KANSAS GEOLOGICAL SURVEY
The University of Kansas

Portrayal of Utahraptors and prey trapped in quicksand deposit of the Stikes Quarry bone bed at Utahraptor Ridge. © Julius Csotonyi, natural history illustrator, used by permission.

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Geochemists at the University of Kansas determine age of the dinosaur Utahraptor

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Three scientists, three state geological surveys, a common fascination with dinosaurs, and one simple yet profound question: Just how old are the rocks that preserve the world's biggest "raptor," Utahraptor?

More than a decade ago, Greg Ludvigson, emeritus senior scientist with the Kansas Geological Survey, Jim Kirkland, state paleontologist with the Utah Geological Survey, and Matt Joeckel, state geologist and director of the Conservation and Survey Division at the University of Nebraska–Lincoln, joined together to tackle that question.

They succeeded beyond their greatest expectations, determining the age of the dinosaur Utahraptor and finding that it was much older than previously supposed. The finding has important implications for the evolutionary history of dinosaurs. The researchers also learned that the rock strata from the Stikes Dinosaur Quarry were deposited during a global change episode known as the Weissert Event.

The scientists described their findings in a recent issue of the journal *Geosciences.*

In the field and in the lab

The field work took place in Utah at the well-known Utahraptor Ridge site, named for the larger cousins of the ferocious velociraptor dinosaur stars of the Jurassic Park movies. The ridge is home to Stikes Quarry, a fossil quicksand deposit packed with dinosaur fossils that are largely intact and preserved in much the same positions as when they died. Stikes Quarry is part of the Cedar Mountain Formation, a rock unit that contains fossils of more kinds of dinosaurs than any formation in the world.

The scientists took two different research approaches. One path — uranium/lead dating of zircon crystals — involved analyzing samples of these minerals collected at different depths in the rock layers. The second looked at changes in the relative abundance of two types of stable carbon isotopes found in buried organic matter and linked results to specific periods in Earth's history when global changes in the carbon cycle were known to have occurred.

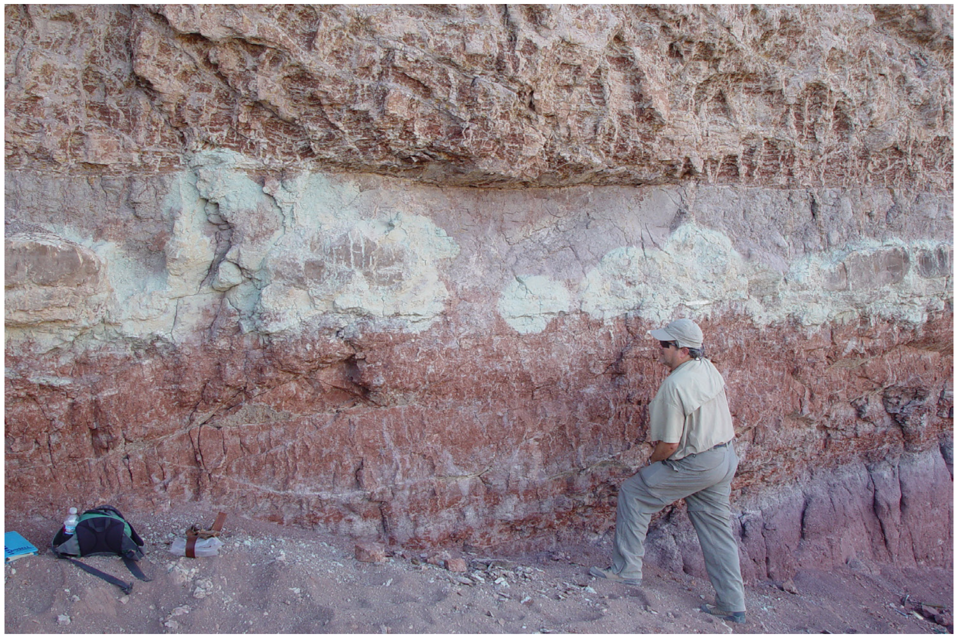
The big take away? Rocks in the Yellow Cat Member of the Cedar Mountain Formation — and the Utahraptor fossils found within — are 10 million years older than previously known. Earlier estimates put the age of the rocks and fossils at 125 million years old. The revised age indicates the rocks at the Stikes Quarry are at least 135 million years old. The oldest rock sample analyzed produced an age of 139.7 million years plus or minus 2.2 million, showing that the lower part of the Yellow Cat Member encompasses even older strata and belongs in the oldest stage (Berriasian) of the Cretaceous Period.

Many scientists, one goal

Behind the headline-grabbing discoveries is a decade-plus of scientific collaboration that combined the talents of 11 researchers in Utah, Nebraska, Arkansas, and Kansas. Their work merged the fields of paleontology and geochemical laboratory analyses.

In 2014, two research teams — one from the University of Kansas and another from Arkansas — independently traveled to Utah to collect samples when workers excavated a haul road in the cliff side at Utahraptor Ridge to remove a nine-ton plaster-jacketed block of the bone bed at Stikes Quarry, an opportunity to study the site when the rock strata were best exposed. The KU team collected samples for zircon dating, and the Arkansas team sampled soil organic matter to analyze carbon cycle changes. Both zircon dating and carbon isotope analyses would yield information about the age of the rocks at Stikes Quarry. The two teams coordinated their efforts to collect samples from known positions so that the two data sets would speak to each other.

To obtain high-precision ages, the KU team looked for fossil volcanic ash deposits. Such deposits are relatively common in marine rocks, formed when ash fell into what was then a sea, but are not as often found in terrestrial rocks, such as those at Utahraptor Ridge. Surface processes, such as shrink-swell phenomena in soils and burrowing activity by soil-dwelling organisms, can mix sediments in soils and obscure the depositional record.



Greg Ludvigson on outcrop of the Yellow Cat Member in May 2009. Photo courtesy of Matt Joeckel.

The team employed an innovative application of a newer concept — cryptotephras — to separate microscopic fragments of volcanic ash in soils that are not visible to the naked eye to find volcanogenic zircon crystals.

The initial analysis resulted in a deposition age of 136 million years ago but came with an inherent 2% uncertainty, or a range of nearly 5.5 million years. The team performed additional analyses using a high-precision technique that involved a time-intensive procedure using chemicals to dissolve the zircons. Those analyses yielded absolute ages for the samples with uncertainties of less than one million years.

Meanwhile, the Arkansas team performed an initial analysis of the carbon isotope samples collected at Utahraptor Ridge then transferred the samples to the Kansas Geological Survey for additional processing and analyses at the Keck Paleoenvironmental and Environmental Stable Isotope Laboratory

Combined results

In 2015, the team began to suspect that they had a record of the Weissert Event, a well-known carbon isotope excursion during the Cretaceous Period that recorded abrupt changes in atmospheric carbon dioxide concentrations related to global volcanic activity. Additional analyses confirmed their results.

The two geochemical research approaches — zircon dating and carbon isotope analysis — gave researchers two independent lines of isotopic geologic evidence for the age of the deposits at Utahraptor Ridge. In the end, their analyses found multiple carbon isotope excursions extending the record at Utahraptor Ridge back to about 140 million years ago, a much longer record than previously known. Moreover, the 135 million year age of strata just below the Stikes Quarry coincided with the most recently accepted age of the Weissert Event.

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