LIFE IN ANCIENT OHIO

EARLY PERMIAN · 295 MILLION YEARS AGO

Overlooking a Permian river on a tropical coastal plain...

*...a sail-backed predator (key, next two pages, number **10**; fig. 1), a relative of early mammals, surveys its territory from atop a small sandstone promontory. Seed ferns (**14**; fig. 2) grow within natural fractures in the sandstone where their roots can absorb water. Shaded by a seed fern, an elongated, snake-shaped amphibian with tiny vestigial limbs (**6**) attends a clutch of eggs, protecting them from predation and desiccation.*

*A large amphibian (**4**; fig. 3) hunts lungfish (**9**), which might otherwise survive in the muds of an evaporating pool of water cut off from the river. A smaller amphibian with a boomerang-shaped head (**5**) exits the pool to seek refuge from this predator.*

*On a bar of sand and gravel within the river channel, a small group of herbivorous edaphosaurids (**11**) bask in the midday sun. A large male, sporting a colorful sail, remains vigilant while two females rest and a juvenile explores its environment. Nearby, a freshwater shark (**7**) searches for prey, such as a small ray-finned fish (**3**).*

The imagined scene described above is based upon actual fossils from a unit of rocks present in southeastern Ohio that geologists call the Dunkard Group. The depictions of these ancient animals are informed by fossils and living relatives of the fossil animals and the roles these relatives play in modern ecosystems. Although some aspects of this image are necessarily speculative, an attempt has been made to depict the animals in a realistic manner consistent with our current knowledge of these ancient life forms and their environment.

Major events in the history of life during the Permian Period

During the Permian Period (299–252 million years ago [mya]), most of Earth's land was in a single supercontinent called Pangaea that stretched from northern to southern polar regions. Glaciers of the Late Paleozoic Ice Age covered parts of southern Pangaea and reached their maximum extent during early Permian time. Through cycles of wetter and drier conditions, Pangaea became increasingly arid and experienced more pronounced seasonality than in the preceding Carboniferous Period (359–299 mya). Although still present in the early Permian, spore-reproducing tree lycophytes and ferns of Carboniferous rainforests were being replaced with seed plants, including some that resembled ferns ("seed ferns," **14**) and conifers (**13**) that were more tolerant of drier conditions.

Drier conditions on Pangaea also advantaged certain vertebrate animal groups. Among these were the amniotes, named for their protective amnion, a membrane covering their developing embryos. Amniote animals had evolved adaptations for terrestrial environments, which included thicker skin, loss of an aquatic larval stage, adaptations

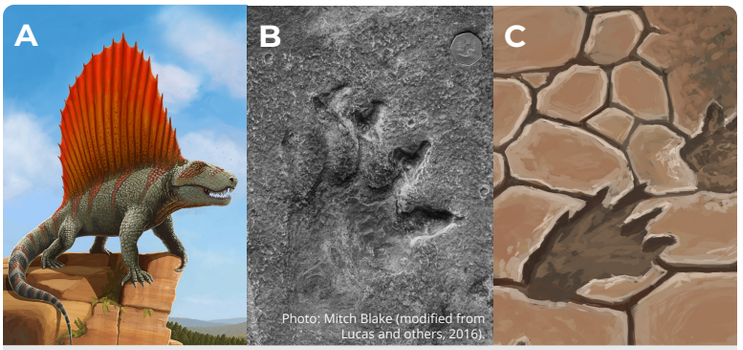


Figure 1. (A) *Dimetrodon* (**10**), a likely maker of the trace fossil *Dimetropus* (**18**). (B) Black-and-white photo of a cast of a *Dimetropus berea* footprint from near Berea, West Virginia; part of the holotype specimen, WVGS 126. Footprint measures ~22 cm (~8.7 in) long. (C) Artist's depiction of *Dimetropus* tracks (**18**) with mud cracks in an overbank clay deposit.

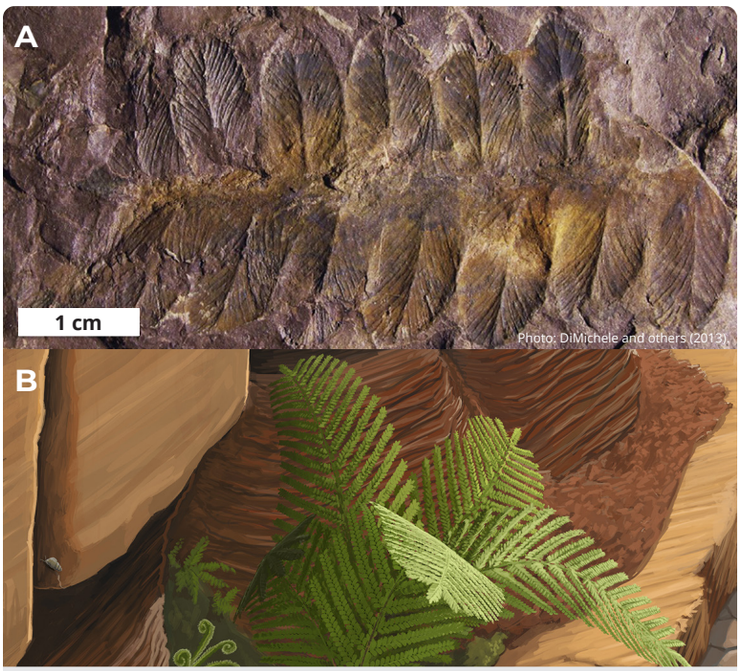


Figure 2. (A) Partial leaf impression of the "seed fern" *Autunia conferta* in a siltstone from Monroe County, Ohio; specimen PP55102-B, Field Museum of Natural History, Chicago. (B) Living reconstruction of *Autunia conferta* (**14**) showing the construction of its compound leaves. Once considered a good index fossil for the earliest Permian, this plant is now known also to occur in older rocks.

for respiration on land, and eggs with shells that helped to prevent them from drying out. Permian amniotes included sauropsids, a lineage which included reptile-like animals (and would later include dinosaurs and birds), and synapsids, a lineage which included *Dimetrodon* and *Edaphosaurus* (and would later include mammals).

A mass extinction at the end of the Permian separates the Paleozoic Era from the Mesozoic Era. This extinction records the loss of more than three quarters of all marine species and a lower but significant percentage of terrestrial species. Entire classes of marine organisms, such as rugose corals, tabulate

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Artwork by Kyle Hartshorn of Cincinnati, Ohio

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(Based on the Washington Formation, Dunkard Group of southeastern Ohio)

ANIMALS

Arthropods

Insects

1. †Meganisopteran (unspecified griffinfly)
2. *Sysciophlebia balteata* (blattoid; "cockroach")

Chordates

Actinopterygians (ray-finned fishes)

3. †Palaeoniscoid (unspecified)

"Amphibians"

4. *Eryops* cf. *E. megacephalus* (†temnospondyl)
5. *Diploceraspis burkei* (†diplocaulid nectridean)
6. *Lysorophus dunkardensis* (†lysorophian)

Chondrichthyans (cartilaginous fishes)

7. *Xenacanthus* sp. (†xenacanthid shark)

†Diadectomorphs

8. *Diadectes* sp. (partial skeleton)

Dipnoans (lungfishes)

9. *Sagenodus* sp. (lungfish)

"Non-therapsid synapsids" ("†pelycosaurs")

10. *Dimetrodon* cf. *D. limbatus* (†sphenacodontid eupelycosaur)
11. *Edaphosaurus* cf. *E. boanerges* (†edaphosaurid eupelycosaur)

Mollusks

Gastropods (snails)

12. *Anthracopupa ohioensis*

PLANTS

Pinophytes (conifers)

13. *Walchia* sp.

†**Pteridospermatophytes** (†pteridosperms, or "seed ferns")

14. *Autunia conferta* (†callipterid peltasperm)

Sphenophytes (horsetails)

15. *Calamites* sp. (arborescent horsetail)
16. *Sphenophyllum thonii*

ICHNOFOSSILS (trace fossils)

17. *Camborygma* isp. (burrows likely made by crayfish)
18. *Dimetropus* isp. (tetrapod trackways attributable to "†pelycosaurs")
19. *Limnopus* isp. (tetrapod trackways; include some attributed to *Eryops*)
20. *Pectichnus multicylindricus* (wood-bored tunnels attributed to beetles; not yet reported from the Permian of Ohio)

Key to Abbreviations

cf.	Latin, *conferre* (species not determined but compare with this species)
isp.	ichnospecies (of trace fossils: indeterminate ichnospecies of the ichnogenus)
sp.	species (of organisms: indeterminate species of the genus)
†	dagger symbol; indicates extinct group or type. Genera and species (italicized names) are all extinct.

corals, and trilobites, became extinct. This "Great Dying," the largest extinction event in the history of life on Earth, coincided with a prolonged period of intense volcanism. Carbon dioxide released from the volcanic eruptions likely caused global warming and ocean acidification. Changes in ocean circulation and the formation of low-oxygen dead zones likely contributed to loss of species.

The Ohio region during the early Permian

Approximately 295 million years ago, during early Permian time, the area that is now Ohio was located only ~0–5 degrees north of Earth's equator. By contrast, its present latitude spans 38–42 degrees north of the Equator, owing to hundreds of millions of years of tectonic plate motions. For most of the Paleozoic Era, Ohio had been submerged beneath shallow seas or alternated between marine and lowland terrestrial environments. By the early Permian, Ohio had emerged from the sea and was on a low, inland coastal plain located to the north and west of a high, young transcontinental mountain range that straddled the low tropics of Pangaea. Rivers carried eroded sediments from these mountains through the Ohio region to an inlet of the sea located up to hundreds of miles to the west. Like much of equatorial Pangaea, this region was transitioning from the tropical rainforests of the preceding Carboniferous Period that had produced vast coal deposits to environments that were seasonally dry.

Ohio's youngest surviving bedrock is early Permian in age; if any younger rocks were deposited, they have subsequently eroded away. There is a nearly 300-million-year gap between Ohio's early Permian-age rocks and the relatively recent, unconsolidated sediments deposited during the Pleistocene Epoch (recent ice age).

The Dunkard Group in Ohio

The Dunkard Group of rocks is exposed in a band up to about 30 miles wide in southeastern Ohio counties bordering the Ohio River, from Meigs County in the south through southern Jefferson County in the north; it is also exposed in adjoining parts of northwestern West Virginia and southwestern Pennsylvania. The Dunkard Group is underlain by Late Carboniferous (Pennsylvanian)-age rocks and the top of the group is defined by the highest (youngest) surviving rocks within the depositional basin.

The Dunkard Group contains ~350 meters (m, ~1,150 feet [ft]) of rock strata including terrestrial mudstones, shales, siltstones, and sandstones. These are primarily river channel and floodplain deposits and paleosols (ancient soil horizons). Coal beds and freshwater lake limestones are minor components. A few of the thicker coal beds can be traced over much of the region and are used by geologists as marker beds for correlating strata (rock layers) in different areas.

For more than a century, geologists have debated the age of the Dunkard Group. The age determination is complicated by the absence of igneous rocks that can be numerically dated and of marine rocks that would contain index fossils used to define rocks of Permian age. Studies based on terrestrial fossils of vertebrates and insects indicate that the Dunkard Group is entirely early Permian in age; studies based on plants and freshwater ostracods (small bivalved arthropods) suggest the lower part of the Dunkard Group could contain the Pennsylvanian-Permian boundary.

Life during the early Permian of Ohio

Many of Ohio's early Permian organisms were already present during the Late Carboniferous. Large pelycosaur-grade synapsids (**10, 11**), close relatives of early mammals, had sails on their backs supported by neural spines. The sails may have assisted these animals with regulation of their body temperatures through radiative heating or cooling, but they may also have served other functions, such as attracting mates. A species of *Dimetrodon* (**10**) in the Ohio region may have reached 3 m (10 ft) in length and was an apex predator of the early Permian. *Edaphosaurus* (**11**), one of the early herbivorous tetrapods, had a proportionately smaller skull than *Dimetrodon* and adaptations to its skull shape, jaws, and teeth for eating plants. *Dimetrodon* and *Edaphosaurus* are known from only partial remains in Ohio.

Diadectes (**8**) was a large (up to 3 m [10 ft]) reptile-like tetrapod with short limbs and a broad, low body. Its specialized teeth indicate that it, like *Edaphosaurus,* was an early large herbivore. Another tetrapod, *Eryops* (**4**; fig. 3) was a large predatory amphibian with many slender, conical teeth that were probably used to catch and hold slippery fishes or smaller amphibians.

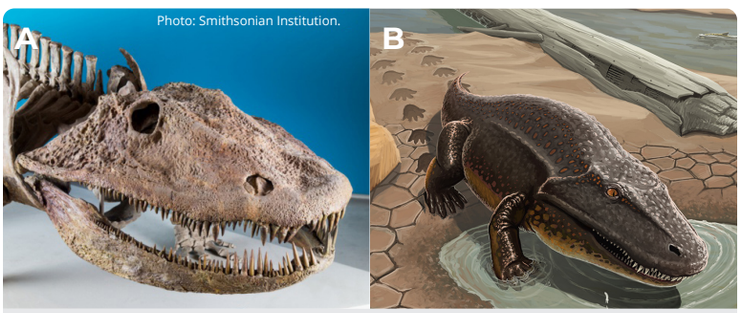


Figure 3. (A) Skull and anterior skeleton of *Eryops* sp. from Texas, part of composite mounted skeleton USNM V 6721. (B) Artist's reconstruction of the amphibian *Eryops* sp. (**4**), which could reach lengths up to 2 m (6.6 ft) or more and had skeletal adaptations for walking on land.

An Ohio natural resource

The few coal beds of mineable thickness in the Dunkard Group were historically mined for local use, but by 1900 they were largely supplanted by higher-quality coal seams in Upper Carboniferous formations. Permian "red beds," many of which represent ancient soil horizons within floodplain mud deposits, owe their color to the presence of hematite (Fe_2O_3), an iron-oxide mineral. Dunkard Group red beds have been mined for clay used to make bricks and ceramic linings of furnaces. Sandstones from the Dunkard Group were historically used for building stone and, from the 1820s to the 1960s, were quarried for grindstones. In addition to economic uses, Dunkard Group rocks provide data for scientists to reconstruct the climate and ecology of the early Permian.

For more information, references, and details about where to view Dunkard Group rocks, visit:

ohiodnr.gov/LIAO

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Life in Ancient Ohio - early Permian

Poster narrative and key by Mark E. Peter, 2024