EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** **SC1340:** X ray µCtscan for quantitative analysis of the cortical bone structure and trabecular patterning of the tibia in extant and fossil primate. **SC1455:** X ray µCtscan for quantitative analysis of the cortical bone structure and trabecular patterning of the human fossil proximal	**Experiment number**: SC1340 SC1455
Beamline: ID17	**Date of experiment**: from: 28/11/03 to: 02/12/03 (SC1340) from: 02/04/04 to: 06/04/04 (SC1455)	**Date of report**: 01/09/04
Shifts: 2x 12 = 24	**Local contact(s)**: Alberto BRAVIN & Christian NEMOZ	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

High resolution microtomographic experiments (**SC1340-SC1455**) at the medical **ID17** beam line have been requested to contribute, in an innovative way, to the current animate debate on the postural behavior and locomotor modes of our extinct hominoid/hominid ancestors (Lovejoy *et al.*, 2002; Nakatsukasa, 2004), as well as of our own genus, *Homo*.

According to the established relationships between inner bone structure/architecture and biomechanical function of the mammalian skeleton, where bone functionally adapts to the magnitude and orientation of stress and strain, non invasive µCT systems offer the possibility to open an original 3D window on the inner bone topographic variation. For the first time in such domain of study, our research team has utilized the µCT system set at the ESRF in order to quantify the site-specific structural properties of the proximal tibia in some primate taxa (including extant humans) which experience different biomechanical constraints.

During the first experiment (SC1340, 28th Nov.-2nd Dec. 2004), we have basically tested the feasibility and reliability of the synchrotron radiation investigative tool on a selected number of recent/modern bones. By means of the second one (SC1455, 2nd-6th Apr. 2004), we have (i) enlarged our extant reference sample and, mostly, (ii) we have successfully experienced our original analytical protocol on a fossil sample. It included: two 7.5 million-year-old ape femurs (belonging to the taxon *Oreopithecus*), 9 hind limb bones of Pleistocene monkeys, and one neanderthal tibia from La Ferrassie, France (Fig. a). As a whole, 55 specimens representing 11 extant and 3 extinct species (Tab. 1) have been detailed (~350 Gb of raw data). The bones belong to the following institutions: Musée de l'Homme, Paris; Museum National d'Histoire Naturelle, Paris; Lab. Anthrop. Pop. Passé, Univ. de Bordeaux I; Museo Nazionale Preistorico Etnografico, Rome; Lab. Paleont., Univ. of Florence; Lab. of Phys. Anthrop., Univ. of Kyoto.

Our preliminary results confirm the validity of this pioneering analytical approach. In facts, even on fossil bones which have suffered post-mortem damages, the ESRF µCT system has been capable to record a inner structural signal suitable for biomechanical interpretation. According to the current debate, this result is of great potential value in paleobiological research.

Following the preliminary analytical phase at the ESRF, we have worked at the high resolution 3D-reconstruction of the investigated specimens. Accordingly, a set of coronal and transverse cross-sections have been selected (Fig. b). On this numerical support, the thickness variation of the "cortico-trabecular complex" - *i.e.*, the internal space under the articular surface which includes both the cortical bone and the most dense part of the underlying trabecular network – has been topographically quantified and mapped (Fig. c). This cancellous bone portion is characterized by plate-like struts and it is differentiated from the remaining part of the sub-articular spongy bone, which shows a rod-like conformation with a more open trabecular lattice.

Results show functionally-related patterns of bone thickness distribution occurring at the tibial plate in both extant and fossil specimens. This original, previously unreported evidence well correlates with documented variation in primate and human locomotor behaviors.

Further steps of this research project foresee the analysis of the 3D distribution (degree of anistropy, bone density) of the trabecular network underlying the compact "cortico-trabecular complex".

The high-quality structural information successfully extracted by means of the ESRF µCT system has been reported by our research groups at different national and international meetings (*1829ième Réunion Annuelle Soc. Anthropol. Paris* [Jan. 2004]; *3D Modeling 2004* [Paris, Apr. 2004). Also, a part of our database is currently under elaboration within the frame of a PhD thesis at the Univ. of Poitiers (by A. Mazurier) and will be reported at the following meetings: *1830ième Réunion Annuelle Soc. Anthropol. Paris* (Jan. 2005), *74th Annual Meeting American Ass. Phys. Anthropol.* (Apr. 2005).

investigated taxa	***specimens***
Homo sapiens	13 tibias including 6 immatures and two pathological cases (healed fracture and rachitism, respectively)
Homo neanderthalensis (fossil)	1 tibia
Pan troglodytes	5 tibias, including 2 immatures
Gorilla gorilla	3 tibias, including 1 immature
Pongo pygmaeus	3 tibias, including 1 immature
Hylobates concolor	3 tibias, including 1 immature
Papio cynocephalus	3 tibias, including 1 immature and 1 pathological case
Macaca fuscata	2 tibias & 2 femora
Macaca fascicularis	2 tibias & 1 femur
Theropithecus gelada	4 tibias, including one pathological case
Colobus angolensis	1 tibia
Pygathrix nemalus	1 tibia
Oreopithecus bambolii (fossil)	2 femora belonging to the same individual
Macaca majori (fossil)	5 tibias & 4 femora

Tab. 1

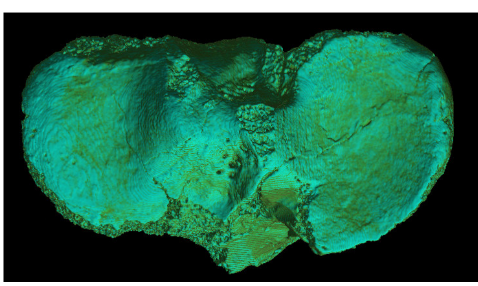

Fig. a

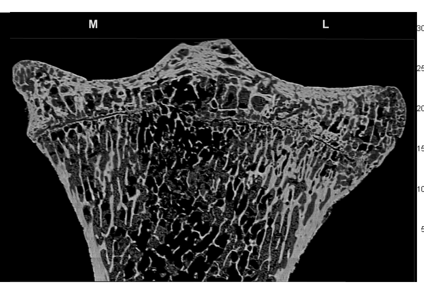

Fig. b

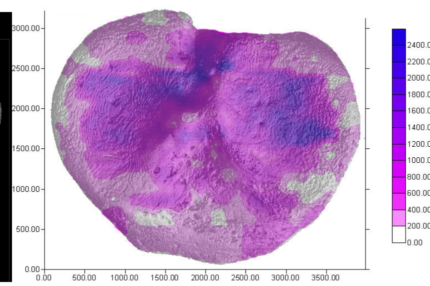

Fig. c

Reference:

Lovejoy C.O., Meindl R.S., Ohman J.C., Heiple K.G. & White TD. (2002) The Maka femur and its bearing on the antiquity of the human walking: applying contemporary concepts of morphogenesis to the human fossil record. *Am. J. Phys. Anthrop.* 119, 97-133.

Nakatsukasa M. (2004) Acquisition of bipedalism: the Miocene hominoid record and modern analogues for bipedal protohominids. *J. Ana*t. 204, 385-402.