ESRF	**Experiment title:** Phylogeny of contemporary and fossil primates, a non-destructive study by microtomography X of 3D teeth structure for the knowledge of the Anthropoids origins.	**Experiment number**: SC1112
Beamline: ID19	**Date of experiment**: from: 02/11/2002 to: 05/11/2002	**Date of report**: 22/08/2003
Shifts: 9	**Local contact(s)**: Xavier Thibault	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Tafforeau Paul*, Institut des Sciences de l'Evolution de Montpellier, UMR 5554 CNRS, Université de Montpellier II.

Mazurier Arnaud*, Laboratoire de Géobiologie, Biochronologie et Paleontologie humaine, UMR 6046 CNRS, Faculté des sciences Fondamentales et appliquées, Université de Poitiers.

Charles Laurent*, Laboratoire d'Anthropologie des Populations du passé, UMR 5089 CNRS, Université de Bordeaux 1.

Report:

This experiment was the continuity of the experiment sc-918. It permitted us to image by X-ray microtomography a great variety of fossil and extant primate teeth and jaws. For that purpose, we used several different technical configurations on the ID 19 beamline. Indeed, the studied samples presented various sizes and mineralisation patterns. We used voxels size from 40 µm for the largest samples up to 6.66 for the smallest.
We notably obtained non destructively very precise data on the teeth structure (thickness of the enamel, fig. 1) of a potential ancestor of the extant orang-utans, *cf. Lufengpithecus chiangmuanensis* (Chaimanee *et al.* 2003). Moreover, with these 3D virtual teeth, we performed reconstructions of the entire jaws of this fossil hominoid from 18 isolated teeth (fig. 2, see also ESRF press release 19/03/2003). Unfortunately, these 3D reconstructions were too hypothetical to be published in a scientific journal.

For several samples we used local microtomography in order to image only the teeth of a mandible or of a skull with a good resolution. We succeeded to obtain usable results with this technique for samples out of which up to 80% of the volume were out of the beam. Some improvements of this technique have recently been developed at the ID19 beamline in order to reduce artefacts due to the part of the sample located out of the beam, but we did not test them for the moment . It could be very useful to examine small parts on big fossils with a high resolution.

Some fossil teeth, especially from Pakistan, were too remineralized, which led to the fact that absorption microtomography failed to show density differences between enamel and dentin. We succeeded to observe the enamel-dentin junction on these teeth by using phase contrast (fig. 3) (Tafforeau *et al,* in prep.). This result is particularly important, because for this kind of fossils, only synchrotron light permits to obtain usable phase contrast. Without this technique, it is presently impossible to obtain pieces of information on the 3D structures of these teeth without cutting them physically. For the moment, we did not test holotomography

on these samples, but it is highly probable that this technique may bring very interesting results. This technique will soon be tested on a molar of the oldest known hominid of the world, *Sahelanthropus tchadensis* (whose skull is known as Toumaï), in the background of the proposal sc-1213.

A part of the beam time of this experiment was dedicated to scan about thirty human teeth, that were previously scanned during the sc-918 experiment and then physically cut. It permitted us to estimate the accuracy of the measurements of enamel thickness carried out non destructively by X-ray microtomography. For that purpose, we compared the virtual cuts obtained by microtomography with the corresponding real cuts in the teeth. We showed that this technique can be used with a very good accuracy (fig. 4) (Tafforeau *et al,* in prep.). This validation is important because X-ray microtomography is nowadays more and more used in paleontology, so it is necessary to show that quantitative studies can be performed.

Finally, we succeeded to extract virtually non erupted teeth from a jaw of a juvenile fossil dermopteran (fig. 5) (Tafforeau *et al,* in prep.). It allowed us to carry out a study of this fossil that would have been impossible without microtomography.

Reference :

Chaimanee, Y., Jolly, D., Benammi, M., Tafforeau, P., Duzer, D., Moussa, I. and Jaeger, J.-J. 2003, A Middle Miocene hominoid from Thailand and orangutan origins. Nature, 422, pp 61-65.

Figures

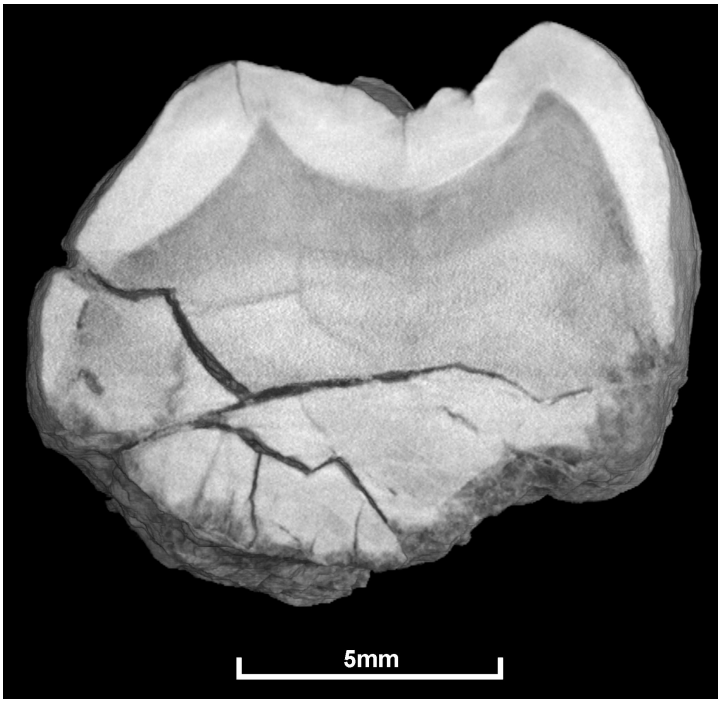

figure 1: virtual cut in a second inferior molar of a male of *cf. Lufengpithecus chiangmuanensis* showing clearly enamel and dentine (voxel size: 30.3µm). On this kind of picture, it is possible to measure the thickness of the enamel with a very good accuracy.

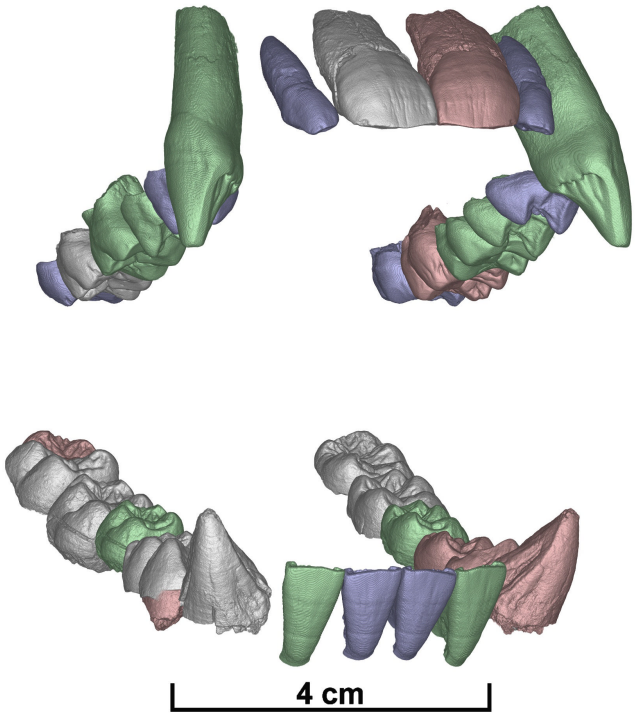

figure 2: hypothetical 3D reconstruction of the jaws of the male of *cf. Lufengpithecus chiangmuanensis.* Grey teeth are real ones, pink teeth are symmetrical of the real teeth, blue ones are female teeth and their symmetrical after size corrections, green teeth have been extrapolated from the others by comparisons with other hominoids.

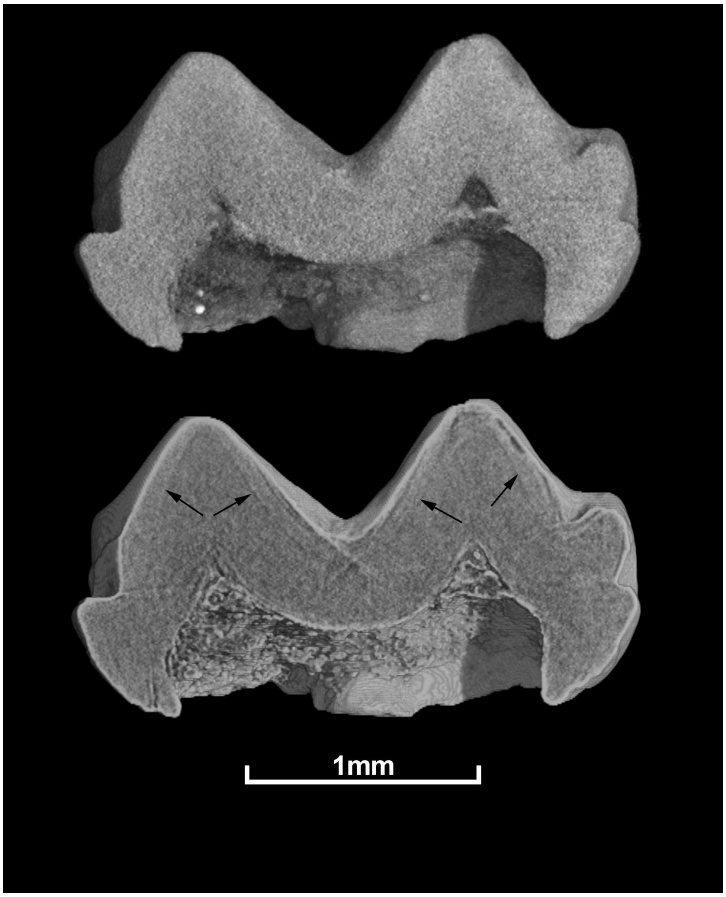

figure 3: virtual cuts through a molar of a fossil primate from Pakistan (voxel size: 7.46 µm). The upper picture shows a scan in absorption mode and the lower one in phase contrast. In this mode, it is possible to observe the enamel dentin jonction (black arrows).

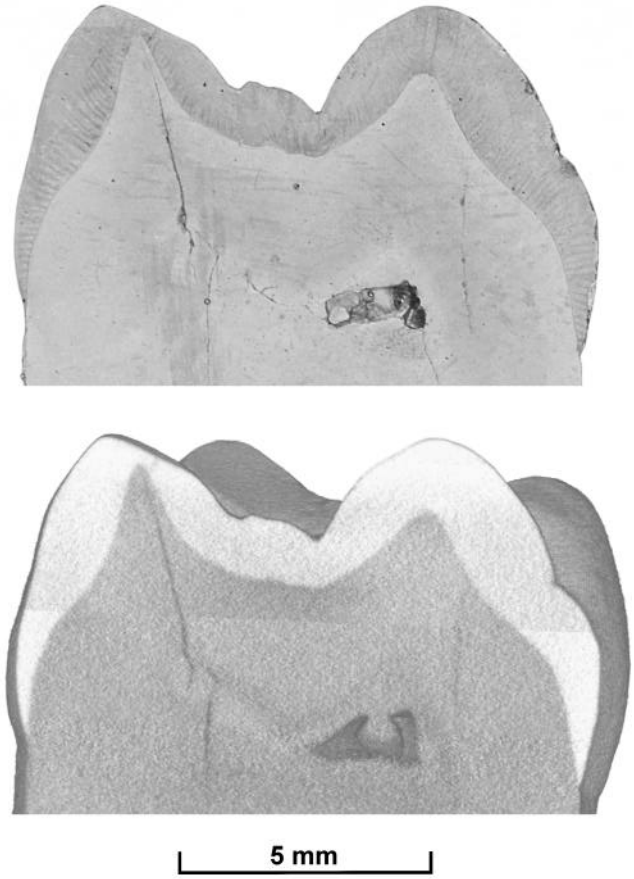

figure 4: comparison between a real physical cut in a human molar (up) and the same virtual cut obtained by X-ray microtomography with a voxel size of 30.3 µm (down).

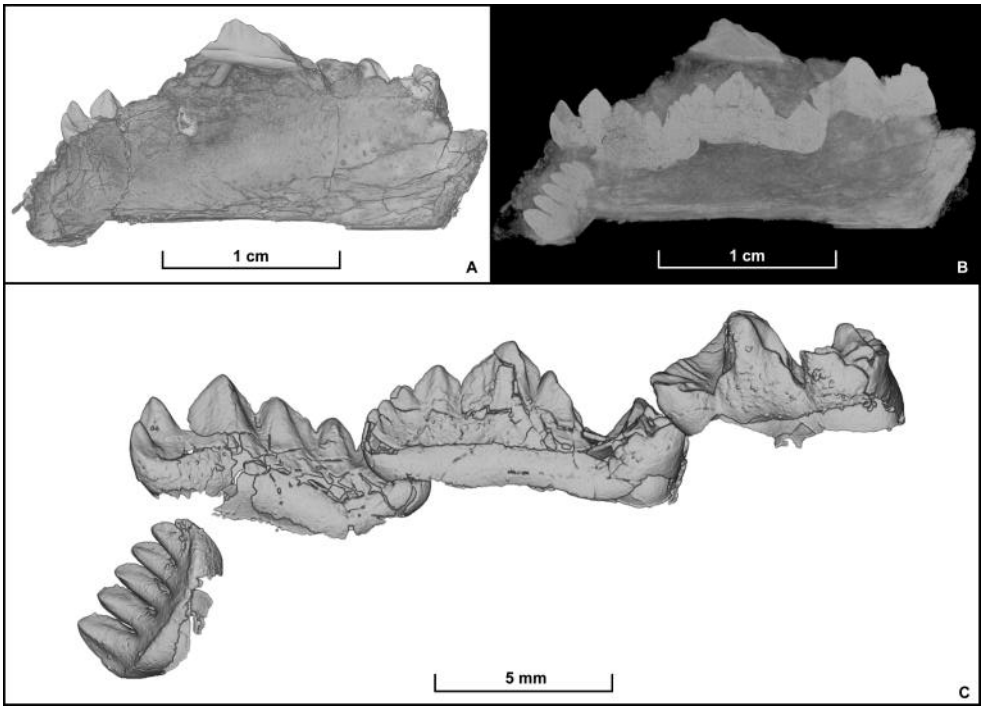

figure 5: virtual extraction of non-erupted teeth of a fossil dermopteran (voxel size: 10.13 µm).
A: 3D external view of the fossil.
B: virtual radiograph generated from the µCT data showing the disposition of the non-erupted teeth (real radiographs are unusable because of metallic oxydes in the fossil).
C: virtually extracted teeth obtained by 3D segmentation.