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SCALARITUBA MISSOURIENSIS AND  
ITS STRATIGRAPHIC DISTRIBUTION

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ABSTRACT

Clear evidence for assignment of *Scalarituba* spoor to a worm or wormlike organism is presented and the genus is considered to be monotypic inasmuch as no distinct morphological trend has been discerned throughout its known stratigraphic range. *S. missouriensis* has wide geographic distribution in North America and stratigraphically it occurs in Ordovician, Mississippian, Pennsylvanian, and Permian sediments; undoubtedly *Scalarituba* has wider stratigraphic range (perhaps throughout the Paleozoic), but it is recognizable only where scalariform ridges are associated with the fossils. These distinctive ridges commonly are excellently preserved in siltstones and fine-grained sandstones, but they are very poorly preserved (or not at all) in finer-grained and coarser-grained sediments. The genus may range into the Mesozoic for KUENEN (1961) has reported structures in Cretaceous sediments of Germany which we tentatively refer to *Scalarituba*. *S. missouriensis* is interpreted as having lived (commonly in prolific numbers) in a tidal-flat environment. Tops and bottoms of *Scalarituba*-bearing siltstone beds are readily differentiated in instances in which there is an alternating sequence of distinct shale and siltstone beds.

INTRODUCTION

We became interested in the monotypic trace fossil genus *Scalarituba* WELLER (1899) during work in collecting foraminiferal samples and studies of the field relationships of the Lower Mississippian (Kinderhookian) Northview Formation of southwestern Missouri (CONKIN & CONKIN, 1964) and Hannibal Formation of northeastern Missouri and western Illinois (CONKIN, CONKIN, & PIKE, 1965).

We have made observations, recordings, and collections of *Scalarituba missouriensis* WELLER (1899) during a period of ten years from several parts of the Paleozoic in Kentucky, southern Indiana, Ohio, Illinois, Missouri, New Mexico, and the state of Tamaulipas, Mexico; we have made no search for *Scalarituba* in Cambrian rocks and

our study of the Permian of North America has been limited to one formation in Tamaulipas.

Our present purposes are to 1) record our findings of the stratigraphic distribution of *Scalarituba missouriensis*; 2) illustrate the spoor, *S. missouriensis*; and 3) demonstrate that these trace markings were made by some species or more than one species (or even genus) of worm or wormlike creatures which lived in great abundance in sediments that in our opinion were deposited in a tidal-flat environment.

ACKNOWLEDGMENTS

Part of the photographic negatives were made by JAMES REID, photographer in the Public Relations Office of the University of Louisville; the remaining negatives were taken and prints made by the senior author.

Thanks go to Señor JOSÉ CARILLO, geologist, who guided us in a study of the Paleozoic beds in Peregrina and Caballeros Canyons of Tamaulipas, Mexico, and to Dr. GROVER E. MURRAY, President of Texas Technological College, Lubbock, Texas, who contributed financially to our study in Mexico and who introduced us to Sr. CARILLO.

Mr. CHARLES BATES, of the Bullitt County (Kentucky) Public Schools, made a large number of measurements which are summarized in Table 1. In addition, we wish to thank Dr. JOHN A. DILLON, JR., Dean of the Graduate School of the University of Louisville, for support in the final stages of preparing the typescript.

Specimens illustrated or discussed herein, or both, were collected by us, occasionally assisted by geology students of the University of Louisville. Specimens from the Pennsylvanian Tradewater Formation were collected by Mr. NEIL WHITEHEAD, III, research assistant in geology at the University of Louisville; specimens from the Pennsylvanian Pottsville beds of Alabama were presented to us by Dr. JACK CARRINGTON, of Birmingham Southern College, Birmingham, Alabama.

### LIST OF LOCALITIES

Specimens of *Scalarituba missouriensis* are reported herein from the following stratigraphic intervals and geographic localities.

#### PERMIAN

- Loc. 1. Guacamaya Formation in Peregrina Canyon, northwest of Victoria, Tamaulipas, Mexico.

#### PENNSYLVANIAN

- Loc. 2. Pottsville Sandstone from the junction of U.S. Highway 78 and the Cahaba River, Jefferson County, Alabama.

- Loc. 3. Tradewater Formation (Allegheny), a few feet below no. 7 coal, one-half mile south of DeKoven, Union County, Kentucky.

- Loc. 4. Float block of micaceous sandstone at Falls of the Ohio, Louisville, Jefferson County, Kentucky.

#### MISSISSIPPIAN (OSAGIAN)

- Loc. 5. Locust Point and Carwood Members of the Brodhead and Edwardsville Formations at Edwardsville, Floyd County, Indiana.

- Loc. 6. Holsclaw Member of the Brodhead Formation and the Muldraugh Formation at Brooks Hill, Brooks, Bullitt County, Kentucky.

- Loc. 7. Holsclaw and Rosewood Members of the Brodhead Formation at Mitchell Hill, Jefferson County, Kentucky.

- Loc. 8. Coral Ridge and Kenwood Sandstone Members of the New Providence Formation at Coral Ridge, Bullitt County, Kentucky.

- Loc. 9. Kenwood Member of the New Providence Formation at Kenlite Quarry, 3.8 miles north of the court house at Shepherdsville, on Kentucky Highway 1020, Bullitt County.

- Loc. 10. Kenwood Member of the New Providence Formation at Button Mold Knob, one-half mile south of Jefferson County line on Kentucky Highway 1020, Bullitt County.

- Loc. 11. Kenwood Member of the New Providence Formation on hill approximately one mile west of I-65 and just north of Floyds Lake, Jefferson County, Kentucky.

- Loc. 12. Kenwood Member of the New Providence Formation at entrance to Tom Wallace Lake, 1.5 miles south of Fairdale, Jefferson County, Kentucky.

## EXPLANATION OF PLATE 1

### SCALARITUBA MISSOURIENSIS Weller, Lower Mississippian

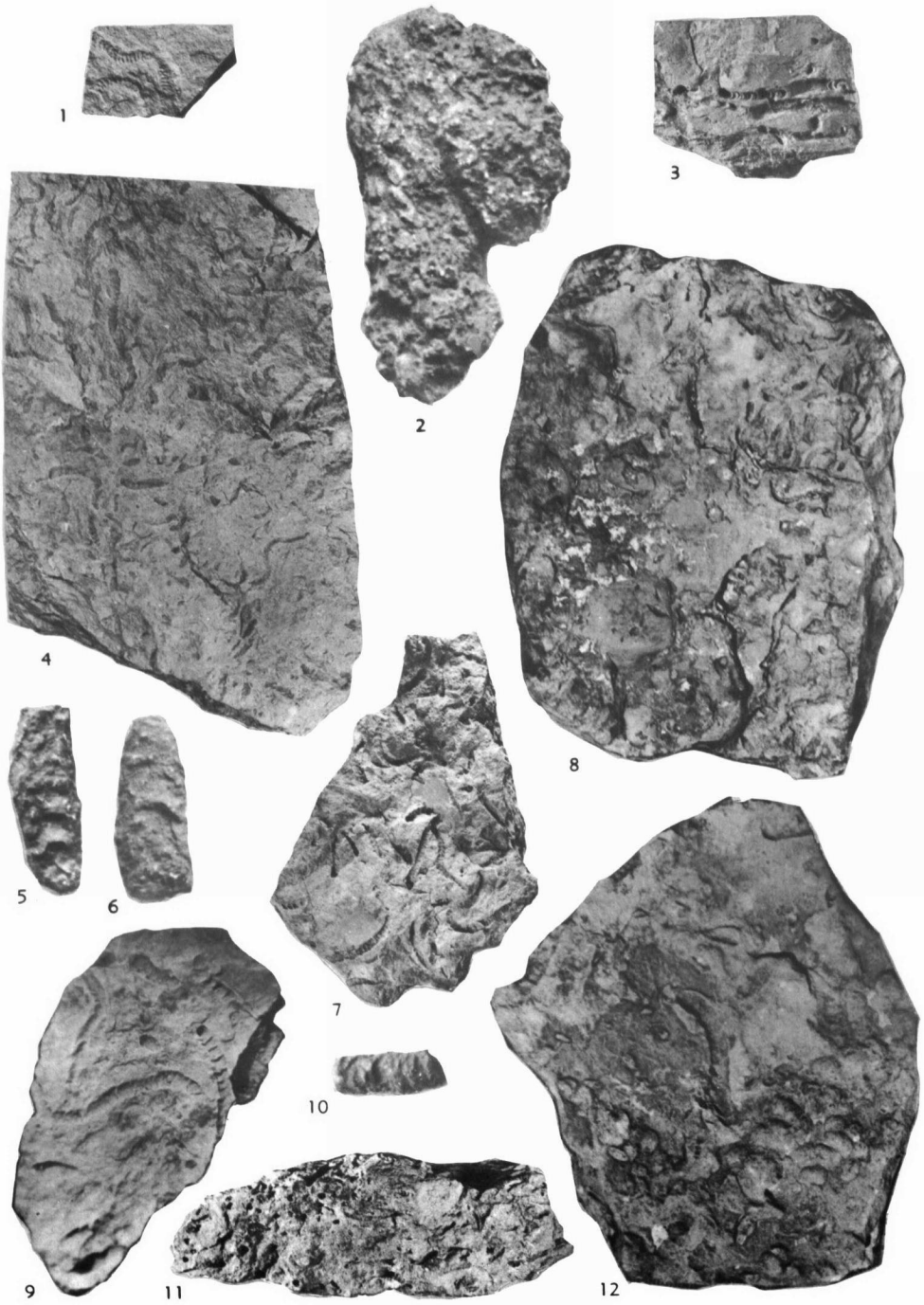
[All measurements approximate]

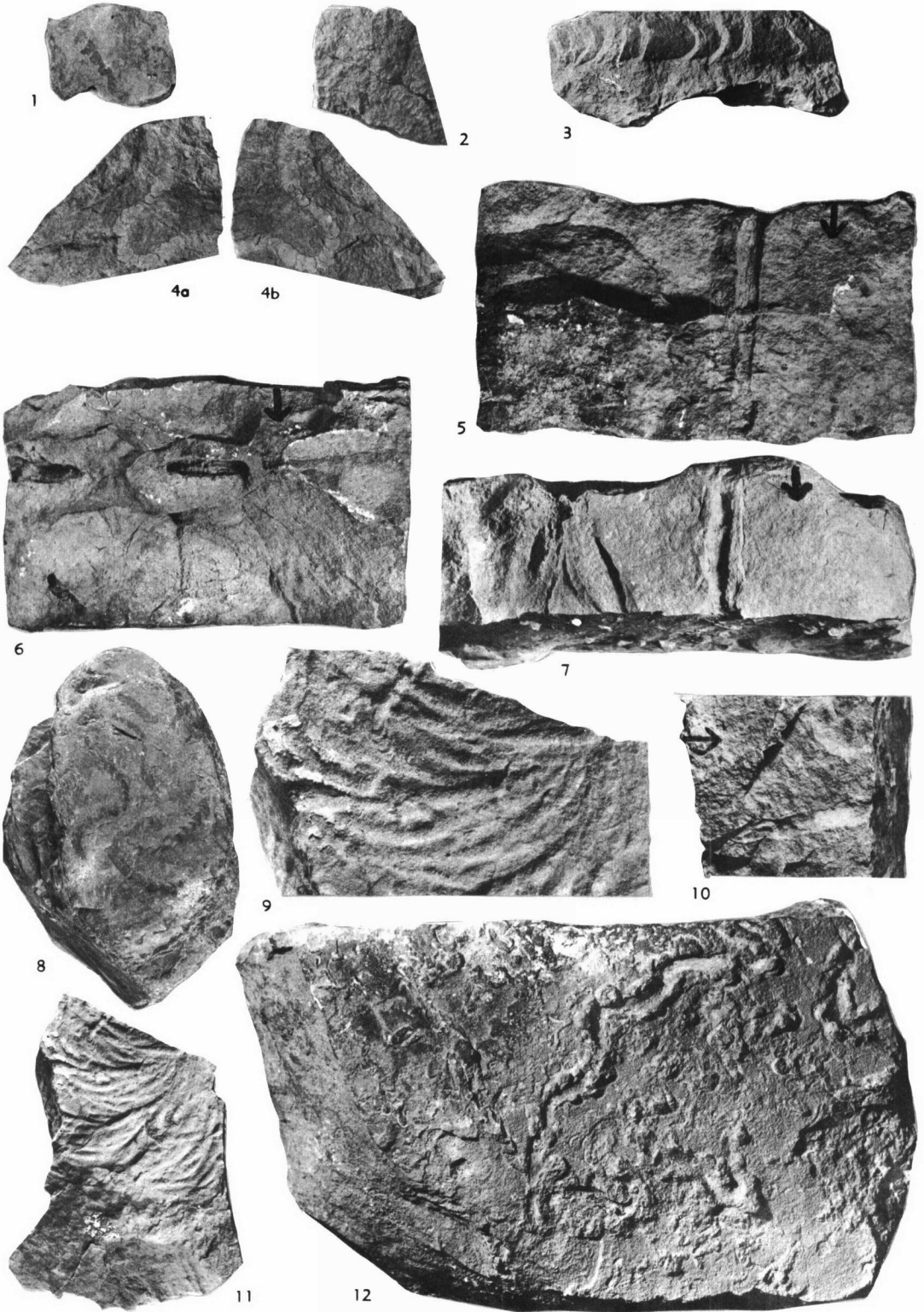
#### FIGURE

1. Specimen from Cuyahoga Formation (Buena Vista Member) in southern Ohio (loc. 15) showing rather closely spaced scalariform ridges on upper surface of siltstone slab (KUMIP 500482),  $\times 0.5$ .
- 2,5-6,10. Specimens from New Providence Formation (Coral Ridge Member) near Louisville, Kentucky (loc. 8).—2. Large marcasitic cast of part of burrow lacking scalariform ridges and doubtfully referred to *S. missouriensis* (KUMIP 500483),  $\times 1.1$ .—5-6,10. Pyrite casts of burrows originally identified as coprolites (Conkin, 1957) (KUMIP 500484, 500485),  $\times 1.1$ . [Specimen in Fig. 10 is lost.]
3. Dolomitic limestone slab from "Sedalia" Formation in western Illinois near St. Louis, Missouri (loc. 14), side view showing horizontal burrows (KUMIP 500486),  $\times 0.5$ .

#### FIGURE

4. Unoriented siltstone slab from Hannibal Formation in western Illinois approximately 45 miles northwest of St. Louis, Missouri (loc. 17), showing numerous burrowings (KUMIP 500487),  $\times 0.3$ .
- 7-8,11-12. Typical specimens from upper part of North-view Formation near Springfield in southwestern Missouri (loc. 16).—7. Unoriented siltstone float block showing many burrows (KUMIP 500488),  $\times 0.3$ .—8. Upper surface of siltstone slab showing burrows and casts of worm-burrowed bivalves and brachiopods (KUMIP 500489),  $\times 0.3$ .—11. Side view of block shown in fig. 7,  $\times 0.3$ .—12. Bottom surface of siltstone slab showing *S. missouriensis* in bas relief (KUMIP 500490),  $\times 0.3$ .
9. Unoriented siltstone slab from Hannibal Formation near Louisiana in northeastern Missouri (loc. 18), (KUMIP 500491),  $\times 0.5$ .





- Loc. 13. Alamogordo and Andrecito Formations in Deadman Branch of Alamo Canyon, near Alamogordo, Lincoln County, New Mexico.
- Loc. 14. "Sedalia" Formation at Jerseyville Hollow, Grafton, Calhoun County, Illinois.
- Loc. 15. Buena Vista Member of the Cuyahoga Formation behind the Greystone Motel, U.S. Highway 52, Portsmouth, Ohio.

MISSISSIPPIAN (KINDERHOOKIAN)

- Loc. 16. Northview Formation at King Butte, Greene County, Missouri.
- Loc. 17. Hannibal Formation east of Belleview, Calhoun County, Illinois.
- Loc. 18. Hannibal Formation at Stark Nurseries, about 2 miles southwest of Louisiana, Pike County, Missouri.

ORDOVICIAN

- Loc. 19. Thebes Sandstone on Illinois Highway 3 at Gale, Alexander County.

SYSTEMATIC DESCRIPTIONS

Genus SCALARITUBA Weller, 1899

SCALARITUBA MISSOURIENSIS Weller, 1899

Plates 1-4

*Scalarituba missouriensis* WELLER, 1899, St. Louis Acad. Sci., Trans. v. 9, no. 1, p. 12, pl. 6, fig. 1.—BRANSON, 1938, Univ. Missouri Studies, v. 13, no. 4, p. 14-15, pl. 20, fig. 28.

*Scalarituba? atoka* BRANSON, 1966, Okla. Geol. Notes, v. 26, no. 9, p. 236, fig. 1-2.

*Description.*—WELLER's (1899, p. 12) description of *Scalarituba missouriensis* follows, with some comments:

"The Vermicular Sandstone [the Hannibal Formation of northeastern Missouri and the Northview Formation of

southwestern Missouri] is named from the innumerable worm burrows which penetrate it in every direction, there rarely being a distance of more than two or three centimeters between burrows in any direction upon the broken surface of the rock. These burrows are 2-4 mm. in diameter [diameter range in the Northview is 2.9-4.4 mm. and in the Hannibal 1.7-3.2 mm.; Table 1 gives measurements in studied specimens from these formations], subcylindrical in form, never straight for more than a few centimeters, curving in all directions, and marked by transverse ridges [herein termed scalariform ridges] situated at distances of one or two millimeters [these intervals between scalariform ridges are here termed interscalar distances, and in the Northview specimens they range from 1.6-2.3 mm. while in the Hannibal specimens they range from 1.4-2.6 mm.; Table 1 gives ranges of interscalar

EXPLANATION OF PLATE 2

SCALARITUBA MISSOURIENSIS Weller, Lower Mississippian

[All measurements approximate]

FIGURE

- 1. Siltstone slab from Edwardsville Formation near New Albany, southern Indiana (loc. 5), unoriented view showing dark fine-grained filling of burrow (KUMIP 500492),  $\times 0.5$ .
- 2,4. Specimens from Brodhead Formation (Rosewood Member) near Louisville, Kentucky (loc. 7.—2. Unoriented view of siltstone slab showing trace of burrow (KUMIP 500493),  $\times 0.5$ .—4a,b. Unoriented counterparts of sinuous burrow nearly parallel to bedding, burrow filled with darker and finer-grained material than matrix (KUMIP 500494a, 500494b),  $\times 0.5$ .
- 3. Unoriented slab from Muldraugh Formation south of Louisville, Kentucky (loc. 6), showing large specimen of *S. missouriensis* (KUMIP 500495),  $\times 0.5$ .
- 5-6. Siltstone slabs from New Providence Formation (Kenwood Member) near Louisville, Kentucky (loc. 10).—5. Side view of slab showing vertical burrow with faint longitudinal and oblique ridges, with irregular burrowed upper surface also seen (KUMIP 500496),  $\times 0.3$ .—6. Side view of slab showing burrows oblique to bedding (lower left quadrant) (horizontal holes not *Scalarituba*) (KUMIP 500496),  $\times 0.3$ .

FIGURE

- 7. Siltstone slab from New Providence Formation (Kenwood Member) near Louisville, Kentucky (loc. 12), side view showing vertical burrows and undulating upper surface of slab (KUMIP 500497),  $\times 0.5$ .
- 8. Unoriented float block from Guacamaya Formation near Victoria, Tamaulipas, Mexico (loc. 1), probably upper surface of hard argillite with several burrows nearly parallel to bedding; burrows filled with darker sediment (KUMIP 500498),  $\times 0.5$ .
- 9,11. Siltstone slab from Brodhead Formation (Carwood Member) near New Albany, Indiana (loc. 5) (KUMIP 500499).—9. Upper surface showing *Taonurus caudagalli* and *S. missouriensis*,  $\times 0.3$ .—11. Part of same slab,  $\times 0.5$ .
- 10. Siltstone slab from New Providence Formation (Kenwood Member) from vicinity of Louisville, Kentucky (loc. 8), side view showing vertical burrows (KUMIP 500500),  $\times 0.5$ .
- 12. Specimen from New Providence Formation (Kenwood Member) near Louisville, Kentucky (loc. 11), upper surface of slab showing disturbed sediment on both sides of *S. missouriensis* burrow (KUMIP 500501),  $\times 0.5$ .



distances of *Scalarituba* from many of the formations herein studied]. These [scalariform] ridges were evidently formed by the worm as it forced itself forward through the mud of the sea bottom, the posterior extremity of the animal pushing up a small ridge of the plastic material behind to serve as a brace while the anterior extremity was forced forward. If this was the method of formation of these ridges, then the direction of progress of the worm itself was always away from the concave side of the ridges. The burrows are now filled with material similar to that which surrounds them, but it is softer and of a finer texture so that on weathered surfaces the burrows become very conspicuous by reason of the removal of the softer material. Upon freshly broken surfaces of the rock, however, the burrows are not conspicuous, but they may be detected by their slightly different color [the darker color is due to reducing conditions which existed in the digestive tract of the worm during life] and by their softness."

## STRATIGRAPHIC DISTRIBUTION OF SCALARITUBA MISSOURIENSIS

### PREVIOUS RECORDS OF SCALARITUBA

SWALLOW (1855) noted the presence of innumerable worm burrowings in his Vermicular Sandstone and Shale (the Northview and Hannibal Formations); WELLER (1899) formally described *Scalarituba missouriensis* from the upper siltstones of the Northview Formation at Northview, Webster County, Missouri.

E. B. BRANSON (1938) recognized *Scalarituba missouriensis* in the Northview and Hannibal Formations and described an additional species, *S. welleri*, from the upper part of the Northview Formation at King Butte, Greene County, Missouri. The nature of *S. welleri* is obscure and this form is of doubtful status (C. C. BRANSON, 1966, p. 236); in any case, it lacks the scalariform ridges which are essential to the generic definition of *Scalarituba*.

*Scalarituba missouriensis* has been reported by BOWSHER (1961, p. 960) from the Lower Mississippian (Osagian) *Cleistopora typa typa* beds of New Mexico.

*Scalarituba missouriensis* also has been recorded from the Pennsylvanian of Arkansas (HENBEST, 1961; C. C. BRANSON, 1964); SEELY (1963) reported it from the Atokan Wildhorse Mountain Formation in Arkansas and Oklahoma; more recently, C. C. BRANSON (1966) reported the species in the Pennsylvanian Atokan siltstones of

*Measurements.*—Table 1 gives various sets of measurements of *Scalarituba missouriensis*.

*Comparison and affinities.*—Presently discussed specimens fit reasonably well the original description of *Scalarituba missouriensis* from the Northview Formation of southwestern Missouri; some difference in size among the specimens is seen, but we have been unable to discern any significant morphological trends in the species.

*Deposition of figured specimens.*—All figured specimens are deposited in the University of Kansas paleontological collection with KUMIP (Kansas University Museum of Invertebrate Paleontology) numbers; individual numbers are cited in explanations of the plates.

Sequoyah, Cherokee, and Muskegee counties, Oklahoma.

GUTSCHICK, SUTTON, & SWITEK (1962) reported *Scalarituba missouriensis* from Mississippian siltstone portion of the Sappington Formation in Montana.

CONKIN (1957) recorded abundant pyritic and marcasitic objects now known to be casts of the burrowings of *Scalarituba missouriensis* (pl. 2, fig. 1, 3-4, 6) from the Coral Ridge Member of the New Providence Formation in Jefferson and Bullitt counties, Kentucky.

KUENEN (1961) figured abundant worm burrowings from the Lower Cretaceous (Lower Barremian) of Germany which exhibit scalariform structures and thus can be referred tentatively, and with some reservations, to the genus *Scalarituba*. We know of no other records of *Scalarituba* outside the Paleozoic; our collecting in the Paleozoic of New South Wales, Victoria, and Tasmania, Australia, did not reveal *Scalarituba* itself, but a number of indeterminate worm borings were encountered, particularly in the upper part of the Tasmanian Permian sequence.

### PRESENT RECORDS OF SCALARITUBA MISSOURIENSIS IN PALEOZOIC ROCKS

We have specimens of *Scalarituba missouriensis* from formations of Ordovician, Mississippian,

and Pennsylvanian age in the United States and from the Permian of northern Mexico.

This paper presents the first record of the genus *Scalarituba*, from the states of Kentucky, Indiana, Ohio, Alabama, and Tamaulipas, Mexico. In somewhat more detail, *S. missouriensis* is reported for the first time from the following stratigraphic units: in Kentucky, from the Mississippian New Providence Formation (Coral Ridge and Kenwood Members), the Brodhead Formation (Rosewood and Holsclaw Members), the Muldraugh Formation, and the Pennsylvanian Allegheny Series; in southern Indiana, from the Mississippian New Providence Formation and the Brodhead Formation (Locust Point and Carwood Members), and the Edwardsville Formation; in Illinois, the Mississippian (Osagian) "Sedalia" Formation and the Ordovician Thebes Sandstone; in Ohio, from the Mississippian Buena Vista Member of the Cuyahoga Formation; in Alabama, from the Pottsville Series; in New Mexico, from the Mississippian (Osagian) Alamogordo Limestone in Deadman Canyon, Sacramento Mountains; and in Mexico, from the Permian Guacamaya Formation in Peregrina Canyon, north of Victoria, Tamaulipas.

We believe that *Scalarituba* will prove to be yet more widely distributed stratigraphically, perhaps throughout the whole Paleozoic in sediments which were deposited in tidal-flat environments; indeed, it is quite likely that some of the worm traces already noted in the literature represent this genus, but, in the absence of the scalariform ridge structures, a generic assignment to *Scalarituba* is not possible. Undoubtedly, *Scalarituba* does occur in many sedimentary rocks without preservation of the scalariform ridges because the sediments forming these particular rocks were too fine-grained or the individual grains not angular enough to hold the shape of the ladder-like markings or both.

In the present materials, the siltstones of the Northview, Hannibal, Kenwood, and Rosewood display excellent to good preservation of scalariform ridges. Fine-grained argillaceous and cal-

careous sedimentary rocks display scalariform ridges very poorly. Scalariform ridges are seldom preserved in limestones; an exception is found in the basal, medium- to fine-grained dolomitic limestone of the Osagian "Sedalia" Formation in Jerseyville Hollow at Grafton, Illinois, in which *Scalarituba missouriensis* shows very good preservation, probably due to the dolomitic rhombs functioning similarly to angular silt grains during compaction of the muds and resisting the compressional forces.

## PALEOECOLOGY

In sediments in which *Scalarituba missouriensis* occurs, with specimens in almost unbelievable abundance in many silty sequences, almost no other fossils are found, or the fauna is generally small in number and variety when present. Rather a notable exception to this is the occurrence of a brachiopod-clam fauna (Pl. 1, fig. 8) in some beds of the uppermost silty portion of the Northview Formation at King Butte, Greene County, Missouri; also, *S. missouriensis* occurs with rare brachiopods (*Productus wortheni* and *Orthotetes keokuk*) and fenestrate bryozoans in the Kenwood Member of the New Providence Formation and with numerous fenestrate bryozoans in the Rosewood Member of the Brodhead Formation in Jefferson and Bullitt counties, Kentucky.

We regard *Scalarituba missouriensis* as having been formed by a marine worm living in shallow water, probably in tidal flats, but certainly not in a deep-water environment.

The worm burrowed through the sediments, probably eating its way through it and passing the sediment through its digestive tract to leave fillings in the burrowings posteriorly. The burrowings are solidly filled on fresh surfaces of rock (Pl. 1, fig. 4; Pl. 2, fig. 4a,b; Pl. 3, fig. 3; Pl. 4, fig. 4), but on weathered surfaces the fillings are removed in large part (Pl. 1, fig. 3, 7-9, 11; Pl. 3, fig. 8).

## CRITERIA FOR DISTINGUISHING TOP AND BOTTOM OF SCALARITUBA-BEARING BEDS

Criteria for distinguishing top and bottom of *Scalarituba*-bearing beds can be divided into those

involving the physical characters of the rock and ones involving the fossils themselves.

We have been able to differentiate tops and bottoms of *Scalarituba*-bearing beds in instances where an alternating sequence of shales and siltstones occurs and where each siltstone bed, whether thick or thin, constitutes a single unit. In such cases, the base of the siltstone is rather planar, resting on the surface of a shale bed which is itself rather even, and the base almost invariably marked by grooves and load casts of various dimensions. Other "fucoidal" structures of obscure origin and indeterminate nomenclature are frequently present. The tops of the siltstone beds are, in contrast, undulating surfaces (Pl. 2, fig. 5, 7; Pl. 4, fig. 1).

Along a shale and siltstone interface, with siltstone above, traces of the burrowing of *Scalarituba missouriensis* in the very basal portion of the siltstone are impressed into the shale below and become preserved in bas-relief on the base of the siltstone unit (Pl. 1, fig. 12; Pl. 3, fig. 4, 7). The scalariform structures are preserved in the center of these bas-relief masses (Pl. 1, fig. 12; Pl. 3, fig. 7). Scalarituboid burrowings present on the upper surfaces of siltstone beds, are not preserved in bas-relief, perhaps because the disturbed sediment was washed away by tides or waves. Burrowings

may be directed at angles up to 90° to the bedding, in which case the openings to the burrows are crater-like. Rarely, disturbed and raised masses of sediment were preserved along the sides of the borrowings on upper surfaces (Pl. 2, fig. 12).

TABLE 1. Selected Measurements of *Scalarituba missouriensis* in Millimeters.

FORMATION	LOC.	LENGTH	WIDTH		INTERSCALAR DISTANCES	
			MAX.	MIN.	MAX.	MIN.
Guacamaya	1	121.6 <sup>a</sup>	5.7 <sup>a</sup>	2.6 <sup>a</sup>	4.1 <sup>a</sup>	1.7 <sup>a</sup>
Pottsville	2	26.5 <sup>a</sup>	3.7 <sup>a</sup>	2.8 <sup>a</sup>	2.9 <sup>a</sup>	1.7 <sup>a</sup>
Tradewater	3	78.4 <sup>a</sup>	7.2 <sup>a</sup>	5.9 <sup>a</sup>	4.2 <sup>a</sup>	2.5 <sup>a</sup>
Penn. float	4	42.8	5.3	4.4	4.6	2.9
Edwardsville	5	39.8	5.8	3.8	4.3	3.3
Muldraugh	6	97.2	9.6	7.1	12.1	4.3 <sup>a</sup>
Carwood	5	19.2	2.9	2.4	2.9	1.8
Holsclaw	7	30.0	4.5	3.0	3.6	2.3
Rosewood	7	89.0	9.0	4.2	4.3	2.6
Kenwood	10-12	157.3	10.2	5.3	5.2	3.4
Buena Vista	15	27.2	3.6 <sup>a</sup>	2.3 <sup>a</sup>	1.8 <sup>a</sup>	0.9 <sup>a</sup>
Hannibal	17	20.9	3.2	1.7	2.6	1.5
Northview	16	30.5	4.4	2.9	2.3	1.6
Thebes	19	11.0	3.7	3.1	2.3	1.4

<sup>a</sup> Less than three measurements.

### EXPLANATION OF PLATE 3

#### SCALARITUBA MISSOURIENSIS Weller, Lower Mississippian

[All measurements approximate]

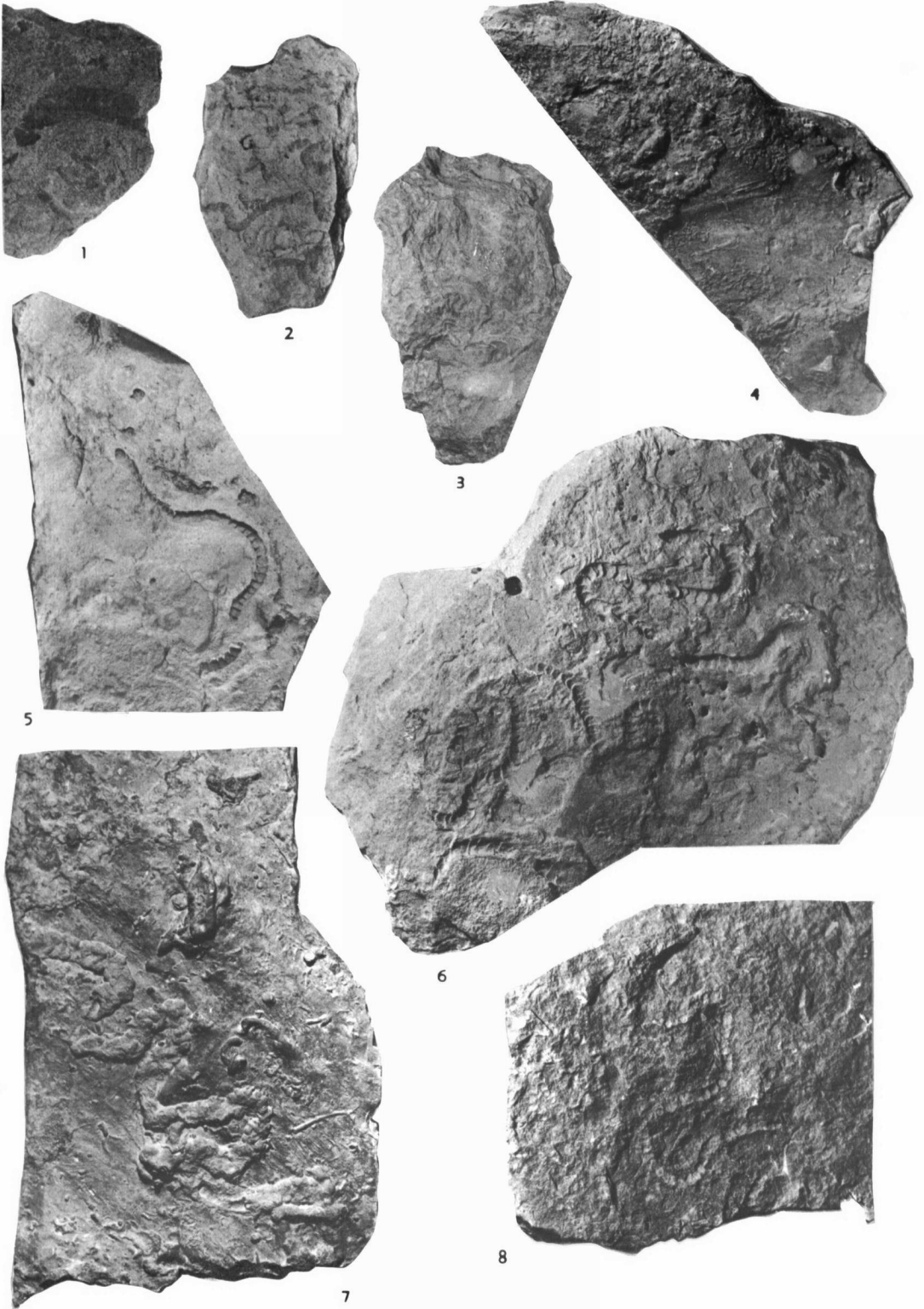
#### FIGURE

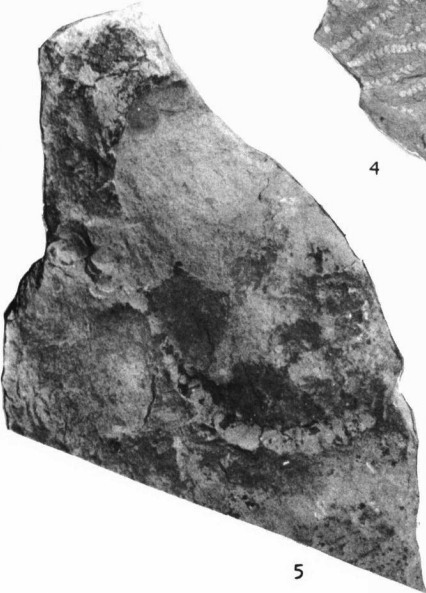
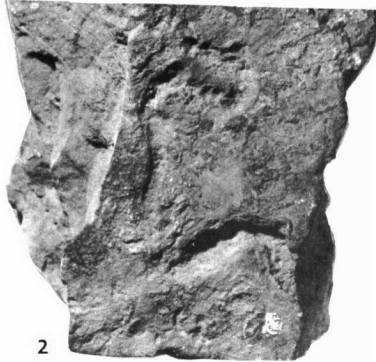
1. Unoriented siltstone slab from Brodhead Formation (Holsclaw Member) near Louisville, Kentucky (loc. 7) showing trace of burrow filled by dark fine-grained sediment (KUMIP 500502),  $\times 1$ .
2. Specimen from Muldraugh Formation in Bullitt County, Kentucky (loc. 6) showing poorly defined traces of *S. missouriensis* (KUMIP 500503),  $\times 0.5$ .
3. Unoriented siltstone slab from Brodhead Formation (Holsclaw Member) also from Bullitt County (loc. 6) with borings nearly parallel to bedding (KUMIP 500504),  $\times 0.5$ .
- 4-5, 7. Specimens from New Providence Formation (Kenwood Member) near Louisville, Kentucky (loc. 12).—4. Bottom of siltstone slab with *S. missouriensis* in bas relief associated with large and small groove casts (KUMIP 500505),  $\times 0.25$ .—

#### FIGURE

5. Part of upper surface of same slab shown in fig. 4 with long sinuous traces of burrows mostly subparallel to bedding but locally directed obliquely into siltstone,  $\times 0.3$ .—7. Bottom surface of specimen (KUMIP 500497) illustrated in Pl. 2, fig. 7, showing remnants of very sinuous trace of *S. missouriensis* in bas relief obliquely crossing middle of slab, with faint scalariform ridges seen midway along trace,  $\times 0.3$ .
- 6, 8. Specimens from New Providence Formation (Kenwood Member) in vicinity of Louisville, Kentucky (loc. 8).—6. Siltstone slab showing burrow with excellently preserved scalariform ridges (KUMIP 500506),  $\times 0.3$ .—8. Bottom surface of slab (KUMIP 500500) shown in Pl. 2, fig. 10, with burrow nearly parallel to bedding,  $\times 0.5$ .







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## EXPLANATION OF PLATE 4

## SCALARITUBA MISSOURIENSIS Weller, Upper Ordovician, Lower Mississippian, Pennsylvanian

[All measurements approximate]

- FIGURE
- 1,5. Siltstone slab from New Providence Formation (Kenwood Member), Lower Mississippian, near Shepherdsville, Bullitt County, Kentucky (loc. 9).—1. Side view of specimen showing burrow at large angle to bedding (KUMIP 500507),  $\times 0.5$ .—5. Same slab (?bottom surface) showing burrows subparallel to bedding,  $\times 0.5$ .
  2. Slab from New Providence Formation (Kenwood Member), Lower Mississippian, at Button Mold Knob, south of Louisville, Kentucky (loc. 10), ?bottom surface of same specimen (KUMIP 500496) illustrated in Pl. 2, fig. 5-6, showing sinuous burrows subparallel to bedding,  $\times 0.3$ .
  3. Specimen from Northview Formation, Lower Mississippian, near Springfield, southwestern Missouri (loc. 16) showing upper surface with *Taonurus caudagalli* associated with some burrows of *S. missouriensis* (KUMIP 500508),  $\times 0.5$ .
- FIGURE
4. Unoriented slab from Pottsville Sandstone, Pennsylvanian, near Birmingham, Alabama (loc. 2) showing burrows in fine-grained, slightly micaceous sandstone (KUMIP 500509),  $\times 0.5$ .
  6. Unoriented float block (?Pennsylvanian) from glacial gravel at Falls of the Ohio, Louisville, Kentucky (loc. 4) with traces of borings in fine-grained, somewhat micaceous sandstone (KUMIP 500510),  $\times 0.3$ .
  7. Unoriented slab from Tradewater Formation (Pennsylvanian) in Union County, western Kentucky (loc. 3), showing burrows in medium-grained micaceous sandstone (KUMIP 500511),  $\times 0.5$ .
  8. Siltstone slab from Thebes Sandstone (Upper Ordovician) near Cairo, southern Illinois (loc. 19) with burrows subvertical or at high angles to bedding, although one nearly parallel to bedding is seen near center of slab (KUMIP 500512),  $\times 1$ .