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Towards a re-appraisal of the Early Neolithic skeleton from Lama dei Peligni (Abruzzo, Italy). Computed tomography and 3D reconstruction of the cranium

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Summary – The skeleton referred to as Fonterossi 1 was found in 1913 near Lama dei Peligni, in Abruzzo (Italy). It probably belonged to an adult female of about 50 years, radiometrically dated to 6,540 +/- 80 years bp. The cranium was supposed in the past to represent a "proto-Mediterranean" morphotype. It is dolichomorphous in appearance, with a wide and bulging braincase associated with small facial structures and a rather gracile mandible. The skull was CT scanned for museological purposes and to analyse the anatomy of the inner volumes. The endocranial cavity is almost entirely filled by heterogeneous geological matrix, not always allowing the recognition of endocranial surfaces. In contrast, the maxillary and the frontal sinuses are clearly characterised, as well as the semicircular canals of the inner ear, and other structures. This paper is also aimed at briefly re-considering such an important specimen, which represents a potential source of information on Early Neolithic population dynamics in the Italian peninsula.

Keywords – *Computed tomography, Virtual paleoanthropology, Cranium, Fonterossi, Neolithic.*

Introduction

The anatomically modern skeleton, formerly known as "Uomo della Maiella" (the "Maiella man"), was found in 1913 near Lama dei Peligni (Abruzzo, Italy) during a survey of prehistoric sites conducted by U. Rellini along the eastern slope of the Maiella massif in the Apennines (Rellini 1914a).

It was found laying on the vault of a gallery during quarry extraction of limestone alluvial sands just before Rellini arrived on the site. Rellini was however able to collect a beautifully preserved cranium with mandible (already removed by the workmen), and a few postcranial elements still *in situ*. He could also examine the circumstances of the finding. The perimeter of the burial was still visible on the concretioned sandy vault of the artificial gallery, rounded by large stones. No grave goods were found, but for a couple of flint flakes. In order to appropriately investigate the sequence of geological layers above the burial, Rellini carried out a brief excavation that allowed him to recognise a series of clearly different strata mostly composed of gravel and

sands, and including – about 1.5 meters above the level of the human skeleton, and clearly distinguishable from it – the archaeological horizon of the Neolithic village already know as Fonterossi (Dall'Osso 1910; compare e.g. Radmilli 1975).

Thus, Rellini concluded for a "pre-Neolithic" age of the human skeleton, since it seemed possible to exclude any stratigraphic and archaeological connection between the burial and the extensive Neolithic assemblage above it (Rellini 1914a, 1914b, 1932). Manzi & Macchiarelli (1986) reviewed about one century of literature on the specimen (e.g., Sergi 1919; Messeri 1969; Facchini et al. 1984) and noted that its anthropological interpretation was largely influenced by such an imprecise chronological attribution. As a matter of fact, rather contradictory evaluations were expressed – including the reference to Neolithic *vs.* late Paleolithic or Mesolithic chronologies and to Cro-Magnon *vs.* Combe Capelle morphologies – preventing any clear identification of this "Maiella pre-Neolithic" human in the context of Italian prehistory.

An absolute dating was finally achieved (Manzi & Macchiarelli 1989), after the specimen was "re-discovered" within the worldwide-ranging cranial collections of the Museum of Anthropology "G. Sergi" at the University *La Sapienza* (Rome), where the specimen has always been preserved. A sample taken from the left humeral portion (OxA – 1958) was submitted to radiocarbon dating at the Radiocarbon Accelerator Unit in Oxford (UK), and the result was 6,540 +/- 80 bp (non calibrated years before present), indirectly supporting G. Sergi's claim that the skeleton from Lama dei Peligni provides the first evidence in Italy of the phenotype it represents – referred to as *Mediterranean* or *proto-Mediterranean* – "since the earliest Neolithic" (Sergi 1919).

Material and methods

A controversial specimen

The early Neolithic skeleton from Lama dei Peligni – or "Fonterossi 1", by the name of the site (according to the standard denomination of fossil hominids introduced by Oakley et al. 1971) – includes a beautifully preserved and fossilized cranium (Fig. 1), complete of the mandible. Only local damages are observed (mostly produced by the discoverers), which affect both the cranial vault and the face: there is a large breakage (800 mm^2) involving the right occipito-parietal region at the level of the

Fig. 1 - The cranium of Fonterossi 1 (Lama dei Peligni, Abruzzo) and its CT-based reconstruction; the drawing on the left is by Maurizio Mei.

intermediate segment of the lambdoid suture; a few extended fractures run along the vault, generally following coronal contours; the apex of the right mastoid is cracked; both the zygomatic processes of the temporal bones are missing; another rupture involves the maxillo-nasal region, especially on the left side; the lateral part of the left mandibular condyle is broken. In addition, the entire *prosthion* region was damaged and some anterior teeth were lost some time after the discovery and the first studies (circumstances unknown).

Some postcranial elements were also collected after the discovery, namely: the left tibia, fibula, talus, and two metatarsals (II and III); portions of both the tibia and fibula of the opposite side; a small diaphyseal segment of the left humerus; fragments of two cervical vertebras. All the skeletal districts appear highly fossilized, especially when compared to the relatively recent chronology of the burial.

After the original description by Rellini (1914b, 1932), only occasionally the specimen has appeared in the literature either in general overviews (G. Sergi 1919; S. Sergi 1941; Messeri 1969; Facchini et al. 1984; Mallegni 1987) or included among comparative samples (Battaglia 1944; Parenti 1957, 1960; Corrain et al. 1976). In addition – after a sporadic mention in a *Catalogue des hommes fossiles* (Blanc & Sergi 1953) – it is neither reported in the general catalogue of fossil hominids edited by the *British Museum* (Oakley et al. 1971) nor in critical reviews of the European fossil record referred to Late Pleistocene/Early Holocene chronologies (e.g. Newell et al. 1979).

More recently, cranial and dental features of Fonterossi 1 were re-evaluated by Manzi and Macchiarelli (1986). A new series of morphometric data were reported in that occasion, together with a new iconography of the specimen, and a number of descriptive observations. These included the first accurate determination of both the sex and age-at-death of the specimen – accordingly, the "Maiella man" resulted to be more probably an old-adult female, not yet senile, died between the fifth and the sixth decades.

The cranium: a brief overview

The cranium of Fonterossi 1 (see Fig. 1) shows a dolicomorphic, highly encephalised, and bulging braincase, apparently in contrast with the small facial skeleton and relatively gracile mandible.

The cranial vault is regularly rounded in lateral view, with only a slight depression above the lambda, contributing to the definition of an occipital bun. In the frontal bone, the glabella region is protruding, delimited by a supraorbital sulcus, followed in turn by the rounded profile of the frontal squama accentuated by the occurrence of bilaterally expressed frontal eminences. The parietal eminence of both sides are also strongly expressed, describing a typical *en-maison* shape of the cranium when viewed from behind, with sub-parallel or even converging lateral walls. The occipital upper scale and the nuchal plane together form a uniform curved profile in lateral view; however, despite the bulging appearance of the entire squamous part, the surface of the bone is characterized by the well defined impressions of supreme, superior, and inferior nuchal lines, in contrast with the smoothed expression of both the occipital protuberance and crest. Both the mastoids are quite small, whereas the supramastoid and angular ridges are fairly marked, and the temporal lines are clearly visible either on the parietal or on the frontal surfaces. The cranium shows a plagiocephalic asymmetry, with slighter frontal-left and more considerable occipital-right protrusions. Thickness of the vault bones is exceptional – values of about 12 and 13 mm are recorded in correspondence of the large break across the right lambdoid suture.

The cranial base apparently reflects the general asymmetry of the vault, as demonstrated by the diverse position and morphology of the two glenoid cavities (mirrored by the different morphology of the mandibular condyles) – the left one being more advanced, with better defined contours and more preserved surfaces than the right one. Bilaterally (but especially on the right side), the digastric grooves are only weakly expressed. On the maxillary arcade most part of the teeth are preserved,

and detailed examination of tooth wear may be carried out. Even in this case, asymmetry is observed when the two molar series are compared, clearly showing deeper effects of dental attrition on the right side.

All the sutures of the cranial vault are closed. Particularly, the degree of synostosis of the entire coronal suture and that of segments of both the sagittal and lambdoid sutures is so advanced that it obscures their identification on the external surface of the cranium. There is also the occurrence of a weakly expressed palatine torus and of a small wormian ossicle at the left parietal notch.

The face is small compared to the volume of the neurocranium; in addition, the *nasion-prosthion* axis is vertically oriented. As a result, the facial skeleton disappears completely when the cranium is viewed from above. In frontal view, the orbits are rather squared in shape and the nasal aperture appears morphometrically balanced with a well defined and sharp inferior margin. The canine fossa is deep bilaterally, although on the left it is accentuated by an ancient *postmortem* fracture of the bony surface. Despite the entire *prosthion* region is missing, most part of the teeth are preserved, including the complete series of maxillary molars of both sides and the premolars on the left; also the roots of the right premolars are still *in situ*, as well as those of the two canines.

The mandible is antero-posteriorly elongated, with a mental protuberance rather massive and protruding, yet rounded. The body is high, while the ascending ramus is low and oblique. The articulation surfaces of both the condyles are flattened, especially on the right side where some evidence of arthritic deformation may be also considered. The coronoid processes are higher than the condyles and slightly diverging. It may be also recorded the bilateral occurrence of weak mandibular torus (in correspondence of the premolars) and absence of the mylohyoid groove, with horizontal medial margin of the mandibular foramen. The mandibular teeth are entirely preserved; only the left M1 is missing because of *ante mortem* tooth loss and complete alveolar remodelling. Asymmetry in dental wear – with the right side being more affected than the left one – is observed here in a similar degree (or even more stressed) to the maxillary dental arcade.

CT-based recording of the cranium

The skull has been CT scanned and virtually reconstructed, according to the recent computed imaging and "virtual anthropology" techniques (Zollikofer et al., 1998; Recheis et al., 1999; Spoor et al., 2000). The scanning procedure has been performed using a Tomoscan AUEP, Phylips. Sequential and contiguous slices (slice thickness: 1 mm; slice increment: 1 mm) have been sampled on the transversal plane for the cranium (according to the Frankfurt horizontal) and the coronal plane for the mandible (resting on the corpus). The scan was performed at 75 mA and 140 kV, on a 512 pixel square matrix, 0.45 mm/pxl resolution, no gantry tilt, and no filters. Images have been exported as DICOM files. Attenuation spectrum, densitometric analyses, slices visualisation, segmentation, and virtual reconstruction have been computed by MIMICS 7.0, by *Materialise*. The scale ranges from 0 to 4096 Hounsfield units (Hu).

Results and discussion

CT data and virtual reconstruction

The tomographic images (Figs. 2 and 3) of Fonterossi 1 show that both the neurocranium and the face are pervaded by sediments of heterogeneous nature, mainly composed by concretioned sand mixed with small and irregular rocky elements. The endocranial cavity, in particular, is almost completely filled with these sediments, with the exclusion of some posterior areas probably cleaned after the discovery (since they have always been accessible to mechanical intervention from both the foramen magnum and the large breakage in the right occipito-parietal region).

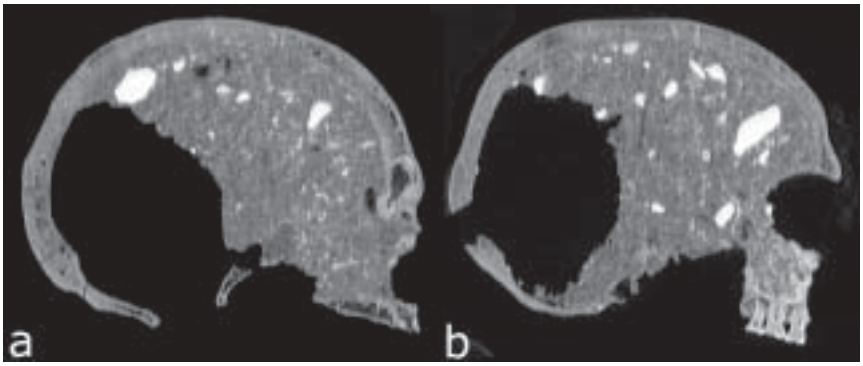

Fig. 2 - Tomographic mid-sagittal (a) and parasagittal (b) slices of the cranium. Note the internal volumes pervaded by sediments, that in many areas – especially across the entire cranial base and in the face – are not distinguishable from the bony elements. The remarkably thickness of the cranial vault bones, the right frontal sinus, the molar teeth (right side of the cranium) are visible; note also the heterogeneous composition of the geological matrix.

The fossilized bony tissues and the geological matrix display densities that roughly ranges between 800 and 3000 Hu (mean and standard deviation = 1757 ± 358 Hu). The dental elements furnish the highest values of this interval (2954 ± 344 Hu), with the internal pulp volumes at lower levels (between 2400-2800 Hu) and the enamel caps close to the overflow threshold (fixed at 4096 Hu). Similarly, the small crushed stones included in the sediments reach high values, ranging above 3000 Hu (3563 ± 314 Hu).

The attenuation values of the densitometric profile reported in Figure 4 are homogeneously distributes, describing a curve with a single pick at about 1700 Hu. In many regions, the identification of the exact surface of contact between the fossilized anatomical structures and the sediments unfortunately rests on a rather subjective ground, being not identifiable by means of densitometric filters. Thus, the bony elements and the geological matrix cannot be effectively distinguished on the basis of these tomographic data.

However, the occipital areas cleaned from the sediments allow the tomographic inspection of the superior sagittal sinus, that turn toward the right lateral sinus. Close to this anatomical region, it may be noted the presence of a deep fracture involving both the left parietal and the occipital, running longitudinally across the left side of the occipital squama, touching the internal occipital protuberance, and connecting with other smaller fractures in relation with the breakage on the other side as well as with the foramen magnum. Differently from other lines of fracture that involve the entire vault, ancient and cemented by the sediments, this one is recent and was probably produced at the moment of the discovery. Its occurrence suggests caution as far as the preservation of the specimen is concerned.

Despite the geological matrix pervades great part of the internal volumes of the cranium, some structures may be recognized and described. Great part of the profile of the internal layer is distinguishable in the braincase and the thickness of the cranial vault bones can be measured in detail, demonstrating that Fonterossi has exceptional values for this parameter not only in the parieto-occipital region (as already reported). For instance, thickness of the frontal squama was measured at the *metopion* and in correspondence of the parietal eminences, showing average values of 13 and 8 mm respectively. In a recent population sample, these same areas show average values of 7.5 and 6 mm (Bruner *et al.*, 2003). The parietal eminences in the Fonterossi cranium show average thickness of 6 mm (thinner on the left side), but the parietal bones

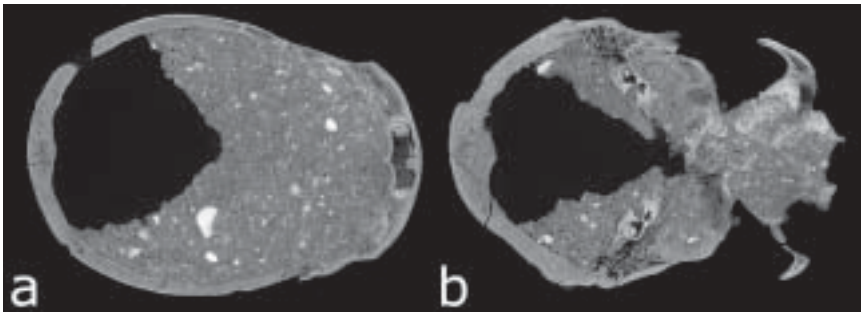

Fig. 3 - Tomographic transversal sections of the cranium. Note here the frontal sinuses, the semicircular canals and cochlea, the cancellous layers of the petrous pyramids, and the morphology of the maxillary structures.

reach the figure of 13 mm near the sagittal suture, while the thickness of the occipital squama ranges from 9 to 13.5 mm.

Looking at the cranial base, the *crista galli* is clearly identifiable and shows a considerable degree of pneumatisation. The maxillary sinus and all the internal volumes of the right side of the face are entirely filled with sediments, whereas the left ones are empty. The distinction between the two components matches exactly the mid-sagittal plane – this evidence apparently requires a taphonomic interpretation.

The frontal sinuses are fully identifiable on both sides and their volumes can be virtually reproduced and tri-dimensionally examined. They appear fan-shaped

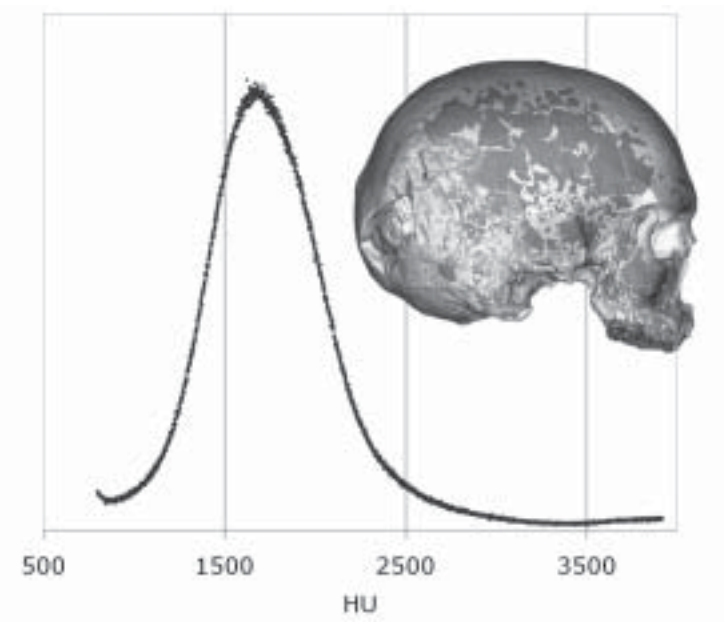

Fig. 4 - Attenuation spectrum expressed in Hounsfield units (Hu), showing a unimodal distribution at 1700 Hu; the virtual reconstruction of the skull in right lateral view shows the more dense component of the geological matrix included inside the endocranial cavity and into the right maxillary sinus.

(according to the categories introduced by Szilvassy, quoted in Hauser & De Stefano 1989) and exhibit large dimensions. However, they are not developed laterally (total width in upper view = 39.5 mm), with a vertical height of 25.0 mm. Their general morphology is therefore laterally compressed, rather globular, and corresponds on the external surface to the protrusion of the *glabella* region, which is not associated with any special extension of the supraorbital arcades. The two sinuses are asymmetrically developed, the right one being much larger (width = 24.5) than the left one (width = 16.5 mm).

The bony pneumatisation of the mastoid regions is weak (compared for instance to the Late Pleistocene African specimen from Nazlet Khater; Bruner & Manzi 2002), while in the petrous portion of the temporal bones the cancellous components are more represented in the bony structure. The structures of the inner ear are also clearly recognizable and may be examined in some detail (Fig. 5).

The inner and outer morphology of the mandible are easily outlined, with a good resolution of the trabecular layers and dental elements (Fig. 6).

Conclusions

Clearly, the main goal of CT-scan and virtual reproducing fossil findings – be they human or not – is to make them available for scientific purposes (including data, iconography, and stereolithographic reproductions for museological and museographic goals), as well as to allow further and more sensible analyses on those particular specimens.

Especially, this is important when the CT-scanned fossil finding represents a unique evidence. This is the case for the so-called "Maiella man", an adult female skeleton dated to the 7th millennium bp, probably referable to Early Neolithic horizons, maybe in relationship with an ancient occupation predating the Neolithic village of Fonterossi (Lama dei Peligni, Abruzzo), whose remains are abundant in layers above the skeleton (Dall'Osso 1910; Geniola, 1990, 1998).

More in general, the region where the site is located is also well known for important findings – both archaeological and anthropological – at the boundary

Fig. 5 - CT-based reconstruction of the Fonterossi 1 cranium (oblique and frontal views). The volumes of the frontal sinuses are shown through the virtual transparency of the skull.

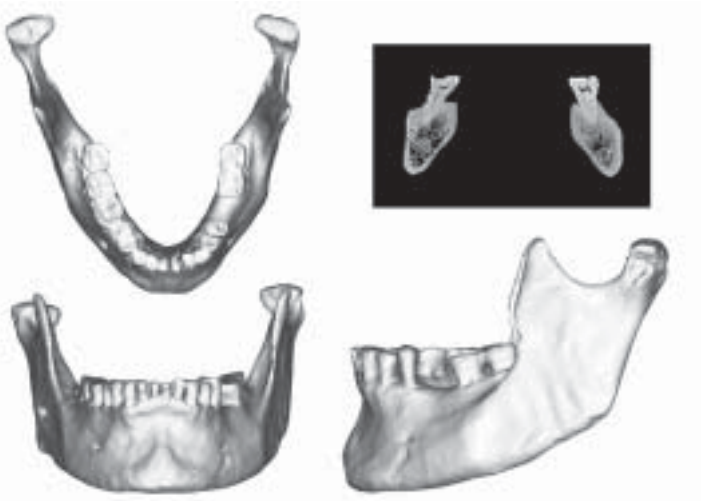

Fig. 6 - CT-based reconstruction of Fonterossi 1 mandible (upper, frontal, and left lateral views); the CT slice shows a coronal section through the second molars.

between the late Paleolithic and the earliest Neolithic (e.g. Radmilli 1977; Newell et al., 1979; Facchini et al. 1984; Mallegni 1987). It represents a rather neglected evidence as far as the population, economic, and cultural transition from hunter-gatherers to Neolithic farmers occurred in Italy (e.g. Ammerman & Cavalli Sforza 1984). We are dealing in fact with the uncommon and interesting opportunity to investigate the bio-cultural interactions occurred across the peninsula in correspondence with the (if any) arrival of demic wave/s from the Levant.

Our hope is that the present collection of new data on such an important fossil skeleton – especially on its esocranial and endocranial morphology – might stimulate new researches on both this particular specimen and the related micro and macro-regional population dynamics.

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ABSTRACT

Per un riesame dello scheletro "pre-neolitico" di Lama dei Peligni (Abruzzo, Italy). Tomografia computerizzata e ricostruzione tridimensionale del cranio

Riassunto – Lo scheletro denominato Fonterossi 1 fu rinvenuto nel 1913 presso Lama dei Peligni, in Abruzzo. Può essere attribuito a una donna adulta di circa 50

anni ed è stato datato radiometricamente al 6540 ± 80 bp . Il cranio è stato riferito a un morfotipo "proto-Mediterraneo". Si presenta dolicomorfo, con volta voluminosa e globulare associata a distretti facciali di piccola taglia e a una mandibola relativamente gracile. Il cranio è stato sottoposto a tomografia computerizzata, sia per finalità museologiche sia allo scopo di analizzare l'anatomia dei volumi interni. La cavità endocranica è quasi interamente riempita di un sedimento eterogeneo, che non sempre permette la risoluzione delle superfici endocraniche. Al contrario, i seni mascellari e frontali sono chiaramente distinguibili, come i canali semicircolari dell'orecchio interno e altre strutture. Questo lavoro è finalizzato a riconsiderare brevemente un reperto importante, in quanto rappresenta una potenziale fonte di informazione sul primo popolamento neolitico della penisola italiana.

Parole chiave – Tomografia Computerizzata, Paleoantropologia virtuale, Cranio, Fonterossi, Neolitico.

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