Iron preserves, hides ancient tissues in fossilized remains

November 26 2013

New research from North Carolina State University shows that iron may play a role in preserving ancient tissues within dinosaur fossils, but also may hide them from detection. The finding could open the door to the recovery of more ancient tissues from within fossils.

Mary Schweitzer, an NC State paleontologist with a joint appointment at the N. C. Museum of Natural Sciences, first announced the surprising preservation of soft tissues in a *T. rex* fossil in 2005. Her subsequent work identified proteins in the soft tissue that seemed to confirm that the tissue was indeed *T. rex* tissue that had been preserved for millions of years. But the findings remained controversial in part because no one understood the chemical processes behind such preservation.

Schweitzer's latest research shows that the presence of hemoglobin – the iron-containing molecule that transports oxygen in red blood cells – may be the key to both preserving and concealing original ancient proteins within fossils. Her results appear in *Proceedings of the Royal Society B*.

"Iron is necessary for survival, but it's also highly reactive and destructive in living tissues, which is why our bodies have proteins that transport iron molecules to where they are needed but protect us from unwanted reactions at the same time," Schweitzer says. "When we die, that protective mechanism breaks down and the iron is turned loose on our tissues – and that destructive process can act in much the same way formaldehyde does to preserve the tissues and proteins."

Hemoglobin seems to be the key. Both birds and crocodiles, the dinosaur's closest living relatives, have large, nucleated red blood cells. Therefore they also have more hemoglobin per cell than mammals. If dinosaur blood cells were similar to either one of those species, which seems likely, then their blood cells would also contain much more hemoglobin than human cells, amplifying iron's preservative effect on the tissues. If the hemoglobin were contained in a bone in a sandstone environment, keeping it dry and insulated from microbes, preservation becomes more likely.

Schweitzer and her team noticed that iron particles are intimately associated with the soft tissues preserved in dinosaurs. But when they chelated – or removed the iron from – soft tissues taken from a *T. rex* and a *Brachyolophosaurus*, the chelated tissues reacted much more strongly to antibodies that detect the presence of protein, suggesting that the iron may be masking their presence in these preserved tissues. They then tested the preservation hypothesis by using blood vessels and cells taken from modern ostrich bone. They soaked some of these vessels in hemoglobin taken from red blood cells, while placing other vessels in water. Two years later, the hemoglobin-treated soft vessels remained intact, while those soaked in water degraded in less than a week.

"We know that iron is always present in large quantities when we find well-preserved fossils, and we have found original vascular tissues within the bones of these animals, which would be a very hemoglobin-rich environment after they died," Schweitzer says. "We also know that iron hinders just about every technique we have to detect proteins. So iron looks like it may be both the mechanism for preservation and the reason why we've had problems finding and analyzing proteins that are preserved."

More information: "A role for iron and oxygen chemistry in preserving soft tissues, cells and molecules from deep time" Mary H.

Schweitzer, et al. *Proceedings of the Royal Society B*, 2013.

Abstract
The persistence of original soft tissues in Mesozoic fossil bone 29 is not explained chemically by current chemical degradation models. We identified iron particles [goethite-αFeO(OH)] associated with soft tissues recovered from two Mesozoic dinosaurs, using TEM, EELS, µXRD, and Fe µXANES. Iron chelators increased fossil tissue immunoreactivity to multiple antibodies dramatically, suggesting a role for iron in both preserving and masking proteins in fossil tissues. Hemoglobin (HB) increased tissue stability ~50-fold, from ~ 3days to >six months at room temperature (25oC) in an ostrich blood vessel model developed to test postmortem "tissue fixation" by crosslinking or peroxidation. HB-induced solution hypoxia coupled with iron chelation enhances preservation as follows: HB + O2 > HB - O2 > - O2 >> + O2. The well-known O2/heme interactions in the chemistry of life, such as respiration and bioenergetics, are complemented by O2/heme interactions in the preservation of fossil soft tissues.

Provided by North Carolina State University