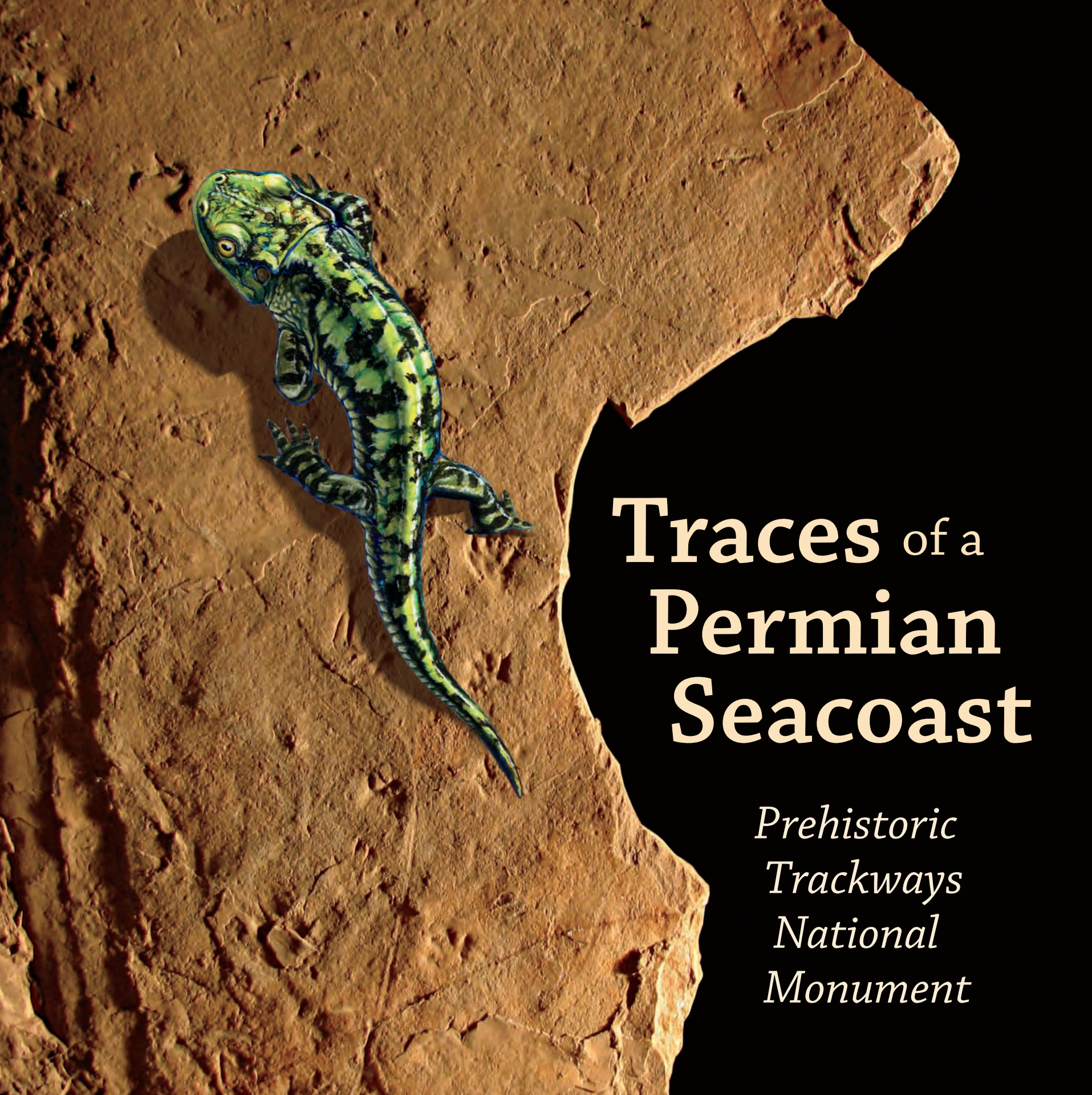

Traces of a Permian Seacoast

Prehistoric Trackways National Monument

Text: Spencer G. Lucas
Layout and Art: Matt Celeskey and Mary Sundstrom

Front Cover:
Temnospondyl on *Batrachichnus* trackway (NMMNH P-23479)
Illustration by Matt Celeskey

Front Inside cover:
Reptile undertracks (NMMNH P-23668), Photograph by Sebastian Voigt

Back Cover:
Dimetrodon making tracks, Illustration by Matt Celeskey

Back Inside cover:
Dimetropus foot track overlain by two smaller trackways (NMMNH P-23622), Photograph by Sebastian Voigt

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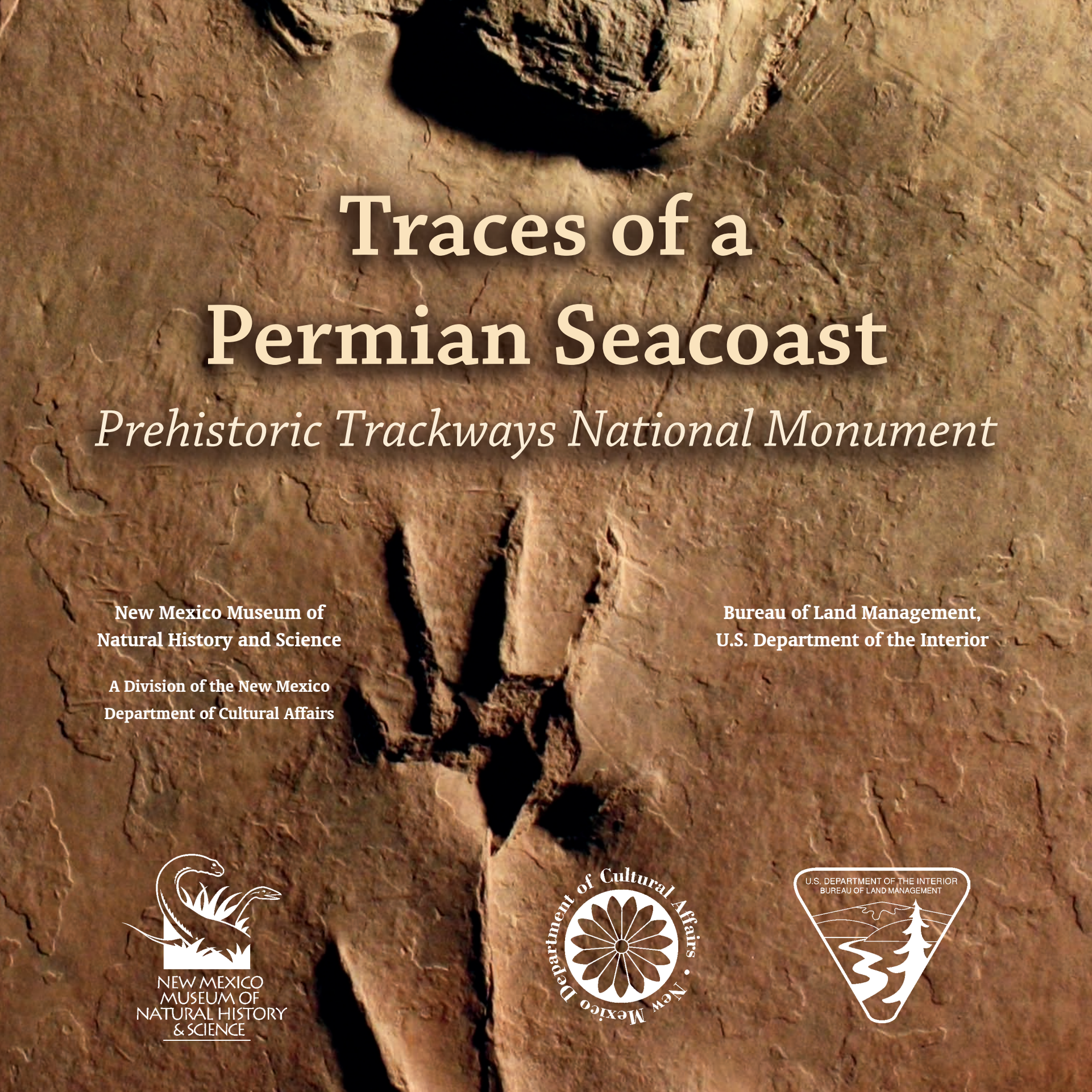


Traces of a Permian Seacoast

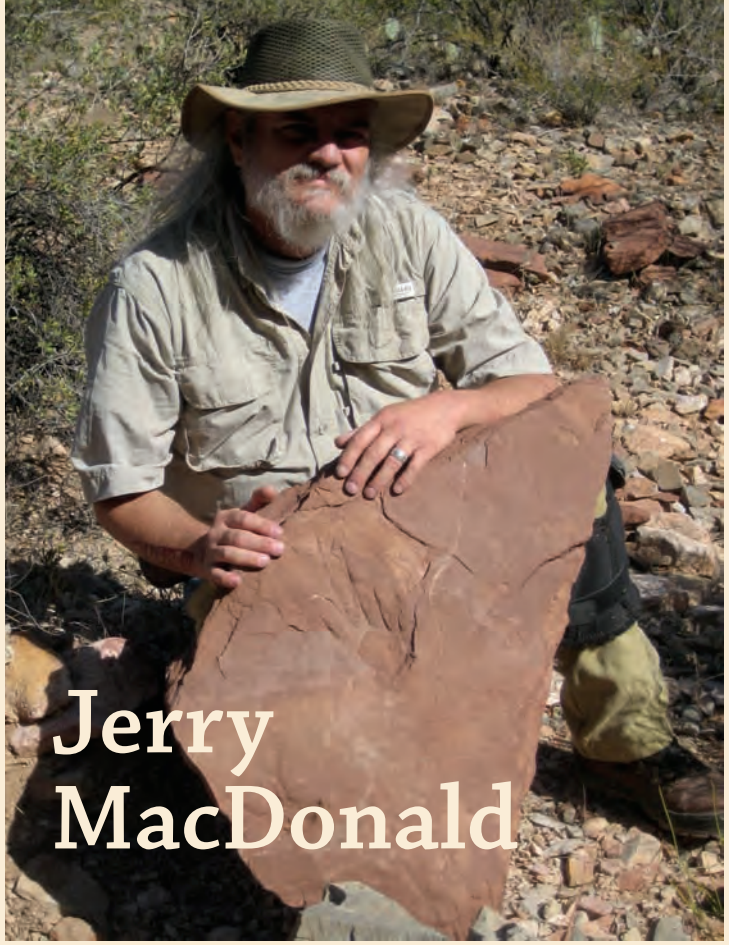
Prehistoric Trackways National Monument

New Mexico Museum of Natural History and Science

A Division of the New Mexico Department of Cultural Affairs

Bureau of Land Management, U.S. Department of the Interior

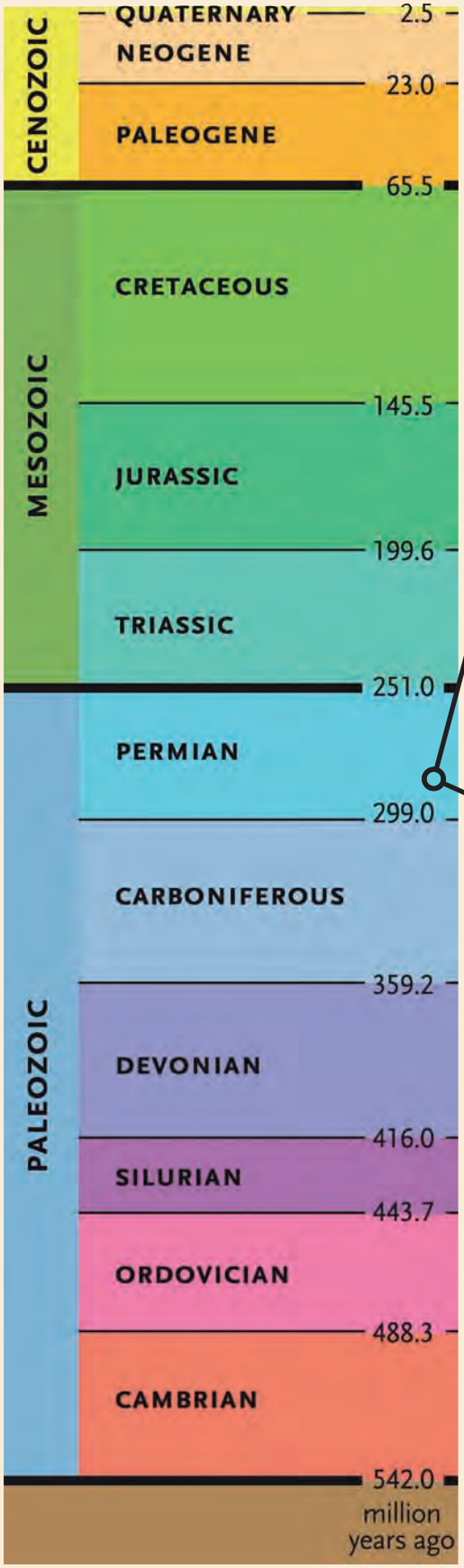
In 2009, an act of the U. S. Congress created the Prehistoric Trackways National Monument, approximately 5200 acres located in the Robledo Mountains of Doña Ana County, southern New Mexico. The legislation endorsed the conclusion of paleontologists that the Monument area includes the most scientifically significant Permian tracksites in the world. It further stated that "designation of the trackways site as a National Monument would protect the unique fossil resources for present and future generations while allowing for public education and continued scientific opportunities."



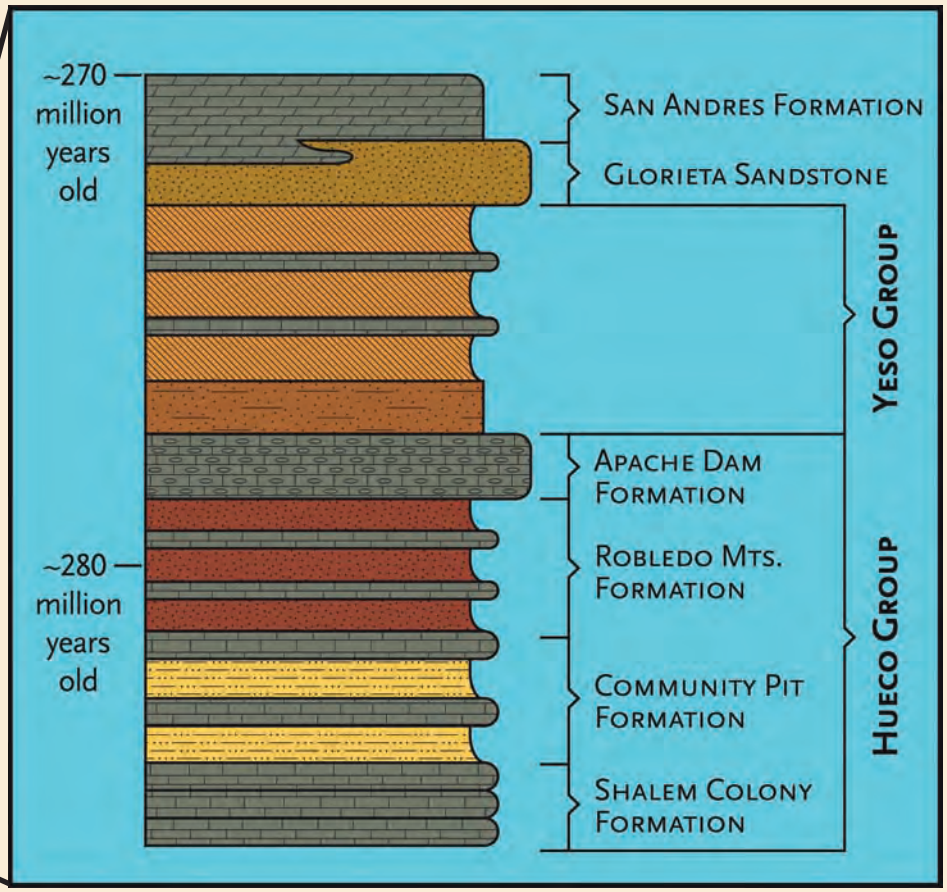
Jerry MacDonald

Not all great fossil discoveries are made by professional scientists. Sometimes, a dedicated, self-taught citizen scientist such as Jerry MacDonald finds scientifically important fossils.

In 1987, hiking alone in the Robledo Mountains, Jerry found the now world-famous Early Permian tracksites that led to the creation of the Prehistoric Trackways National Monument. Since the late 1980s, Jerry has worked closely with scientists to develop a totally new understanding of the Permian trackway record based on his discoveries. Jerry's determination to preserve the Robledo trackways for future generations was a huge factor in ultimately convincing the U. S. Congress to establish the Prehistoric Trackways National Monument to protect the fossils and promote their further study and interpretation.



Permian rocks in southern New Mexico



Most of the rocks exposed in the Prehistoric Trackways National Monument are of Early Permian age, about 280 million years old. More than 150 fossil localities are known from these rocks in the Monument. They include the most extensive and prolific Early Permian trackway localities known to science.

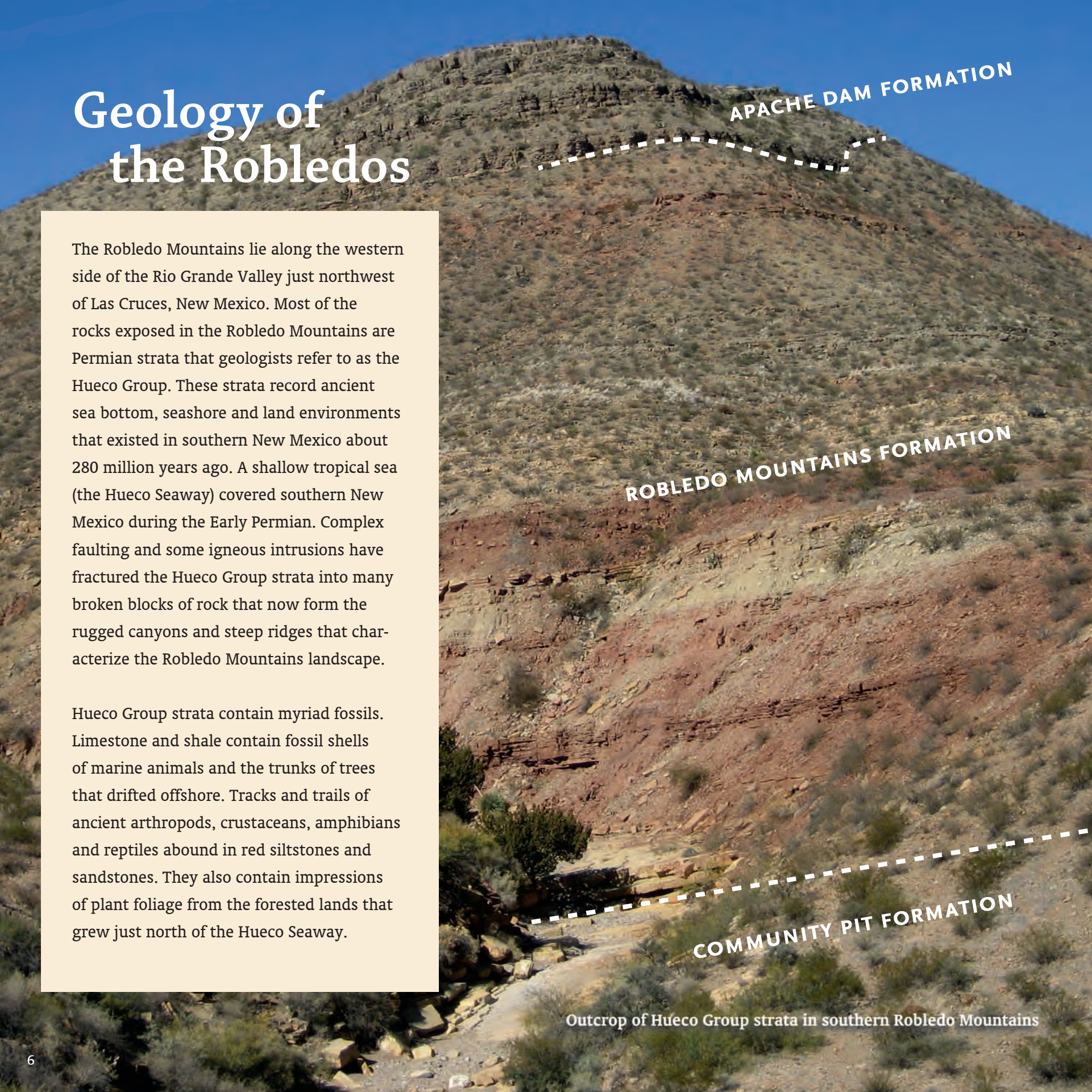
The Permian Period in Earth history (251 to 299 million years ago) takes its name from the city of Perm in Russia, where rocks of this age were first recognized in the 1800s.

When the Permian Period began, there were ice ages in the southern hemisphere. It ended with the most devastating mass extinction during the history of life. The Permian Period also witnessed all the Earth's continents united in the single supercontinent called Pangea (pan-JEE-uh).

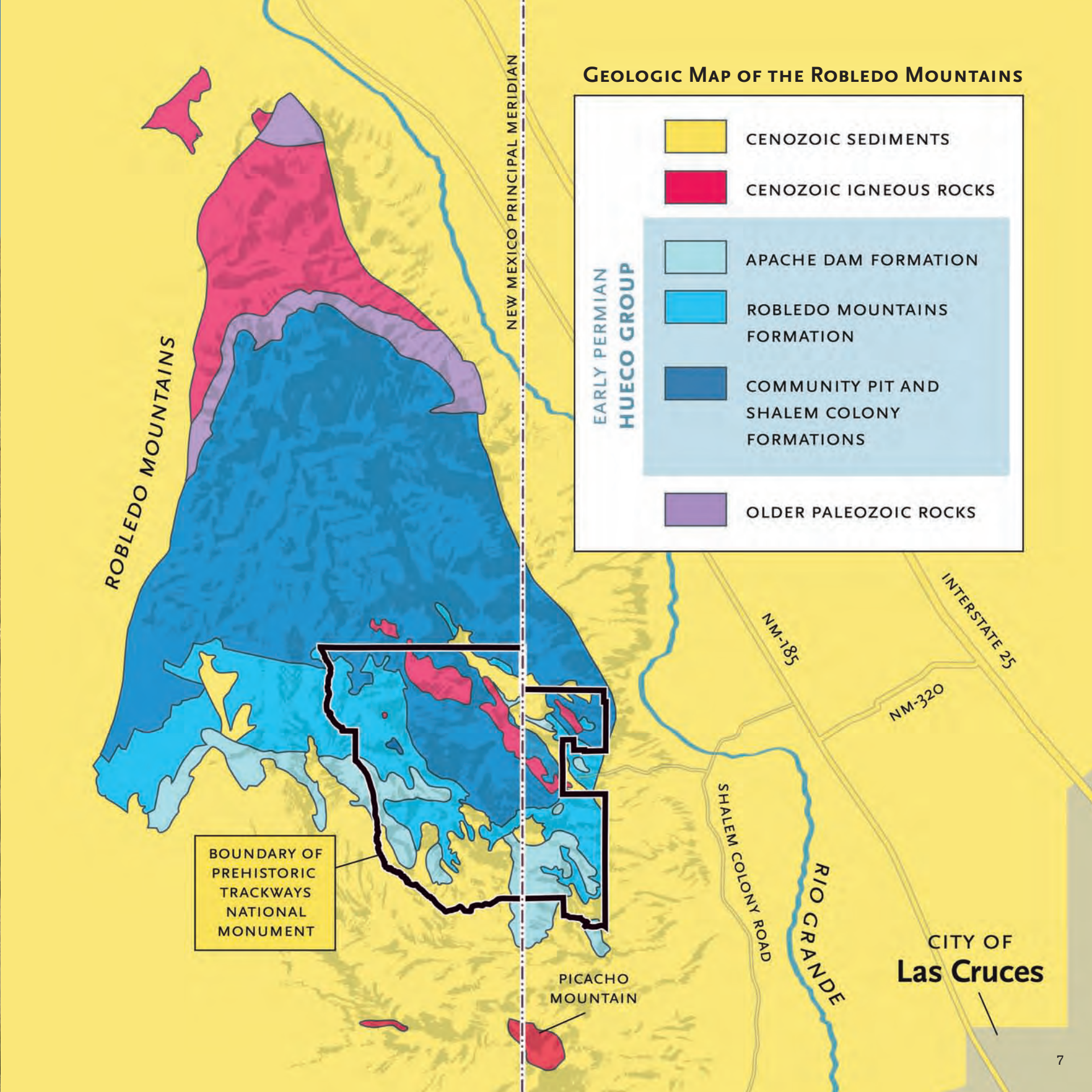
Geology of the Robledos

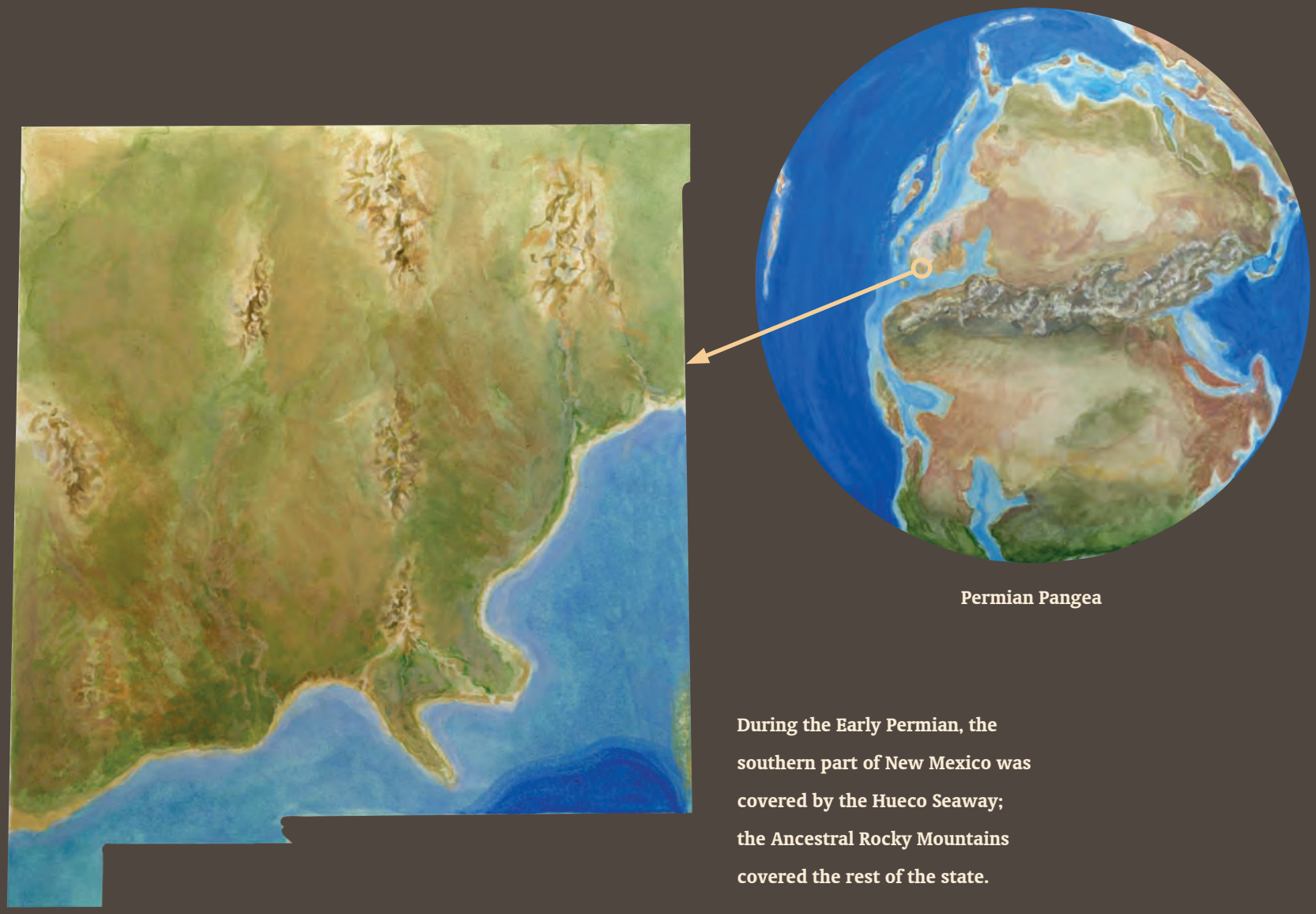
The Robledo Mountains lie along the western side of the Rio Grande Valley just northwest of Las Cruces, New Mexico. Most of the rocks exposed in the Robledo Mountains are Permian strata that geologists refer to as the Hueco Group. These strata record ancient sea bottom, seashore and land environments that existed in southern New Mexico about 280 million years ago. A shallow tropical sea (the Hueco Seaway) covered southern New Mexico during the Early Permian. Complex faulting and some igneous intrusions have fractured the Hueco Group strata into many broken blocks of rock that now form the rugged canyons and steep ridges that characterize the Robledo Mountains landscape.

Hueco Group strata contain myriad fossils. Limestone and shale contain fossil shells of marine animals and the trunks of trees that drifted offshore. Tracks and trails of ancient arthropods, crustaceans, amphibians and reptiles abound in red siltstones and sandstones. They also contain impressions of plant foliage from the forested lands that grew just north of the Hueco Seaway.



Outcrop of Hueco Group strata in southern Robledo Mountains


Geologic Map of the Robledo Mountains
CENOZOIC SEDIMENTS
CENOZOIC IGNEOUS ROCKS
EARLY PERMIAN
HUECO GROUP
APACHE DAM FORMATION
ROBLEDO MOUNTAINS FORMATION
COMMUNITY PIT AND SHALEM COLONY FORMATIONS
OLDER PALEOZOIC ROCKS
ROBLEDO MOUNTAINS
NEW MEXICO PRINCIPAL MERIDIAN
INTERSTATE 25
NM-185
NM-320
SHALEM COLONY ROAD
RIO GRANDE
BOUNDARY OF PREHISTORIC TRACKWAYS NATIONAL MONUMENT
PICACHO MOUNTAIN
CITY OF
Las Cruces



Permian Pangea

During the Early Permian, the southern part of New Mexico was covered by the Hueco Seaway; the Ancestral Rocky Mountains covered the rest of the state.

The Early Permian World

During the early part of the Permian Period, about 280 million years ago, all the continents had united to form the supercontinent Pangea. In southern Pangea, great ice sheets and glaciers waxed and waned, driving global sea levels up and down. What is now New Mexico was in the western equatorial tropics of Pangea. No snow fell, and there were only two seasons, one very wet and the other very dry. Primitive amphibians and reptiles roamed the hot and seasonally arid landscape, while brachiopods, bryozoans and crinoids covered the warm, shallow seafloor.

Skull of the pelycosaur *Sphenacodon* (sfee-NACK-oh-don) from Lower Permian Cutler Group strata near Abiquiu, in northern New Mexico (NMMNH P-55367). *Sphenacodon* was one of the top predators of the Early Permian landscape.

Only footprints (no fossil bones) of amphibians and reptiles are found in the Lower Permian rocks of the Robledo Mountains. But to the north, especially in Socorro, Sandoval, and Rio Arriba Counties, many fossil bones of Early Permian amphibians and reptiles have been discovered. About 280 million years ago, these animals hunted and were hunted on the river floodplains that formed the valley floors among ancient highlands called the Ancestral Rocky Mountains.

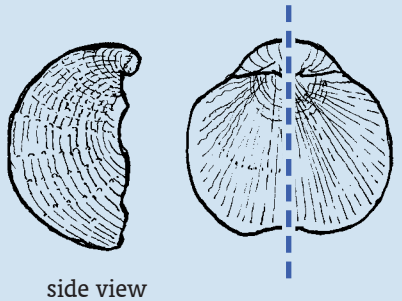
Life in the Sea

The Hueco Seaway, a shallow tropical sea, covered much of southern New Mexico during the Early Permian. The warm waters were home to a diversity of marine animals, most notably the clam-like brachiopods, bryozoans (sea fans) and crinoids (sea lilies). A few clams and snails lived among these animals, and, in places, many fusulinids (shelled protozoans) blanketed the sunlit seafloor. Predators in the waters above included cephalopods (nautiloids and ammonoids) as well as sharks. Some rock layers in the Robledo Mountains yield millions of fossil shells, especially of brachiopods. They indicate Early Permian seafloors like the shallow, warm, sunlit sea bottoms of today's Caribbean Sea.

Cross-section of a fusulinid shell only a few millimeters wide.

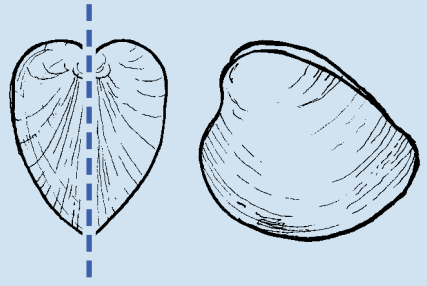
What is a brachiopod?

Brachiopods are shelled animals that look like clams, but have different symmetry.



side view

A line drawn across the shells of a brachiopod divides it into two equal parts.



side view

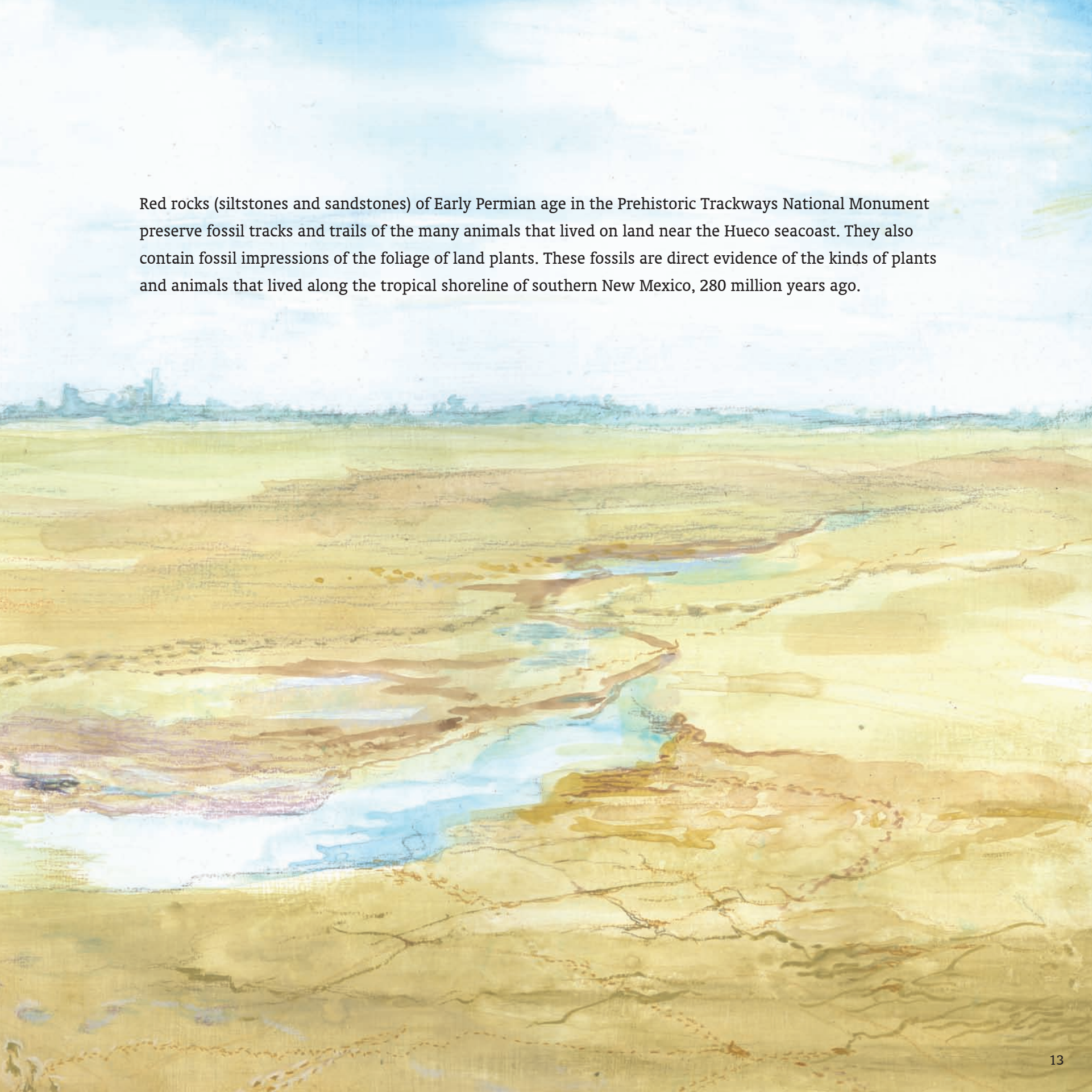
In a clam, the line must be drawn between the shells to divide it equally.

Fusulinids

On the sunlit Permian seafloors, single-celled animals built complex chambered shells, some as large as or larger than rice grains. These fusulinids are extinct relatives of living foraminiferans, and were common inhabitants of the Hueco Seaway.

Life on Land

During the Early Permian, in what is now southern New Mexico, many plants and animals lived along the seacoast and on the inland river floodplains to the north. Conifer forests dotted the landscape. Various arthropods, including primitive insects, spiders and scorpions searched the sandflats for food. Small, salamander-like amphibians and lizard-like reptiles hunted the arthropods. Even larger predators, especially the pelycosaurs, fed on the amphibians and the smaller reptiles.



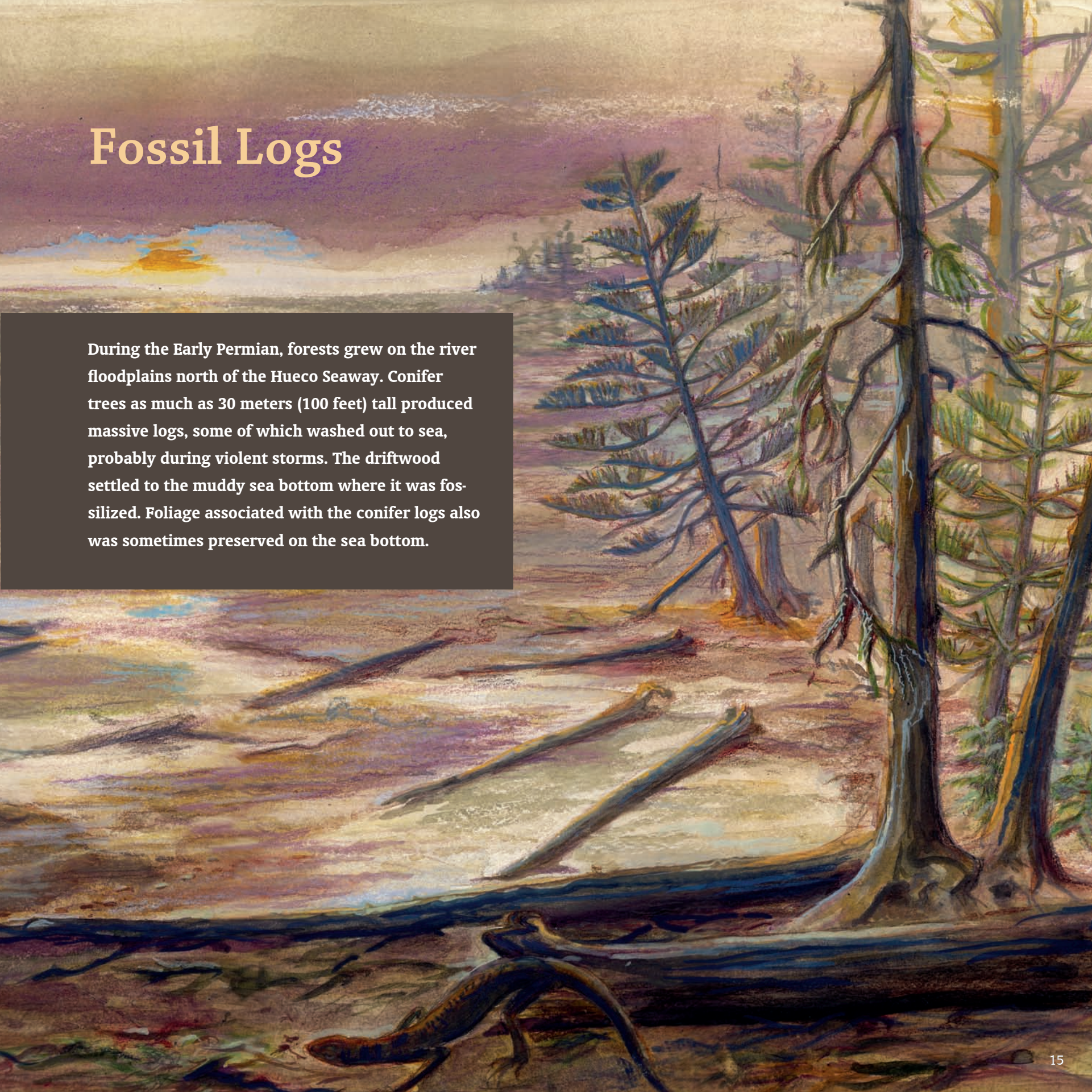
Red rocks (siltstones and sandstones) of Early Permian age in the Prehistoric Trackways National Monument preserve fossil tracks and trails of the many animals that lived on land near the Hueco seacoast. They also contain fossil impressions of the foliage of land plants. These fossils are direct evidence of the kinds of plants and animals that lived along the tropical shoreline of southern New Mexico, 280 million years ago.

Fossil log

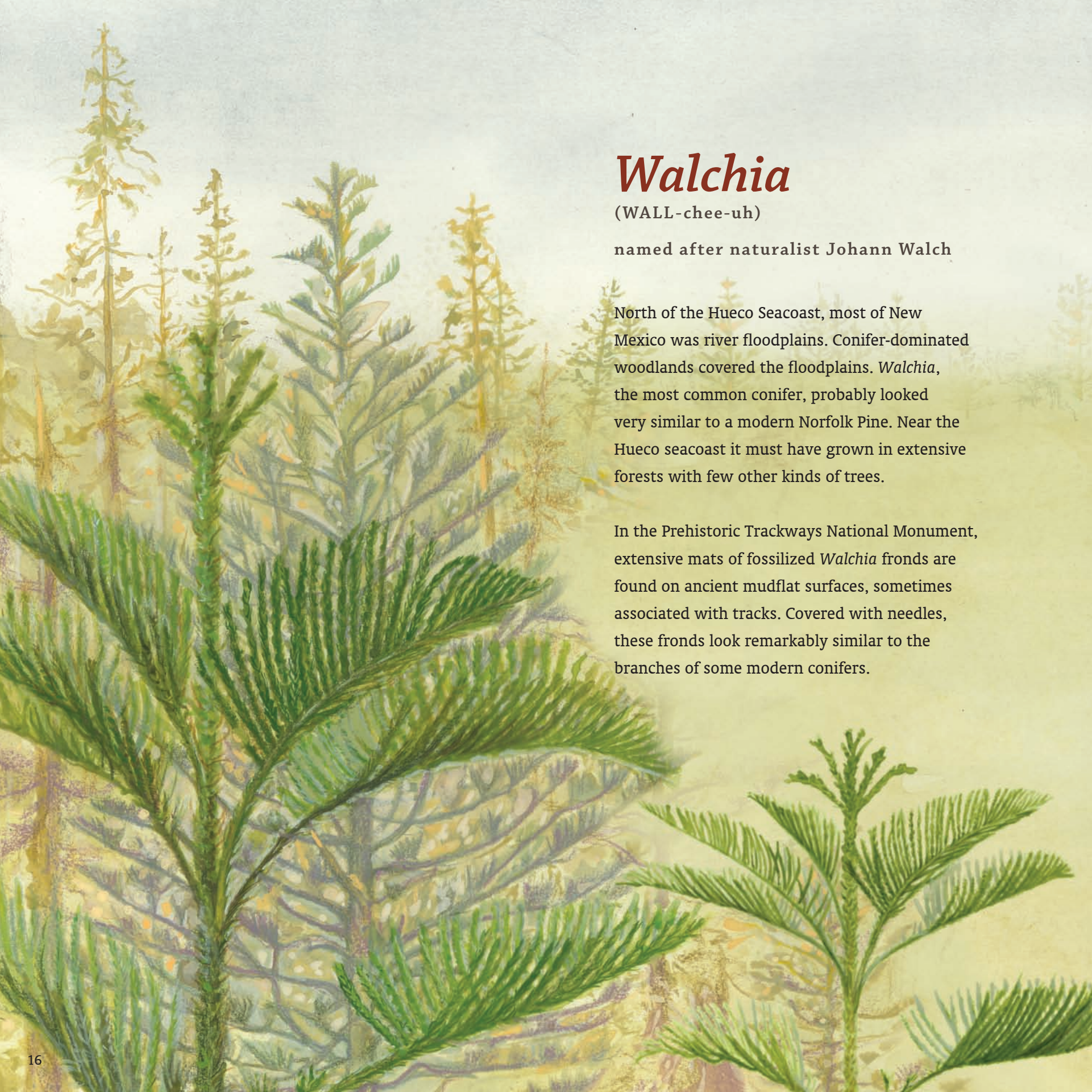
Foliage with cone

Cross-section of fossil log

Fossil Logs



During the Early Permian, forests grew on the river floodplains north of the Hueco Seaway. Conifer trees as much as 30 meters (100 feet) tall produced massive logs, some of which washed out to sea, probably during violent storms. The driftwood settled to the muddy sea bottom where it was fossilized. Foliage associated with the conifer logs also was sometimes preserved on the sea bottom.



Walchia

(WALL-chee-uh)

named after naturalist Johann Walch

North of the Hueco Seacoast, most of New Mexico was river floodplains. Conifer-dominated woodlands covered the floodplains. *Walchia*, the most common conifer, probably looked very similar to a modern Norfolk Pine. Near the Hueco seacoast it must have grown in extensive forests with few other kinds of trees.

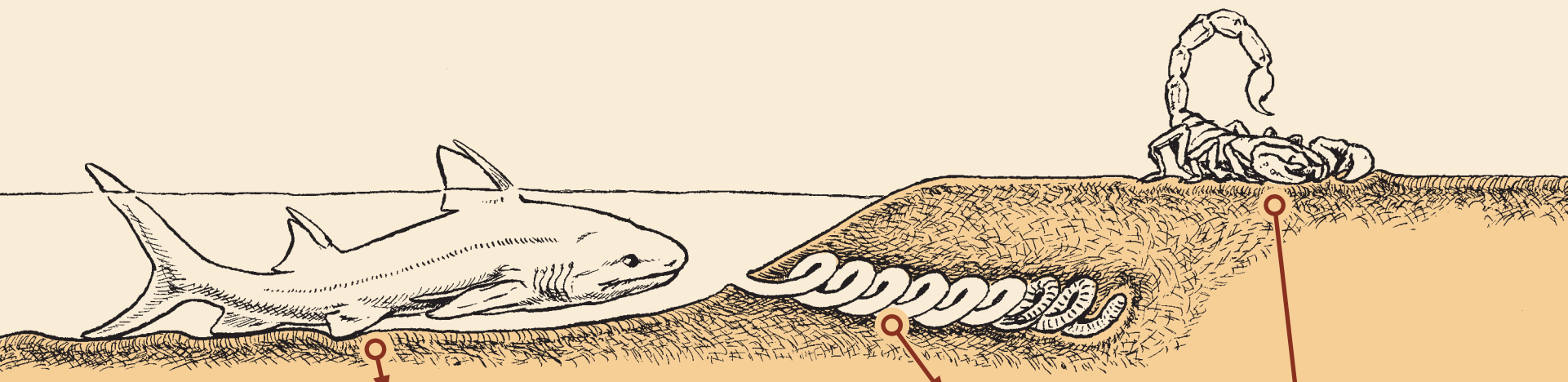
In the Prehistoric Trackways National Monument, extensive mats of fossilized *Walchia* fronds are found on ancient mudflat surfaces, sometimes associated with tracks. Covered with needles, these fronds look remarkably similar to the branches of some modern conifers.

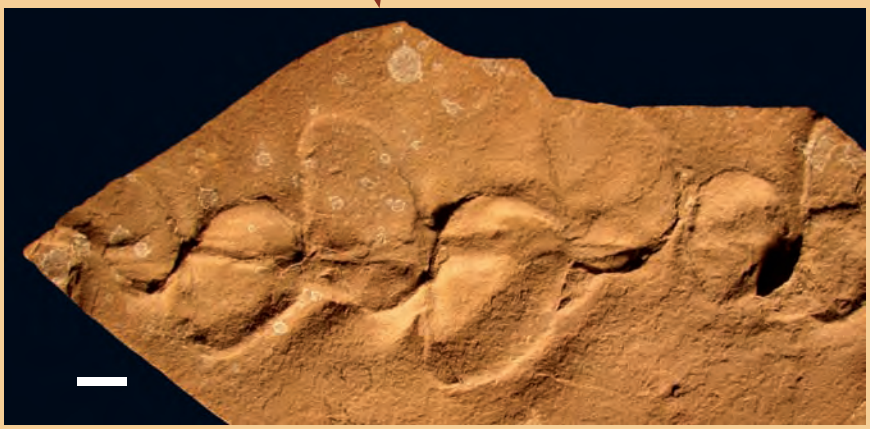

WARNING-WEAR
SAFETY GOGGLES

Trace fossils

Paleontologists distinguish two kinds of fossils. Body fossils are usually the mineralized remains of the hard tissues of a plant or animal—petrified wood, shells or bones. Trace fossils are evidence of the work of an organism—a trail, a burrow or a track. When most of us think of fossils we think only of body fossils (such as a dinosaur skeleton), however trace fossils have much to tell us about ancient life.

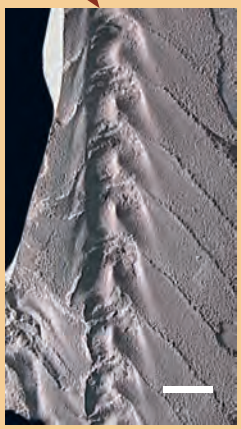
Trace fossils are fossilized behavior. They tell us not only that a plant or an animal was present, but also what it was doing—how it walked, how it made a burrow, where it lived and many other things we cannot learn directly from body fossils.





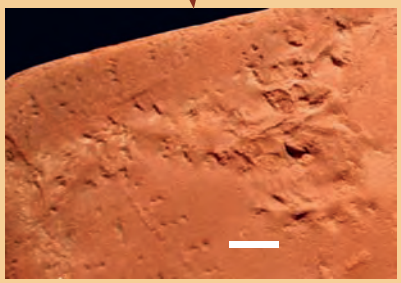
Swimming trace

NMMNH P-24090 *Undichna* (pp. 34–35)



Burrow

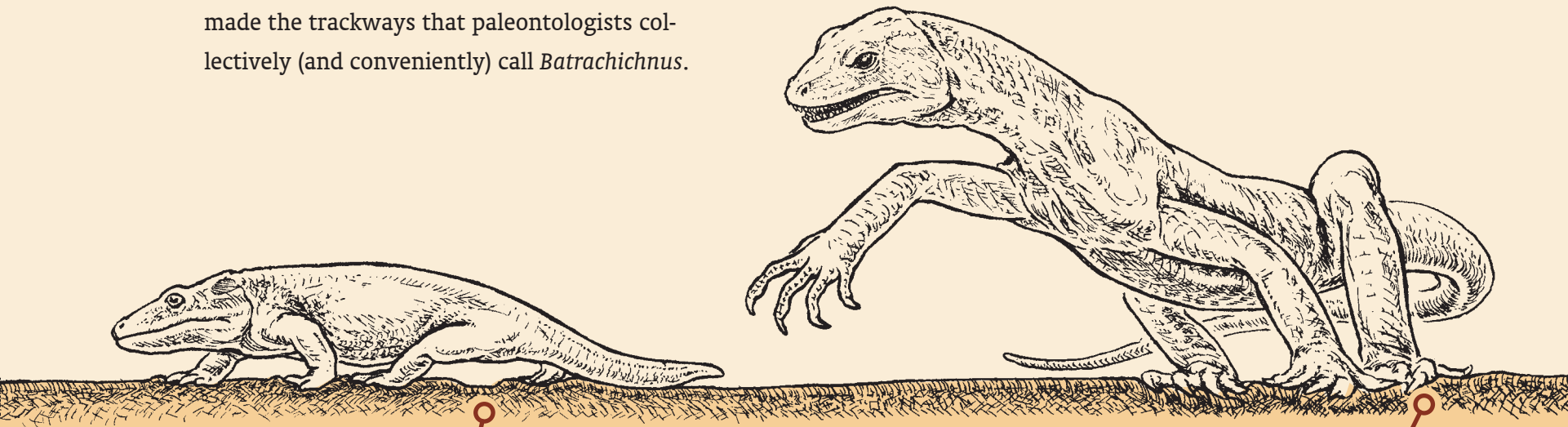
NMMNH P-24224
Augerinoichnus (pp. 32–33)

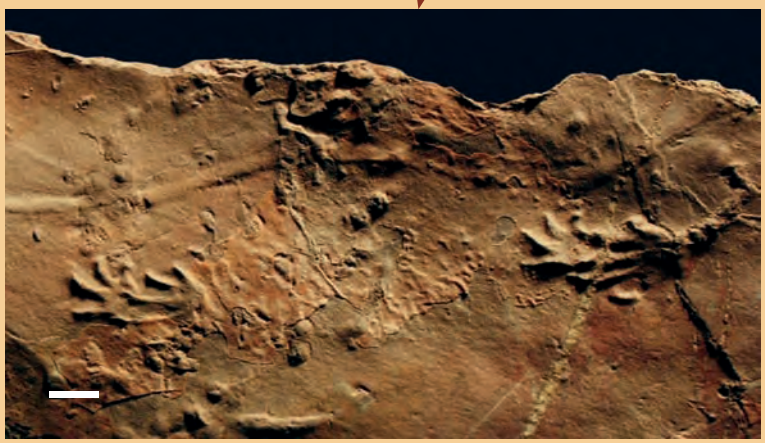


Resting trace

Scorpion body impression (p. 27)

Trace fossils receive Latinized scientific names, just like body fossils. Thus, the scientific name for small amphibian footprints is *Batrachichnus*, which literally means "trace" (Greek *ichnos*) of a "frog" (Greek *batrachos*). Many different species of small Permian amphibians probably made the trackways that paleontologists collectively (and conveniently) call *Batrachichnus*.





Footprints and tail drag

NMMNH P-24090 *Batrachichnus* (pp. 38–39)

Footprints with skin impressions

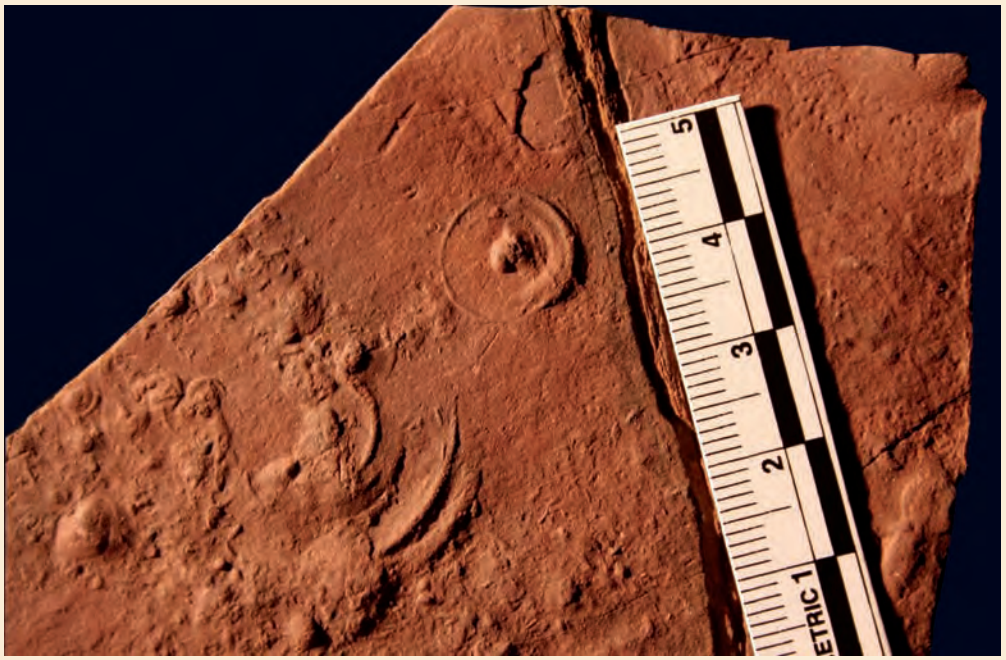
NMMNH P-62093 *Dromopus* (pp. 40–41)

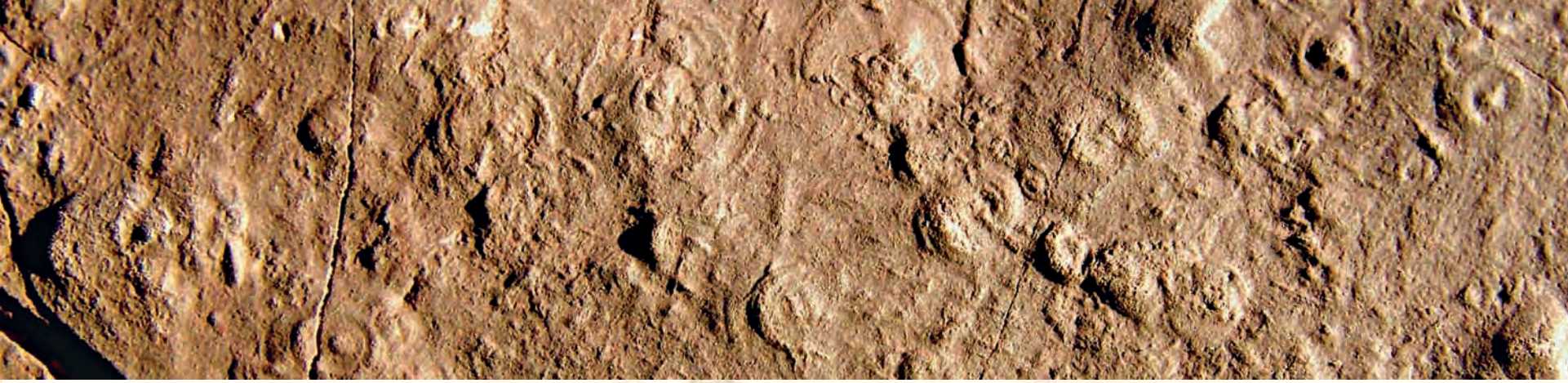
All scale bars = 1 centimeter.

Hydrozoans

(HI-dro-zo-ans) meaning "water animals"

Hydrozoans are close relatives of jellyfish and are best known today from the "by-the-wind sailor" *Velella*. Today, mass strandings of hydrozoans are common on some beaches, and evidence of such a mass stranding 280 million years ago is known from the Prehistoric Trackways National Monument. The fossil impressions of the soft-bodied hydrozoans consist of concentric circular imprints found in profusion on some rock layers that were deposited along the Hueco Seacoast.





Controversy: Are they scratch circles?

Some paleontologists argue that circular impressions like those found in the Prehistoric Trackways National Monument are not the fossil impressions of hydrozoans or other animals, but instead are scratch circles—sets of concentric grooves cut in sand or mud by the action of objects anchored at one end. For example, a plant swept around by waves or wind can trace circles in the ground around its stem, which is anchored at the center of the scratch circles.

Selenichnites

(sel-EEN-ick-NIGHT-eez) meaning "moon-shaped trace"

When the head shield of a horseshoe crab touches the sediment it can leave a crescent-shaped imprint. Such imprints found as trace fossils have been named *Selenichnites*. The presence of this trace fossil in the Prehistoric Trackways National Monument documents resting and feeding behaviors of relatively small (head shield about the size of a quarter) horseshoe crabs.

Today, when walking, horseshoe crabs (limulids) leave a very distinctive trackway that often consists of two symmetrical rows of imprints around a medial, thin drag mark. The imprints vary in shape from elongate scratches to ellipsoids to v-shaped indents. Similar fossil trackways, such as those from the Prehistoric Trackways National Monument, are named *Kouphichnium*, and are readily attributed to horseshoe crabs. Today, horseshoe crabs live along seashores, much as they evidently did along the Hueco Seacoast.

NMMNH P–23573

Kouphichnium

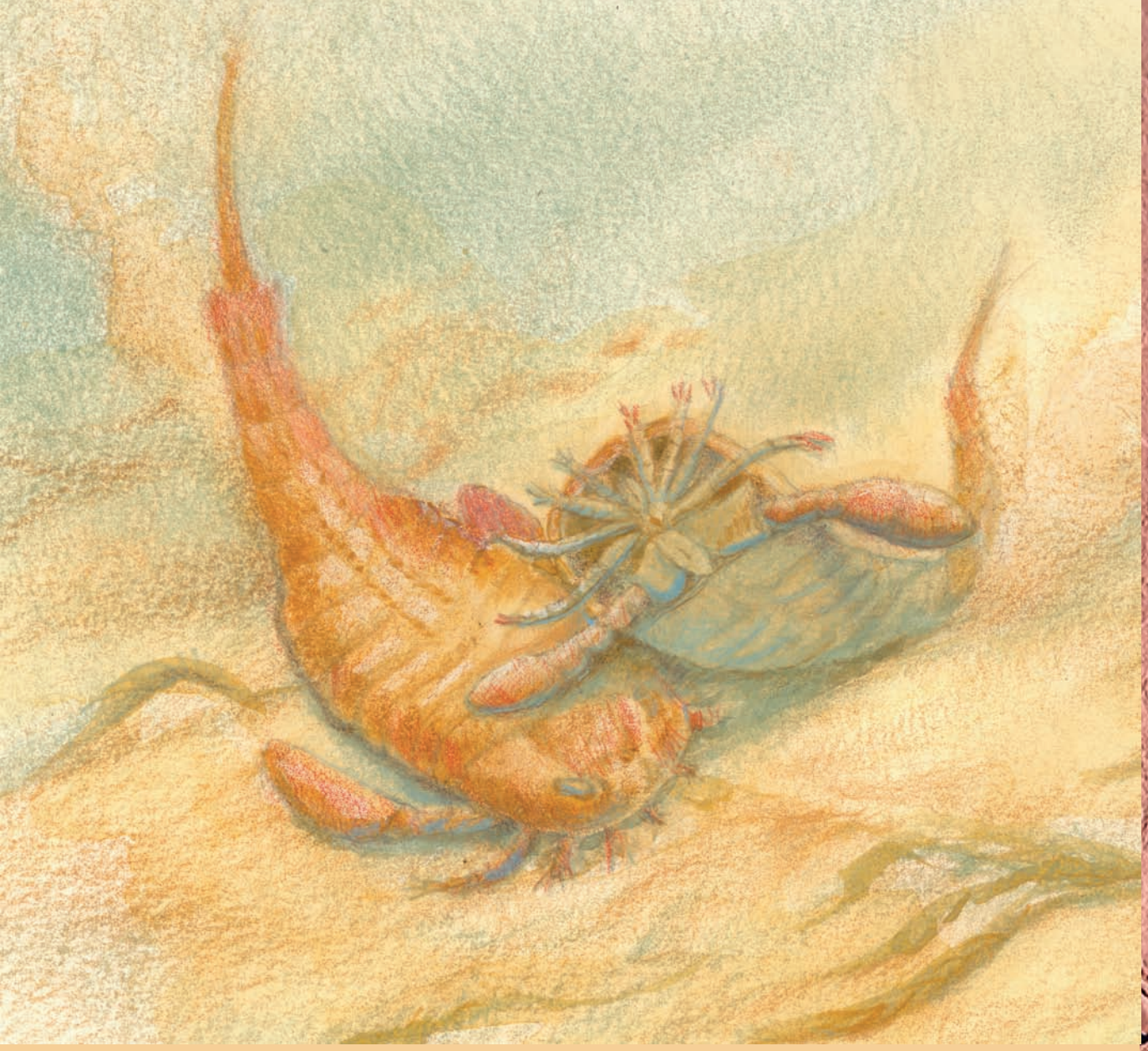
(koof-ICK-nee-um) meaning "light trace"

NMMNH P–23404
Holotype of *Palmichnium macdonaldi*

Palmichnium

(palm-ICK-nee-um) meaning “palm [frond] trace”

Palmichnium is the name applied to fossil trackways that consist of three to four sub-circular tracks that are symmetrical around a midline impression that is arranged en echelon with a high angle to the midline. An eurypterid (sea scorpion) likely made the Robledo Mountains *Palmichnium* with its outer pair of paddle-shaped limbs and long tail (telson).



NMMNH P-23457

life-size

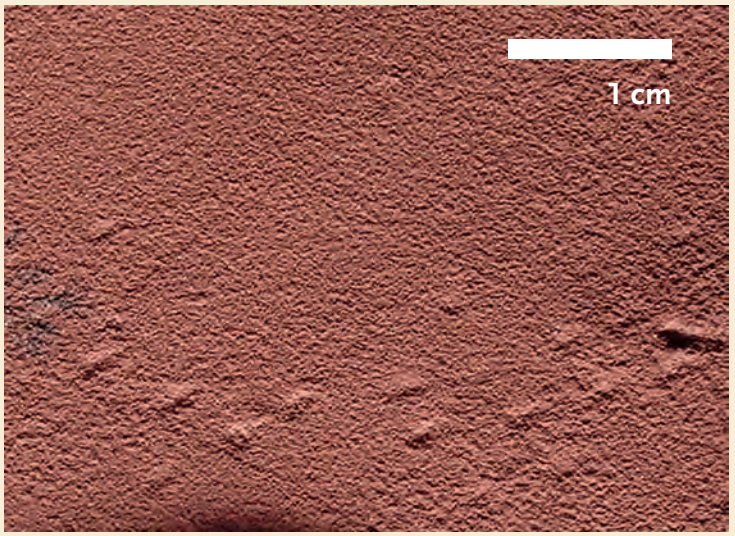
Earlier in the Paleozoic, some eurypterids were terrifying marine predators over 2 meters (7 feet) long. But, the *Palmichnium* traces from Prehistoric Trackways National Monument were probably made by tiny eurypterids swimming in freshwater pools—animals like this *Adelophthalmus* (a-dell-op-THALL-muss) from the Pennsylvanian of central New Mexico.

NMMNH P–23884

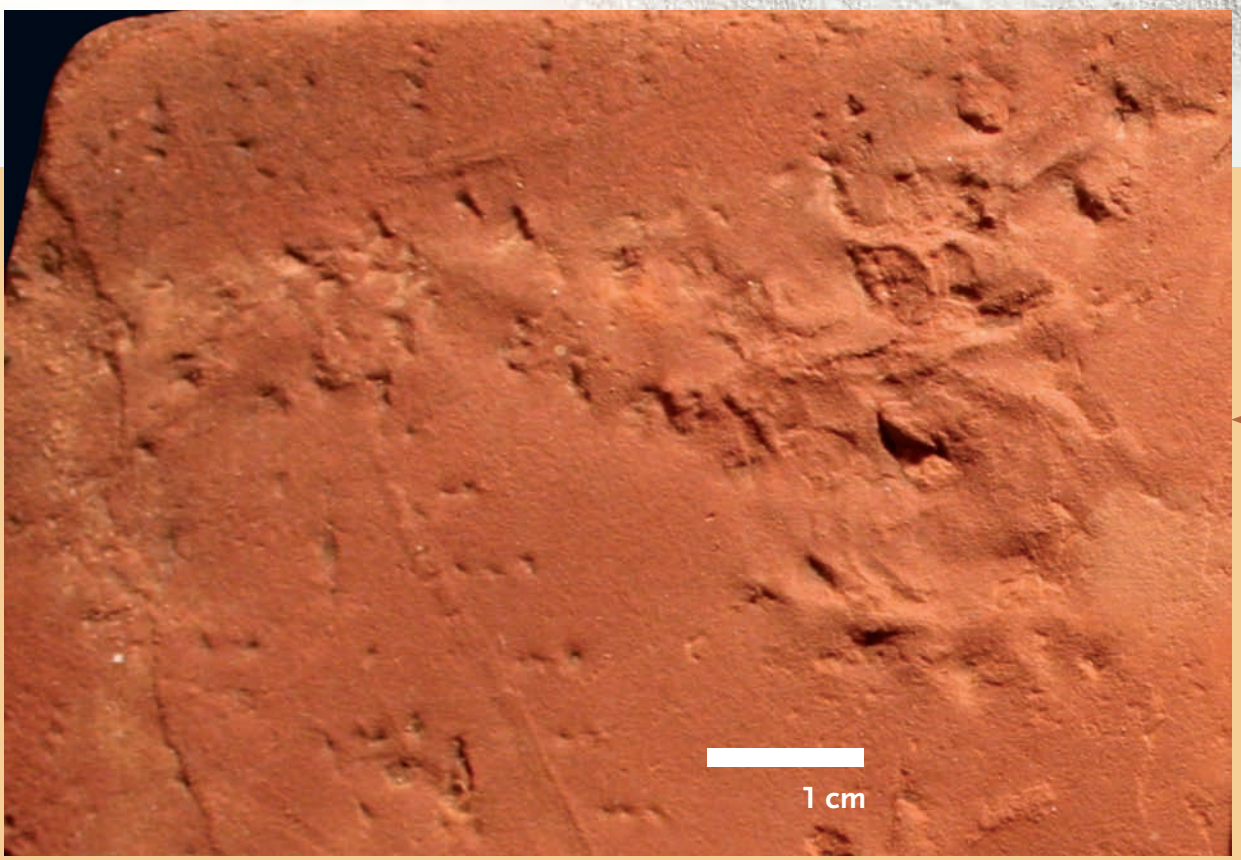
Octopodichnus

(oct-toe-pod-ICK-nuss) meaning “eight-footed trace”

The trace fossil named *Octopodichnus* typically consists of four tracks arranged with alternating symmetry. The tracks may be circular, elongate, two-toed (didactyl) or three-toed (tridactyl). Usually attributed to spiders such as tarantulas, scorpions could also have made *Octopodichnus* tracks.



The Robledo *Octopodichnus* are unusual because only one side of the trackway is well preserved. This suggests the animal was walking on a slope so that one side of the trackway was impressed more deeply than the other.



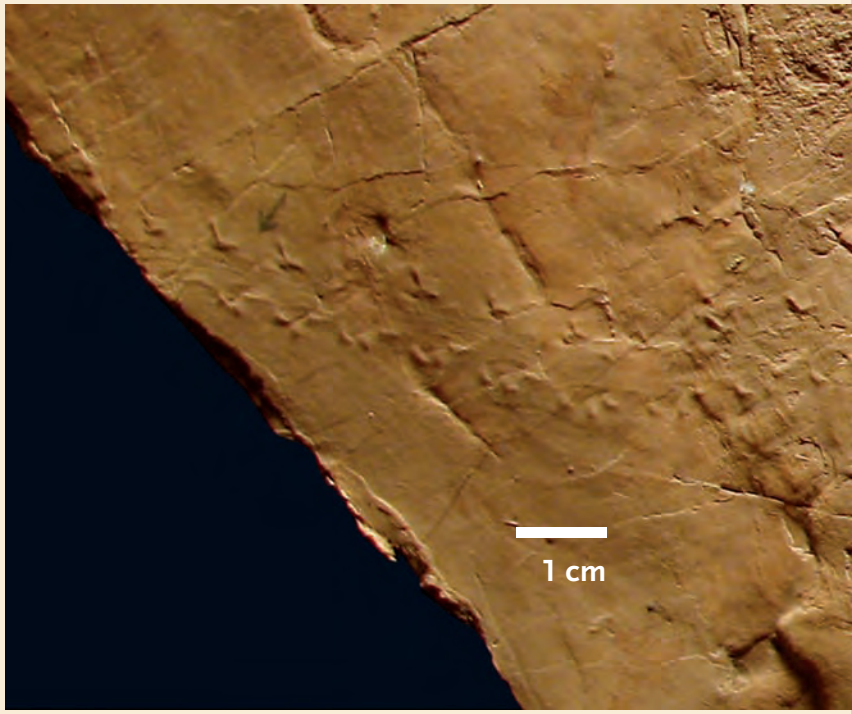
This slab of rock from the Robledo Mountains preserves the imprint of a scorpion, as well as its walking traces. Impressions of the tail, pincers, and even some body segments can be seen in the resting trace.

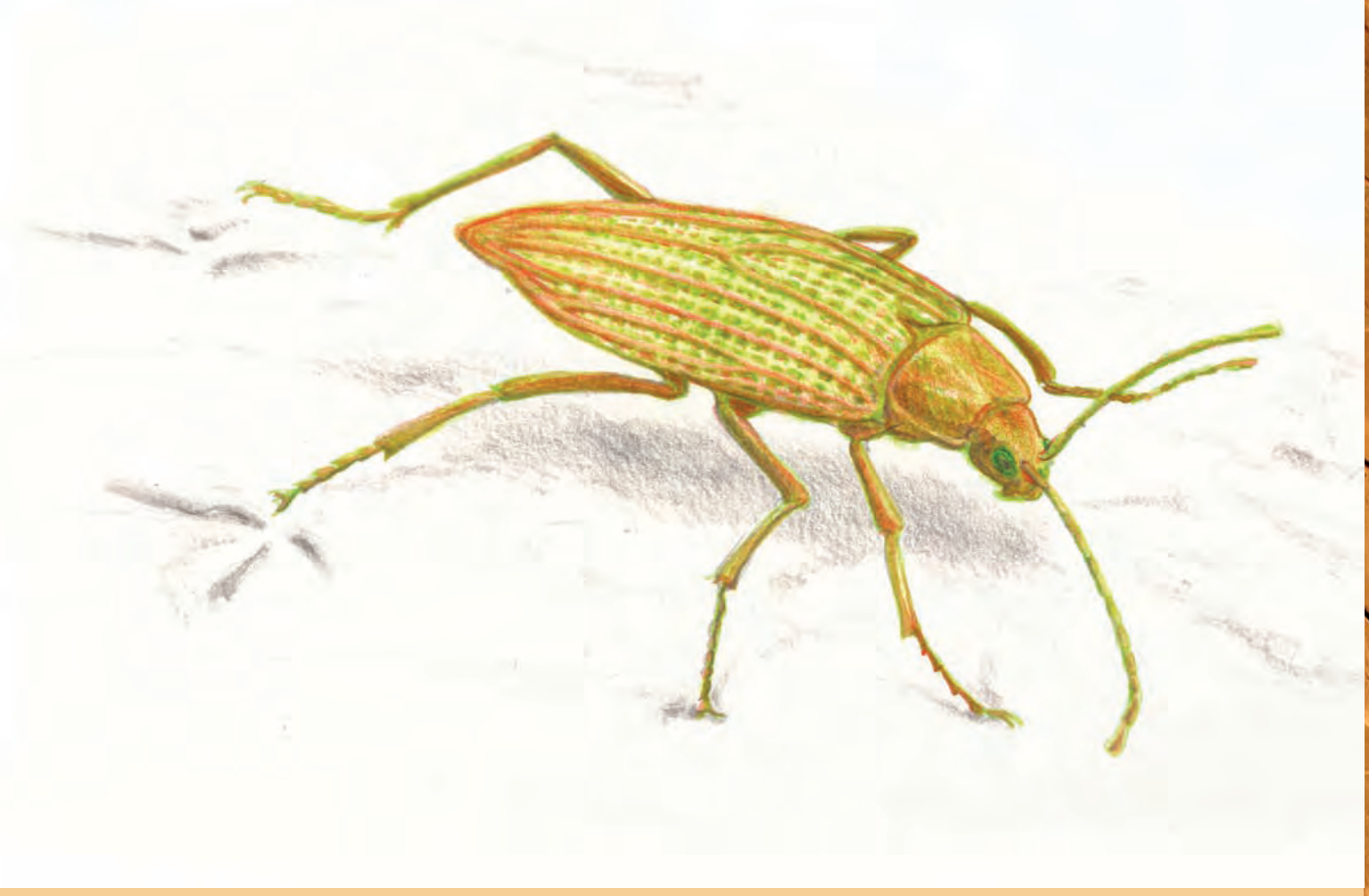
NMMNH P-47797

Lithographus

(lith-oh-GRAFF-us) meaning "rock writing"

Paleontologists apply the name *Lithographus* to fossil trackways that consist of (usually) a series of three linear tracks with different orientations, often arranged in an arrow-shape, with alternate symmetry on either side. Today, some cockroaches and beetles make tracks like these. Therefore, a primitive insect, probably a beetle, made the fossils of *Lithographus* from the Robledo Mountains.





Several long *Lithographus* trackways are known from the Prehistoric Trackways National Monument.

NMMNH P-24462

NMMNH P-3997

1 cm

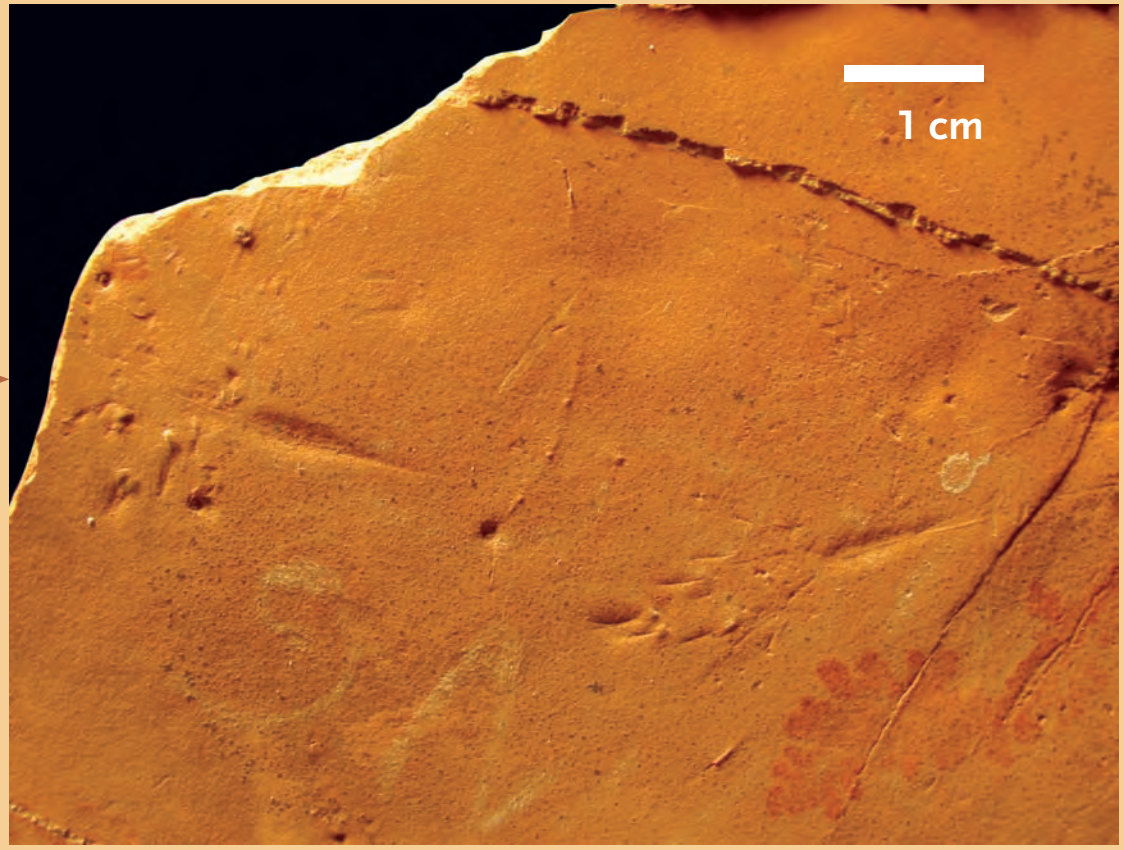
NMMNH P–24019 & P–24020
Holotype of *Tonganoxichnus robledoensis*

Tonganoxichnus

(tong-a-nox-ICK-nuss) meaning "Tonganoxie [Kansas] trace"

Imagine a bristletail lying on mud and you can see how the resting imprint called *Tonganoxichnus* was made. This impression begins (at the front end) with two lines (the palps, which are the mouth parts) followed by a single circular imprint (the head), followed by three pairs of linear imprints (the legs) and then another oval imprint (abdomen), followed by a long, linear imprint (the tail). Less complete traces preserve little more than the palp and tail imprints.

NMMNH P-3902,
Holotype of
Tonganoxichnus apacheensis



Series of *Tonganoxichnus* imprints from the Prehistoric Trackways National Monument provide direct evidence of jumping by Early Permian insects. This supports the conclusion that jumping was a primitive method of insect locomotion.

NMMNH P–25990

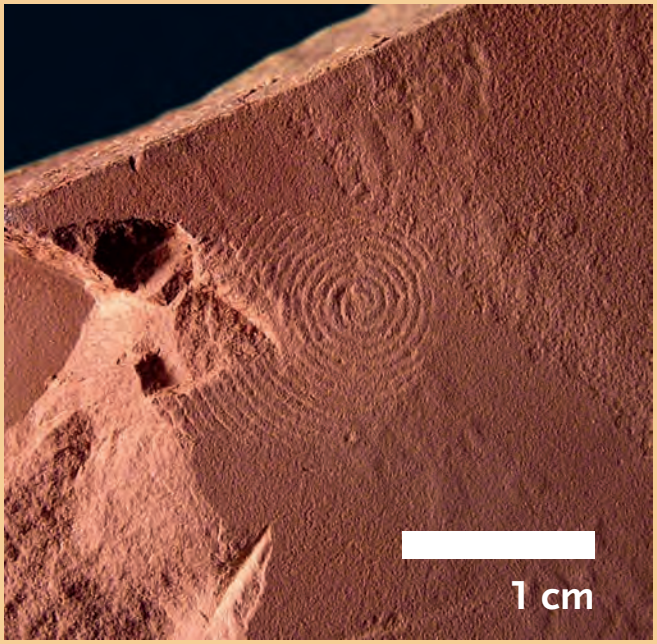
Augerinoichnus

(aw-gurr-EE-no-ICK-nuss) meaning "Augerino trace"

Typically found as a series of horseshoe-shaped imprints, *Augerinoichnus* is actually the trace of a helically-shaped (corkscrew) burrow. First discovered in the Robledo Mountains, this trace fossil records a worm-like animal "drilling" through the sediment to live and to feed. Normally, such corkscrew burrows are found in the mud of deep sea bottoms, so their discovery in the Robledo coastal mudflat deposits was a surprise to scientists. It demonstrated, for the first time, that such burrows were also made in the shallow shoreline zone.

The horseshoe-shape of *Augerinoichnus* imprints is due to the fact that only one edge of the corkscrew burrow is preserved.

The name *Augerinoichnus* honors the **Augerino**, a creature of old farming folklore. Described as an enormous, corkscrew-shaped worm, the troublesome Augerino devotes its life to draining the water out of irrigation ditches.



NMMNH P-45651

Augerinoichnus isn't the only dizzying trace from the Robledo Mountains. The tiny spiral seen here was probably made by another worm-like animal as it burrowed through the mud along the Hueco Seacoast.

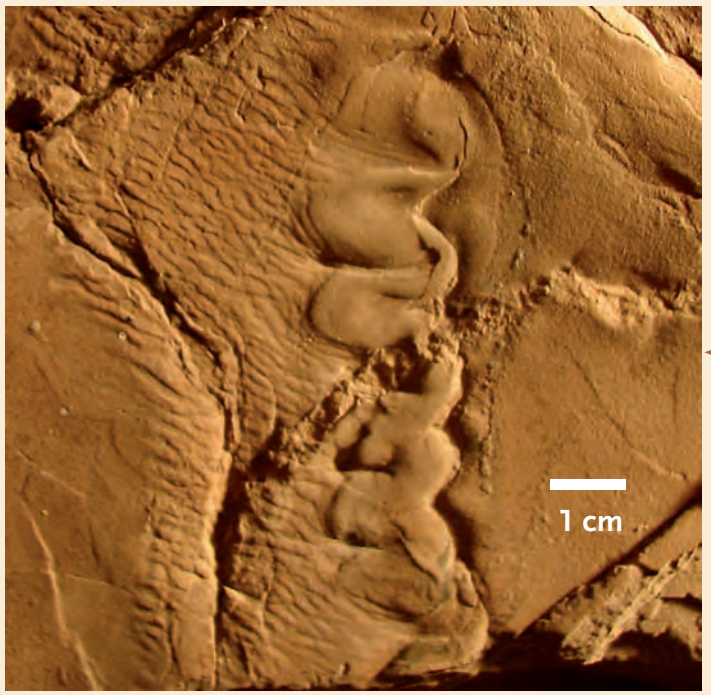
NMMNH P-24224

NMMNH P–24090

Undichna

(und-ICK-nuh) meaning "wave-shaped trace"

When a fish swims in shallow water or near the bottom in deep water, the tips of its fins may graze the sediment. Most fish swim with an eel-like body motion, flexing the body from side to side. Combining this flexing with forward motion leads to a characteristic sine-wave pattern of the fin impression, which paleontologists have named *Undichna*.



NMMNH P-24454

Undichna fossils can preserve different numbers of fin impressions, depending on the type of fish that made them and how many fins were touching the sediment as it swam.

NMMNH P-23466

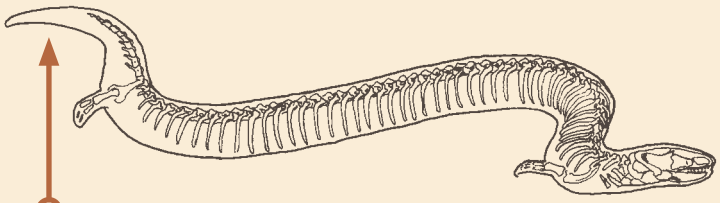
Part and counterpart of a slab containing an *Undichna* trace

NMMNH P-23493

Serpentichnus

(sir-pent-ICK-nuss) meaning "snake-like trace"

Imagine a long-bodied, snake-like amphibian swimming in shallow water as it pushes off the bottom with its feet. The trace that could result would a be a series of regularly-repeated, L-shaped imprints where part of the body hit the substrate. First recognized in the Robledo Mountains, this kind of trace fossil was named *Serpentichnus*. It documents the presence of long-bodied, small-limbed amphibians along the Hueco Seacoast.

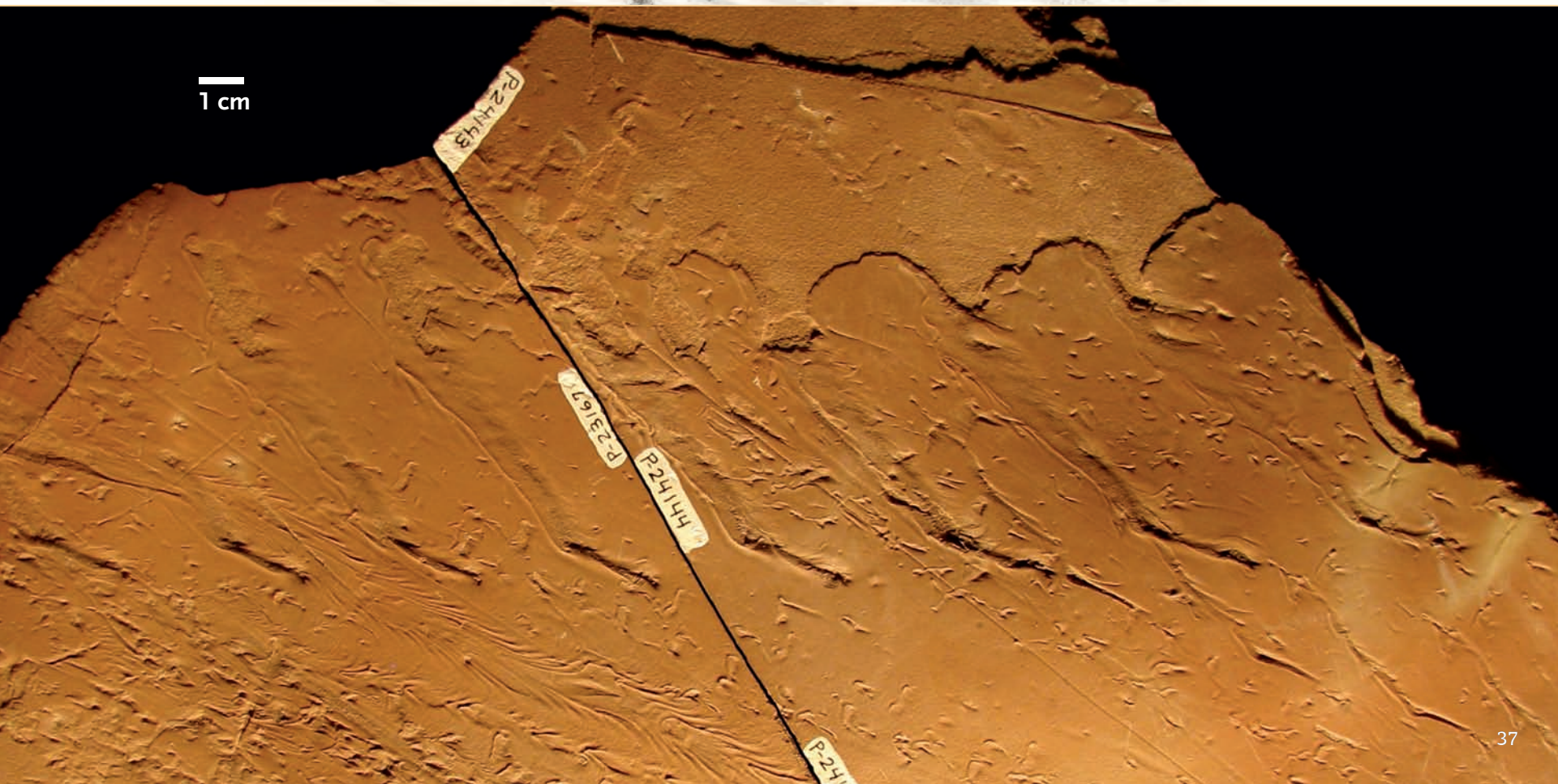


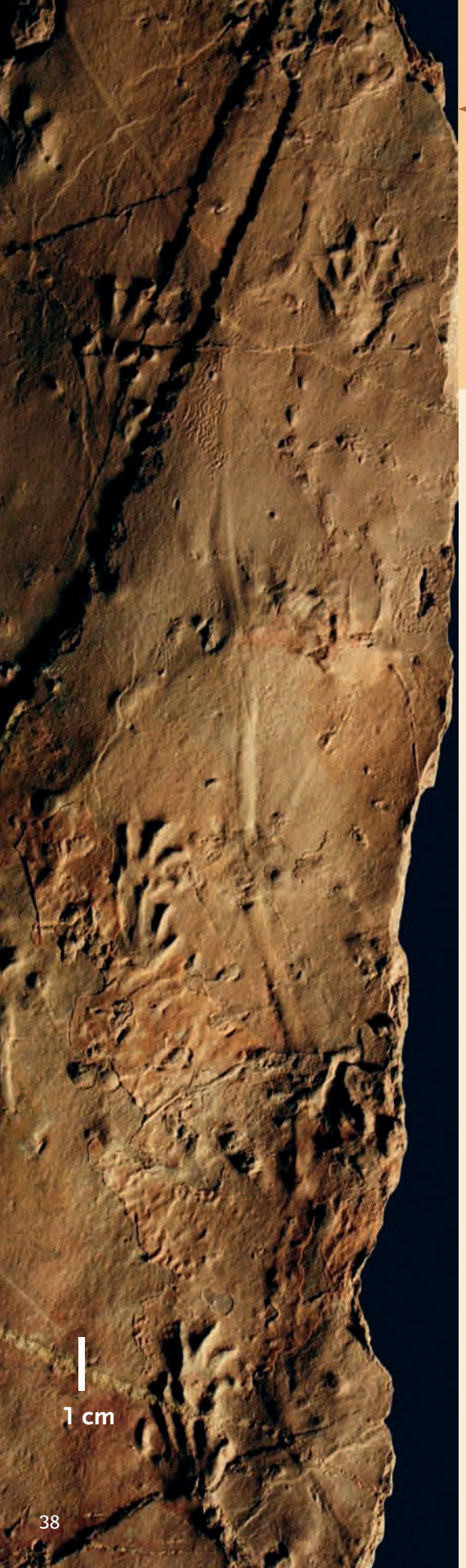
Some Paleozoic amphibians, like *Brachydectes* (brack-ee-DECK-tees) shown here, had long, snake-like bodies and tiny arms and legs. Animals like this may have made *Serpentichnus* traces.

This slab contains several traces, including two *Serpentichnus* trails that criss-cross near the right side of this photo.

Controversy: Are they tool marks?

Geologists use the term "tool mark" to refer to impressions made by an object being dragged over a sediment surface by a current. The object, or "tool," is usually a rock or piece of vegetation. Some paleontologists argue that the repetitive marks from the Prehistoric Trackways National Monument named *Serpentichnus* are tool marks, not trails made by long-bodied, "sidewinding " amphibians.

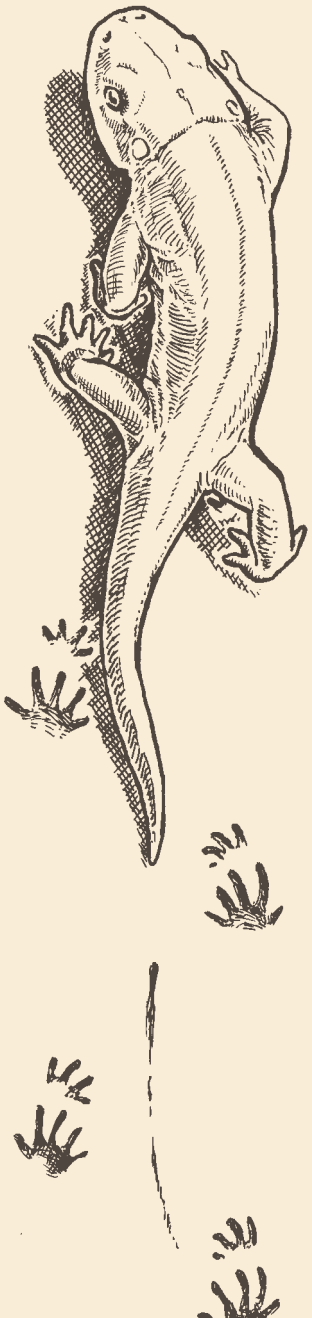




NMMNH P–47800

Batrachichnus

(baa-track-ICK-nuss) meaning “frog trace”



Small, salamander-like amphibians left numerous tracks along the shoreline of the Hueco Seaway. These little tracks are less than 2.5 centimeters (1 inch) long and look like the prints of a human baby, with four fingers in the hand and five in the foot. Named *Batrachichnus*, these tracks are among the most common footprints found in the Robledo Mountains.

Like almost all of their living relatives, the little Permian amphibians probably could not tolerate salt water. Their abundant tracks in the red rock layers of the Prehistoric Trackways National Monument thus indicate freshwater habitats very close to the Hueco Seacoast.

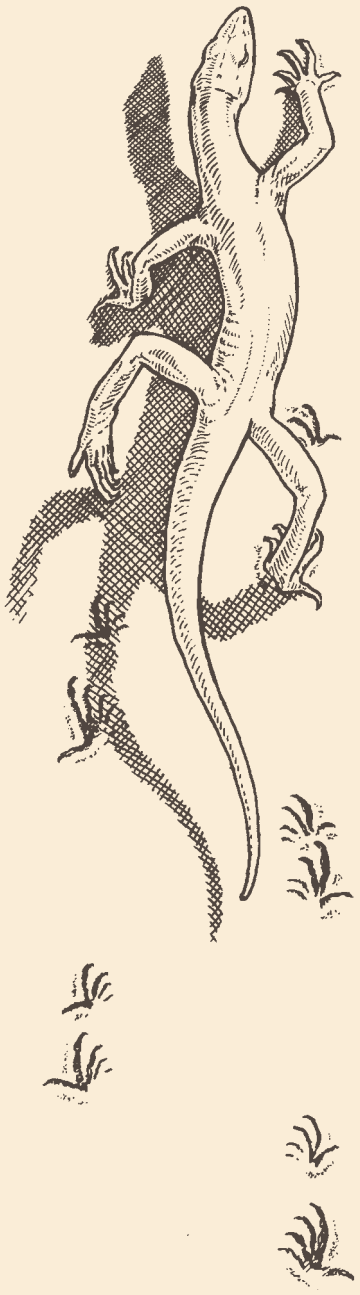
NMMNH P-23060

NMMNH P-23174

NMMNH P–23283

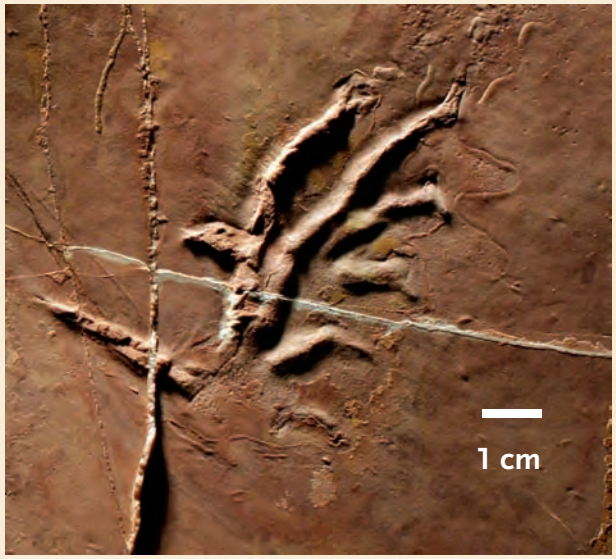
Dromopus

(dro-MOE-puss) meaning “running foot”



Today, most lizards have long, thin, pointed and curved toes of varied lengths. Tracks of this kind are very common in Lower Permian strata of the Robledo Mountains, but predate the oldest lizard fossils by more than 100 million years. Paleontologists identify the Early Permian trackmaker of *Dromopus* as an araeoscelid, a kind of early reptile with a lizard-like foot. *Dromopus* tracks rival those of small amphibians in abundance and thus suggest the presence of numerous insect-eating araeoscelids along the Hueco Seacoast.

NMMNH P-62905



Some large slabs contain dozens of *Dromopus* tracks.

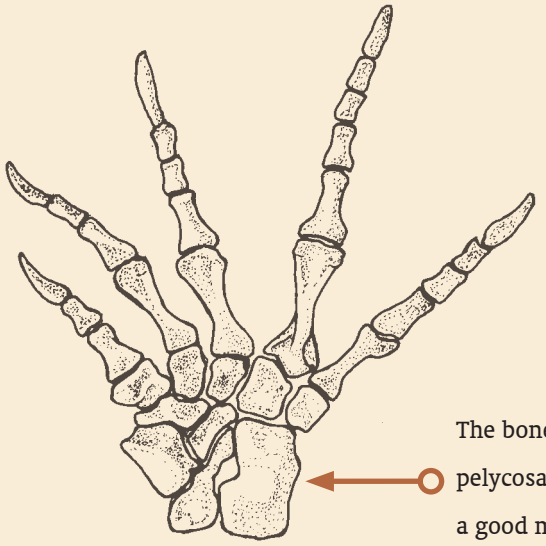
NMMNH P-62903. These *Dromopus* footprints are so well-preserved that you can see impressions of joints, claws and even the scales on the fingers and toes.

NMMNH P–23065

Dimetropus

(die-MEET-row-puss) meaning "*Dimetrodon* foot"

Pelycosaurs were the top predators of the Early Permian landscape. Up to 4 meters (13 feet) long, the sail-backed *Dimetrodon* was the largest pelycosaur, a ferocious, meat eater—the "*T. rex*" of its day. Footprints made by these animals are named *Dimetropus*. Some *Dimetropus* trackways from the Robledo Mountains record more than 50 footfalls of a single animal and show pelycosaurs walking with a surprisingly upright posture.



The bones of a pelycosaur foot are a good match for *Dimetropus* tracks.

NMMNH P-23536

Some pelycosaur tracks are as large as an adult human hand.

NMMNH P-23395

Further Resources

Prehistoric Trackways National Monument Website: http://www.blm.gov/nm/st/en/prog/recreation/las_cruces/trackways.html

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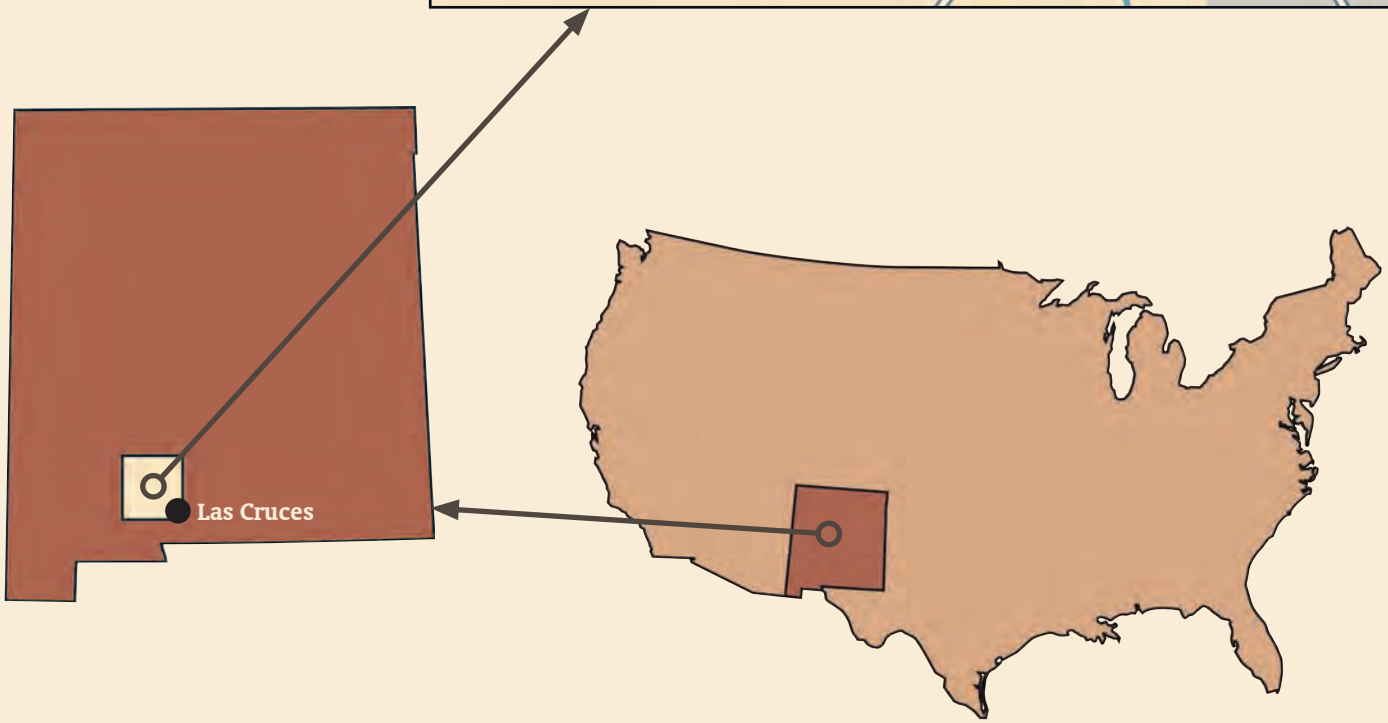
* New Mexico Museum of Natural History and Science Bulletins are available free online at: http://nmnaturalhistory.org/bulletins

Visiting PTNM

The Prehistoric Trackways National Monument is easily reached by leaving I-25 at the Doña Ana exit (Exit 9) north of Las Cruces and heading west on NM Highway 320 about 2 miles, to its intersection with NM Highway 185. There, turn right and proceed north on Highway 185 for 0.5 miles, then turn left and proceed west on the Shalem Colony Road. After crossing the Rio Grande, turn right and proceed north on Doña Ana County Road 13 for about 0.3 miles. Finally, turn left on the unpaved road that leads to the Community Pit (large stone quarry) at the eastern edge of the Monument.



Glossary

Araeoscelid (AIR-ee-os-sell-id): Extinct, lizard-like reptiles of the late Paleozoic.

Arthropod (AR-throw-pod): Segmented animals with a skeleton of chitin and jointed legs, such as insects.

Brachiopod (BRACK-ee-oh-pod): Marine, shelled animals with two unequal shells, each of which is bilaterally symmetrical.

Bristletail (BRISS-ul-tale): A primitive, wingless insect with bristles at its posterior end.

Bryozoan (BRIE-o-zo-an): Marine, colonial animals that often build moss-like or fan-shaped shells.

Cephalopod (SEFF-uh-low-pod): Marine mollusks that had straight or coiled shells made up of separate chambers; includes extinct ammonoids and living squid, octopi and the Nautilus.

Conifer: Group of plants that are often large trees and have needle- or scale-like leaves and seeds in cones.

Crinoid (CRY-noid): Marine animals consisting of a head, numerous radiating arms, an elongated and jointed stem and roots that attached to the seafloor (sea lily).

Crustacean (cru-STAY-shen): Group of arthropods with two pairs of antennae, such as shrimp.

Eurypterid (you-RIP-tur-id): The sea scorpions, extinct relatives of trilobites.

Fault: A fracture in rocks along which movement has taken place.

Floodplain: A plain built by stream deposits next to river channels.

Foraminiferan (fo-RAM-in-IF-ur-an): Tiny, single-celled animals protected by a many-chambered shell.

Fusulinid (few-sul-IN-id): A single-celled marine animal of the late Paleozoic that built a shell that looks similar to a rice grain.

Holotype (HOLL-o-tipe): The single specimen of a plant, animal, or trace that characterizes a species.

Hueco Group (HWAY-ko Group): Sedimentary strata (mostly limestones and shales) of Early Permian age that record ancient sea and shoreline environments in parts of southern New Mexico and West Texas.

Hueco Seaway (Seacoast): The sea (and shoreline) that covered much of southern New Mexico and parts of West Texas during the Early Permian.

Hydrozoan (hi-dro-ZO-an): Small, disc-like marine animals related to jellyfish.

Igneous (IG-nee-us): Refers to rocks formed from a molten state (lava), including all volcanic rocks.

Limestone: Sedimentary rock formed from calcium carbonate, usually on a sea bottom.

Limulid (LIM-you-lid): Horseshoe crab.

Paleontologist (pale-ee-on-TOL-o-jist): A scientist who studies fossils and the history of life.

Pangea (pan-JEE-uh): The supercontinent of the late Paleozoic-early Mesozoic made up of all the present continents.

Pelycosaur (PELL-i-ko-sore): Group of Paleozoic reptiles best known from the sail-backed *Dimetrodon*; not dinosaurs.

Permian (PERM-ee-an): The Period of earth history that spans approximately 300 to 251 million years ago; the youngest Period of the Paleozoic Era.

Shale: Layered sedimentary rock made up of clay particles.

Telson (TEL-son): The terminal body segment of an arthropod; the “tail.”

Trace fossil: Fossil evidence of the activity of an organism, such as tracks, trails and burrows.

Dedication

Jerry MacDonald, through his discoveries, dedication and determined hard work has made this book possible. In the 1980s, working alone in the Robledo Mountains, Jerry discovered the now world-famous tracksites that led to the creation of the Prehistoric Trackways National Monument. He hauled tons of rock out of those tracksites and collaborated with scientists from three continents to see that the tracks were studied and interpreted. The collections Jerry made now reside at the New Mexico Museum of Natural History and Science in Albuquerque, as the "Jerry MacDonald Paleozoic Trackways Collection." Jerry's discoveries revolutionized scientific understanding of the Permian trace fossil record and inspired the creation of a National Monument dedicated to those fossils. Therefore, we dedicate this book to him.

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About the Authors

Spencer G. Lucas received a Ph.D. in geology from Yale University in 1984 and has been Curator of Geology and Paleontology at the New Mexico Museum of Natural History and Science since 1988. He has collected and studied Permian fossils for more than 15 years and has undertaken extensive research on the geology and paleontology of the Prehistoric Trackways National Monument.

Matt Celeskey has designed and developed exhibits for over 15 years. He joined the New Mexico Museum of Natural History and Science in 1998. His art and interactive displays can be seen in several of the Museum's permanent exhibits, and he has illustrated numerous books and technical publications.

Mary Sundstrom has a degree in Fine Arts. Her experience encompasses art instruction, fine arts printer/printmaker, book illustrator with 17 children's book titles and an Audubon field guide series as well as numerous exhibit illustrations for the New Mexico Museum of Natural History and Science.

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