The Pulse of Washington County

OUR 250 MILLION Year Legacy

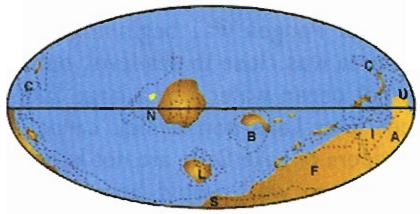
by Jerry D. Harris, Ph.D., Dixie State College Paleontologist

The St. George Dinosaur Discovery Site at Johnson Farm (SGDS) is a unique, world-class paleontological site and internationally-renowned fossil resource. Its discovery in 2000 by Dr. Sheldon Johnson was a boon not only for St. George but for the understanding of the history of life on Earth.

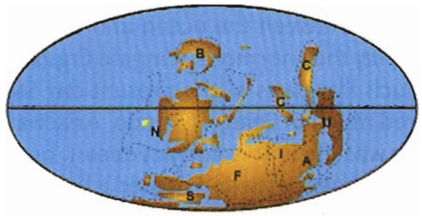
Utah has an exceptionally rich geological history, one of the richest in the world for an area its size. There are rocks in Utah that are billions of years old, closer in age to the initial formation of the Earth (4.6 billion years ago) than they are to us today. Very few of these rocks are visible in the St. George area—with a keen eye, one can spot them when driving out of the Beaver Dam Mountains toward Littlefield on old Highway 91. Most of the Beaver Dam Mountains, and most of the rocks exposed in the Virgin River Gorge—and, in fact, most of Utah—lie under a series of ancient oceans that existed from 510 until 235 million years ago. These rocks also lie deep under St. George itself; tectonic movements of the plates have either tilted them to the surface (the Beaver Dam Mountains) or they have been exposed by the down-cutting action of the Virgin River (the gorge). Many of these rocks contain fossils, but only of invertebrates and, rarely, fish that lived in these oceans (these rocks all predate the appearance of dinosaurs). This is particularly true of the grey, 250 million-year-old Kaibab Limestone, which is exposed in and around Bloomington and Bloomington Hills. The Kaibab Limestone was deposited when all of the Earth's land masses were joined into the super-continent of Pangea. After that, during the Early and Middle Triassic epochs (~250–245 million years ago), the sea became very shallow and, over time, fluctuated in and out, so the environment alternated between being under shallow ocean water and vast tidal flats—the colorful orangish and red rocks formed by the sediment deposited in this area are today called the Moenkopi (MOH-en-KOH-pee) Formation, and they can be seen along I-15 south of Bloomington, in Washington (particularly Shnabkaib Hill), and in the Virgin Anticline around Quail Creek Reservoir. Giant amphibians; large, four-legged reptiles; and small, short-tailed synapsids (ancestors of mammals) dominated the Earth at this time; some of their fossils have been found in Arizona, but not yet in Utah. That the ocean was not far away is attested to by the fossils of giant ichthyosaurs (superficially dolphin-like, ocean-going reptiles) that are found in rocks of this age in northern Nevada.

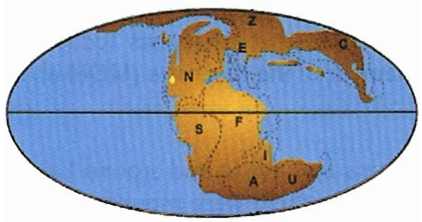
After that, at the end of the Triassic Period (around 215–200 million years ago), the sea retreated and river systems crisscrossed what is today the St. George area. At this time, the land mass that would eventually become

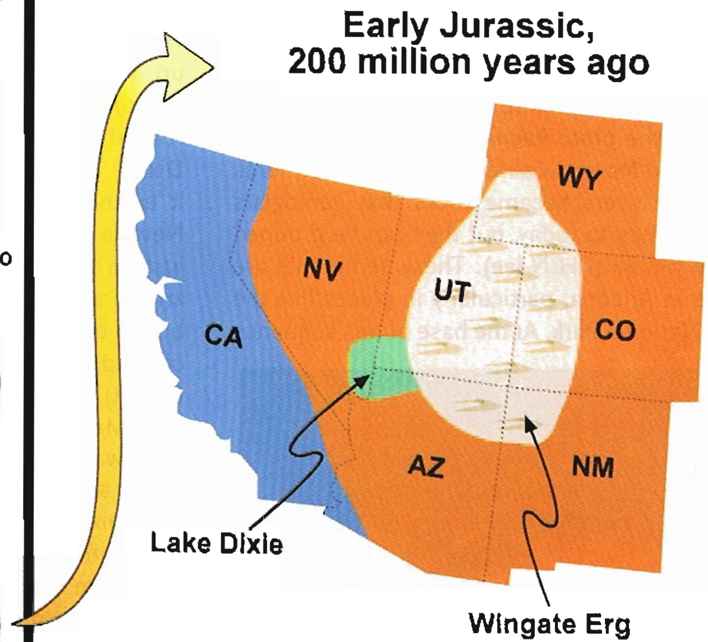
Late Cambrian, 514 million years ago



Early Devonian, 390 million years ago



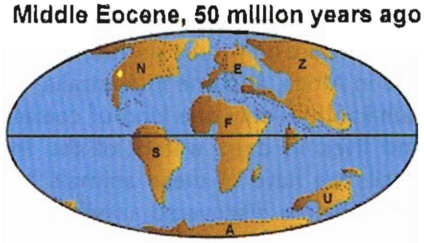




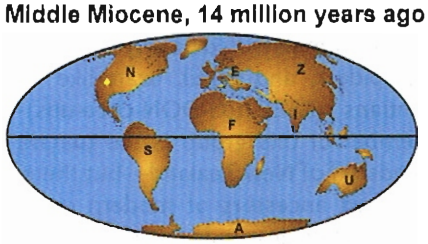
The American Southwest at the beginning of the Jurassic Period, roughly 200 million years ago, showing the positions of Lake Dixie and the Wingate Erg.

Late Cretaceous, 95 million years ago

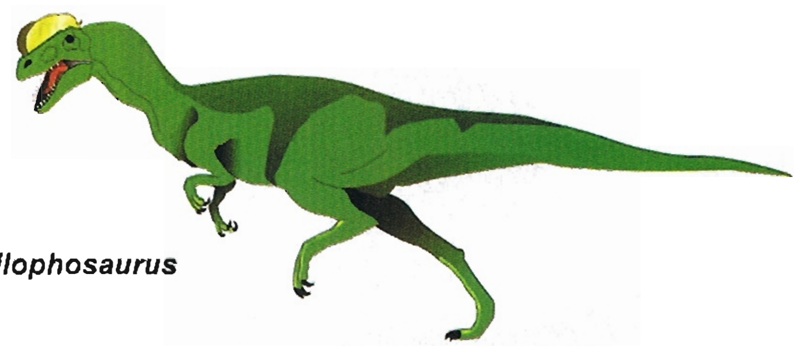
Middle Eocene, 50 million years ago



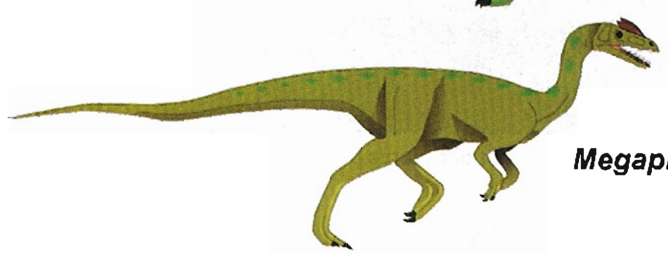
Middle Miocene, 14 million years ago



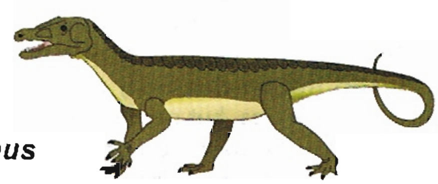
Positions of land masses (brown) through time. Dotted lines indicate present-day margins of continents. A = Antarctica; B = Siberia; C = China; E = Europe; F = Africa; I = India; L = Baltica; N = North America; S = South America; U = Australia; Z = Asia. Approximate location of Utah in yellow.



Dilophosaurus



Megapnosaurus



Protosuchus

The early crocodylian *Protosuchus* and the carnivorous dinosaurs *Dilophosaurus* and *Megapnosaurus* are similar to the kinds of animals that lived in the St. George area at the beginning of the Jurassic and made many of the footprints found at the St. George Dinosaur Discovery Site at Johnson Farm.

North America was located much further south than it is now—it, and Utah in particular, was rather close to the equator. None of the features that make Utah spectacular today existed at this time—the Rocky Mountains would not begin forming for another 140 million years, Lake Bonneville would not come into existence for over 198 million years, and the proto-Pacific Ocean shoreline was somewhere near the Nevada-California border. Sediments deposited by these rivers became rocks that geologists give a variety of names to today, but they can be grouped under the name Chinle (CHIN-lee). These sediments are most noticeable in Arizona, particularly in places like the Petrified Forest National Park. At the base of this sequence is the thick Shinarump (SHIH-nah-rump) Conglomerate, which forms the thick sandstone ledges of Webb Hill and the ridges along Telegraph Road and around Quail Creek Reservoir. Over this is a series of grey, red, and purple striped mud rocks that weather easily and so do not have much exposure in the area, but can be seen around Santa Clara.These are also the rocks responsible for the "blue clay" that is the bane of many a homeowner in southern St. George. It was while the Chinle sediments were being deposited that the first dinosaurs appeared; some of their footprints have been found near Santa Clara and Leeds, but their bones have only been found in Arizona, New Mexico, Colorado, and Texas.

Dilophosaurus painting by Jeff Ham

Approximately 200 million years ago, at the very beginning of the Jurassic Period, dinosaurs were just starting to diversify and become the dominant land animals, and the vast super-continent of Pangea was beginning to break up. The St. George area was close to sea-level, but it was still under water—not ocean water, but a large lake (not related to the much later Lake Bonneville), called "Lake Dixie." The exact borders of Lake Dixie are not known, but it extended westward into what would become eastern Nevada, south into central Arizona, and east to a point just on the other side of Zion National Park. Not much is known about what lay between the ocean and Lake Dixie, but on the east side lay the enormous Wingate Erg (a "sea" of sand dunes, much like parts of the present-day Sahara Desert) that covered much of Utah, Colorado, Arizona, and New Mexico. There was life in this ancient desert, but Lake Dixie was much more hospitable and hosted a very diverse fauna and flora. The sediments that were deposited in Lake Dixie—and fossils of many of the components of the fauna and flora—became what geologists today call the Whitmore Point Member of the Moenave (MOH-eh-NAH-vee) Formation.

Some of the organisms that live in and around Lake Dixie would be familiar today—there were mounds of bacteria and tiny, shelled invertebrates such as clam shrimp that still exist in many lakes today. The lake was also home to small horseshoe crabs.Today, horseshoe crabs live only in the oceans, but during the Jurassic, there were some that lived in freshwater, too. Plants lining the shores of the lake included ferns, cycads, and conifers, although they were only distantly related to living members of those groups. Some other organisms would be vaguely familiar—the lake was a haven for fish, but most of the fish that lived in it are extinct today. Among the fish were small, freshwater sharks, a lungfish (of which there are only three kinds today: one in South America, one in Africa, and one in Australia) and a coelacanth (SEE-luh-kanth)—only one kind of coelacanth survives today and lives in deep waters of the Indian Ocean. All the fossils we have of these animals belong to new species, never before discovered anywhere in the world.

On shore, many of the animals would be very familiar. There were insects and spiders, and small, lizard-like reptiles called sphenodontians (SFEE-noh-DON-chee-uns)—the only surviving member of this group is the tuatara that lives on small islands off of New Zealand—but there were also small, long-legged ancestors of modern crocodiles and alligators. Unlike their descendants, these early croc ancestors had upright limbs and would probably run very quickly. Most impressive were the dinosaurs, although these were not very big dinosaurs. The most common seem to have been two-legged carnivorous dinosaurs of two sizes: small (upwards of 3–4 ft. high at the hip and 8–10 ft. long) like Megapnosaurus (meh-GAP-noh-SAW-rus), which is known from both South Africa and Arizona;

and large (probably upwards of 8 ft. at the hip and 25–30 ft. long), probably similar to a slightly younger dinosaur called Dilophosaurus (dy-LOH-foh-SAW-rus), known from Arizona. Also, small, two-legged plant eaters occasionally ventured into the area. We do have actual body fossils of some of these organisms, including the shelled invertebrates, fish, and a few teeth of the carnivorous dinosaurs—the teeth are particularly interesting because they do not appear to belong to any known meat-eating dinosaur, and they may belong to something completely new to science. But most of the fossils preserved here are, instead, trace fossils (mostly footprints, but also including burrows and sediment-filled tubes once occupied by plant roots). While everyone likes to come to a museum and see fossil shells and bones, these are the remains of dead organisms—trace fossils tell us what these organisms were like when they were alive!

As with all lakes, Lake Dixie's shoreline fluctuated, and sediment being deposited in the lake formed layer upon layer through time. Many of these layers preserve fossils today. In the immediate vicinity of the SGDS, at least 25 layers have been identified as containing important fossils. In most of these layers, the sediment was of just the right consistency to preserve the tracks of the animals in exquisite detail, better than most other places in the world. The "Main Track Layer," a part of which is today covered by the museum building on Riverside Drive, is extremely unusual in the annals of geology: the exposed surface of this layer preserves trace fossils formed on the beach of Lake Dixie. Right across Riverside Drive, in the same layer, are fossils that formed underwater—these were offshore. In some cases, the tracks of individual animals can be followed from onshore to offshore and vice-versa. These tracks and trackways preserve unusual, and sometimes unique, behaviors of many of these animals, information that could never be gleaned from skeletons. There are trackways made by the early croc ancestors walking down a slope, entering the water, and beginning to swim, possibly the first time in history when the croc lineage showed a tendency to enter the water.

More impressively, there are tracks made by both small and large carnivorous dinosaurs doing the same thing! As the animals entered the water, the sediment became slippery, so their feet slipped around in the mud. As their bodies became buoyed up by water, they paddled around using their mostly three-toed hind feet, kind of like a duck would, but since the water was still shallow, their feet, usually just the claws, would rake (and sometimes plunge into) the sediment, leaving long, parallel marks called "swim tracks." Most of the swim tracks were made by small meat-eating dinosaurs, but two things make these unique: (1) the sheer number of them—previously, dinosaur swim tracks were very rare and often claimed to have not been made by dinosaurs; and (2) the fact that most of them are oriented in the same direction. This strongly suggests that the tracks were made by one large group of animals—a flock, if you will—moving together at the same time, a kind of behavior that is retained today by the only surviving dinosaurs: birds.

Back on shore, another unique trace was made by a large carnivorous dinosaur that exited the lake. It sat down on the side of a long berm, leaving not only prints made by its hind feet but also by its hips, tail, and, most unusually, its hands. This is the only verifiable case of carnivorous dinosaur hand prints anywhere in the world. After a while, the animal stood up and walked off, and its trackway can be followed for several yards across the surface in the SGDS museum. (This trackway is not currently visible to visitors while the surface it is on is stabilized, but a pathway out to follow it is being planned.)

Geologically speaking, Lake Dixie existed only for an instant, and its preservation of essentially an entire ecosystem that provides us with a fairly detailed "photograph" of ancient life is very rare in the fossil record. As North America drifted northward later in the Jurassic, the environment would become increasingly arid. Lake Dixie was replaced by river and pond deposits of the Kayenta Formation, which also preserves dinosaur footprints (again, mostly small and large carnivores, including the tracksites in Fort Pearce Wash, Warner Valley, and the Washington water tank) until, ultimately, it was largely covered by the Navajo Erg, the largest sand dune "sea" in Earth history whose sediments are preserved today as the Navajo Sandstone, spectacular exposures of which are exposed in Snow Canyon and through much of Zion National Park. Later still, a thin tongue of the shallow Carmel Seaway extended into the St. George area from the northeast, leaving the yellowish limestones and white gypsum deposits of the Carmel Formation that today can be seen around Diamond Valley and Gunlock. After that, at the end of the Jurassic, when vast river systems were preserving bones of giant plant- and meat-eating dinosaurs all over eastern Utah (including Dinosaur National Monument and the Cleveland-Lloyd Quarry near Price), western Utah was the site of mountain building. Nothing is preserved in the area, a trend that would continue until late in the Cretaceous period (from roughly 85 million years ago until just after the mass extinction event at the end of the Cretaceous, 65 million years ago), when a vast, shallow seaway extended from the Arctic to what is today the Gulf of Mexico, dividing North America into two halves. In Washington and Iron counties, this is preserved as alternating layers of river and mountain-front deposits and oceanic deposits—around St. George, these sediments ring the Pine Valley Mountains and can be seen around Veyo and Gunlock. A few, sparse bones of dinosaurs and other animals have been found in these rocks, but mostly they remain uninvestigated, so there is great potential for more dinosaur discoveries in our area, and many of these dinosaurs could be new!

With this potential paleontological wealth right at hand, the St. George Dinosaur Discovery Site at Johnson Farm has the potential to expand and become a major museum, one that preserves not only the unique footprints of the Moenave Formation, but all the geological and paleontological resources of the area. At present, our museum does not have the standing it needs to collect and preserve these fossils—most fossils found in the area belong to other museums, mostly ones in Salt Lake City. To preserve the resources of Washington County in Washington County, the SGDS must grow much larger to house our important resources. This will, of course, take a great deal of time and money, but there is no other natural history museum within four hours of St. George, and with the startlingly rapid growth of our community, a natural history museum would be both an educational asset and a boon to the tourist industry.

But there is a further problem, as well: the unique geological resources of our area are the very thing that entices people to move here, fostering the growth. While growth is undoubtedly good for our community in an economic sense, the pace of growth may have unforeseen consequences, and proposed plans for growth have not adequately accounted for the very resources that draw people here. For example, the 2006 Washington County Growth and Conservation Act, currently before Congress, paves the way for changing what are presently public lands into private lands that can be developed. Much of this land has fossils on it (not to mention archeological resources and endangered species), but the development plans do not include any assessment, documentation, or removal (if possible) of these resources before they are developed. Some known sites, such as the footprints in Warner Valley and Fort Pearce Wash, could end up submerged under new reservoirs; others could be destroyed before ever being discovered. In short, much of what makes our area unique and attractive could be lost simply by trying to accommodate the people who want to be here to enjoy our unique and attractive resources! St. George still has many important contributions to make to geology and paleontology—all it needs is more of the same commitment and dedication of the community that has already made the St. George Dinosaur Discovery Site at Johnson Farm a world-class scientific, educational, and tourist resource.


Dr. Jerry Harris with an allosaurus leg.

DR. JERRY D. HARRIS

Dr. Jerry D. Harris was born in Chicago, Illinois, in 1970 and became enamored with dinosaurs at an extremely early age (somewhere around two, his mother reports). This fascination with dinosaurs broadened to include all life on Earth through time, but remained centered on dinosaurs. Jerry lived in Chicago until 1979 when his family relocated to Colorado Springs, Colorado. This is where he grew up, moving away only to attend college at the University of Colorado at Boulder. While at Boulder, he became involved as a volunteer with the Denver Museum of Natural History (now the Denver Museum of Nature and Science). After graduating in 1993 with a Bachelor of Arts degree in Geoscience, he was employed as a Fossil Preparator at the Denver Museum, helping prepare specimens and construct displays in their "Prehistoric Journey" exhibit. In 1995, he moved on to Southern Methodist University in Dallas, Texas, where he earned a Master of Science degree in Geology in 1997. Relocating yet again, he was again employed as a Fossil Preparator, this time at the New Mexico Museum of Natural History and Science in Albuquerque, New Mexico. While in Albuquerque, he met his wonderful wife Tracey, who was a volunteer in the fossil preparation lab at the museum. Jerry and Tracey lived happily in Albuquerque until making the decision that Jerry should return to school and get his doctorate. In 2000, he was accepted to and began school at the University of Pennsylvania in Philadelphia, from which he earned his Ph.D. in Earth and Environmental Science in 2004. Literally one day after successfully defending his dissertation, he began the long trek back west to take his current position as Director of Paleontology at Dixie State College. Both he and Tracey were extremely happy to have an opportunity to return to a place where fascinating rocks are abundant and not covered by houses and roads.They love St. George and its people, and are grateful to be able to help in the construction of the St. George Dinosaur Discovery Site at Johnson Farm. Dr. Harris also enjoys teaching Introduction to Geology and Introduction to Dinosaurs courses at the college.

Presently, Dr. Harris is helping City Paleontologist Andrew R.C. Milner publish a great deal of research based on fossils from the site, including editing two forthcoming books: one, a non-technical volume, will focus on the geology and fossils of the Johnson Farm site, and the other includes technical papers on this and other sites of similar age from around the world by researchers from several countries.

Dr. Harris is also engaged in other research, including projects in Argentina and China. The latter project recently garnered much press owing to the discovery in 110 million-year-old rocks in northwestern China of several fossils of a small, early bird that is close to the ancestors of all modern birds. Some of this research was recently published in the prestigious journal *Science*.

When not dealing with dinosaurs or teaching, Dr. Harris enjoys archery, origami, movies, music, and reading.

St. George

Today

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The Pulse of Southern Utah

Visitors Welcome
We hope you find this publication helpful in planning your activities while in our area.

To keep in touch with what's up in Washington County after returning home, visit www.stgeorgetoday.com.

Lyle Hurd
Editor