Reflecting Back in Time to Uncover the Rich Fossil Record of Grand Canyon National Park

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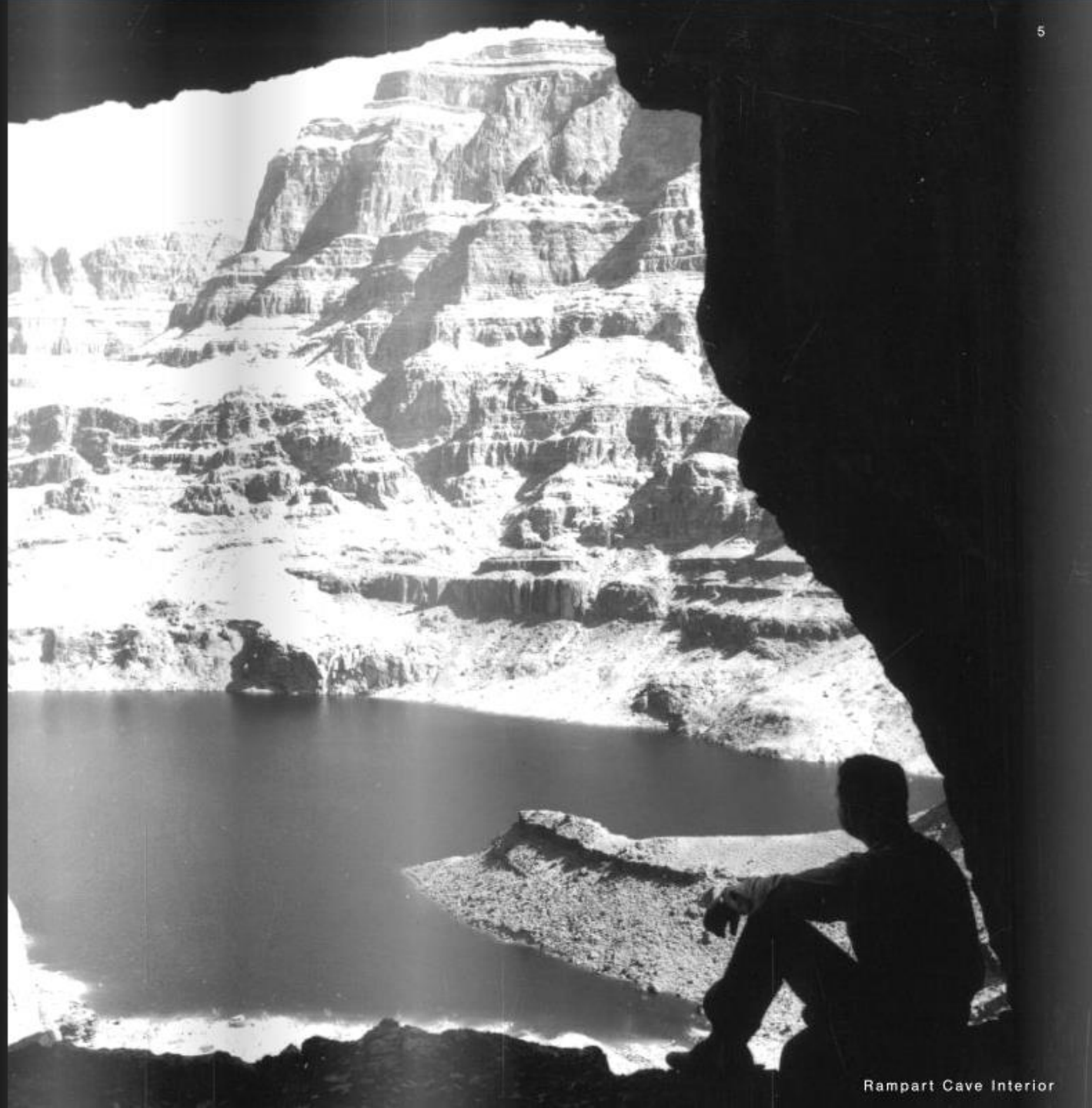
Although the fossil record for the Grand Canyon extends back into the Precambrian, approximately 1.25 billion years, the human dimension of the story begins in April 1858 with the first reported discovery of a fossil in the canyon. This history is tied to the Ives Expedition, which traveled up the Colorado River in the canyon during 1858. Members of this party collected fossils near Diamond Creek, near the present-day Hualapai Tribal Reservation. These specimens were eventually published in 1861 by John Strong Newberry, nearly 60 years before the Grand Canyon National Park was established as a unit of the National Park Service on February 26, 1919.

All photos in this story courtesy National Park Service.



Rampart Cave Interior

The history of paleontological field work and research at Grand Canyon National Park and the surrounding area includes a list of notable and respected paleontologists. Beginning with the foundational work of Charles Walcott during the 1880s, a sustained scientific interest in the fossils of Grand Canyon was carried forth from one generation of paleontologists to the next, uncovering an expansive fossil record. The paleontological treasures of the park and canyon were captured in scientific publications and preserved within museum fossil collections.

During 2019, and in conjunction with the Centennial Celebration for Grand Canyon National Park, a team of paleontologists and park scientists collaborated to piece together the remarkable story about the park's rich fossil record. The fossil inventory documented a wide variety of fossil plants, invertebrates, vertebrates, and trace fossils, primarily from Paleozoic sedimentary rocks exposed in the canyon. Additionally, the fossil inventory team identified and evaluated the various resource management issues associated with the park's paleontological resources to help inform park leadership and staff. The culmination of this work resulted in the first comprehensive publication on the paleontology of Grand Canyon National Park, completed in March 2020.

Seed Fern Fossil

Seed Fern Fossils in Permian Hermit Shale on Kaibab Trail

Seed Fern Fossils

Fossil Plants

An important record of fossil plants is beautifully preserved within the sedimentary layers of Grand Canyon National Park. The study of fossil plants, known as paleobotany, has a long history at the park. Fossil plants were first found at Grand Canyon in 1915, within the Hermit Shale. These plants date to approximately 285 million years ago and represent the spread and diversification of plants onto land surfaces during the Paleozoic Era. This first collection of terrestrial fossil plants from Grand Canyon National Park was forwarded to a famous paleobotanist named David White, who worked for the U.S. Geological Survey, beginning many years of work to study and identify these early plants.

During the past 100 years, the field collection of fossil plants in Grand Canyon National Park has resulted in the discovery of more than 40 different species of fossils plants. The fossil flora has been found primarily within two geologic formations in the park, the Hermit Shale and the Surprise Canyon Formation. These plant fossils yield valuable information about the early diversity of these prehistoric plants and the ancient environments in which the plants lived.

Fossil Invertebrates

The most abundant and diverse portion of the Grand Canyon paleontological record is represented by the Paleozoic invertebrate fossils. Hundreds of species of fossil invertebrates have been identified from both marine and terrestrial sedimentary rocks within the canyon. The fossil invertebrates span the Paleozoic from the Cambrian through the Permian, including 16 different geologic formations. Fossilized remains of sponges, rugose and tabulate corals, bryozoans (moss animals), brachiopods (lamp shells), bivalves, snails, cephalopods, insects, trilobites, sea urchins, crinoids (sea lilies), and other invertebrates are indicators of the many environmental systems that punctuated the geologic history of Grand Canyon. The concentrations of Cambrian trilobites observed and documented by U.S. Geological Survey geologist Eddie McKee, preserved in the Bright Angel Shale, represent rocks laid down in a shallow marine environment. By contrast, the fossil remains of a dragonfly wing in the Permian Hermit Shale denotes a sedimentary sequence deposited in a terrestrial environment on the ancient continent.

Crinoid columnal found in Upper Kaibab Limestone

Fossil Bryozoan in Redwall Limestone

Worm Trails in Bright Angel Shale

Trilobite Fossil

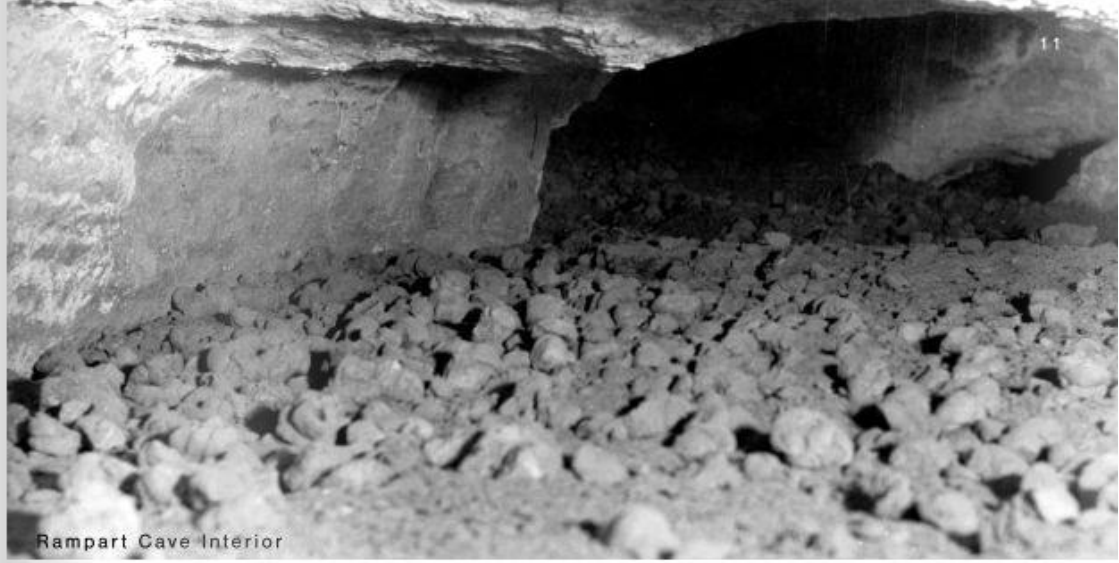
Fossil Vertebrates

The Grand Canyon fossil record of vertebrates—animals with an internal skeleton and a backbone (vertebral column)—consists of two very different groups of ancient organisms. The first group includes sharks and other fishes that lived in ancient oceans and marine environments during the Paleozoic Era. The second group includes the remains of ice age (Pleistocene) vertebrates that have been preserved and discovered in the many caves within Grand Canyon National Park. These fossil vertebrates document the extraordinarily diverse geologic history and fossil record preserved for the park.

The first report of fossil vertebrates from Grand Canyon dates to 1880, nearly 40 years prior to the creation of the national park. Dr. Charles Doolittle Walcott, from the U.S. Geological Survey, reported on some remains of Devonian fish from the Temple Butte Formation in Grand Canyon. Over the next 140 years, fossil remains of Paleozoic sharks and other fishes have been discovered in Grand Canyon strata spanning the Devonian, Mississippian, Pennsylvanian, and Permian time periods. Recent research by fossil shark paleontologist John-Paul Hodnett has led to the identification and naming of several new fossil shark species from Grand Canyon.

Sloth Dung

Rampart Cave Shasta Ground Sloth Skull



Rampart Cave Interior

Bones of various animals collected from Rampart Cave. Includes mountain goat horns and possibly camel bones.

American Cheetah found in Rampart Cave

The area within and around Grand Canyon National Park is considered one of the largest concentrations of caves in the United States. Within some of these caves are the remains of extinct ice age animals, among them ground sloths, vampire bats, the American cheetah, and the Pleistocene condor. Paleontologist Jim Mead has spent much of his career exploring and documenting fossils from the caves within Grand Canyon, and he believes there are likely many more ice age fossils to be discovered. One of the most important fossil caves in the park is known as Rampart Cave, in the western portion of the canyon. More than 50 species of Pleistocene vertebrates have been identified from Rampart Cave. During the 1930s the Civilian Conservation Corps assisted Smithsonian paleontologist Remington Kellogg with an excavation of a portion of Rampart Cave. Thick stratified sequences of sloth dung (feces) were found within the cave, which also contained bones and other remains of ancient animals and plants. In 1976, a fire in Rampart Cave destroyed a portion of the fossil-rich sloth dung deposits, requiring a team of firefighters to extinguish the fire. Rampart Cave was featured as the 2019 National Fossil Day annual logo.

Fossil Footprints, Tracks, Trails, and other Trace Fossils

Some of the more intriguing fossils from Grand Canyon are the wide variety of footprints, tracks, trails, and other evidence of biological activity locked in time in the sedimentary rocks. Collectively, these fossils are commonly known as trace fossils, whereas scientists often refer to them as ichnofossils. Although trace fossils are not the ordinary physical remains of a prehistoric organism (such as fossilized bones, shells, or wood) which are often associated with the word "fossil," they are quite valuable in that they preserve direct evidence of behaviors and activities frozen in time from once-living organisms. A wonderful diversity of both invertebrate and vertebrate trace fossils is documented throughout the park strata, reflecting activities by prehistoric animals within both marine and terrestrial environments.

The first fossil vertebrate footprints reported from Grand Canyon were collected by paleontologist Charles Schuchert (Yale University) in 1915 from along the Hermit Trail. These fossils gained the attention of the paleontological community and drew Smithsonian paleontologist Charles Gilmore to the canyon during the 1920s to study and collect fossil footprints left by Late Paleozoic amphibians and reptiles. Today the remarkably well-preserved trace fossils from the Coconino Sandstone, Hermit Shale, and Wescogame Formation attract paleontologists from around the world, who come to learn about and document these prehistoric journeys across a Paleozoic landscape.

Tracks at Jackass Creek

Charles Gilmore

Fossil Tracks in Coconino Sandstone

Planning a Future for Preserving the Past

The development and publication of the Grand Canyon National Park Centennial Paleontological Resource Inventory in March 2020 was the first attempt to comprehensively pull together over 160 years of paleontological research, field work, and fossil collecting. This ambitious project represents the single largest park-specific paleontological inventory undertaken by the National Park Service. The investment in this inventory, involving a team of several dozen paleontologists and park staff, will provide a solid baseline of paleontological resource information to inform current and future park managers and scientists. The documentation of the scope, significance, distribution, and management issues related to paleontological resources is essential, mandated by federal law, and supports resource stewardship goals for the National Park Service.

The paleontologist's view into the expanses of Grand Canyon is naturally met with contemplation and wonder. Given the widespread and continuous weathering and erosion of highly fossiliferous strata in the canyon, the paleontologist's thoughts are directed to the questions,

"What unknown fossil remains are still out there in the canyon?" and, "What prehistoric creatures are yet to be discovered?" The future of paleontology at Grand Canyon National Park will undoubtedly uncover new specimens and reveal new stories, reshaping our understanding of this remarkable history of life.

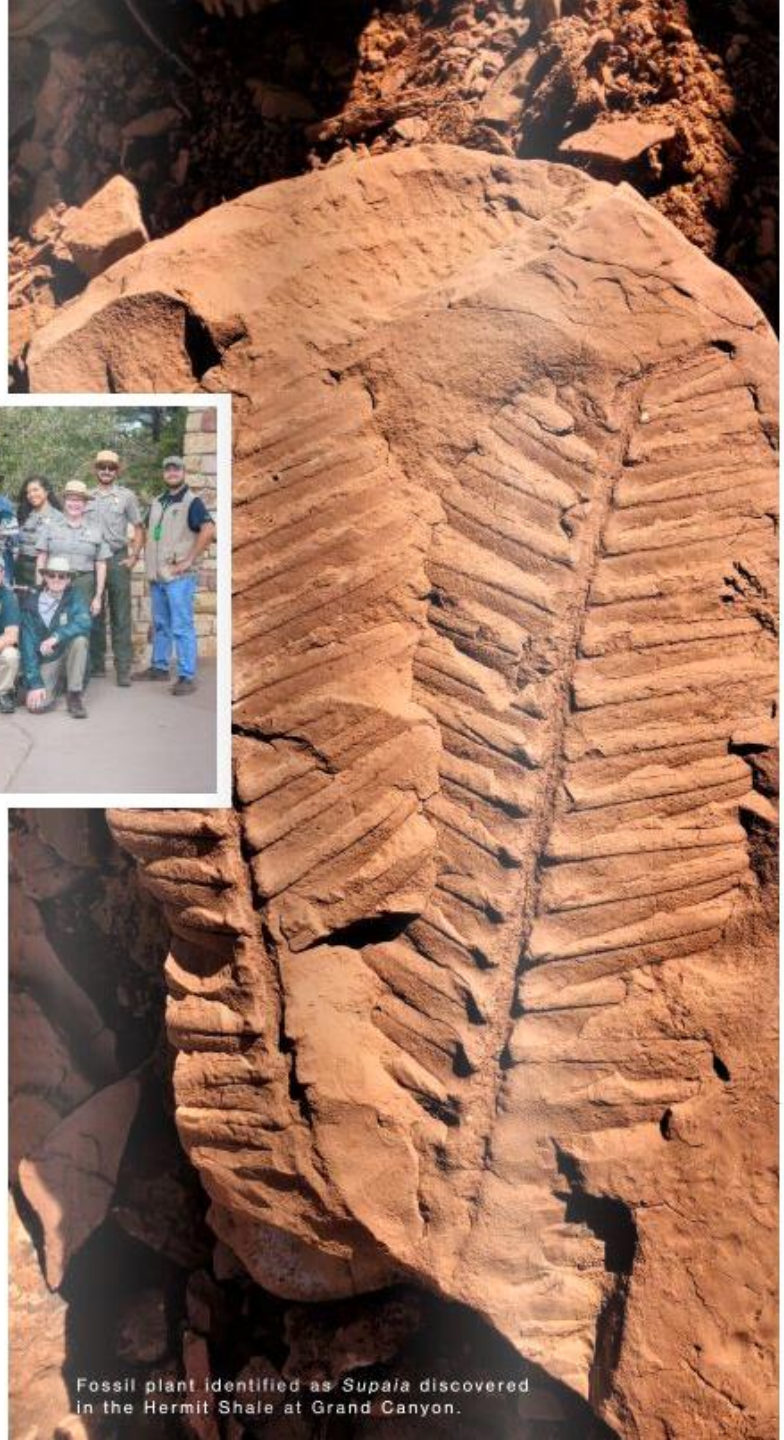
Celebrating Grand Canyon National Park's Paleontological Heritage

In recognition of Grand Canyon National Park's centennial in 2019, a number of fossil-focused activities were undertaken. A team of paleontologists and park rangers participated in research, field inventories, and a public outreach event to celebrate the rich fossil record preserved at the park. The team published the first comprehensive paleontological resource inventory for Grand Canyon National Park.

Paleontologists and park rangers celebrate National Fossil Day at Grand Canyon National Park during the park's centennial.

The park hosted a field-based event called the "Grand Canyon National Park PaleoBlitz" during which teams of paleontologists participated in fossil surveys at various remote locations within the park. The fossil surveys resulted in some new and important fossil discoveries. Two localities yielded rare and interesting fossil teeth from primitive sharks that lived in ancient seas during the end of the Paleozoic Era. New fossil footprint impressions were documented from a previously unrecorded location in the park. These trackways preserve the journey of a four-legged animal (tetrapod) across sand dunes of an arid desert environment approximately 275 million years ago.

To celebrate the fossils of Grand Canyon, the park hosted a National Fossil Day event in 2019. The educational outreach event showcased the wide variety of prehistoric life found in the layers of Grand Canyon strata. Paleontologists met with park visitors to discuss some of the new fossil discoveries uncovered during the "PaleoBlitz." Visitors of all ages participated in the Junior Ranger Program and took the pledge to become an official National Park Service Junior Paleontologist. A public ceremony with park and guest speakers was held at Mather Point to proclaim National Fossil Day at Grand Canyon National Park on October 16, 2019.



Fossil plant identified as *Supaia* discovered in the Hermit Shale at Grand Canyon.

The fossil record of plants at Grand Canyon National Park gained the attention of the scientific community through the work of paleobotanist David White. In 1889 White joined the U.S. Geological Survey, where he later became the chief geologist. He was also appointed as the associate curator for paleobotany at the Smithsonian Institution beginning in 1903. White coordinated field trips to Grand Canyon National Park during the summers in the late 1920s, collecting fossil plant specimens from the Permian Hermit "Shale" Formation. He took great pride in the fact that he cooperated with the National Park Service and was permitted to wear a ranger uniform while in the field at the park. He published an important monograph describing the fossil plants from the Hermit Shale in 1929.

One of the more important localities that David White worked and collected plant fossils in the park was along the Yaki Trail (now called the South Kaibab Trail). The Civilian Conservation Corps (CCC) assisted with quarrying White's fossil plant locality and constructing a "fossil fern exhibit" at the site in 1937. Future restoration of this exhibit is planned by the National Park Service in the near future. The legacy of paleobotanist David White is preserved by the "fossil fern exhibit" and his headstone located in the cemetery at Grand Canyon National Park.

Paleontologists Dr. David White and Dr. John C. Merriam sitting at Cedar Ridge fossil quarry circa 1927.

Photos by NPS.

Ancient Shark Encounters

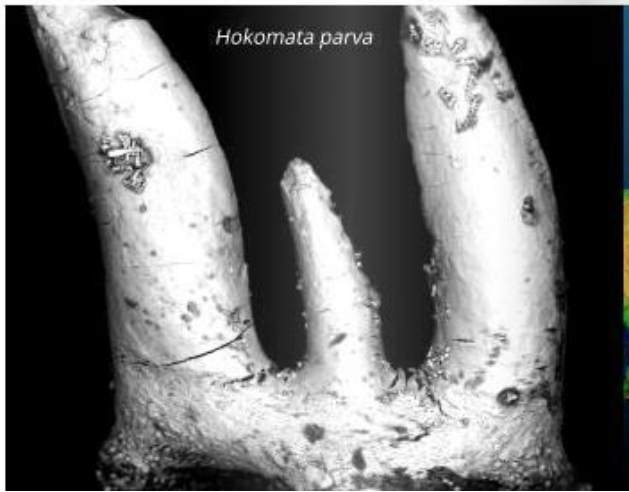
Ancient marine rocks within and around Grand Canyon National Park preserve an important fossil record of Paleozoic sharks. The cartilaginous composition of shark skeletons generally limits their fossil remains to teeth and dorsal fin spines. The Late Mississippian-aged Surprise Canyon Formation and the Early Permian-aged Kaibab Limestone have been the source of some diverse and interesting fossil remains of primitive sharks.

Some refer to the Late Paleozoic as the "Golden Age of Sharks" due to the extraordinary diversity of primitive sharks thriving in both freshwater and marine environments. Prehistoric sharks from Grand Canyon range in size from one of the largest spanning between five and seven feet long for the genus *Megactenopetalus* down to about six inches long for the genera *Amaradontus* or *Hokomata*. Paleontologists J.P. Hodnett and David Elliott have been studying and describing the Late Paleozoic sharks of northern Arizona to share an important story about these extinct aquatic predators.

Top Image: Tooth of the giant shark *Megactenopetalus* from the Permian Kaibab Limestone at Grand Canyon.

Bottom Image: Tooth of the Early Pennsylvanian shark *Hokomata parva* from the Watahomigi Formation.

Photos by J.P. Hodnett



Following in the Footsteps of Ancient Animals

Concealed within the layers of ancient strata at Grand Canyon National Park are the footprint impressions of long-extinct four-footed animals known as tetrapods. These fossilized tracks and trackways are frozen in time within terrestrial sediments in the park and represent one of the most important Paleozoic vertebrate footprint localities in the world. These traces of prehistoric journeys have been documented and studied for more than a century, with new fossil tracks continuously being discovered in the canyon. In 2019 an international team of paleontologists published on a recently discovered track block with footprints identified as *Ichniotherium* (marking creature) which is the youngest and last record of this type of track in the world.

The study of fossil footprints, tracks, trails, and burrows is referred to as ichnology. Trace fossils preserve evidence of ancient biological activity within the sedimentary environments in which the animal lived. At Grand Canyon National Park, some of the fossil footprints exhibit features which indicate the tetrapod trackmaker was walking either up or down a sand dune in an ancient arid desert environment.

One of the tools used to both document and monitor fossil footprints is known as photogrammetry, where photographs are obtained to create three-dimensional models. The photogrammetric models are used to evaluate and measure changes in the stability and condition of fossils subject to natural processes or human impacts. The large block containing the *Ichnotherium* trackways would be nearly impossible and impractical to collect from the field and transport to a museum facility. The photogrammetric models can also be used to support research and public education. Interactive 3-D models can be posted on virtual fossil websites to share fossils otherwise not easily accessible to the public.

Bottom Right Image: Fossil footprints identified as *Ichniotherium* from a block of Coconino Sandstone. Photos by NPS.