Human brain evolution, new insight through X-rays

September 8 2011

This is a 3-D rendering of the skull of *Australopithecus sediba* made from X-ray data gathered an experiment at the ESRF beamline ID19. Credit: ESRF/P. Tafforeau

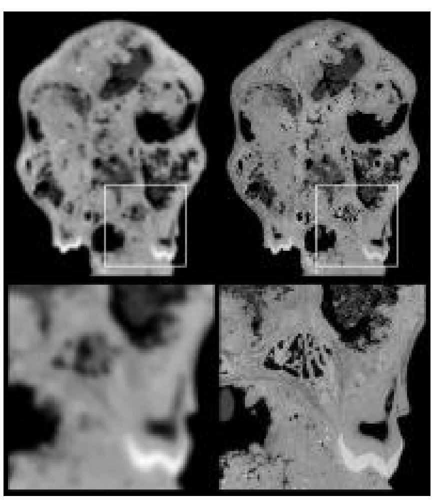
A paper published today in Science reveals the highest resolution and most accurate X-ray scan ever made of the brain case of an early human ancestor. The insight derived from this data is like a powerful beacon on the hazy landscape of brain evolution across the transition from *Australopithecus* to *Homo*.

The publication is part of a series of five papers based on new evidence pertaining to various aspects of the anatomy of the species *Australopithecus sediba* (announced in April 2010 by Berger et al.)

published in *Science* on 9 September 2011. Led by the University of the Witwatersrand in Johannesburg (South Africa), over 80 scientists from numerous institutes in Germany, the U.S., UK, Australia, Germany South Africa and Switzerland worked on the project. The work on the brain includes a scientist from the European Synchrotron Radiation Facility (ESRF) in Grenoble (France), where the X-ray micro-tomography scan was performed.

The exceptionally well-preserved cranium of MH 1 (*Australopithecus sediba*) was scanned at the ESRF at a resolution (3-D pixel size) of around 45 microns, just below the size of a human hair. Thanks to this high resolution, incredible details of the anatomy of sediba's endocast could be revealed.

According to Prof. Lee Berger from the University of the Witwatersrand in Johannesburg (South Africa) who found the fossil in 2009, "the many very advanced features found in the brain and body make it possibly the best candidate ancestor for our genus, the genus *Homo*, more so than previous discoveries such as *Homo habilis*."



This image shows a comparison of a classical computer tomography (CT) scan (left) with a scan using synchrotron microtomography at the ESRF (right). The much higher resolution and contrast are clearly visible. The lower part depicts a zoom-in view of an area which on the upper part is indicated with a square. This area includes a tooth and a cavity in the skull. Credit: ESRF/P. Tafforeau

Humans have a very large brain relative to their body size, about four times that of chimpanzees. Evolution from the brain of our shared ancestor with chimpanzees has seen this radical size increase. However, the reconstructed endocast (volume of the cranium) of MH1 is surprisingly small, with a volume of 420 cm^3, on average only about 40 cm3 larger than chimpanzees.

The study of this brain shows a surprising mix of characteristics. Its overall shape resembles humans more than chimpanzees and, given its small volume, this result is consistent with a model of gradual neural (brain) reorganisation in the front part of the brain. "Indeed, one of our major discoveries is that the shape and form of sediba's brain is not consistent with a model of gradual brain enlargement, which has been hypothesised previously for the transition from Australopithecus to *Homo*", adds Dr Kristian Carlson from the University of the Witwatersrand, who is the main author of the paper.

This image shows a reconstruction of the skull of MH1 (partially transparent) with the brain endocast depicted in green. Dentition also visible and the specimen is viewed from slightly above and anterolateral. Credit: Witwatersrand University/K. Carlson

Use of synchrotron X-rays was instrumental for this discovery. The external shape of a brain is reflected, like in a mould, in the inner surface of a cranium. By mapping the contours of this internal surface, an image of the original brain located in the skull can therefore be produced. However, the skull of MH-1 was not emptied from bedrock after its discovery, and only the powerful X-rays at the ESRF could penetrate deep into the fossil to reveal the cranium's interior shape at the desired resolution. Leaving the rock inside the cranium also ensured that its delicate inner surface was not damaged or altered during its extraction.

"The ESRF is the most powerful installation worldwide for scanning fossils, setting the standard for what can be achieved during non-destructive studies of internal structures of fossils," concludes Paul

Tafforeau, staff scientists at the ESRF and a co-author of the paper.

More information: The Endocast of MH 1, Australopithecus sediba, Kristian J. Carlson, Dietrich Stout, Tea Jashashvili, Darryl J. de Ruiter, Paul Tafforeau, Keely Carlson, Lee R. Berger, *SCIENCE* 9 September 2011

Provided by European Synchrotron Radiation Facility