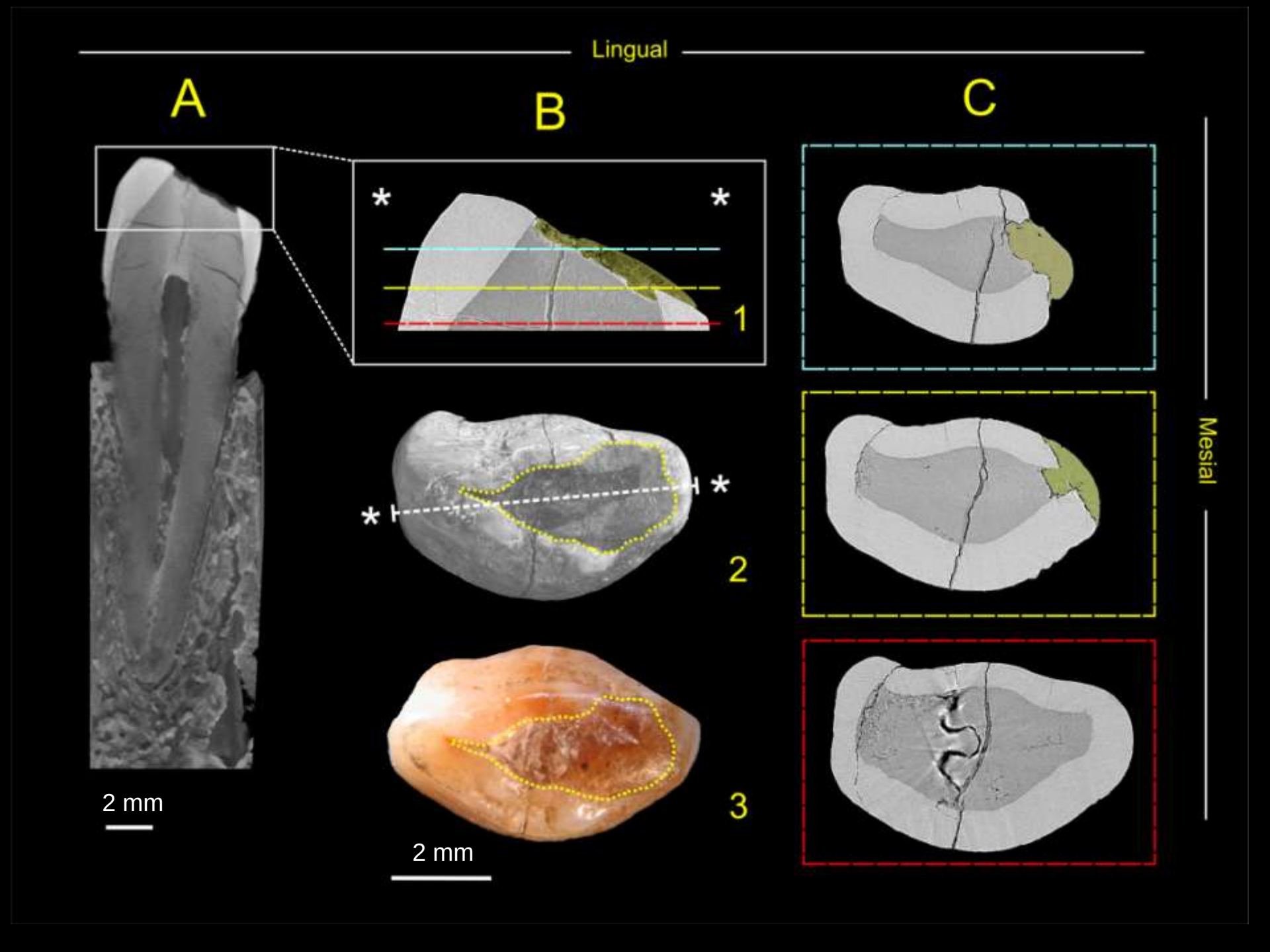
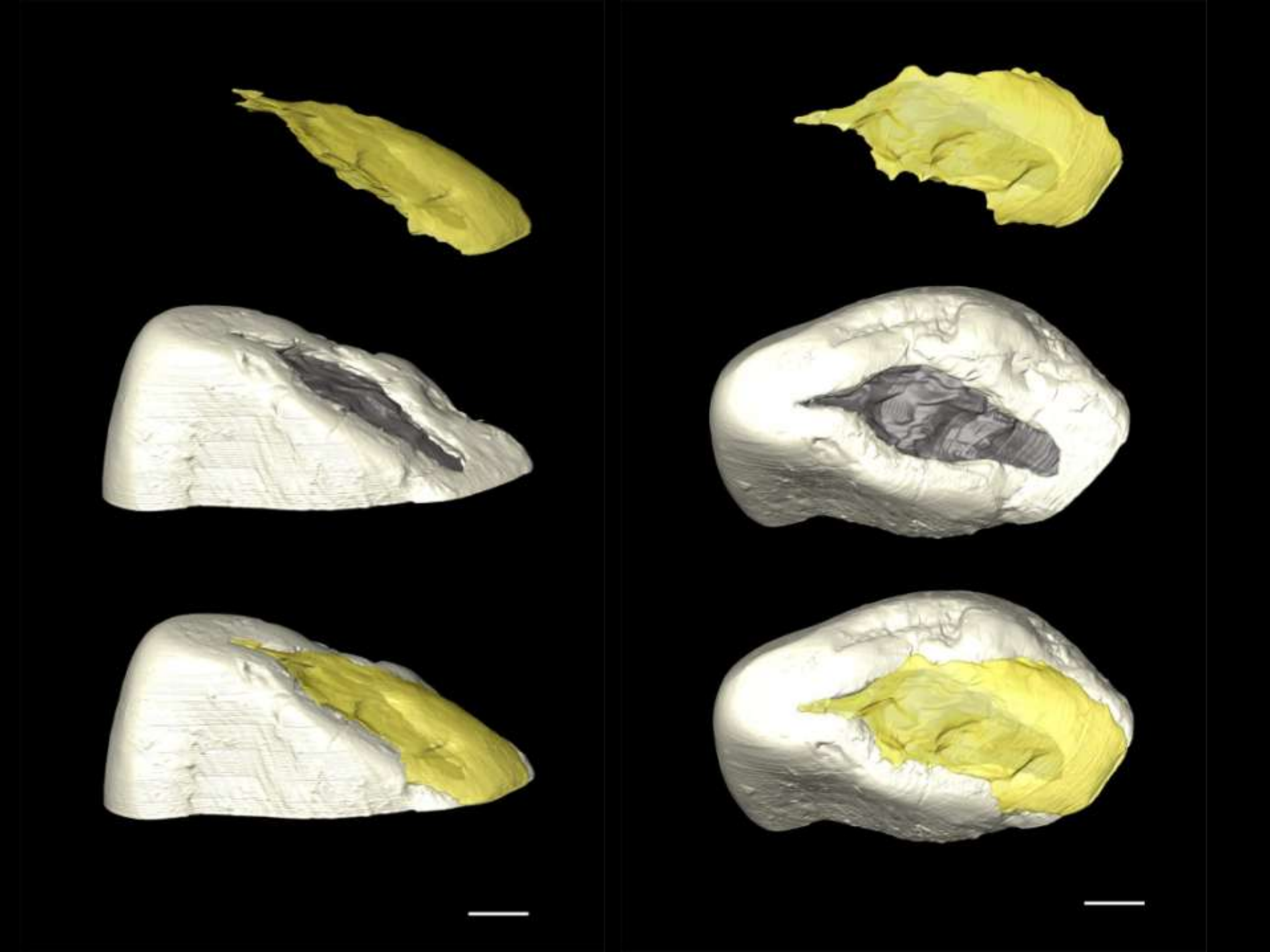
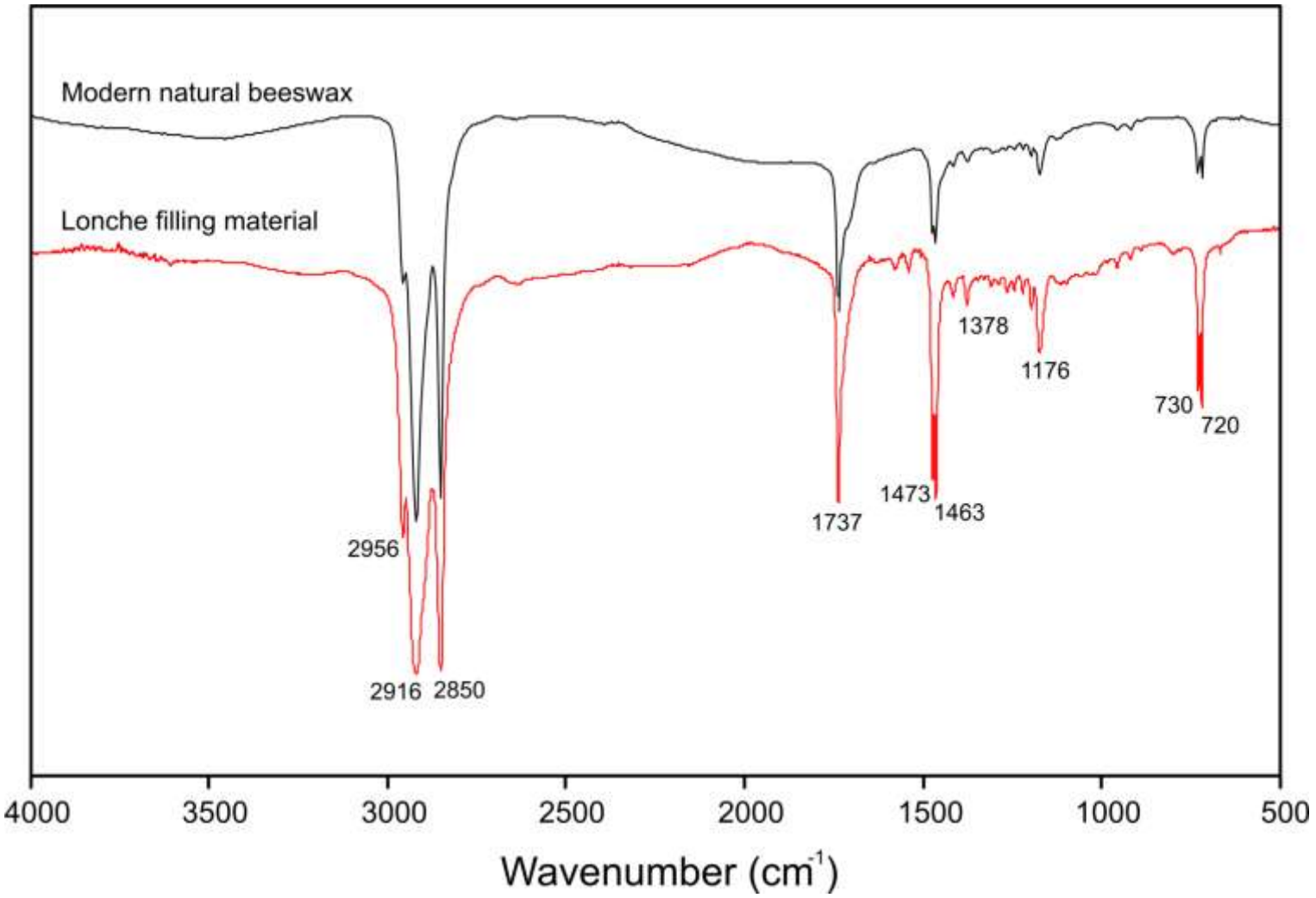
Elettra - Trieste


Scene
Z
X




Lingual
A
B
C
Mesial
1
2
3
2 mm
2 mm





Infrared spectroscopy

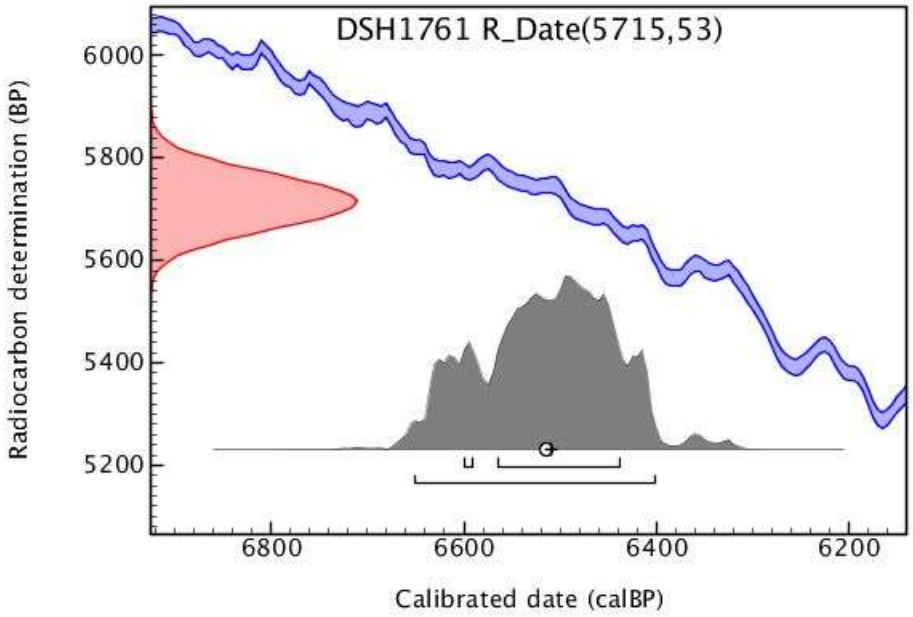
C*enter for* **I***sotopic* **R***esearch on* **C***ultural and* **E***nvironmental heritage*

a s e r t a

INNOVA
CENTRO REGIONALE DI COMPETENZA PER LO SVILUPPO ED IL TRASFERIMENTO DELL'INNOVAZIONE APPLICATA AI BENI CULTURALI E AMBIENTALI

DSA-SUN

Lucas Heights - Australia

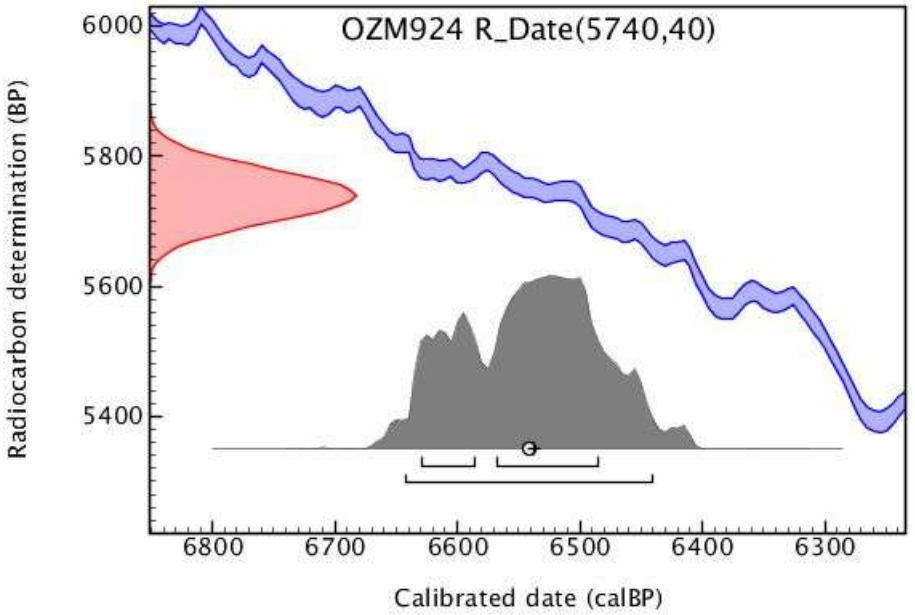


Beeswax:
4695-4453 BC (two sigma)

^{14}C measurements were performed using the STAR facility at ANSTO (Australia)

Mandible:
4688-4496 BC (two sigma)

^{14}C measurements were performed using the CIRCE AMS facility (Italy)



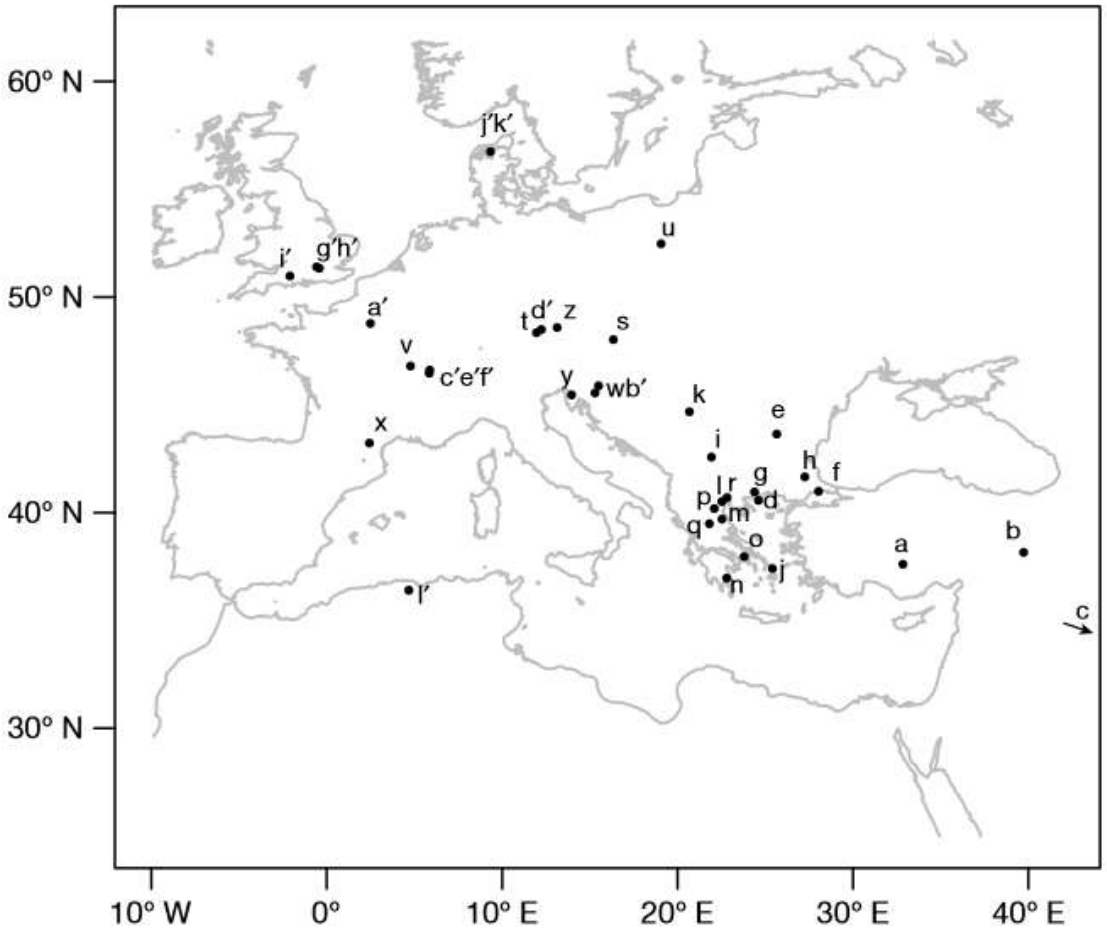
LETTER

doi:10.1038/nature15757

Widespread exploitation of the honeybee by early Neolithic farmers

Mélanie Roffet-Salque[1], Martine Regert[2], Richard P. Evershed[1], Alan K. Outram[3], Lucy J. E. Cramp[1,4], Orestes Decavallas[5,6], Julie Dunne[1], Pascale Gerbault[7,8], Simona Mileto[3,9], Sigrid Mirabaud[4]†, Mirva Pääkkönen[1,10], Jessica Smyth[1,4], Lucija Šoberl[1,11]†, Helen L. Whelton[1], Alfonso Alday-Ruiz[12], Henrik Asplund[13], Marta Bartkowiak[13], Eva Ilayer-Niemeier[14], Lotfi Belbouchet[15], Federico Bernardini[16,17], Mihael Budja[11], Gabriel Cooney[18], Miriam Cubas[19]†, Ed M. Danaher[20], Mariana Diniz[21], László Domboróczki[22], Cristina Fabbri[23], Jesus E. Gonzalez-Urquijo[19], Jean Guilaine[24], Slimane Hachi[25], Barrie N. Hartwell[26], Daniela Hofmann[27], Isabel Hohle[28], Juan J. Ibáñez[29], Necmi Karul[30], Farid Kherbouche[25], Jacinta Kiely[31], Kostas Kotsakis[32], Friedrich Lueth[33], James P. Mallory[26], Claire Manen[24], Arkadiusz Marciniak[13], Brigitte Maurice-Chabard[34], Martin A. Mc Gonigle[35], Simone Mulazzani[36,37], Mehmet Özdoğan[30], Olga S. Peric[38], Slaviša R. Peric[38], Jörg Petrasch[39], Anne-Marie Pétrequin[40], Pierre Pétrequin[40], Ulrike Poensgen[41], C. Joshua Pollard[42], François Poplin[43], Giovanna Radi[23], Peter Stadler[44], Harald Stäuble[45], Nenad Tasić[46], Dushka Urem-Kotsou[47], Jasna B. Vuković[46], Fintan Walsh[48], Alasdair Whittle[49], Sabine Wolfram[50], Lydia Zapata-Peña[12]‡ & Jamel Zoughlami[51]

The pressures on honeybee (*Apis mellifera*) populations, resulting from threats by modern pesticides, parasites, predators and diseases, have raised awareness of the economic importance and critical role this insect plays in agricultural societies across the globe. However, the association of humans with *A. mellifera* predates post-industrial-revolution agriculture, as evidenced by the widespread presence of ancient Egyptian bee iconography dating to the Old Kingdom (approximately 2400 BC)[1]. There are also indications of Stone Age people harvesting bee products: for example, honey hunting is interpreted from rock art[2] in a prehistoric Holocene context and a beeswax find in a pre-agriculturalist site[3]. However, when and where the regular association of *A. mellifera* with agriculturalists emerged is unknown[4]. One of the major products of *A. mellifera* is beeswax, which is composed of a complex suite of lipids including *n*-alkanes, *n*-alkanoic acids and fatty acyl wax esters. The composition is highly constant as it is determined genetically through the insect's biochemistry. Thus, the chemical 'fingerprint' of beeswax provides a reliable basis for detecting this commodity in organic residues preserved at archaeological sites, which we now use to trace the exploitation by humans of *A. mellifera* temporally and spatially. Here we present secure identifications of beeswax in lipid residues preserved in pottery vessels of Neolithic Old World farmers. The geographical range of bee product exploitation is traced in Neolithic Europe, the Near East and North Africa, providing the palaeoecological range of honeybees during prehistory. Temporally, we demonstrate that bee products were exploited continuously, and probably extensively in some regions, at least from the seventh millennium cal BC, likely fulfilling a variety of technological and cultural functions. The close association of *A. mellifera* with Neolithic farming communities dates to the early onset of agriculture and may provide evidence for the beginnings of a domestication process.


60° N
50° N
40° N
30° N
10° W
0°
10° E
20° E
30° E
40° E
j′k′
u
i′
g′h′
a′
t
d′
z
s
v
c′e′f′
y
wb′
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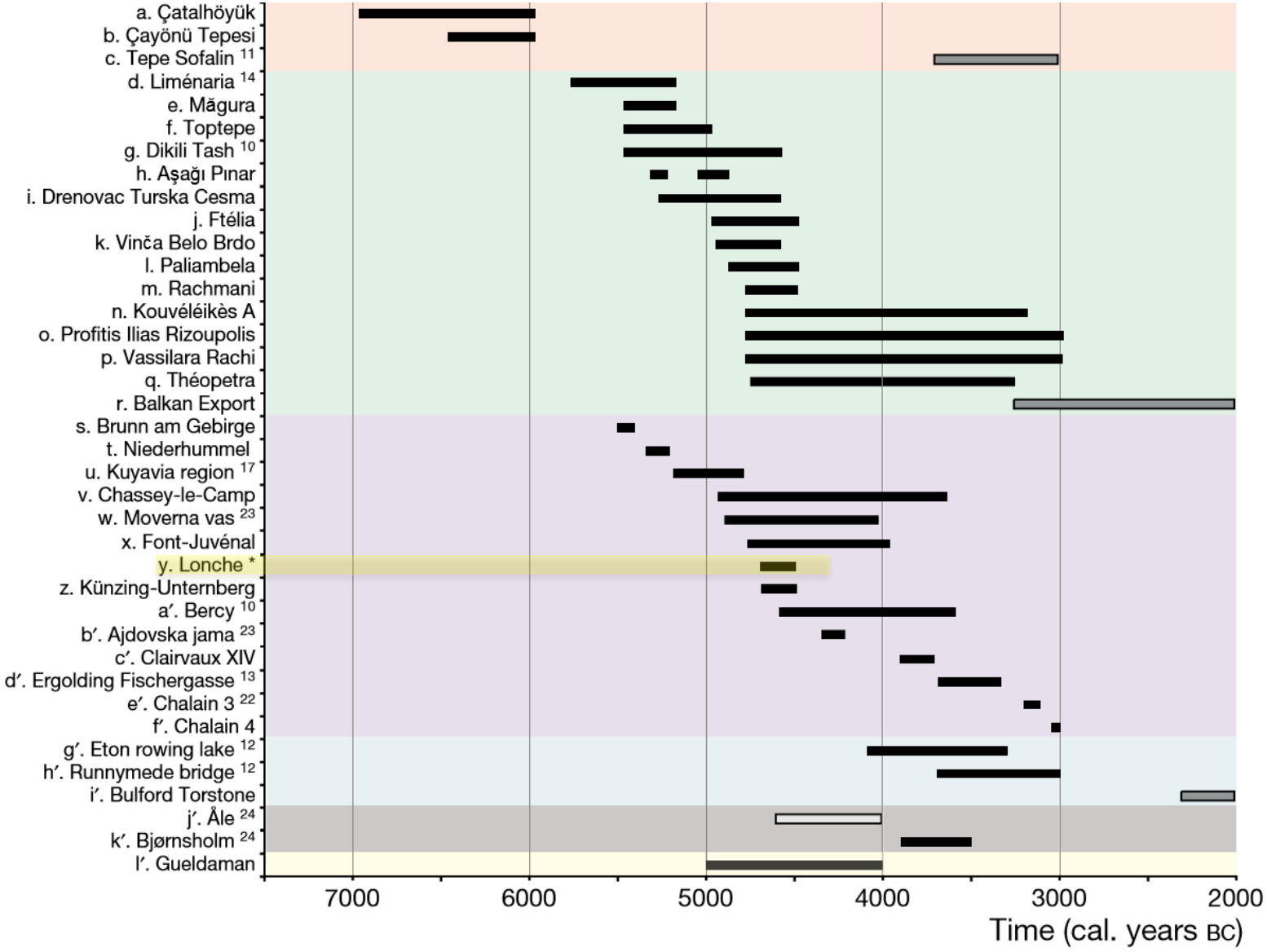
a. Çatalhöyük
b. Çayönü Tepesi
c. Tepe Sofalin [11]
d. Liménaria [14]
e. Măgura
f. Toptepe
g. Dikili Tash [10]
h. Aşağı Pınar
i. Drenovac Turska Cesma
j. Ftélia
k. Vinča Belo Brdo
l. Paliambela
m. Rachmani
n. Kouvéléikès A
o. Profitis Ilias Rizoupolis
p. Vassilara Rachi
q. Théopetra
r. Balkan Export
s. Brunn am Gebirge
t. Niederhummel
u. Kuyavia region [17]
v. Chassey-le-Camp
w. Moverna vas [23]
x. Font-Juvénal
y. Lonche *
z. Künzing-Unternberg
a′. Bercy [10]
b′. Ajdovska jama [23]
c′. Clairvaux XIV
d′. Ergolding Fischergasse [13]
e′. Chalain 3 [22]
f′. Chalain 4
g′. Eton rowing lake [12]
h′. Runnymede bridge [12]
i′. Bulford Torstone
j′. Åle [24]
k′. Bjørnsholm [24]
l′. Gueldaman
7000
6000
5000
4000
3000
2000
Time (cal. years BC)

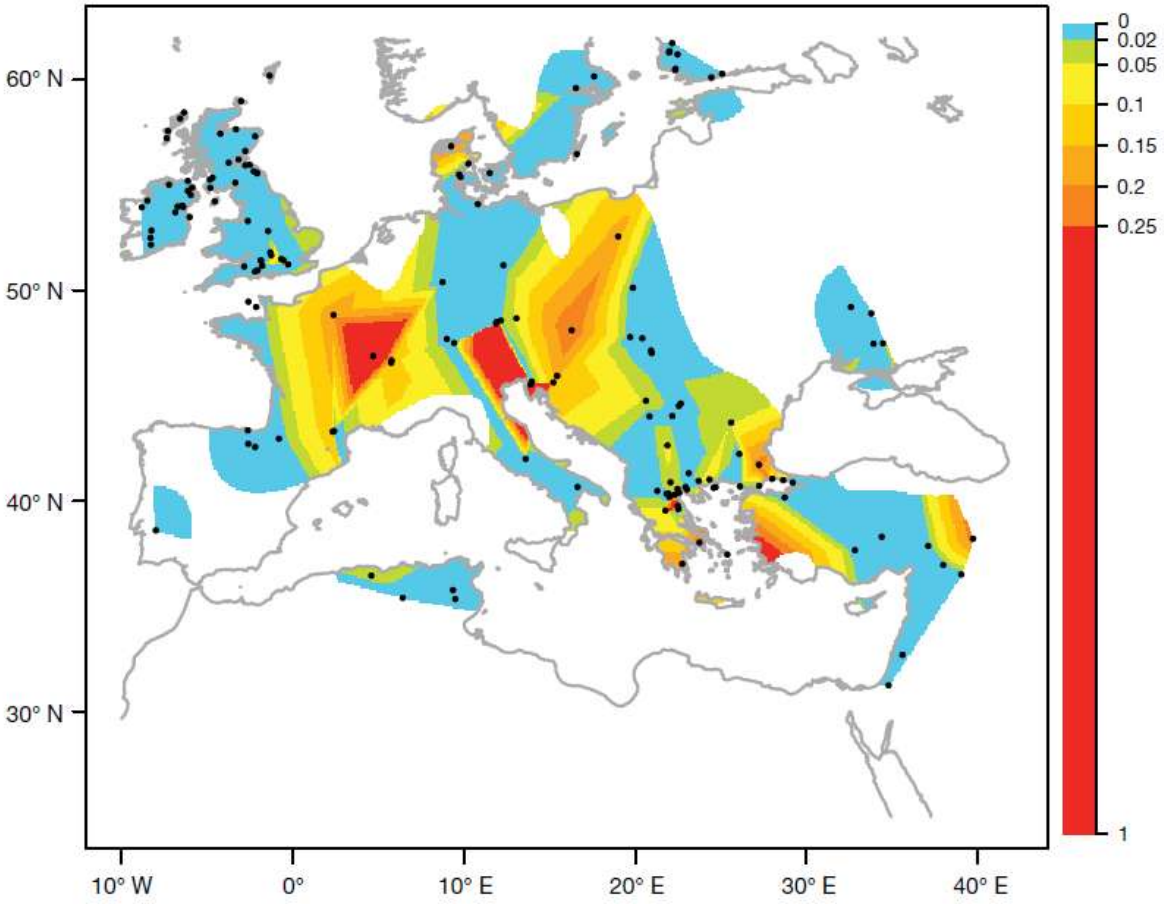

Figure 4 | Regional distribution of beeswax residues in potsherd lipid extracts. Interpolated map of Old World beeswax occurrences (proportion of beeswax residues per number of residues in pottery sherds, in percentages) during the Neolithic (including the Mesolithic sites available). Colours and colour key show the proportions of beeswax residues estimated by surface interpolation, where collection locations are represented by dots ($n = 154$).

Southern India


Thank you for your attention!