APPLICATION CASE

Nikon Metrology's micro-CT scanning unveils mysteries of nature at the natural history museum

Researchers of the renowned Natural History Museum in London investigate diverse natural specimens using a X-Tek micro-CT scanner installed earlier this year. Stunning 3D visualizations of the interior structure of fossils, animals, rocks and meteorites enable them to acquire ground-breaking insight into mineral sedimentary deposits and the evolution of animal anatomy. Researchers additionally apply their micro-CT scanning expertise to advance industrial research focusing on carbon-fiber material, aluminum honeycomb structures and other innovative materials.

Insight into the inside increases research depth and pace

A vital aspect of studying specimens is the ability to visualize their internal structure. Most investigatory methods available solely capture the outer specimen surface, or require edged and colored sample slices to offer a glimpse of the interior. "A search for non-destructive research methods resulted in the installation of an industrial computer tomography (CT) system at the Natural History Museum (NHM)," says Dr. Richard Abel, Micro Tomography Specialist at NHM in London, Great-Britain. "Mineralogists, paleontologists, zoologists, ornithologists and entomologists at the museum have already revealed remarkable aspects of present and past species that were unknown to date."

In collaboration with institutions in Germany and America, staff at NHM used micro-CT scanning technology to investigate the hearing organ of birds. The hearing organ is encased in a bony capsule, the cochlea duct. In most animals the cochlea duct fossilizes, but it is normally hidden by surrounding skull bones unless the specimen is damaged. Dr. Abel says that they used micro-CT scanning to investigate whether the size of the cochlea duct in living birds and reptiles can predict their hearing ranges and possibly their behavior. "Scanning of nearly 60 species of birds and reptiles at resolutions of around 30 microns provided enough accurate measurement data to build statistical models of hearing sensitivity, vocalization, sociality and habitat preference. Data from these living species has for the first time allowed hearing sensitivity to be predicted in their extinct relatives, including the earliest known bird Archaeopteryx."

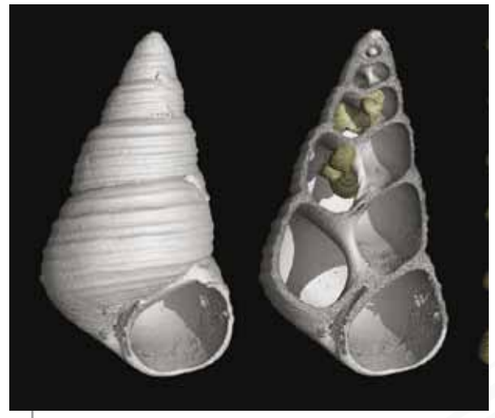
About trigonotarbids, snail embryos and coral samples

The X-Tek HMX ST CT system is equipped with a 225 kV micro-focus radiography source with 3 micron focal spot size and a 400 x 400mm detector panel counting 2000 pixels in each direction. Dr. Abel points out that the system is capable of generating 3D volumes that offer an incredible level of detail. "In a recent 3D fossil study of a trigonotarbid – an early relative of modern day spiders and some of the earliest land animals – micro-CT helped demonstrate patterns in their evolution that provide insight into their growth. Similar techniques have been used in the investigation of enigmatic fossil groups, revealing internal anatomy, such as stomach, gills, and even muscle tissue hidden under creatures' shells. Quite impressive are the micro-CT images that are used as input for colored volume renderings and movies using Volume Graphics Studio Max software that comes with the X-Tek system."

Nikon Metrology's XT H @ NHM

DEK Screens invested in a Nexiv VMR-6555 video CNC inspection system to obtain higher-precision sensor strip micro structures of handheld blood glucose meters.

- Fast automated inspection of 500 micro circuits located on just 300mm²
- Coated emulsions edges are precisely located using a unique 8-segment LED ring illumination
- Increased measurement accuracy resulted in a higher quality end product



Stunning 3D portraits of fossil snail embryos that were discovered inside a shell using micro-CT scanning.

Micro-CT helped reveal a 3D trigonotarbid fossil's internal anatomy, including stomach, gills, and even muscle tissue.

NIKON METROLOGY | VISION BEYOND PRECISION

Micro-CT volume of a barn owl skull with one half rendered transparent to reveal the inner ear (in orange).

To illustrate the variety of specimens that Dr. Abel and his colleagues investigate, he shows a snail's shell. "Nothing unusual until you look at the stunning 3D portraits of fossil snail embryos that were discovered inside the shell using micro-CT scanning. Without this unique volumetric imaging technology, it would simply be impossible to gain access to these tiny snail embryos." Similarly, NHM researchers studied palaeontological coral structures to indirectly determine past sea water temperatures during the period of development.

Hope's Nose rock and its hidden mineral deposits

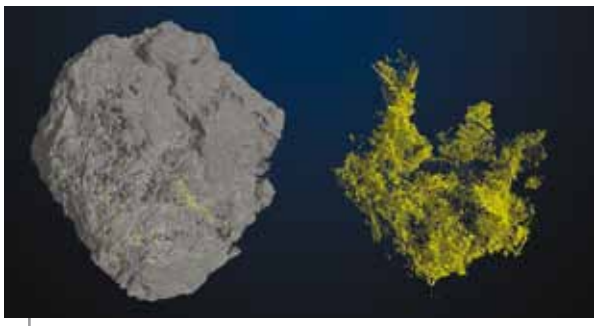
The scanner's powerful radiography beams even penetrate through high-density samples, such as a Hope's Nose rock that contains crystallized gold, within calcite, selenium and other mineral deposits. Researchers at the Mineralogy Department applied micro-CT scanning to this extraordinary specimen to lay bare the rock's complex network of gold fronds that were formed after water erosion. "After sectioning out a density range that leaves out the rock substances, remarkable 3D images pop up showing the beautifully shaped mineral deposits," Dr. Abel explains. "With the software, it is even possible to calculate the volumetric fraction of each individual mineral. This approach is equally helpful in quantifying metallic fractions in meteorites, to retrieve more detailed information about the conditions in which the solar system was formed."

According to Dr. Abel, this 3D research approach is more straightforward and much faster than traditional destructive 2D visualization techniques, such as serial sectioning. "Instead of cutting samples and polishing slices to observe the structure using light transmission or scanning electron microscope, we simply position the specimen in the micro-CT scanner's inspection compartment and investigate the resulting volume. Time-to-volume is typically 40 minutes. This is really impressive considering the processing of approximately 8 billion voxels (3D equivalent of a pixel) that make up a high-resolution micro-CT volume."

Opening up unlimited research opportunities

In addition to collaborating with leading research institutions, NHM also participates into advanced material research projects for industrial parties. Dr. Abel mentions that Mineralogy Department researchers applied their in-depth material expertise and micro-CT scanner operation skills to assist in developing light-weight material with high strength. One design application concerned carbon fiber parts consisting of laminate layers that are bonded together. The aim of the company was to take better control over the bonding process, which involved a heating phase that is energy and time consuming. Ultimately, micro-CT scanning at NHM helped define the specific heating conditions that resulted in the predefined mechanical strength characteristics the part specimens need to exhibit. In this way, heating temperature and duration can be flexibly adapted depending on custom part strength requirements, reducing fabrication cost and throughput time.

Researchers spot the need for a micro-CT scanner, after using advanced equipment for outside surface morphometrics and laborious volumetric inspection methods. "Having a micro-CT scanner in a museum is revolutionizing the way that biological and mineralogical specimens are studied," concludes Dr. Abel. "The system's superior volumetric imaging capabilities and rendering software literally allows us to dissect organic anatomy and section out material in the virtual world. This has opened up an enormous number of research opportunities that we are only just beginning to discover. Micro-CT is a major step forward in our efforts to unveil mysteries of nature."



Micro-CT scanning helped lay bare the rock's beautifully shaped gold fronds and calculate their volumetric fraction.

More information about Natural History Museum can be found at http://www.nhm.ac.uk/

More information about XT H can be found at http://www.nikonmetrology.com/products/xray_ct_inspection/