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An Armored Dinosaur from the Lower Cretaceous of Utah

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ABSTRACT.—Descriptions of armored dinosaurs are limited primarily to Upper Cretaceous fossil finds. This paper concerns discovery and description of an armored dinosaur from the Lower Cretaceous Cedar Mountain Formation of eastern Utah. The collection amounts to thirty percent of one animal, consisting of vertebrae and dermal armor segments.

Previously described Lower Cretaceous dinosaurs include *Polacanthus foxi* (Hulke, 1882) from the Isle of Wight and *Hoplitosaurus marshi* (Lucas, 1901) from the Lakota Formation of South Dakota. The fossil described in this paper bears close similarity to *Hoplitosaurus marshi* (Lucas, 1901) and is tentatively placed in the genus *Hoplitosaurus*. A close similarity to *Polacanthus foxi* (Hulke, 1882) is also evident, and references are made to it in description of present material, particularly to the positioning of the dermal armor.

Particular parts of other dinosaurs, such as *Nodosaurus, Ankylosaurus, Hierosaurus, Panoplosaurus, Stegopelta, Edmontonia,* and *Anodontosaurus,* all of Upper Cretaceous age, are comparable to certain parts of the dinosaur described in this paper.

The recent discovery of another armored dinosaur five miles southeast of the present fossil locality indicates favorable environmental conditions for armored dinosaurs during deposition of the Cedar Mountain Formation.

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INTRODUCTION

Purpose and Scope

Descriptions of armored dinosaurs are limited primarily to Upper Cretaceous fossil finds. This paper concerns discovery and description of an armored dinosaur form Lower Cretaceous rocks of Utah.

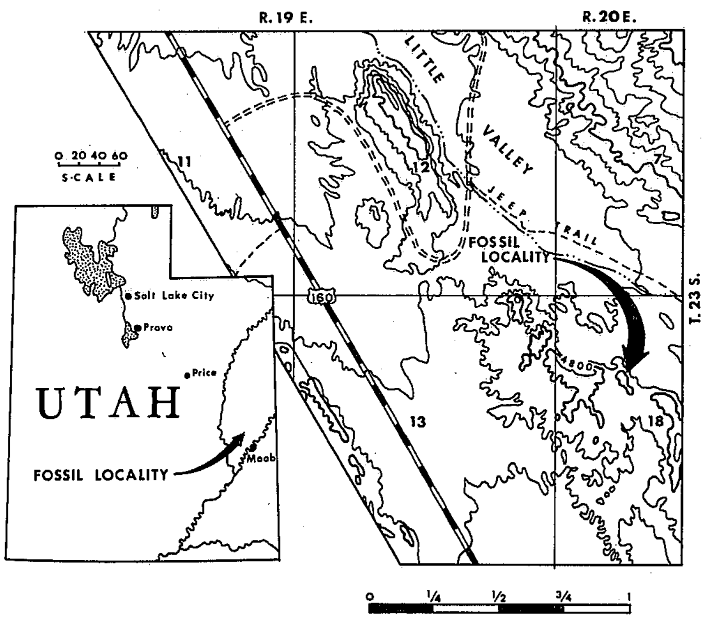
The major objective of this study is a systematic description of the fossil material. The whole collection amounts to about thirty percent of one animal, including the following bones: 7 caudal vertebrae, 66 complete dermal scutes, 14 dermal plates, 3 dermal spines, 3 chevrons, 1 portion of a rib, 2 limb-bone fragments, and numerous fragments of armor plates and limb bones.

Location

The fossil locality is in Grand County, southeastern Utah (Text-fig. 1), approximately ten miles south of Crescent Junction and twenty-one miles north of Moab. The fossil site is in sedimentary rocks which form a low cliff along the west side of Little Valley, on the southwest flank of the Salt Valley anticline, in Sec. 18, T. 23 S., R. 20 E., almost due east of a microwave tower near Canyonlands Airport. The area is accessible by way of a jeep road, two miles down Little Valley from a turnoff on U.S. Highway 160, eight miles south of Crescent Junction.

Previous Work

The Lower Cretaceous Cedar Mountain Formation was described from near Castle Dale in Emery County, by Stokes (1944). Geology of the area around the fossil locality is included in a paper by Stokes (1952) on the Salt Valley anticline (uranium-vanadium deposits, Thompson area). His paper has been particularly useful since the fossil locality is on the southwest flank of the anticline. Stokes (1952) has described the Cedar Mountain Formation from several localities in Utah, including one location on the flank of the Salt Valley anti-



TEXT-FIGURE 1.—Index map of fossil locality.

cline about five miles north of this dinosaur locality, in a summary paper on the Lower Cretaceous rocks of the region.

Literature concerning armored dinosaurs is very limited. Two Lower Cretaceous forms, *Polacanthus foxi* described by Hulke (1882), redescribed by Nopcsa (1905) from Europe, and *Stegosaurus marshi* (Lucas, 1901), renamed *Hoplitosaurus marshi* (Lucas, 1902), redescribed by Gilmore (1914) from the Lakota Formation, Buffalo Gap Station, South Dakota, have the closest similarity to the material described in this paper. Both *Polacanthus foxi* and *Hoplitosaurus marshi* were originally included in the suborder Stegosauria, but Romer (1956) has listed both genera in the suborder Anklosauria, as true armored dinosaurs.

Particular parts of other dinosaurs, such as *Nodosaurus textilis* described by Marsh (1889), redescribed by Lull (1921), *Ankylosaurus magniventris* (Brown, 1908, *Hierosaurus sternabergii* (Wieland, 1909), *Panoplosaurus mirus* (Lambe, 1919), *Stegopelta landerensis* described by Williston (1905), redescribed by Moodie (1910), *Edmontonia rugosidens* (Russell, 1940), *Edmononia longiceps* (Sternberg, 1928), and *Andontosaurus lambei* (Sternberg, 1929), all from the Upper Cretaceous, are comparable to certain parts of the dinosaur described in this paper.

Discoveries of Lower Cretaceous armored dinosaurs, in recent years in Europe and Asia, especially *Syrmosaurus* from Mongolia, may eventually establish a world-wide correlation of armored dinosaurs.

Present Work

Present investigation began in October, 1967, with a reconnaissance trip to the fossil locality. Additional trips were made to the area during the spring and early summer of 1968. A section of the upper beds of the Morrison Formation, the Cedar Mountain Formation, and the basal Dakota Sandstone was measured at the fossil locality (Text-figs. 2, 3). This section was correlated to the northwest and southeast with known sections to establish the horizon of the fossil site.

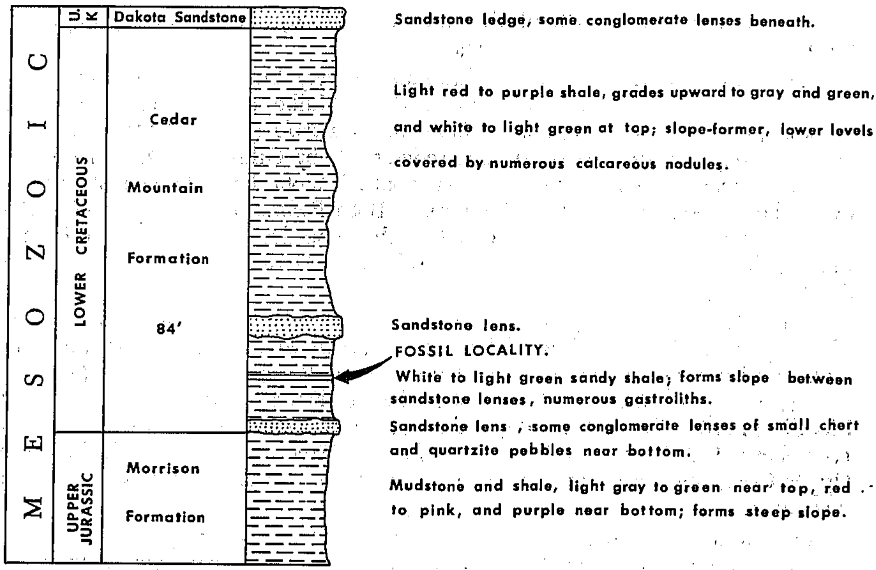
Preparation of the fossil material was done during the winter and spring of 1967-68.

Acknowledgments

The writer wishes to express appreciation to Dr. Morris S. Petersen, who served as thesis chairman, and Dr. Wm. Kenneth Hamblin, as committee member. Special thanks to Dr. J. Keith Rigby for his critical evaluation of the manuscript and Dr. Wilmer Tanner of the Department of Zoology for his advice. The fossil site was originally discovered by Mr. Lin Ottinger of Moab, who reported the find to Mr. Jim Jensen, curator of the Earth Science Museum at Brigham Young University. Mr. Jensen collected the specimen in the spring of 1965. Thanks is due him for his assistance in preparation and description of the material. Messrs. David Nash and Alan Washburn have been most helpful in assisting in the field investigation. Thanks is also due Mr. William Chesser for drafting of the illustrations.

Much of the cost of the study was covered through the Geology Department of Brigham Young University by a grant from Marathon Oil Company.

Some of the larger dermal plates and most of the vertebrae were prepared for a museum display by Mr. Dennis Belnap before the present study was begun.



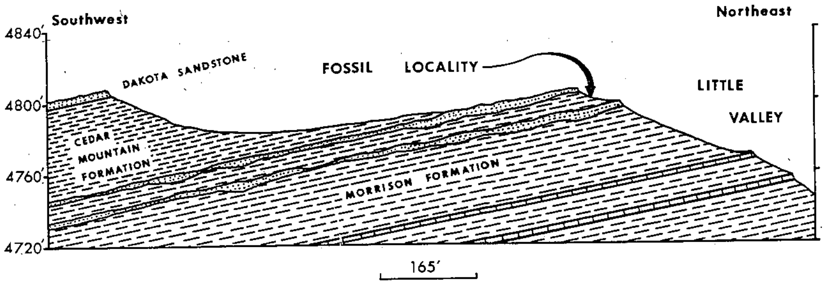
TEXT-FIGURE 2.—Generalized stratigraphic section of the Lower Cretaceous Cedar Mountain Formation at the fossil locality, including the upper portion of the Morrison Formation and the lower portion of the Dakota Sandstone.

Techniques

Much preparation was necessary before the material could be described, because the preservation was only fair. The material had been near the surface for a long time and suffered considerable damage. Plant roots sought the skeletal parts, so the material was fragmented by their growth.

The skeleton was uncovered by removal of overlying sediment and careful exposure of individual parts. As each part was exposed the upper surface was cleaned and painted with gelva dissolved in acetone to harden the material, and was then covered with tissue paper and encased in a plaster cast. Individual parts were completely uncovered, turned over, and the lower exposed surface cleaned, hardened, and covered with plaster. Each part was preserved as nearly whole as possible. Fragmented material was wrapped, as individual skeletal parts, in tissue and taped together in the field.

In the laboratory plaster casts were cut open and surface of the specimen completely cleaned. Most of the skeletal parts, such as the dermal plates and vertebrae, were fractured by plant roots and the fractures were filled with matrix. Skeletal material would usually break when freshly removed from the cast. The broken fragments were cemented together with a mixture of Hydrocal and Dextrin. Surfaces to be cemented were cleaned, then cement with a consistency of thin mud was applied to each surface, and the surfaces placed tightly together, forcing the excess cement out. Excess cement was removed and the outer surface cleaned with a small dental scraper and a damp sponge. In some cases small fragments of a skeletal part were missing and the missing fragment was reconstructed. In reconstruction the cement of Hydrocal and Dextrin was used, but was slightly thicker. The missing section was filled with cement,



TEXT-FIGURE 3.—Generalized northeast-southwest cross-section of the fossil locality.

allowed to harden slightly, then the excess was removed and trimmed to match the outline of the specimen. Matrix material and excess cement were removed using an Air-Scribe when necessary. Some of the more fragile plates were left with their hollow base still filled with matrix.

STRATIGRAPHY

General Statement

The stratigraphy involves essentially the Lower Cretaceous Cedar Mountain Formation. Until Stokes (1944) proposed the Cedar Mountain Formation as a separate formation, these beds were included in the Morrison Formation. The Morrison Formation then included the units from the top of the Summerville Formation to the bottom of the Dakota Sandstone. Stokes (1944) proposed the separation of the Cedar Mountain Formation from the Morrison Formation on the basis of lithologic differences, correlation of the formations to well-dated formations, and a younger (Stokes, 1952) paleontologic age. This established the Cedar Mountain Formation as Lower Cretaceous, and the Morrison Formation as Upper Jurassic in age.

Cedar Mountain Formation

The basal unit of the Cedar Mountain Formation at the type section on the southwest flank of Cedar Mountain, Emery County, Utah is the widespread Buckhorn Conglomerate. This basal conglomerate is absent in the area involved in this study (Text-figs. 2, 3).

Along Little Valley the basal unit of the Cedar Mountain Formation is a sandstone lens of variable thickness. The sandstone lens can be traced to the south of the fossil locality for many miles, where it forms a prominent ledge along the top of a steep shale slope. The sandstone lens thins and disappears to the north of the fossil locality. Thin, conglomerate lenses of small pebbles of chert and quartzite occur beneath the sandstone in many places. A gentle slope, above the sandstone ledge, is formed by light green to gray shales, laced by numerous thin sandstone lenses. A second sandstone ledge occurs above the light-colored shales. This sandstone is even bedded and light brown. It thickens toward the north of the fossil locality, but eventually lenses into the lower sandstone and disappears. This sandstone lens extends several miles to the south, but thickens and thins, and eventually lenses out into the varicolored shales. The upper unit of the formation is varicolored shales, the lower portion of which is predominantly light red to light purple, grading gradually upward into light gray and green shales. This unit forms a gentle slope covered with numerous irregular nodules and concretions.

The basal sandstone of the Cedar Mountain Formation rests on the upper Bushy Basin Member of the Morrison Formation. The Cedar Mountain Formation contact with the overlying Dakota Sandstone is placed at the top of the varicolored shale, at the base of the distinctive sandstones of the Dakota.

Previously reported Cedar Mountain Formation fossils are primarily invertebrate material and miscellaneous dinosaur fragments.

The following section of the Cedar Mountain Formation was measured at the fossil locality (Text-figs. 2, 3), NW$\frac{1}{4}$ Sec. 18, T. 23 S., R. 2 E., Grand County, Utah.

DAKOTA SANDSTONE

Unit	Description	Feet
	Sandstone and conglomerate, light yellow, weathers dark brown; sandstone breaks into large blocks; thin, conglomerate lenses of small chert and quartzite pebbles beneath sandstone ledge.	
	CEDAR MOUNTAIN FORMATION	
4	Shale and mudstone, light gray to green near top, light red to purple toward base. Forms gentle slope with the lower portion covered by abundant concretions and nodules	62
3	Sandstone, even bedded, silty, light brown to brown, weathers dark brown, forms distinct ledge	3
2	Shale, sandy, light gray to green, small thin sandstone lenses, forms gentle slope	15
1	Sandstone and conglomerate, brown to gray, thin, basal conglomerate lenses of chert and quartzite pebbles, sandstone thickness variable, even bedded forms distinct ledge, light brown to brown, light-colored lenses of quartzite	4
	Total, Cedar Mountain Formation	84

MORRISON FORMATION

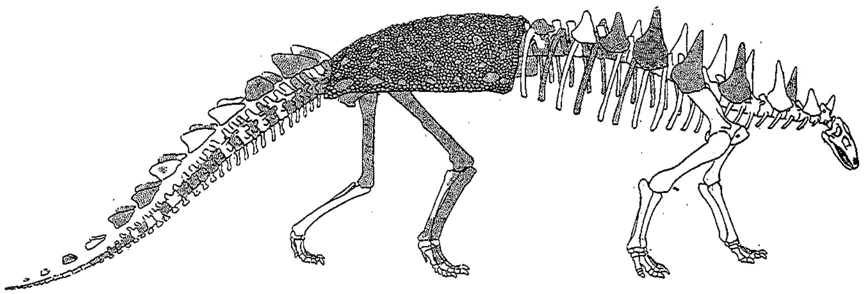
Fossil Locality

Site of the fossil collection is in light gray shales between the sandstone lenses about 12 feet above the base of the Cedar Mountain Formation. The quarry is in a slope, west from the edge of the ledge capped by the basal sandstone (Text-figs. 2, 3). The fossil material was surrounded by slightly sandy, light gray to green shale. Numerous "gastrolith" rock types and fragments of fossil wood and bone are present on the slope surface.

The Cedar Mountain Formation is equivalent to the lower Cretaceous Burro Canyon Formation of southern Utah and Colorado. Other equivalents in the western states include the Cloverly Formation of Wyoming, Lakota Sandstone of South Dakota, Kootenai Formation of Montana, and Kelvin Formation of northern Utah.

CONCLUSIONS

The specimen described in this paper and *Hoplitosaurus marshi* (Lucas, 1902) are closely related. Similarity is particularly evident in comparison of dermal armor of the two dinosaurs as described in this paper and by Gilmore (1914). This comparison is limited in its scope because of fragmental remains. Because of a lack of diagnostic material the specimen described here is tentatively placed in the genus *Hoplitosaurus*.



TEXT-FIGURE 4.—Skeletal restoration of *Polacanthus foxi* Hulke, after Nopcsa (1905, pl. 12), showing spine and plate arrangement and the lumbosacral shield. On *Hoplitosaurus* (?) sp. the dermal scutes may have formed a shield over the entire body rather than only a lumbosacral shield as figured by Nopcsa.

The European *Polacanthus foxi* (Hulke, 1882) from the Isle of Wight is one of the more complete Lower Cretaceous armored dinosaurs (Text-fig. 4). Position of the dermal plates, spines, and scutes on *Hoplitosaurus* may be similar to that of *Polacanthus,* as based on the similarity of these armor segments.

Colbert (1961) has noted two other Lower Cretaceous dinosaurs, *Syrmosaurus* from Mongolia and *Acanthopholis* of Europe, as among the oldest known armored dinosaurs. Both of these have important implications in correlating Lower Cretaceous armored dinosaurs. Comparison between these dinosaurs and the dinosaur described in this paper is difficult because of limited material.

Comparison of the present specimen to Upper Cretaceous armored dinosaurs has been useful in determining the arrangement of dermal scutes, position of vertebrae, and recognition of skeletal parts, such as the tendon bones. One can conclude from these comparisons that the structure and function of many of the armored dinosaur skeletal parts did not change greatly from Early to Late Cretaceous times.

The recent discovery of another armored dinosaur five miles southeast of the present fossil locality, in approximately the same horizon, may have some important implication on armored dinosaur study. The new material has not been described, but it is very similar to the present *Hoplitosaurus* (?) sp.

Discovery of two armored dinosaurs in such close proximity indicates that the environmental conditions of the area were favorable for these animals. A close study of the paleoecology of the Lower Cretaceous Cedar Mountain Formation may reveal many interesting facts concerning armored dinosaurs.

SYSTEMATIC PALEONTOLOGY

Family NODOSAURIDAE Marsh, 1895

Genus HOPLITOSAURUS Lucas, 1902

HOPLITOSAURUS (?) sp.

Plates 1-5

Vertebrae

Seven caudal vertebrae, which appear to be representative of the anterior two thirds of the tail, were collected from the fossil locality. The four largest vertebrae are apparently proximal, and one of these appears to be a sacrocaudal. Two vertebrae of moderate size are from the middle of the tail, and the smallest vertebrae is from the posterior two thirds of the tail. On all seven vertebrae the neural arch is completely coossified with the centrum. The numbering of the vertebrae in the following description is for convenience and merely represents approximate location.

Caudal 1.—This vertebra (Pl. 1, fig. 1) appears to be a sacrocaudal with the neural spine missing above the partially destroyed postzygapophyses. A definite increase in the size of the centrum face and a distinct downward slope of the centrum are evident from the anterior to posterior face. Depressions are present on the sides of the centrum below the transverse processes and extend ventrally. The centrum is amphiplatyan with subcircular faces. Prezygapophyses are well developed with the articular facets sloping inward, at approximately a 20 degree angle, and upward. Postzygapophyses are fractured, but the downward and outward slope of their articular facets is still evident. The neural spine is missing above the postzygapophyses.

Caudal 1 has thin transverse processes extending from an expanded base. The processes are almost horizontal for their entire length. Ends of both transverse processes have been broken off. The preserved part of the process on the right side of the vertebrae is 185 mm long, while that preserved on the left side is only 95 mm long. Throughout their length the processes show a marked decrease in thickness distally, because much of the bone has been eroded away.

Caudal 2.—This vertebra (Pl. 1, figs. 2, 3) may or may not have been in contact with caudal 1. It is the best preserved of the seven vertebrae. The centrum is cylindrical, about three-fourths as long as wide, and is slightly wider than high. The centrum is amphiplatyan with circular faces. Edges of the centrum faces are expanded to form a ridge around the lateral edges. Concavity of the sides and ventral area of the centrum is similar to caudal 1. Evidence of chevron attachment in the posterior ventral area is completely lacking.

The neural canal on caudal 2 is subcircular and well-preserved. The short, robust neural spine has a radial expansion midway and a transversely spreading bilobed dorsal portion. The entire spinal process has been compressed laterally and is slightly twisted. Prezygapophyses are almost flush with the centrum, with their articular facets facing inward, at an angle of 25 degrees from the horizontal, and upward. Articular facets of the postzygapophyses face outward, at an angle of 25 degrees from the horizontal, and downward, with a definite overhang on the centrum. The supra-postzygapophysal lamina are moderately developed.

Transverse processes extend from an expanded base, the dorsal surface of which slopes down from the ventral edge of the supra-postzygapophyses. For 70 mm to a length of 190 mm they thin vertically to blade-like forms which deflect downward. Ends of the processes are missing so the exact length cannot be

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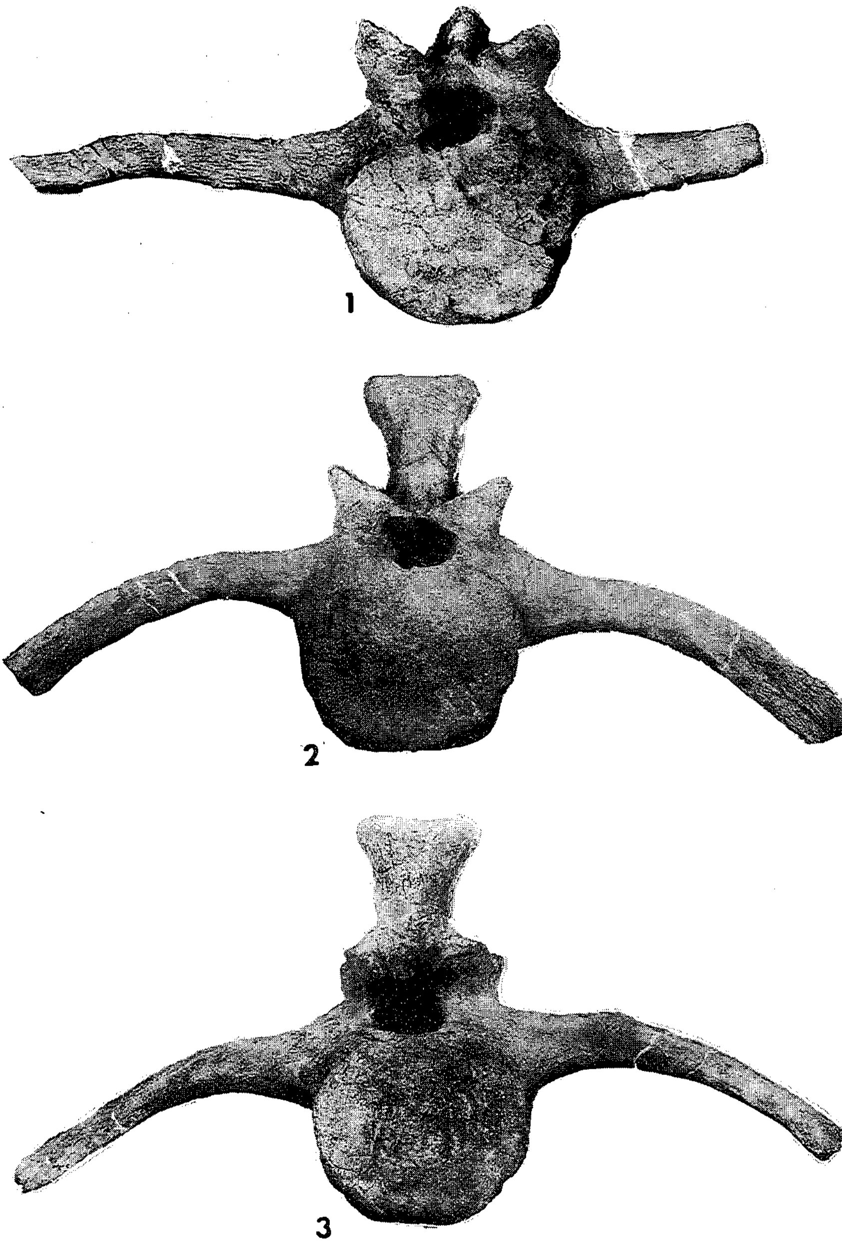
EXPLANATION OF PLATE 1

HOPLITOSAURUS (?) SP. VERTEBRAE

FIG.. 1.—Sacrocaudal vertebra of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Anterior View, ¼ nat. size.

FIG. 2,3.—Vertebra 2 of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. *Fig.* 2 anterior view, Fig. 3 posterior view, ¼ nat size.

PLATE 1



determined; however, judging from the thickness of less than 10 mm at the broken ends, only a small portion is missing. Both of the transverse processes exhibit the same general form when viewed from a superior position. They expand posteriorly near their base, but toward their extremities they arch anteriorly with posterior slope of the blade-like forms.

Caudal 3.—The bone (Pl. 2, fig. 1) is well preserved except for distortion of the neural spine, caused by lateral compression. This deformation has destroyed the pre- and post-zygapophyses on the left side and has distorted the neural canal.

The centrum is cylindrical, with height slightly less than width and the length a little less than three-fourths the width. The centrum is amphiplatyan to slightly platycoelus with the posterior end more concave. Edges of the centrum are expanded forming a ridge around the circumference of the face. Below the transverse processes the surface of the centrum is concave, with the concavity extending ventrally. A flat surface on the posterior ventral edge of the centrum, is at a 30 degree angle to the posterior face and was the surface of attachment of the chevron.

The neural spine is large, with a height above the centrum of 120 mm, and is inclined posteriorly. The top of the spine flares laterally to a width of 65 mm, giving it a bilobed appearance. The main part of the spine is oval in cross-section with its greatest diameter, 35 to 40 mm, slightly smaller than caudal 2. The base of the spine is broadened to support the prezygapophyses.

The neural canal is large, although distorted, with the anterior opening measuring 35 mm wide by 25 mm high. There is no apparent change in the canal size from anterior to posterior.

The transverse processes project horizontally from an expanded base for 50 mm, then deflect downward at an angle of 35 degrees for the remainder of their 170 mm length. Their base is about 40 mm in diameter and subcircular in cross section, with the dorsal surface sloping down from the ventral edge of the suprapostzygapophyses. The downward deflected portion of the processes is wide and flat terminating in a swollen blunt end. Both processes are inclined slightly anteriorly.

EXPLANATION OF PLATE 2

HOPLITOSAURUS (?) SP. VERTEBRAE AND DERMAL SCUTES

FIG. 1.—Vertebra 3 of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum, Posterior view, ¼ nat. size.

FIG. 2.—Vertebra 6 of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Anterior view, (?), ¼ nat. size.

FIG. 3.—Vertebra 8 of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Posterior view, ¼ nat. size.

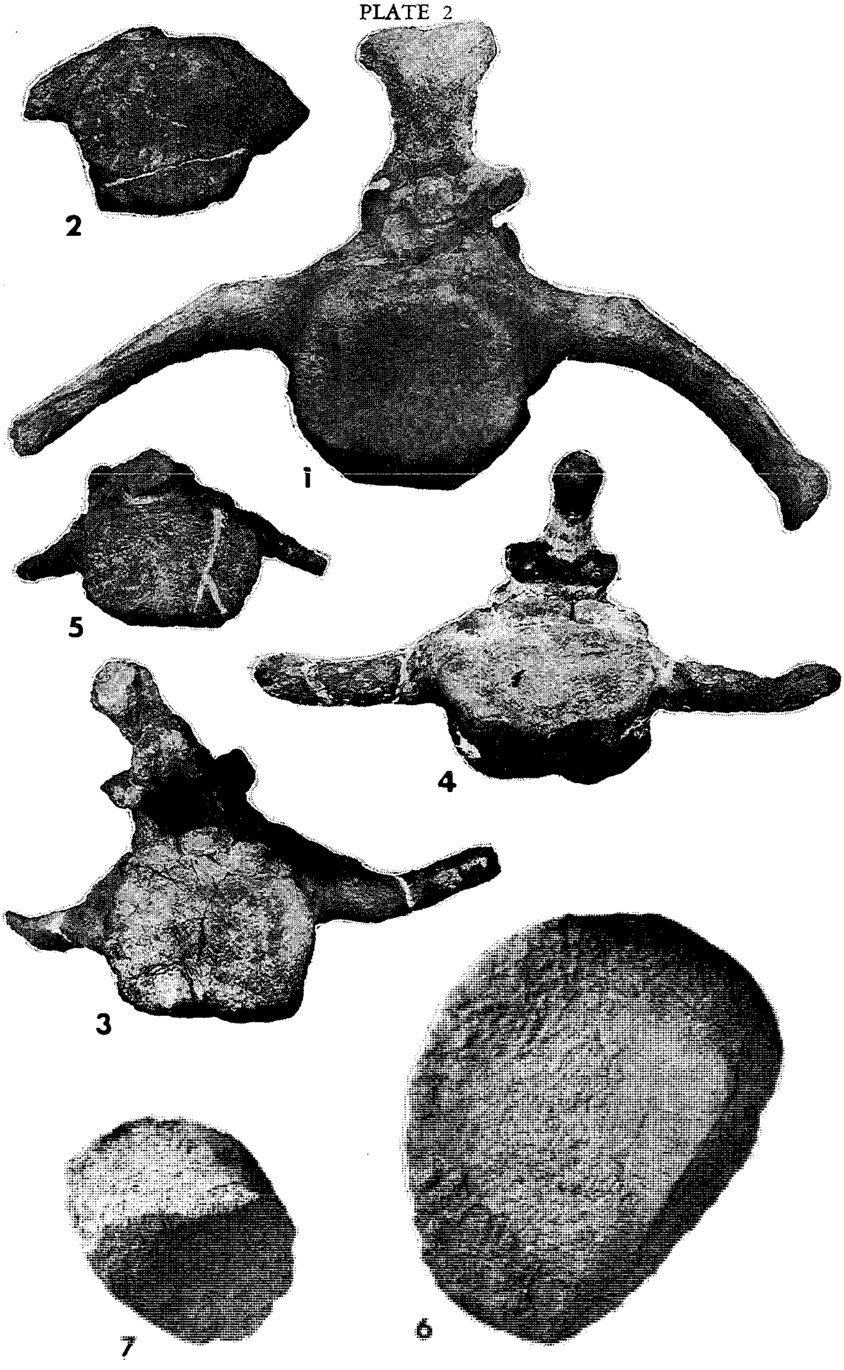
FIG. 4.—Vertebra 10 of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Posterior view, ¼ nat. size.

FIG. 5.—Vertebra 20 of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Posterior view, ¼ nat. size.

FIG. 6.—Dermal scute of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Dorsal view of keeled scute with lengthwise extending keel, approx. ⅓ nat. size.

FIG. 7.—Dermal scute of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Dorsal view of keeled scute with high pointed keel, approx. ⅓ nat. size.

PLATE 2



Caudal 6.—Of the original vertebra all that remains is the lower portion, the neural arch and spine having been broken off (Pl. 2, fig. 2). The centrum is amphiplatyan, with subcircular faces. Below the transverse processes the centrum sides are concave. A ventral depression is evident with a small median ridge. On either side of the ventral depression are strong ridges developed in alignment with the chevron facets.

The transverse processes have been broken off near their expanded bases but appear to have extended horizontally.

Caudal 8.—This is a median caudal with a well-developed centrum, and slightly distorted neural spine and transverse processes (Pl. 2, fig. 3). The centrum is cylindrical and amphiplatyan, with a length less than the width and height. Below the transverse processes on the centrum sides are depressions. A deep depression is evident on the ventral surface, along either side of which are antero-posteriorly extending ridges aligned with the chevron facets. The neural spine is distorted to the left, with the pre- and postzygapophyses completely missing or only partly evident. The neural spine with a width of 25 mm at its summit, is much thinner than any of the previously described vertebrae. The neural canal is still large with a width of 25 mm and a height of 30 mm.

The transverse processes extend horizontally for 80 or 90 mm from their expanded base, however, they have been twisted and bent out of their original position.

A large bulbous growth is present above the right postzygapophyses which may be evidence of some disease.

Caudal 10.—On caudal 10 (Pl. 2, fig. 4) the neural spine has been depressed posteriorly, causing an extreme overhang on the centrum. The centrum is platycoelous, and the height and length are three-fourths that of the width. Ridges around the centrum faces are broad, with shallow depressions on the side and ventral surfaces. The chevron facets are distinct, but no anterior extending ridges are evident.

The neural spine is thin and long, with a ridge along the anterior surface. The neural canal has collapsed so no details of its structure can be observed. Postzygapophyses are preserved with the articular facets facing outward and upward. Prezygapophyses are present but the articular facets are distorted. The zygapophyses are narrow with a maximum transverse width of 65 mm.

The transverse processes are approximately 90 mm long and extend horizontally as thin blade-like forms.

Caudal 20.—This is the smallest of the vertebrae found (Pl. 2, fig. 5), and has been placed in this position in the tail because of its size in relationship to the other vertebrae (Table 1). The neural spine has been depressed posteriorly, destroying the postzygapophyses and distorting the neural canal. Length and width of the centrum are almost the same, 80 and 90 mm respectively, with the height shortened to 60 mm. Ridges around the centrum faces are broad with wide shallow depressions on the centrum sides. The ventral depression is deep with strong antero-posteriorly extending ridges aligned with the chevron facets.

Prezygapophyses are broken and distorted except for the one on the right side which shows an elongate, narrow tapering articular facet.

Short remnants of the transverse processes extend horizontally for a length of 35 to 40 mm.

Summary.—All seven vertebrae have large centra with large to medium size neural spines. Vertebrae 2 and 3 have large centra and high spines in contrast to the low spines and small centra described for *Nodosaurus textilis* (Lull, 1921). In general shape they resemble *Polacanthus foxi* (Hulke, 1882); however, the literature afords no close comparison. The largest vertebrae described from *Polacanthus foxi* are somewhat smaller than the largest described in this paper. Caudal vertebrae of *Ankylosaurus magniventris* (Brown, 1908) are similar but larger than those described in this paper.

Dermal Armor

Numerous armor plates and scutes, none of which were articulated, were collected from the fossil locality. On the basis of size, shape, and general characteristics the dermal armor may be divided into four different forms; (1) simple rounded scutes; (2) keeled scutes; (3) plates; and (4) spined plates.

Simple rounded scutes

Simple rounded scutes are the smallest elements of the dermal armor; without either a specific size or shape, they range from 25 mm to 45 mm in diameter and are rounded, to oblong or elliptical in outline. Twenty complete rounded scutes were found, the majority of which are less than 35 mm in diameter. Many of the smaller scutes are rounded with a flat ventral surface and a slightly arched dorsal surface. Edges are 4 mm thick while the center is as much as 8 mm thick. Larger scutes tend to be oblong with a high-arched dorsal surface.

The position that the scutes occupied on the animal is difficult to determine. Lucas (1901), in his original description of *Hoplitosaurus marshi* compared similar scutes with the ossicles forming the gular armature of *Stegosaurus*. Gilmore (1941) in his more detailed description of *Hoplitosaurus marshi* described the ossicles as elements of a lumbosacral shield similar to *Polacanthus foxi* (Hulke, 1882), (Nopsca, 1905) and *Stegopelta landerensis* (Williston, 1905). Since the scutes were not articulated it is not possible to reconstruct

TABLE 1
Measurements of Caudal Vertebrae

	1 mm	2 mm	3 mm	6 mm	8 mm	10 mm	20 mm
Length over all	95	100	100		85		
Height over all		230	230		170	160	90
Centrum, length	73	78	75	75	75	70	80
Centrum, anterior face, height	90	100	100	90	80	70	60
Centrum, anterior face, width	110	115	115	90	80	100	90
Centrum, anterior face, circumference	350	370	365	305	290	300	280
Centrum, posterior face, height	95	105	105	90	80	85	60
Centrum, posterior face, width	110	115	110	85	95	100	90
Centrum, posterior face, circumference	355	360	370	325	315	325	280
Neural canal, anterior end, height	25	25	25			20	
Neural canal, anterior end, width	30	35	35			25	
Width across prezygapophyses	95	95	95		60		
Width across postzygapophyses		75			55		
Neural spine, length, summit		120	120		90	95	85

the original armor. However, because the scutes lack a uniform shape and are variable in thickness, they probably were separate and occupied positions between the larger scutes, thus forming a tight armor covering.

Keeled scutes

Keeled scutes are the most numerous of the preserved scutes and vary considerably in size and shape. On the basis of size, shape and particularly the extent of the keel, four major types of keeled scutes may be differentiated; (a) keel extending the length of the scute; (b) high pointed keeled scute; (c) round scute with central conical keel; and (d) flat scute with short central keel.

Keel extending length of scutes.—There are nineteen well-preserved scutes with a dorsal keel which extends antero-posteriorly (Pl, 2, fig. 6). They range in size from 65 mm long by 60 mm wide, to 160 mm long by 120 mm wide. The keel rises to a prominent projection toward one end. Lambe (1919), in a description of keeled scutes from *Panoplasaurus mirus,* designated this end as the posterior of the scute. Lambe has used the asymmetrical arrangement of the keels as a basis for position on the left or the right side of the dorsal midline of the animal. He states (1919, p. 44) that "the further a scute is from the dorsal midline, the nearer the keel approaches the lower border of the scute."

Basing the arrangement of the scutes on the description by Lambe and others, the keeled scutes in the present collection represent rows on both sides of the dorsal midline with the majority from the left side of the animal.

The two largest scutes measure 160 mm antero-posteriorly, by 120 mm wide, with a maximum thickness of 70 mm. The scutes are narrow anteriorly, expanding to a maximum width midway through their length, then tapering slightly posteriorly. Viewed laterally the keel rises from the anterior edge and continues posteriorly at a 40 degree angle for 60 mm, then levels off to a gentle slope to its apex, 110 mm behind the anterior edge. The ventral surface is slightly convex and scrobiculate with some tubercles.

The next smaller scute is from the right side, measuring 135 mm anteroposteriorly and 112 mm transversely, with a variable thickness of 10 to 60 mm. The right side is concave just below the keel, where part of it may have been broken away.

Fourteen of the remaining twenty scutes are approximately medium sized, with anterior-posterior measurements ranging from 90 mm to 105 mm and transverse measurements 80 to 95 mm. Some scutes show pitting on the dorsal surface similar to the keeled scutes described from *Anodontosaurus* (Sternberg, 1929) and to undescribed scutes recovered from a locality five miles south of the present site. The ventral surface is convex to flat toward the upper edge and scrobiculate.

The two smallest scutes of this type measure 80 mm and 65 mm anteroposteriorly and 65 mm and 60 mm transversely. Shallow pits are evident on the dorsal surface, and the ventral surface is scrobiculate with tubercles. The keel is nearly median, indicating that the scutes were near the dorsal midline.

High pointed keeled scutes.—The main characteristic of these scutes (Pl. 2, fig. 7) is the high apex of the keel. Twenty scutes of divergent size and shape representative of this group are preserved.

Two of the larger scutes exhibit close similarity to the keeled scutes previously described, except for termination of the keel in a high pointed spur. These scutes both measure 80 mm transversely with a maximum vertical height of 65 mm, however, one scute is antero-posteriorly 100 mm long and the other only 95 mm long. These scutes appear to be from opposite sides of the dorsal midline, with almost median keels indicating that they were near the midline of the animal. Both have a steep slope laterally from the keel ridge toward the lower edge of the scute, while one shows a concave lateral surface toward the upper edge and the other is convex. The posterior slope is almost a vertical surface from the apex of the keel to the posterior margin, but the anterior surface of the keel slopes gradually to the anterior edge. The ventral surface is almost flat with numerous shallow depressions.

Two other keeled scutes have approximately the same dimensions but have a less prominent keel. Both of these scutes measure 90 mm antero-posteriorly and 75 mm transversely, with the keel apex 65 mm above the base. The keel slopes gently posteriorly, terminating in a point directly above the posterior edge of the scute. Lateral surfaces are smooth and slope steeply from the keel ridge to the edges of the scute. The keel spur projects upward and slightly posteriorly and forms the termination of the dorsal surface of the scute. The ventral surface is flat and scrobiculate.

The remaining sixteen scutes are almost uniform in shape and are divided equally between two size-groups. The eight larger scutes range in size from 75 mm by 75 mm, to 55 mm antero-posteriorly and 65 mm transversely. Height of the keel apex ranges from 45 mm to 65 mm above the base of the scute. The ventral surface is flat to convex and scrobiculate. The eight smaller scutes range in size from 30 mm to 40 mm antero-posteriorly and 25 mm to 35 mm transversely, with a keel height ranging from 35 mm to 40 mm above the base of the scute. The scutes are conical with flat ventral surfaces, and the dorsal surfaces sloping steeply from the posteriorly located keel apex to the edges of the scutes.

Scutes of this nature have not been described in the literature, so their exact location on the animal is speculative. They may be specialized forms of the lengthwise keeled scutes, possibly developed in the neck or caudal armature.

Round Scutes with central conical keel.—Seven of these button-like scutes are in the collection. They are round to slightly oval, with the dorsal surface rising to an off-centered conical projection (Pl. 3, fig. 1). Dorsal summit of the projection is blunted with the apex of the point missing. The ventral surface is convex on the four larger scutes but almost flat on the three smaller ones. The larger scutes are approximately 80 mm in diameter, and the smaller ones average 60 mm across. The ventral surface of all seven scutes is scrobiculate. Button-like, keeled scutes of *Hoplitosaurus marshi,* described and illustrated by Gilmore (1914), seem to have the closest similarity to these scutes.

Flat scutes with short central keel.—These scutes are characterized by a low profile with a flat ventral surface. The keel extends antero-posteriorly and is highest in the center, gradually sloping toward each end (Pl. 3, fig. 2). The scutes are oval in shape, with the average dimensions antero-posteriorly being 75 mm and transversely 55 mm, and a maximum thickness of 25 mm. Both the ventral and dorsal surfaces are scrobiculate.

In general the keeled scutes resemble the scutes described by Gilmore (1914) from *Hoplitosaurus marshi.*

Plates

The largest scutes recovered from the fossil site are subtriangular plates, which resemble the triangular plate-like scutes of *Hoplitosaurus marshi* (Gilmore, 1914) and the caudal plates described from *Polacanthus foxi* by Nopcsa (1905).

On the basis of triangular form the plates can be divided into two groups: modified acute triangular and modified isosceles triangular plates.

Acute triangular plates.—Eleven complete plates are representative of this group, all of which are characterized by having a narrow basal width, being elongated antero-posteriorly and having a dorsal ridge which extends antero-posteriorly to terminate in a posteriorly projecting spur (Pl. 3, figs. 3, 4, 5).

The four largest plates of the eleven are most similar to the anterior caudal plates of *Polacanthus foxi.* They probably represent two plates from each side of the midline, as evidenced by their asymmetrical bases. Dimensions of the plates (Table II) indicate that the two largest plates are a pair from opposite sides of the midline of the animal.

Measurements of plate 1 (Pl. 3, figs. 3, 4), are 260 mm antero-posteriorly, 65 mm transversely at the base, with a maximum height of 170 mm. Viewed from the side the plate is scythe-shaped with a blunt anterior end. A narrow dorsal ridge rises from the anterior end and extends posteriorly and reaches maximum height near the posterior edge of the plates. This dorsal ridge extends posteriorly over the base of the plate, terminating as a spur. Lateral surfaces slope steeply from the dorsal ridge to the base of the plate. One surface is slightly concave, probably due to postmortem collapse of the plate.

The central portion of the base is hollow (Pl. 3, fig. 4), extending as much as 40 mm upward. Irregular surfaced ridges occur on either side of the cavity. One ridge extends farther ventrally than the other. The more ventrally extending ridge is considered to be on the external surface of the plate. Plates can be positioned either on the left or the right of the midline of the animal by use of the asymmetry of the base. The irregular ventral surface of the ridges, with their numerous pits and depressions, were probably buried in the animal's skin and attached to muscles and tendons which kept the plates rigidly positioned.

The posterior edge of the plate, when viewer laterally, curves slightly to the anterior, then extends posteriorly to form the ventral edge of the dorsal spur. When viewed from above, the upper portion of the plate curves slightly inward.

Plate 2 is similar to plate 1 in almost all aspects except it was from the opposite side of the animal, as judged by the reversed asymmetry of the basal ridges.

EXPLANATION OF PLATE 3

HOPLITOSAURUS (?) SP. DERMAL SCUTES AND PLATES

FIG. 1.—Dermal Scute of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Dorsal view of keeled scute with central conical keel, approx. ⅓ nat size.

FIG. 2.—Dermal scute of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Dorsal view of keeled scute with short central keel, approx. ⅓ nat. size.

FIGS. 3,4.—Dermal scute of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Fig. 3 lateral view, Fig. 4 ventral view of acute triangular plate 1, approx. ⅓ nat. size.

FIG. 5.—Dermal plate of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Lateral view of smallest acute triangular plate, approx. ⅓ nat. size.

FIG. 6.—Dermal spine of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Lateral view of spinal plate, approx. ⅓ nat. size.

PLATE 3

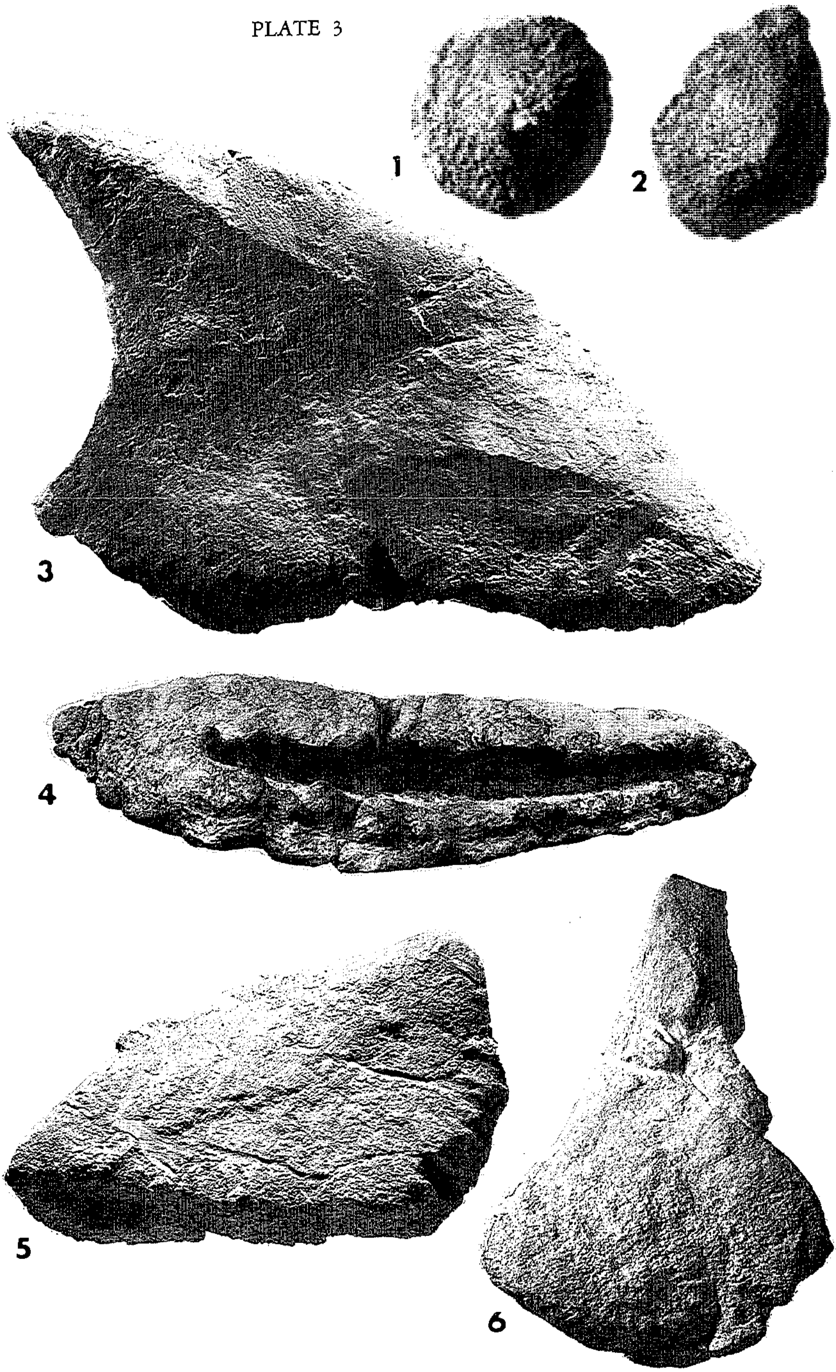


Plate 3 is slightly smaller but similar to plate 1. It is from the same side and was probably immediately posterior to plate 1.

Plate 4 is from the same side as plate 2 and is similar to the other three plates except smaller. Both the anterior-posterior length and the maximum height are less, but the basal width of 70 mm is greater than on the larger plates. This change seems to represent a trend toward a decrease in anterior-posterior length and height of the plate but an increase in base width.

The largest three of the eight remaining plates closely resemble the previously described plates but are poorly preserved. All three appear to have been hollow but have collapsed and are compressed to relatively thin plates.

Four of the remaining five plates are well preserved, and are similar to plates 1 to 4, except they lack the prominent spurs. Two of these plates appear to be from the left side as indicated by the asymmetry of their bases. Both of these plates have an anterior-posterior length of 230 mm, with one plate 130 mm high, slightly higher than the other one which is 125 mm high. The taller plate has a maximum width of 90 mm versus 80 mm for the shorter plate. The dorsal spur is almost directly above the posterior edge in both plates and is a blunt projection instead of a sharp spur as found on the other plates. An expanded base is evident almost to the dorsal ridge, with the entire plate having a swollen appearance. The hollow basal cavity is deeper than that of the thinner plates. Upper portion of the plates curves very distinctly inward when viewed from above, especially on the posterior spur. A third plate is from the opposite side and is similarly curved but in the opposite direction. It is 210 mm antero-posteriorly, 120 mm high, and is smaller in these dimensions than the plates described above, but with a maximum basal width of 95 mm it is wider than any of the other plates of the group.

The smallest plate of the series (Pl. 3, fig. 5) shows a reversal of the trend towards broadening of the base. This plate measures 180 mm antero-posteriorly and 100 mm high, with a maximum basal width of 60 mm. It is from the left side of the midline. The basal cavity is relatively narrow and shallow. The posterior spur is blunt and directed more dorsally than posteriorly. Small size of the plate suggests it probably occupied a more posterior position than the other eleven plates.

One other plate with some similarity to these plates is tentatively included in this grouping. Base of the plate measures 120 mm transversely and 180 mm antero-posteriorly, with a maximum height of 80 mm. The dorsal ridge is narrow and has a slight posterior projection. The lateral dorsal surface slopes steeply to one edge but gently to the other edge. Several deep pits occur along

TABLE II

Measurements of Four Largest Plates

	1 mm	2 mm	3 mm	4 mm
Anterior posterior length	260	260	255	240
Maximum height of plate	170	168	165	160
Height of spur above base	145	145*	155*	125
Maximum width of base	65	65	65	70

*approximate, spine incomplete

the edge of the plate. The ventral surface is concave but lacks the hollow cavity of other plates. The plate seems to combine the characteristics in appearance of both keeled scutes and spurred plates.

These plates are closest to plates of *Hoplitosaurus marshi* and *Polacanthus foxi.* Nopcsa (1905) referred to similar plates from *Polacanthus* as caudal plates and arranged them in two rows over the entire length of the tail, positioning them with the apex of the dorsal-surface ridge directed posteriorly.

Isosceles triangular plates.— Three plates are representative of this group, two of which are very similar, though from opposite sides (Pl. 4, fig. 1). The third plate has a more modified triangular outline (Pl. 4, fig. 2).

It is almost impossible to determine the anterior or posterior end on the two similar plates (Pl. 4, fig. 1). The anterior-posterior basal length is 265 mm with the ventral surface curving upward at the ends. The maximum height of the plates is 220 mm and 210 mm respectively. Ventrally the surface is narrow and broken, with small sections missing. The plates expand rapidly to a maximum transverse width of 45 mm, then taper gradually to a thin dorsal ridge. The plate edge forms a blunt projection from which the dorsal ridge rises steeply to the maximum height of the plate. The ridge then slopes gently to the opposite end of the plate. The upper one-third of the plate curves strongly to one side when viewed from above. A ridge is formed along the maximum transverse width, extending antero-posteriorly on the lateral surface of the plates.

The third plate (Pl. 4, fig. 2) has been placed in this group because of its triangular shape and other similar features. Antero-posteriorly the plate measures 245 mm, with a maximum height of 210 mm, and a basal width of 60 mm. The dorsal ridge slopes gently upward from one end of the plate to a maximum height which is projected slightly over the other end of the base. From the maximum height the ridge drops almost vertically to the base. Both lateral surfaces slope steeply down from the dorsal ridge, except for slight concavity caused by partial collapse of the plate. The base is transversely expanded medianly and then narrows rapidly toward the anterior and posterior ends. A distinct ridge extends the length of the plate slightly above the ventral surface. The ventral surface below this ridge is scrobiculate. A thin flange forms one end of the plate and extends from the expanded portion of the base and narrows dorsally toward the dorsal projection.

The fourteen dermal plates described in this paper are closely similar to some forms of *Hoplitosaurus marshi.* The difficulty in establishing a direct relationship is the lack of sufficient material in both cases. Gilmore (1914), in his description of dermal plates of *Hoplitosaurus marshi,* made numerous references to *Polacanthus foxi,* particularly to the arrangement of the dermal plates on the back of the animal. References in the present paper on the proposed position of the plates are based mainly on the Nopsca's (1905) reconstruction of *Polacanthus foxi.*

Dermal spines

There are three well-preserved examples of spined plates and are of two different forms. For convenience they will be described separately.

Spinal plate.— This plate (Pl. 3, fig. 6) appears to be incomplete, with portions of one side missing. The base expands antero-posteriorly but contracts rapidly upward, terminating in a high, rounded spine which rises from the center of the plate. Maximum height from the base of the plate to the summit of the spine is 180 mm. The spine is 17 mm in diameter as measured across the broken upper surface. This spinal plate is comparable to one described by Gilmore (1914) from *Hoplitosaurus marshi* except that the present specimen is only one half as large.

Asymmetrical triangular spinal plates.—The two larger dermal spine plates are approximately the same size and appear to be a matched pair (Pl. 5, fig. 1). Their bases are narrow, measuring 40 mm transversely, and 300 mm anteroposteriorly. A narrow hollow cavity extends most of their length. Basal ridges, with one ridge extending lower than the other, occur on either side of the hollow base. There is a reversal of their asymmetry as the ridges extend anteroposteriorly.

Viewed laterally, bases of the plates curve upward at the ends. A rounded spine projects dorsally reaching a maximum height of 200 mm. The dorsal ridge rises steeply from the blunt end of the plate to the spine, then slopes more gently to the opposite end. Lateral surfaces slope very steeply from the dorsal ridge to the base of the plate. The plate is very thin dorsally except for the spine base.

Dermal spines from *Hoplitosaurus marshi* and *Polacanthus foxi* are very similar to the spine at hand. Nopcsa (1905) placed similar spines of *Polacanthus foxi* in two rows along the anterior of the animal's back, extending forward from the lumbosacral shield to the back of the skull.

Summary.—Dermal armor of the present specimen and that of *Hoplitosaurus marshi* and *Polacanthus foxi* are closely parallel. Particular similarity of dermal plates and spines suggest that the arrangement on *Polacanthus foxi,* as described by Nopcsa (1905), as two rows which extended along the back and tail, may be valid for both *Hoplitosaurus marshi* and the current collection. The incidence of paired plates and spines tend to substantiate the idea of two dorsal rows of plates. The major difficulty in the comparison of the overall armor is the number and size variation of the keeled scutes found, more than could be reasonably placed in a lumbosacral shield such as described for *Polacanthus foxi.* An overall shield of keeled scutes, similar to that of *Ankylosaurus magniventris* (Brown, 1908), with two rows of spines and plates extending the full length of the animal seems more reasonable.

Individual scutes described in this paper are similar to scutes described from *Nodosaurus textilis* (Lull, 1921), *Stegopelta landerensis* (Williston, 1905), and *Panoplosaurus mirus* (Lambe, 1919), but the comparison is not inclusive and pertains to a particular kind or kinds of scutes.

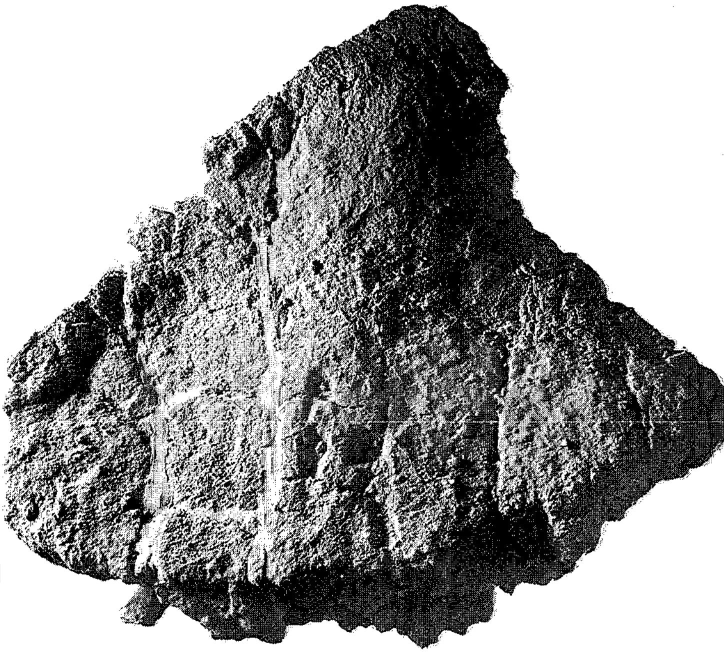
EXPLANATION OF PLATE 4

HOPLITOSAURUS (?) SP. DERMAL PLATES AND SPINES

FIG. 1.—Dermal plate of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Lateral view of isosceles triangular plate, approx. ⅓ nat. size.

FIG. 2.—Dermal plate of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Lateral view of isosceles triangular plate 3, approx. ⅓ nat. size.

PLATE 4



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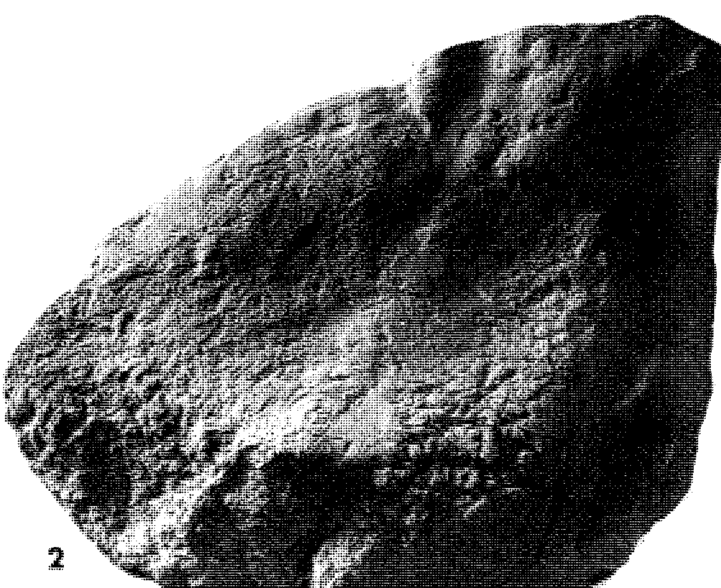


2

Other Material

Three complete chevrons, a portion of a rib, and two large bone fragments occur in the collection and are well enough preserved to be described. Remaining fragmental material is too broken and disassociated to warrant detailed description.

Chevrons

Three chevrons in the collection appear to be representative of the proximal, middle and distal section of the tail. Proximal location of chevron 1 is based on overall size, particularly its maximum height. Chevron 1 (Pl. 5, fig. 2) is 153 mm high, with an anterior posterior length of 43 mm along the dorsal surface, tapering to 27 mm ventrally. The chevron has a transverse dorsal width of 50 mm, gradually tapering to a narrow ventral edge. The haemal canal varies from an anterior opening measuring 25 mm high by 12 mm across to the posterior opening 20 mm high by 10 mm across.

Viewed anteriorly, the chevron is Y-shaped with the haemal canal bridged. The haemal spine is elongated and twisted slightly laterally. The articulating surface of the chevron slopes steeply to the anterior, with an overhanging ridge extending transversely across its anterior edge and laterally upward and around the posterior edge. The haemal arch is strong with broad thick rami which join below the haemal canal to form the flattened haemal spine. A deep groove extends down the posterior face from the dorsal surface to the haemal canal. The dorsal surface is flat and bilobed posteriorly, with the entire surface rugose.

Chevron 2 is slightly shorter than chevron 1 but still retains the general chevron outline. It measures 120 mm high; antero-posteriorly the length varies from 39 mm dorsally to 55 mm ventrally. The chevron is 58 mm transversely across the dorsal surface, narrowing to 10 mm across the ventral surface.

Viewed from the side, the anterior edge of chevron 2 slopes steeply downward from the broad dorsal surface. Posterior and anterior surfaces slope in from the dorsal edge to their narrowest point, just below the haemal canal, then taper gently forward and rearward to form the anteroposteriorly broadened haemal spine. The haemal spine is thin ventrally when viewed from the anterior but thickens rapidly upward to a strong haemal arch, terminating in the broadened dorsal head. An overlapping ridge surrounds the dorsal articulating surface.

EXPLANATION OF PLATE 5

HOPLITOSAURUS (?) SP. DERMAL SPINE AND BONES

FIG. 1.—Dermal spine of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Lateral view of asymmetrical triangular spined plate, approx. ⅓ nat. size.

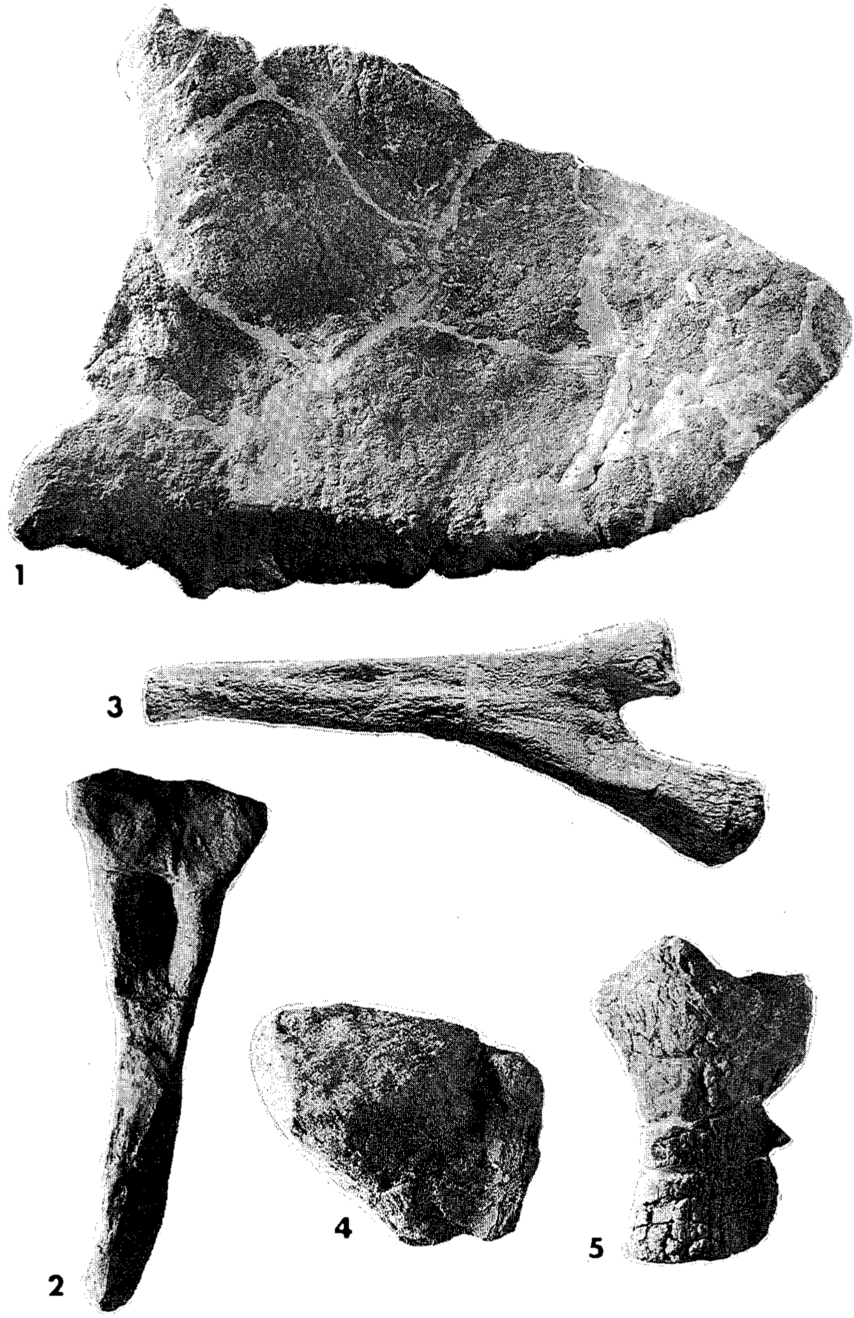
FIG. 2.—Chevron of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Anterior view, approx. ⅓ nat. size.

FIG. 3.—Rib of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Lateral view, approx. ½ nat. size.

FIG. 4.—Limb bone of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Lateral view, approx. ⅓ nat. size.

FIG. 5.—Limb bone of *Hoplitosaurus* (?) sp., BYU-R245 Earth Science Museum. Lateral view of smaller bone, approx. ⅓ nat. size.

PLATE 5



Chevron 3, with a maximum height of 70 mm, is the smallest of the series. Anterior-posterior length varies from 35 mm dorsally, to 30 mm midway, to 69 mm ventrally. Transverse measurements vary from a maximum 45 mm across the dorsal surface to 7 mm across the ventral surface.

The haemal spine broadens antero-posteriorly, with the posterior edge rounded, but the anterior is terminated in a spur. Dorsal surface is rugose with a modified ridge around the edge. A groove, more extreme than on chevron 1, extends down the posterior face from the dorsal surface to the haemal arch, making the dorsal surface bilobed. Haemal canal is narrow and high, measuring 11 mm across, 17 mm high, and 30 mm long.

All three chevrons exhibit a flattened dorsal surface with over-lapping edges. Anterior-posterior length of the ventral edge increases from the proximal to distal section of the tail, while the overall height decreases. Dimensions of the haemal canal vary slightly, with a gradual decrease in width and height distally.

Rib

A portion of one rib (Pl. 5, fig. 3) is in the collection. It is probably one of the cervical ribs, since it is dichocephalous and small. Most dorsal ribs from armored dinosaurs, described elsewhere in the literature, are coossified with the vertebrae from the capitulum to the tuberculum, and are triangular to T-shaped in cross-section. The rib in the present collection is probably an anterior cervical.

The rib measures 130 mm from the bow of the proximal branches to the tip of the distal end. Both the capitulum and the tuberculum extend laterally at an angle from the main rib shaft for a length of 50 mm and 20 mm, respectively. The capitulum is slightly enlarged with the articulating surface flattened. It has a maximum diameter of 20 mm.

The main shaft of the rib is broad at the area of branching but tapers distally. The end of the shaft appears to be the actual distal end of the rib. At the distal end the rib is triangular in cross-section with the dorsal surface broadened.

No other ribs were found at the fossil locality, so occurrence of this cervical rib among material which appears to have been from the posterior portion of the animal is difficult to explain. Few references are made in the literature to ribs other than dorsal ribs, so comparison is difficult to make.

Limb Bones

Two fragments of limb bones were found at the fossil site; both are incomplete and it is impossible to determine what bones they represent.

The larger of the two (Pl. 5, fig. 4) appears to be near the end of a major limb bone. The larger end is scrobiculate, and may be a broken surface rather than an articulating surface. From this broad rounded surface to the narrow broken opposite end the bone measures 85 mm and varies from 115 mm to 40 mm transversely. Viewed from one side the face of the bone is marked by a groove running lengthwise near one edge; the bone is thin from this groove to the nearer edge, but is very thick toward the opposite edge.

The smaller bone fragment (Pl. 5, fig. 5) is also the end of a limb bone. One end is triangular in cross-section, with the lower part of the bone broken away. One edge is thick and rounded, lateral surfaces slightly concave, and the opposite edge thin. Transversely the bilobed end of the fragment measures 80 mm across and 60 mm at the opposite end, with a total length of 130 mm.

Several other fragments of limb bones were preserved, only/one of which can be tentatively identified. It appears to be a portion of a phalange 45 mm long. Approximately one-third of the bone is preserved, and it is broken lengthwise. Both ends of the bone are concave with their lateral edges enlarged. One lateral surface is preserved with slight concavity.

Miscelaneous Material

Numerous small rod-like fragments which were not articulated with any of the other material were also uncovered. These rod-like structures vary from almost round to flattened in cross-section, with a variable diameter of 5 mm to 8 mm and the longest preserved section measuring 130 mm. One small block of matrix containing several of these structures was collected. The only reference in the literature to similar rod-like structures from armored dinosaurs was made by Brown (1908) in his description of tendon bones from *Ankylosaurus magniventris*. Brown refers to ossified tendons along the dorsal spines of dorsal vertebrae as rod like in midsection, but he makes no reference to their size.

Repository.—Specimen is BYU-R245 in the Earth Science Museum, Brigham Young University.

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