CASESTUDY

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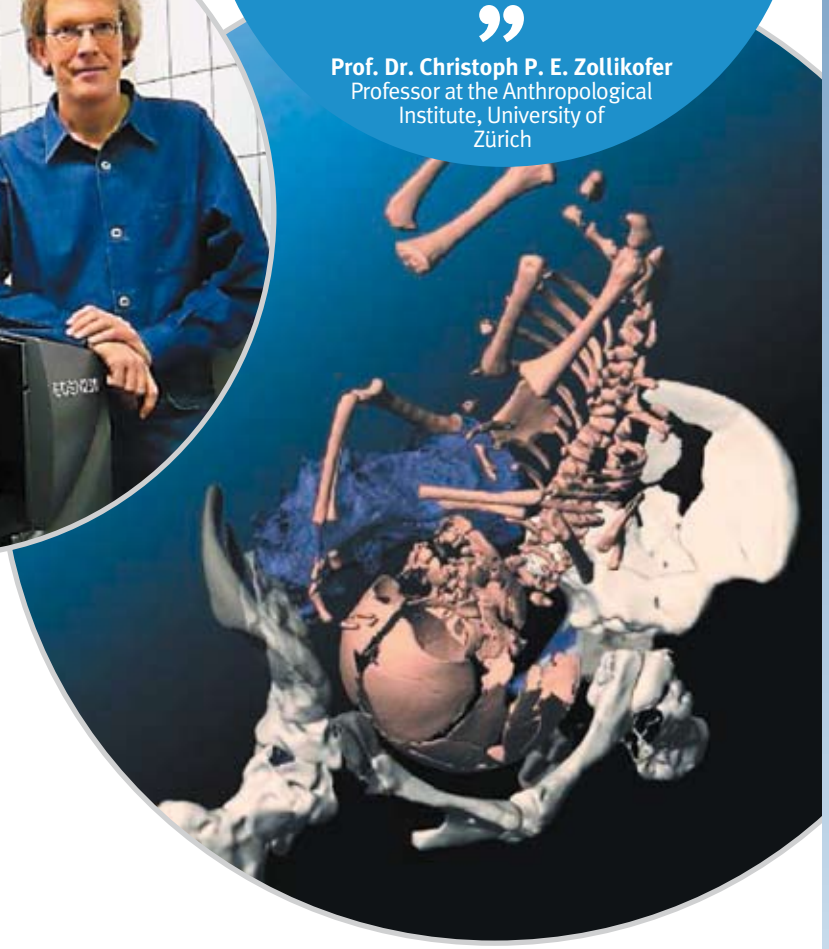
>
> **Prof. Dr. Christoph P. E. Zollikofer**
> Professor at the Anthropological Institute, University of Zürich



AT A GLANCE

Company: Anthropological Institute, University of Zurich, Switzerland
URL: www.aim.uzh.ch
Location: Zurich, Switzerland
Industry: Research into the origins of human morphology and behavior

Challenges

- Provide exact computerized reproductions of fossils for research purposes
- Provide detailed models of fossils to facilitate the understanding of anatomic structures
- Provide non-invasive replication possibilities to prevent damage to delicate fossils

Solution

- Eden250™ 3D Printing System from Objet Geometries

Results

- Objet models enabled researchers to gain new insights into female Neanderthals' anatomical structures, Neanderthal brain size evolution and other aspects of the history of human evolution
- Printing parts from CT images of fossils makes it dramatically easier and faster to reconstruct the placement of skeletal parts
- New revelations were discovered in fossil bone that were otherwise invisible to the eye, including tooth roots and inner ear cavities
- Exact models of fossils are available for display in museums and for research

Objet 3D Printing Helps Shed Light on Ancient Human Evolution

Recently, when the Anthropological Institute at Zurich University was investigating Neanderthal brain size at birth (fossils dating ~50,000 yrs of age), it gained new insights into the history of human evolution. Using the remains of a newborn from the Mezmaiskaya Cave (Crimea, Russia) and of two infants from the Dederiyeh Cave (Syria), Prof. Dr. Christoph P. E. Zollikofer and his team were able to procure new insights into 'Neanderthal obstetrics', patterns of brain growth and the evolution of human life history. These remarkable findings were further developed using computerized reconstruction techniques on a fragmentary female Neanderthal pelvis (discovered by Dorothy Garrod in the early 1930s) from the Tabun Cave (Israel). By simulating scanned imagery and embedding the remains of the

infants digitally with that of the 'Tabun Lady', Prof. Zollikofer and Dr. Marcia Ponce de Le'on were able to shed new light on female Neanderthals.

The research undertaken by the Anthropological Institute at Zurich University made use of Objet's PolyJet™ Technology. Being proud owners of an Eden250™ 3D printing system, Prof. Zollikofer and his team were able to use 3D modeling to further enhance their findings regarding Neanderthal brain size evolution.

High-accuracy printing makes Objet the only solution

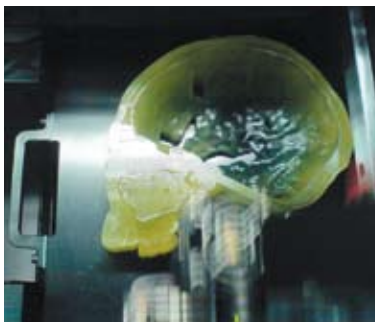
Prof. Zollikofer first saw an Objet system in 2005 at Tokyo University. Prof. Gen Suwa of the University Museum, which has an Eden™ system, showed Prof. Zollikofer the capabilities of combining 3D printing with anthropological findings. "It became apparent to me that we needed this technology in-house. The advantages were immediately clear to me," recalled Prof. Zollikofer.

Left: Mezmaiskaya Right: Dederiyeh 1

At the time, the team at Tokyo University was using the system (employing micro-CT technology) to scan teeth from the hominid fossils and to scale them up to be able to classify and show both the variation and evolution of the teeth. "Such a straightforward yet simple application convinced us we needed Objet in-house," said Prof. Zollikofer. Although there were other technologies available, it was clear to him that Objet could best fulfill all his demands. "We needed highly accurate parts to best replicate the actual fossils found. Academic research does not allow us to have anything less than an accurate replica of a fossil skeleton. Objet was the only solution that offered us such capabilities."

Left: Dederiyeh 1 Right: Mezmaiskaya

Furthermore and due to budget constraints, the resin cartridges used by Objet aided in its selection. "Often, we have budgetary constraints. Cartridges allow us to purchase material upon need and to not invest massively in materials unless needed," attested Prof. Zollikofer.



Printing of a replica fossil skull

The Eden250 allowed Prof. Zollikofer to better understand brain size at birth. 'Dederiyeh 1', the fossil Neanderthal skeleton found in the Mezmaiskaya Cave in Russia, was unique in that the infant was assessed to be one week old upon death. "The ability to find a Neanderthal brain case at its infancy was a remarkable discovery. It allowed us to calibrate our findings and thus better understand brain developments during this period. Until this finding, we had only older infant brains and had to guess what a newborn's brain would look like," explained Prof. Zollikofer. The tooth structure, the size of the skull and the assessed brain size all provided massive insight into Neanderthal brain evolution. But as amazing as these findings potentially were, challenges in this field of science always remain.

"Imagine uncovering hundreds of pieces of a puzzle and needing to reconstruct all that on a given plane. Now add to that years of archeological findings and deformations brought as a result of an elapsed timeframe. You get one big puzzle!" continued Prof. Zollikofer. Indeed one does. The archeological digging

at the Dederiyeh cave lasted for some 15 years, with all the parts brought together to form the skull of "Dederiyeh 1" itself taking an additional several years of research. Using in-house software developed by the University called 'Form It', Prof. Zollikofer was able to reconstruct the various Neanderthal brains digitally after scanning the fossils found using micro-CT technology. "Having reconstructed the fossils, seeing the puzzle on a computer screen is challenging. We discovered that by printing the CT-imaged parts using the Objet system, the puzzle became much easier to understand," said Prof. Zollikofer.

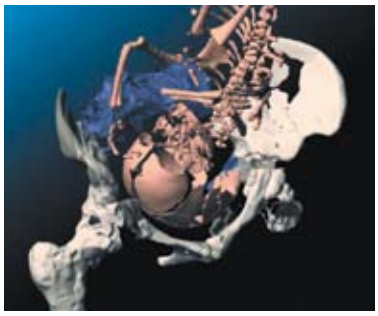
A printed replica fossil skull prepared for silicon moulding

Objet is used for additional applications aside from what is now called within the institution 'Quality Control': printing parts to assist in placing all the fossils in the right configuration. One additional anthropology application for Objet is in what is called 'Non-Invasive Replication'. A fossil is a treasure. Once found, it is preserved with the highest possible care, both because of its rarity and because of its brittleness. Scanning the fossils Prof. Zollikofer prints the parts using the Objet system so they can be used for silicon molding. "It is simply not possible to mould a brittle fossil skull. The part is too valuable. But using scanning technology, the replica can be used for silicon molding. Objet's high accuracy and fine details makes for a perfect copy of the original. This in turn allows experiments to be performed that would otherwise be impossible," explained Prof. Zollikofer

To better understand anatomy structure, inner ear fossils are scanned and printed to reveal details otherwise invisible to the human eye (middle and right: original size)

Enabling new discoveries

But that's not all. New revelations can be discovered using Objet technology. Nicknamed 'Real Virtuality' by Prof. Zollikofer, scanning technology can help reveal findings inside bones that are otherwise invisible to the eye. The original fossil cannot be damaged to reveal internal structures. However, researchers can scan the fossil and then digitally remove outer layers. By printing the results, it is possible to reveal new findings. In the research undertaken by the University, both tooth roots and inner ear cavities were better understood using this technique. The ability to scale up the model prior to printing further enhances and reveals new findings.



The next project: the pelvis of 'Tabun Lady' with Mezmaiskaya reconstructed and repositioned

All these findings are worth little if they cannot be shown to the interested public. "It may be trivial but nevertheless it is crucial!" commented Prof. Zollikofer. "Objet replicas of the fossils can be displayed at exhibitions and museums across the globe. This would be simply impossible with the original fossil because its uniqueness and fragility don't allow the part to be easily moved."

With communication and non-invasive replication possibilities, 'Real Virtuality' applications and exhibitions, Objet technology allows anthropologists to better understand the past using state of the art technology. "Objet assisted us, through its 3D printing technology, to better understand Neanderthal brain size evolution" proclaimed Prof. Zollikofer.

Watch this space...

So what does the future hold? The Anthropological Institute at Zurich University and Objet are currently preparing the next project: printing the entire findings of 'Mezmaiskaya' inside the pelvis of the 'Tabun Lady'. "Embedding all the fossils of 'Mezmaiskaya' into the pelvis of the 'Tabun Lady' and then printing them in 3D has never been done before! We are very excited about this joint project with Objet and plan to exhibit it globally," declared Prof. Zollikofer.

About Objet Geometries

Objet Geometries Ltd., the innovation leader in 3D printing develops, manufactures and globally markets ultra-thin-layer, high-resolution 3-Dimensional printing systems and materials that utilize PolyJet™ Polymer Jetting technology, to print ultra-thin 16-micron layers.

The market-proven Eden™ line of 3D Printing Systems and the Alaris™30 3D desktop printer are based on Objet's patented office-friendly PolyJet™ Technology. Connex500™ is based on Objet's PolyJet Matrix™ technology, which jets multiple model materials simultaneously and creates composite Digital Materials™ on the fly. All Objet systems use Objet's FullCure® materials to create accurate, clean, smooth and highly detailed 3-dimensional models.

Objet's solutions enable manufacturers and industrial designers to reduce cost of product development cycles and dramatically shorten time-to-market of new products. Objet systems are in use by world leaders in many industries, such as automotive, electronics, toy, consumer goods, and footwear industries in North America, Europe, Asia, Australia and Japan.

Founded in 1998, Objet serves its growing worldwide customer base through offices in USA, Europe and Hong Kong, and a global network of distribution partners. Objet owns more than 50 patents and patent pending inventions.

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