LOWER TETRAPODS OF 1/4 BILLION YEARS AGO

Smaller than Dinosaurs, but Equally Interesting

by John Bolt

Dinosaurs are popular with paleontologists as well as with the public. It would be natural, then, to assume that a large natural history museum such as Field Museum has many dinosaur specimens in addition to those on display, and that the curator of fossil reptiles (and amphibians) does research on dinosaurs. In fact, interesting as dinosaurs are, I do not do research on them. This would be difficult in any case, since (again contrary to expectations) Field Museum has few dinosaurs other than those on display, and dinosaur specimens can hardly be borrowed from other institutions *via* parcel post. This dearth of dinosaurs is compensated by the excellence of the collection in other areas.

Most large natural history museums have a collection of fossil vertebrates, usually including lower tetrapods (reptiles and amphibians). Within the seemingly narrow limits implied by "fossil lower tetrapods," even very good collections of various museums may differ in emphasis. For instance, a strong point in Field Museum's collection is the excellent material from the Lower Permian of (mostly) Texas and Oklahoma. Most of this material, though housed at Field Museum, actually belongs to the University of Chicago. In fact, all of the university's paleontological collections are here, reflecting a recent centripetal trend of university museum collections of all kinds into a few large museums. The collection of Lower Permian tetrapods is excellent largely because paleontologists associated with the University of Chicago have been collecting and studying this material since the nineteenth century.

The Lower Permian is an interval in geologic time currently thought to range from about 255 to 270 million years ago. This is considerably earlier than even the most primitive dinosaurs, which appeared some 200 million years ago during the Upper Triassic. The largest dinosaurs are confined to the Jurassic and Cretaceous periods, which together span the time from 180 million to 70 million years ago. A number of typical Lower Permian vertebrates are displayed in Hall 38, including perhaps the most famous (and one of the largest)—*Dimetrodon*, a "sail-backed" pelycosaur. Pelycosaurs, which were primitive mammal-like reptiles, commonly occurred in the Lower Permian. Their contemporaries included a number of much more primitive reptiles, very similar to the earliest reptiles known, and a variety of large and small amphibians. One of the largest Lower Permian amphibians, *Eryops*, is also on display in Hall 38. Many of the amphibian groups disappeared by the end of the Lower Permian. Paradoxically, this period

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Left: Concentration of fossil bone from Agate Springs locality, of Lower Miocene age. Width: 78 inches.

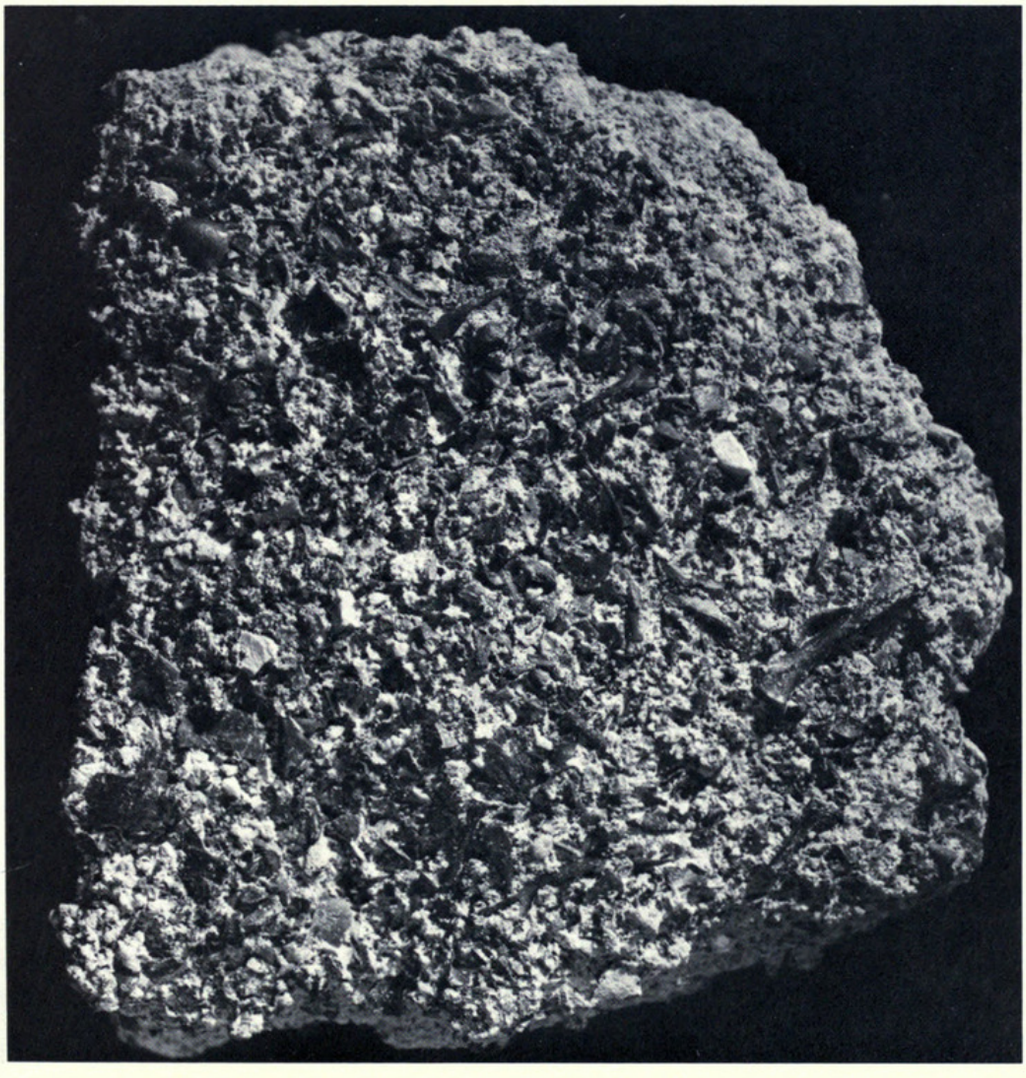
is nevertheless a source of specimens which tell us much about primitive amphibians, the first land-dwelling vertebrates. Amphibians originated some 350 million years ago, approximately at the time of the transition from the Devonian period to the Mississippian, but relatively few specimens this old have been found. The Lower Permian amphibian fauna is naturally not the same as that of early Mississippian time. However, the similarities are strong enough to make the Lower Permian a valuable source of information about these much earlier amphibians.

Lower Permian tetrapod specimens tend to be rather unspectacular in appearance, and difficult to study. One reason for this difficulty is their relatively small size; but just as important is the usual type of preservation. Most specimens, even those a paleontologist would consider quite good, are more or less crushed and incomplete. Often they have been chemically altered in ways which make it hard to study them. Finally, but very important, is the fact that many are found in fairly hard rock. This must be removed by a preparator, generally using dental tools to chip and grind away the rock. In the process, no matter how skillful the preparator, specimens are inevitably damaged to some extent. In general, the smaller the specimen the more serious the damage will be. Some areas of small specimens, such as the braincase and palate, cannot be cleaned very thoroughly.

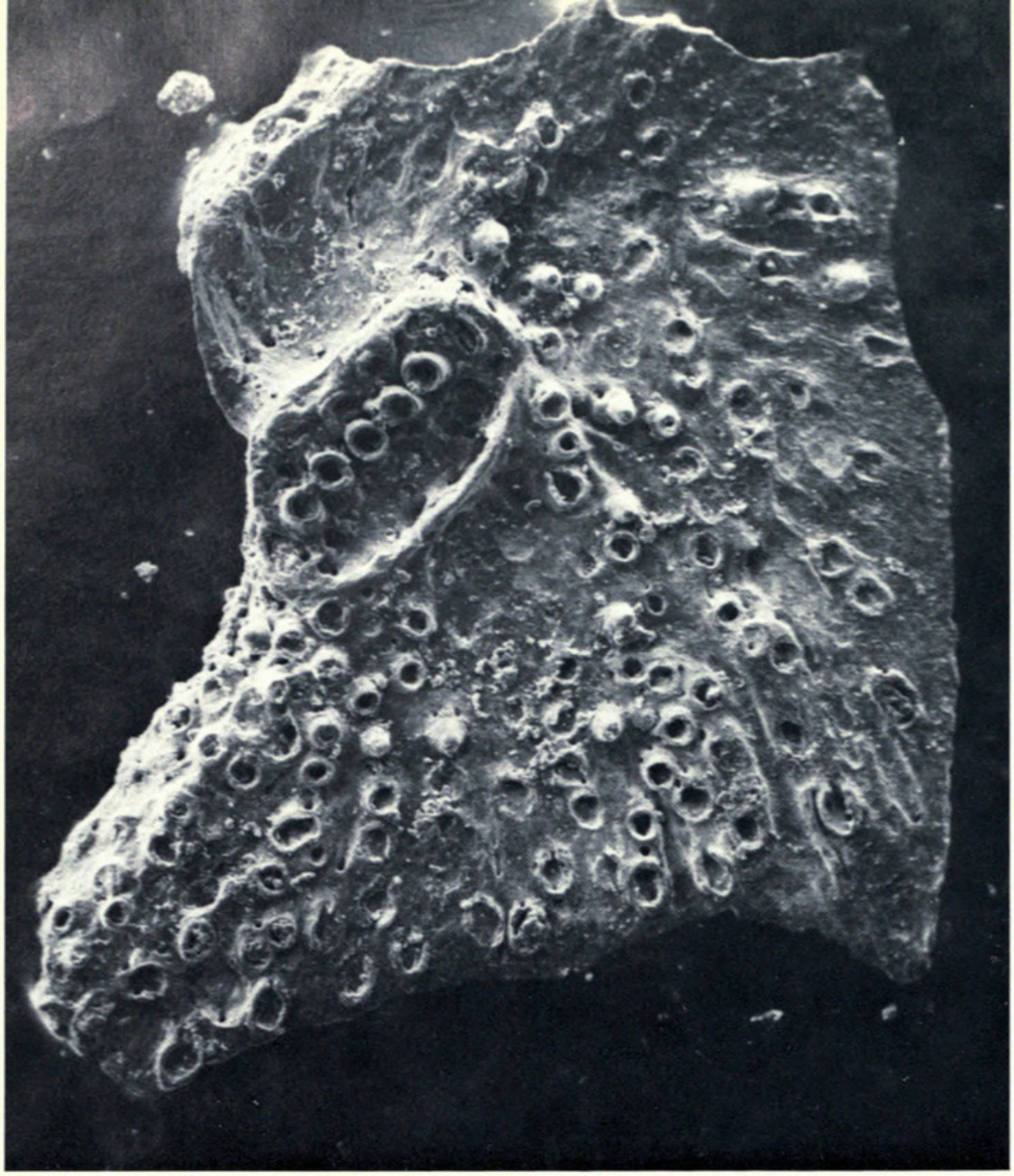
As a result, even my fellow paleontologists are liable to comment on some of my specimens in such terms as "Yuck! How can you make anything out of that?" To tell the truth, sometimes I can't. But often a combination of approaches will yield a surprising amount of information from even poorly preserved specimens. A particularly helpful approach is to use very well preserved material to interpret the morphology of a different but related species. Fortunately, Field Museum has some truly spectacular Lower Permian material. In this article I will describe a unique Lower Permian locality which has produced large numbers of excellent reptile and amphibian specimens. I will refer to it as the Kiowa locality since it is in southwestern Oklahoma, the home of many Kiowa Indians.

The Kiowa locality is a mass occurrence of fossil lower tetrapods; The photo on page 8 shows typical Kiowa material. Compare this to a concentration of fossil mammals from the Lower Miocene (about 20 million years ago), shown below. In each case the bones are shown in the positions in which they were found, although some of the covering sediment has been removed. Bones from both the Miocene and Lower Permian locality are comparably well preserved. They are of very different sizes, however. The Miocene fossils are about the size one would expect; the width of the area shown is 78 inches. The width of the Kiowa specimen, which also includes many bones (not easily visible here), is about 1.4 inches. The number of individuals represented at the Kiowa locality is undoubtedly in the tens of thousands, and may be much greater.

What accounts for such an unusual concentration? The Kiowa locality is a Lower Permian fissure fill in Ordovician limestones (roughly 470 million years old). Under the proper conditions, limestone deposits may develop an extensive system of interconnected fissures and caves, due to weak organic acids which dissolve the limestone. Where fissures open at the surface, they may form traps for animals. Probably most of the animals at the Kiowa locality were trapped in this way. It is possible, however, that some of them lived in the caves which were probably part of the fissure system. Except for one locality a few miles from the Kiowa site, I know of no other fissure locality this old which has produced any fossil tetrapods.

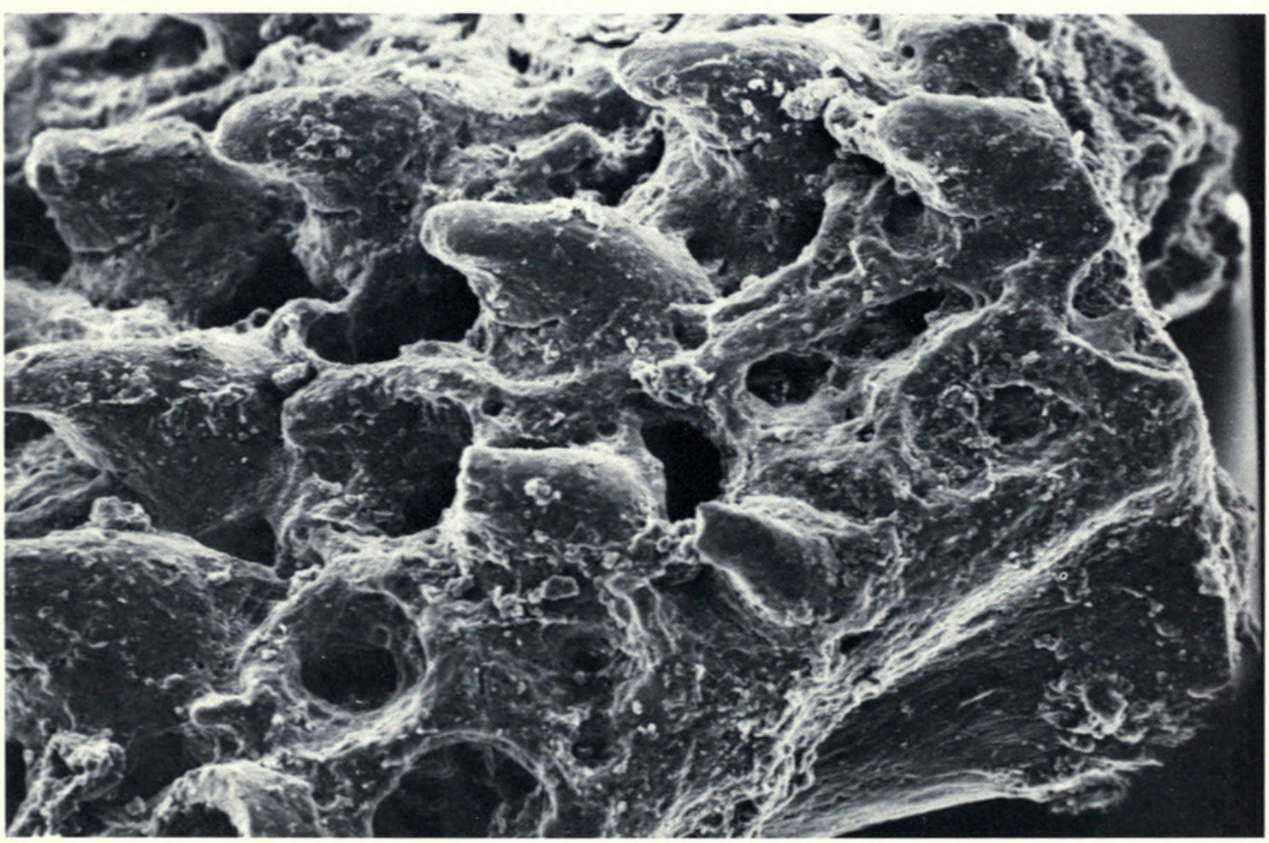


Left: Concentration of fossil bone from Kiowa Locality, of Lower Permian age. Width: 1.4 inches.



Aside from the abundance and small size of specimens, the Kiowa locality has other remarkable features. Most important is the fact that the fissure fills are mostly soft clay. Specimens can therefore be prepared with a minimum of damage, often simply by gently washing them with water in a screen-bottomed box. The amount of detail thus revealed is astonishing. The specimens shown on this page will give some idea of this. The photo reproduced below shows minute teeth from the roof of the mouth in a fossil amphibian. These teeth have a zone of weak calcification near their base, a discovery which I believe points to the origin of the living amphibians from a Lower Permian group. Such teeth are usually (and unavoidably) removed in preparation even of much larger specimens, from other localities. It is just not possible to clean between fragile teeth a millimeter or so apart, when they

Left: Scanning electron microscope photograph of a nearly complete bone (vomer) from roof of mouth of fossil amphibian (Doleserpeton annectens) *found at Kiowa locality. Width: about 2 mm.*



Right: Scanning electron microscope photograph of several denticles from roof of mouth, same amphibian species as shown above. Enlarged about 100 times.

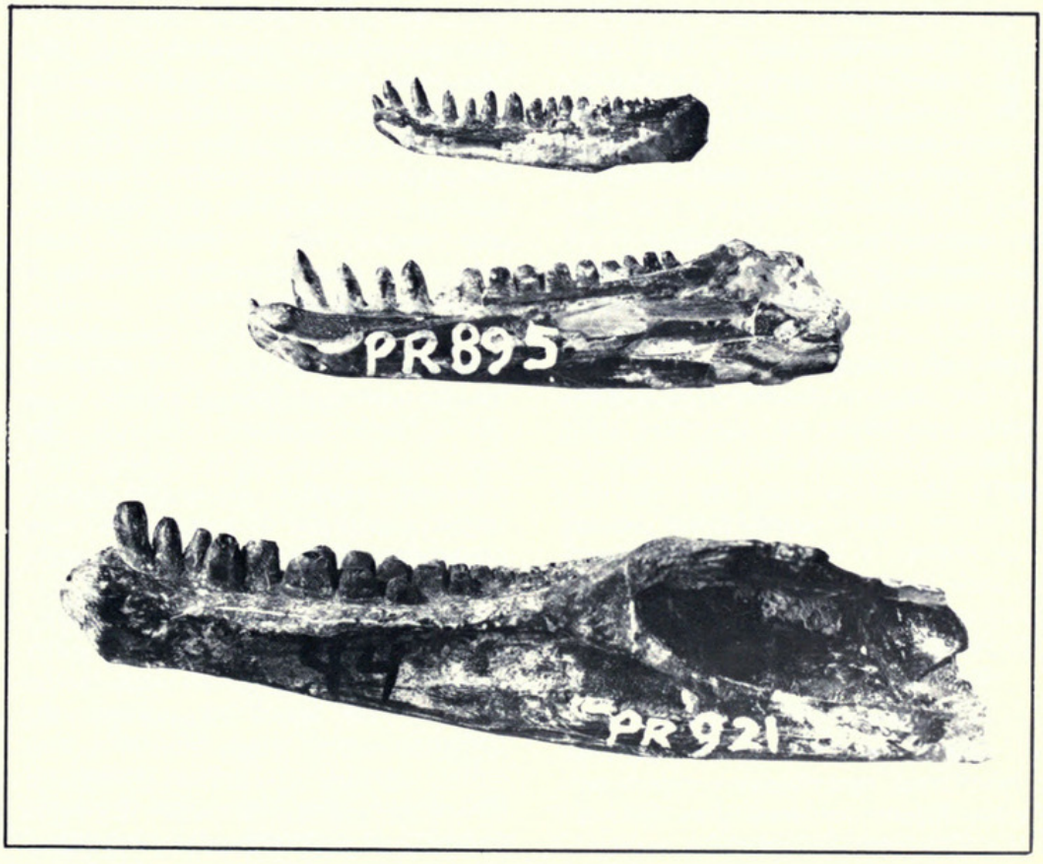
are imbedded in hard rock. Thin sections of Kiowa bone, when examined under a microscope, show growth lines within the tiny bones, the spaces (lacunae) once occupied by bone cells, and calcified cartilage at the ends of long bones. The shape and surface features of these ancient bones can be studied just as well as those of recently cleaned modern bones. And as a bonus, the Kiowa bones are quite strong and can be handled with little chance of damage.

The Kiowa fauna is diverse; I estimate that there are at least a dozen species of small reptiles and amphibians present. It is clear that for at least some species, a growth series is present. Shown below is a series of jaws from a small reptile, *Captorhinus aguti*, which is by far the most common species at the locality. *C. aguti* has an unusual dentition, recently studied by myself and Robert DeMar of the University of Illinois at Chicago Circle campus. We were interested in certain aspects of tooth replacement for which *C. aguti* might provide a model—but only if such perfectly preserved material was available. *C. aguti* exemplifies another important aspect of the Kiowa fauna: its terrestrial nature, which in the case of *C. aguti* can be confirmed from other localities where the species occurs. Most known Lower Permian tetrapods were inhabitants of rather low-lying areas in a widespread system of deltaic sediments (that is, sediments deposited as river deltas near the point where ancient rivers entered a sea). The majority of Lower Permian tetrapod faunas therefore include stream- and pond-dwellers, and terrestrial animals which lived in close proximity to water. The faunas of better-drained areas are not so well known. The Kiowa fauna, however, consists almost entirely of terrestrial animals; aquatic species are extremely rare.

The Kiowa locality has been known to paleontologists since 1938. There are considerable collections of this material in a number of museums, although I believe the collection in Field Museum is now the most extensive. In view of the description above, one might think that this material has been thoroughly studied. In fact, surprisingly few papers have dealt with Kiowa specimens. One reason for this may be the small size of the animals. This is suggested by a story I heard about a well-known paleontologist who, among other interests, had studied the Lower Permian for years; the Kiowa locality was discovered toward the close of his long and distinguished career. He obtained some of the material, but never worked on it because it was "just little stuff."

Small size, however, is not the major reason for the relative lack of interest in Kiowa material. The problem is the disarticulated condition of almost all of it: There are innumerable individual bones, but few skulls, either complete or partial; and entire skeletons—skull, vertebral column (backbone), and limbs—are almost nonexistent. I know of more than one person who began work on the fauna but eventually gave it up because of the difficulty in determining just which pieces belonged together. The mixture of numerous species, some of them undoubtedly new, and at various growth stages, was just too hard to untangle.

I would like to report that by sheer brilliance I have succeeded in overcoming these problems. This, alas, is not the case. I have, however, been able to learn quite a lot about the fauna by more prosaic methods. Although specimens (other than *C. aguti*) with even a few bones in their natural association are very rare, they do occur. Each such fragment makes it possible to assign many individual bones to a single species. And sometimes a nearly complete specimen is found. I was fortunate to find several such specimens at the beginning of my study several years ago, and others have shown up since. As a result, although I also collect and study other areas, I am still excited about this unique locality. The association of most of the disarticulated bones is still uncertain, but I think that many more bones can eventually be assigned to the proper species. There is no better source of information on the small terrestrial tetrapods of the Lower Permian, and the importance of the locality is bound to increase as more associations are made. Thus, despite the small size of Kiowa animals—or perhaps because of it—the search is just as exciting as a dinosaur hunt. □



Three lower jaws of the small reptile Capthorinus aguti, *from Kiowa locality. Enlarged about 3 times.*