Neutron tomography: Insights into the interior of teeth, root balls, batteries, and fuel cells

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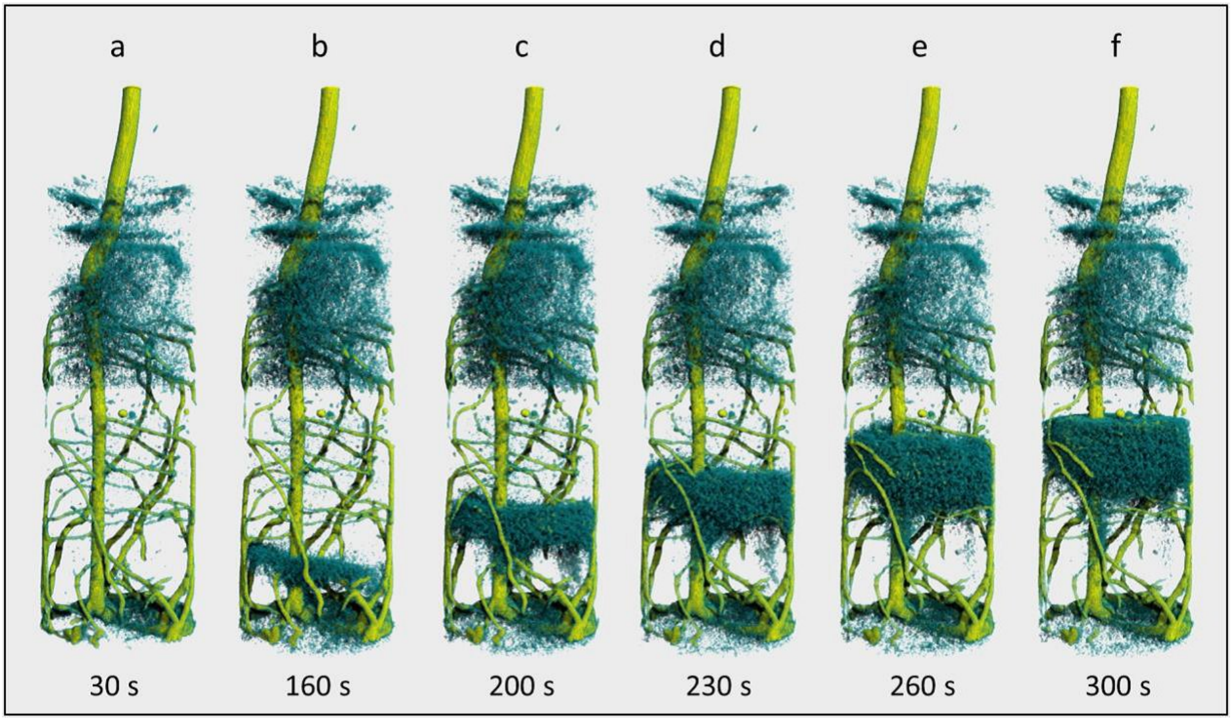
Fossils like this 250 million year old skull of a lystrosaurus can be examined very carefully by neutron tomography. Credit: MfN Berlin

A team of researchers at Helmholtz-Zentrum Berlin (HZB) and European Spallation Source (ESS) has now published a comprehensive overview of neutron-based imaging processes in the renowned journal *Materials Today*. The authors report on the latest developments in neutron tomography, illustrating the possible applications using examples of this non-destructive method. Neutron tomography has facilitated breakthroughs in diverse areas such as art history, battery research, dentistry, energy materials, industrial research, magnetism, palaeobiology and plant physiology.

Neutrons can penetrate deep into a sample without destroying it. In addition, neutrons can also distinguish between light elements such as hydrogen, lithium and substances containing hydrogen. Because neutrons themselves have a magnetic moment, they react to the smallest magnetic characteristics within the material. This makes them a versatile and powerful tool for materials research. Neutron tomographs, 2-D or 3-D images, can be calculated from the absorption of the neutrons in the sample. A world-renowned team headed by Dr. Nikolay Kardjilov and Dr. Ingo Manke is working with BER II, the neutron source at HZB, to expand and improve neutron tomography methods.

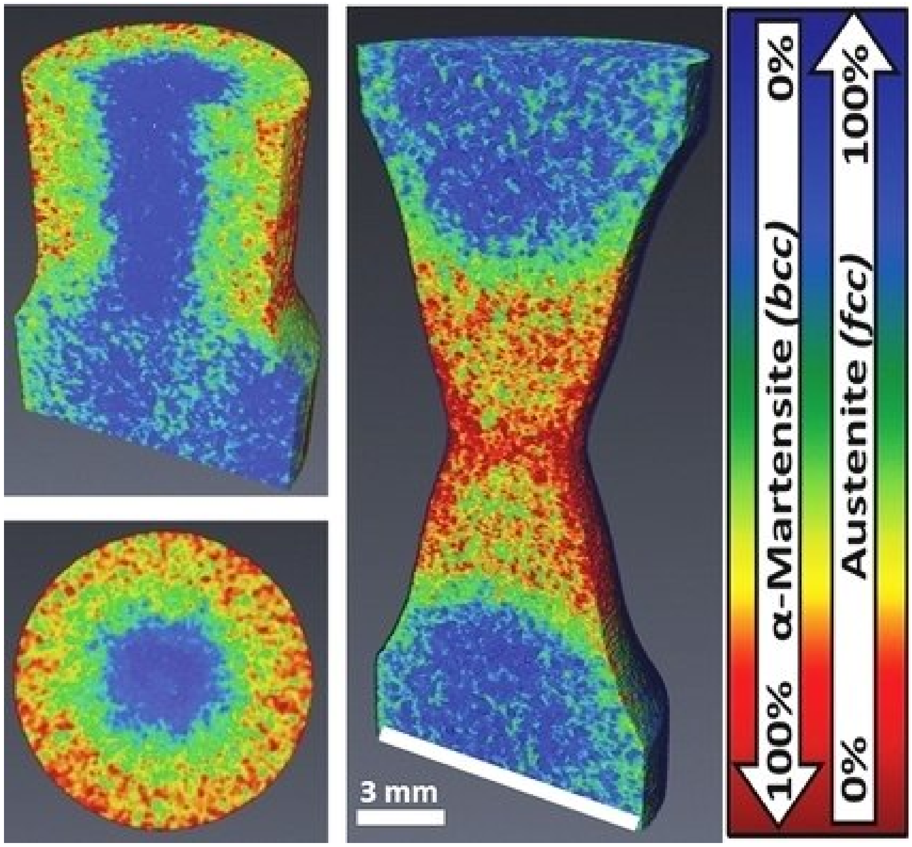
In their review paper, the authors describe the latest improvements in neutron imaging and present outstanding applications. Improvements in recent years have extended the spatial resolution down into the micrometer range. This is more than 10 times better than with typical medical X-ray tomography. Faster images are also possible now, which makes observing processes in materials feasible, such as the measurements of a fuel cell during its actual operation that shows precisely how the water is distributed within it. This provides important information for optimising the design of the cell.



Sequential tomography of a lupin root (yellowish green) after deuterated water (D2O) was introduced from below. The rising water front (H2O, dark blue) is displaced by the D2O from below over the course of time. Credit: Christian Tötzke/ University of Potsdam

Applications range from observing the transport of lithium ions in batteries and strength analyses of industrial components, to examinations of teeth, bones, and the roots of plants, to non-destructive analyses of historical objects such as old swords and knights' armour in order to obtain information on historical manufacturing methods.

"Neutron tomography is extremely versatile. We are working on further improvements and hope that this method, which is in great demand, will also be available in modern spallation sources in the future," says Nikolay Kardjilov.



Neutron tomography shows how torsion (images left) and tensile forces (image right) are changing the distribution of different crystalline phases. Credit: HZB/Wiley VCH

More information: Nikolay Kardjilov et al, Advances in neutron imaging, *Materials Today* (2018). DOI: 10.1016/j.mattod.2018.03.001

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