NEUTRON IMAGING FOR PALEONTOLOGY

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X-ray radiography and computed tomography (CT) reveal hidden subsurface features within fossil specimens embedded in matrix. With X-rays, distinguishing features from the background (i.e., contrast) results from sample density and atomic X-ray attenuation—fundamental properties of the sample. However, even high energy X-rays may poorly resolve hard and soft tissue structures when the matrix has similar density or X-ray attenuation to the fossil. Here, neutron radiography and neutron tomography complement X-ray imaging, as the source of contrast comes instead from how a neutron beam interacts with the sample's atomic nuclei. The contrast is highly nonlinear across the periodic table, and so researchers can see enhanced contrast between adjacent features when X-ray imaging could not. As the signal source is completely different than X-ray imaging, some intuition from X-rays must be discarded. For instance, neutrons quite easily pass through lead, but are blocked by hydrogen.

Since neutron imaging is uncommon within paleontology, we introduce this exciting technology at a high level with an emphasis on applications to paleontology. We cover some basic physics underlying neutron imaging, where one can perform such experiments, and sample considerations. The neutron source, concepts of beam flux, and image resolution will also be covered. As neutron imaging typically complements X-ray imaging, we discuss how to digitally combine modalities for segmentation and inference. We present examples of how neutron imaging informed fossil descriptions. This includes the skull of a Paleocene mammal *Tetraclaenodon* from New Mexico and a variety of Permian vertebrate specimens from Richards Spur, Oklahoma and imaged at the DINGO nuclear imaging facility in Australia. Though neutron sources will always be difficult to access, we aim to assist interested researchers considering this exciting imaging technology for their paleontology research.