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A TRIGONOTARBID ARACHNID FROM THE PENNSYLVANIAN OF KANSAS

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ABSTRACT—Two new specimens of a trigonotarbid arachnid are described from Upper Pennsylvanian (Virgilian) rocks of Kansas, U.S.A., from a horizon which elsewhere has yielded scorpion and mite remains. They are the first representatives of the arachnid order Trigonotarbida to be found in Kansas. The specimens are referred to the genus *Anthracomartus* but are not identified to species pending revision of the American anthracomartids.

INTRODUCTION

TRIGONOTARBIDA IS a diverse, extinct order of terrestrial Paleozoic arachnids (Shultz, 2007) known from the late Silurian (Jeram et al., 1990; Dunlop, 1996a) to the early Permian (Rößler et al., 2003). Trigonotarbids are superficially spider-like in morphology but lack the characteristic spider autapomorphy of spinnerets and also differ from spiders in having opisthosomal tergites divided longitudinally into median and lateral plates. Phylogenetic analysis has shown trigonotarbids to be the sister group to Tetrapulmonata, within the Pantetrapulmonata (Shultz, 2007). While trigonotarbids are the most frequently recorded arachnids in the Carboniferous deposits of Europe and North America, they are, nevertheless, uncommon fossils. In this paper, we describe the first trigonotarbids from Kansas, from Upper Pennsylvanian (Virgilian) rocks near Lawrence.

The family Anthracomartidae Haase, 1890, was placed as a separate order (=Anthracomartida) from Trigonotarbida by Petrunkevitch (1949) with the reasoning that anthracomartid opisthosomal tergites are longitudinally divided into five plates, while all other trigonotarbids possess only three. Shear et al. (1987) suspected that Trigonotarbida and Anthracomartida could be synonymous, arguing that Petrunkvevitch's (1949) division between the two groups to be superficial, on the basis that the two different patterns of tergite division were weak grounds for splitting the order. Dunlop (1996b) followed this reasoning in his evaluation of arachnid systematics and reunited Trigonotarbida and Anthracomartida as a single order under the name Trigonotarbida, with anthracomartids comprising the family Anthracomartidae. The family presently contains just three genera: *Anthracomartus*, *Brachypgye* and *Maiocercus*, which are differentiated on the basis of the shape of the opisthosomal margin (smooth in *Anthracomartus* or scalloped), and the relative breadth of the opisthosoma (separating *Brachypgye* and *Maiocercus*) (Garwood and Dunlop, 2011).

In spite of tens of thousands of insect fossils having been collected from the Permian Wellington Formation of Kansas (Beckemeyer and Hall, 2007), no arachnid has been found there. The only fossil arachnids reported from Kansas are from Pennsylvanian rocks: a scorpion and a uropygid from the Hamilton Quarries (Hanson et al., 1988), and a scorpion and undescribed mite remains from Lone Star Lake (Jeram, 1994). Therefore, the present find of trigonotarbid arachnids from the Pennsylvanian of Kansas increases the number of arachnid orders now known as fossils from the state. Anthracomartids occur in many of the Carboniferous coal basins of the world, and those from the USA are in particular need of revision, especially following Garwood and Dunlop's (2011) synonymy of numerous genera into *Anthracomartus*. The nearest localities to Kansas where anthracomartids have been found are Fayetteville, Arkansas, from where 22 specimens of *Anthracomartus trilobitus* were described by Scudder (1884), and Mazon Creek, Illinois, from where at least 14 specimens are known but which have yet to be formally described (Beall, 1997).

GEOLOGICAL SETTING AND PRESERVATION

The specimens were found in an unnamed shale unit above the Amazonia Limestone Member of the Lawrence Formation (Upper Pennsylvanian: Virgilian), located on the south side of the Clinton Lake spillway between the South Lawrence Trafficway (Kansas 10) and E 900th Street, south-west of Lawrence in Douglas County, Kansas (Figs. 1, 2). The unit contains green and red shales with minor amounts of siltstone and sandstone (Zeller, 1968). The fossils come from a nodular zone just above a red paleosol horizon containing rhizoliths, plant remains, and the Williamsburg coal bed. The fossils were accessioned to the University of Kansas Museum of Natural History in 1980; despite several more collecting trips to the locality, no further specimens have been found. The scorpion *Corniops mapesii* Jeram, 1997 also comes from shales immediately above the upper Williamsburg Coal, i.e., the same horizon as the trigonotarbid specimens described here, from the spillway of Lone Star Lake, 15 miles south-west of Lawrence. This locality is no longer accessible, but the horizon crops out in many places near Lawrence, so an intensive search could produce more fossil arachnids.

Both trigonotarbid specimens are preserved in siderite concretions with minor pyrite, sphalerite and kaolinite. The specimens are mainly preserved as dorsal and ventral external molds, but there is some superimposition of dorsal and ventral surfaces in places, e.g., the ventral pygidium is impressed onto the dorsal surface of the part in 197185, and the lateral margins of the carapace cannot be traced with certainty. These taphonomic features are common in trigonotarbids preserved in clay-ironstone nodules. Specimen 197185, part and counterpart (Figs. 3, 4), is an almost complete animal with most of the appendages preserved. Preservation of the pedipalp is limited to isolated segments just in front of the carapace. Most podomeres are preserved on the left side of the part while preservation is limited to proximal appendages on the counterpart. Coxae are hidden beneath the carapace, but trochanters to metatarsi can be seen, and the proximal ends of the tarsi in legs II and III. On the right side of the part, trochanters and proximal parts of the femora of legs I–III are preserved, and the femur of leg IV. Specimen 197185, part and

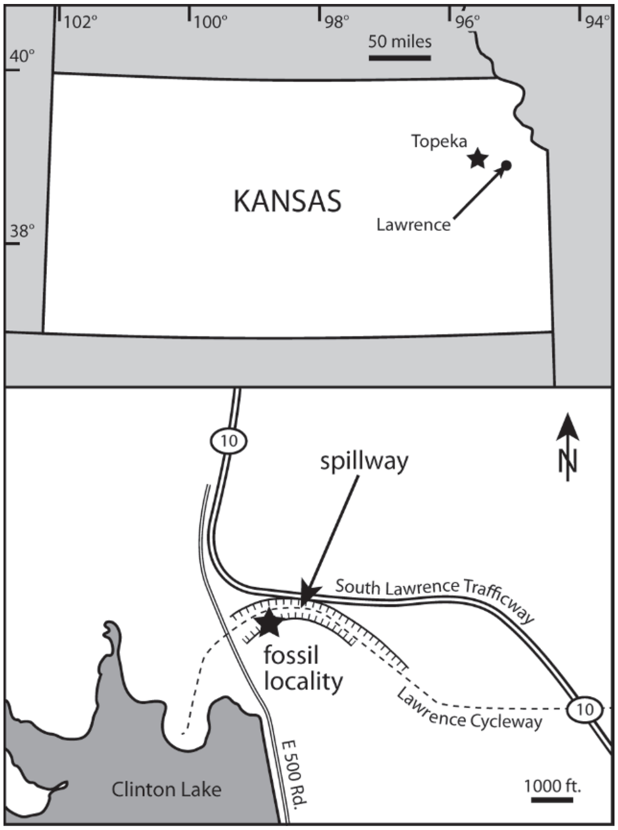

FIGURE 1—Locality map of the Clinton Lake spillway on the southwestern edge of Lawrence, Kansas.

counterpart (Figs. 5, 6), consists of a carapace and opisthosoma without preserved appendages, with some overprinting in both part and counterpart. Note that some authors (e.g., Petrunkevitch, 1956; Selden and Pillola, 2009) have referred to the ultimate opisthosomal plate, beyond the anal pygidium, as tergite 10, but Dunlop (1996b) considered the last tergite to be divided (essentially, the lateral fringe of additional plates continues posteriorly) and thus to correspond to tergite 9 of other trigonotarbids.

MATERIAL AND METHODS

The fossils are held in the collections of the University of Kansas Natural History Museum and Biodiversity Research Center Division of Invertebrate Paleontology (KUMIP), with category numbers 197185 and 156097. The specimens were studied and drawn both dry and under alcohol using a Leica M205C microscope with a camera lucida attachment, and photographed with a Canon 5D digital camera and 50 mm macro lens, both dry and coated with ammonium chloride. The specimens were also visualized with a NextEngine 3D laser scanner. This technique produces results similar to that of whitening with ammonium chloride, but the resulting scans can be rotated in three dimensions on the computer. In this way, the surface can be flipped so that, for example, an external mold can be viewed as if it were a cast. Unfortunately, the resolution of the 3D scanner is rather low in comparison to macrophotography. Each method emphasizes different morphological features: coating and 3D scanning show tergite and sternite boundaries best, coating reveals cuticular structure, while uncoated specimens show differences in mineralogy which reveal the leg podomeres. Abbreviations: I–IV, leg numbers; 1–9, opisthosomal tergite numbers; Fe, femur; Mt, metatarsus; Pa, patella; Pd, pedipalp; Ta, tarsus; Ti, tibia; Tr, trochanter.

SYSTEMATIC PALEONTOLOGY

Order TRIGONOTARBIDA Petrunkevitch, 1949
Family ANTHRACOMARTIDAE Haase, 1890

Remarks.—The specimens are referred to Anthracomartidae because of the characteristic opisthosomal tergites divided longitudinally into five plates rather than three as in other trigonotarbid families.

Genus ANTHRACOMARTUS Karsch, 1882

Remarks.—The smooth opisthosomal margin is diagnostic of the genus (Dunlop and Rößler, 2002).

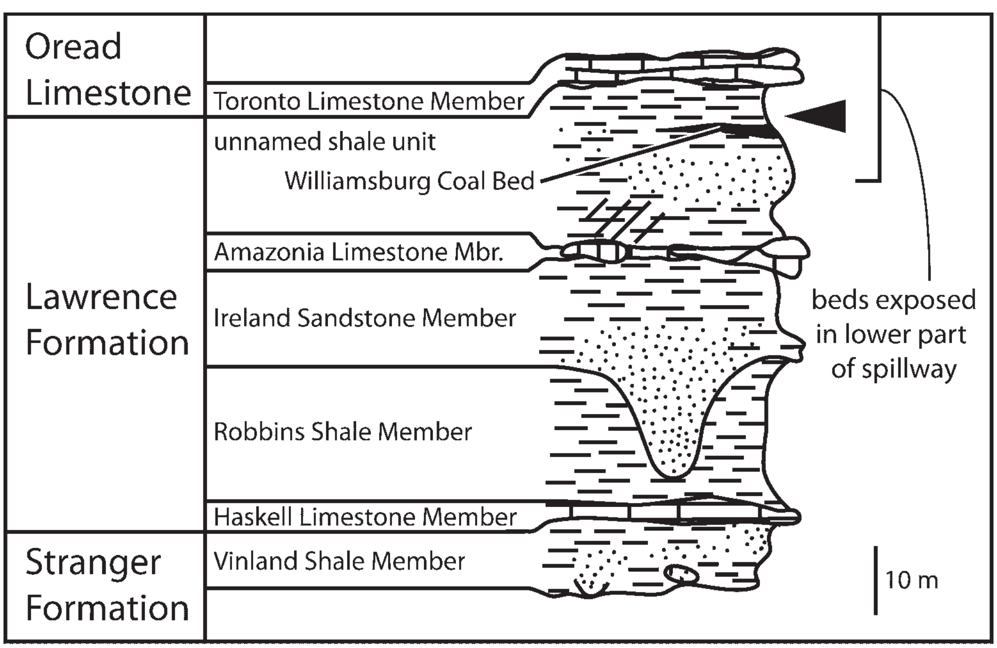

FIGURE 2—Stratigraphic section of the Lawrence Formation, Lawrence, Kansas, showing the extent of the exposure at the Clinton Lake spillway and the location of the horizon bearing the trigonotarbid fossils described here (arrow). (After Zeller, 1968).

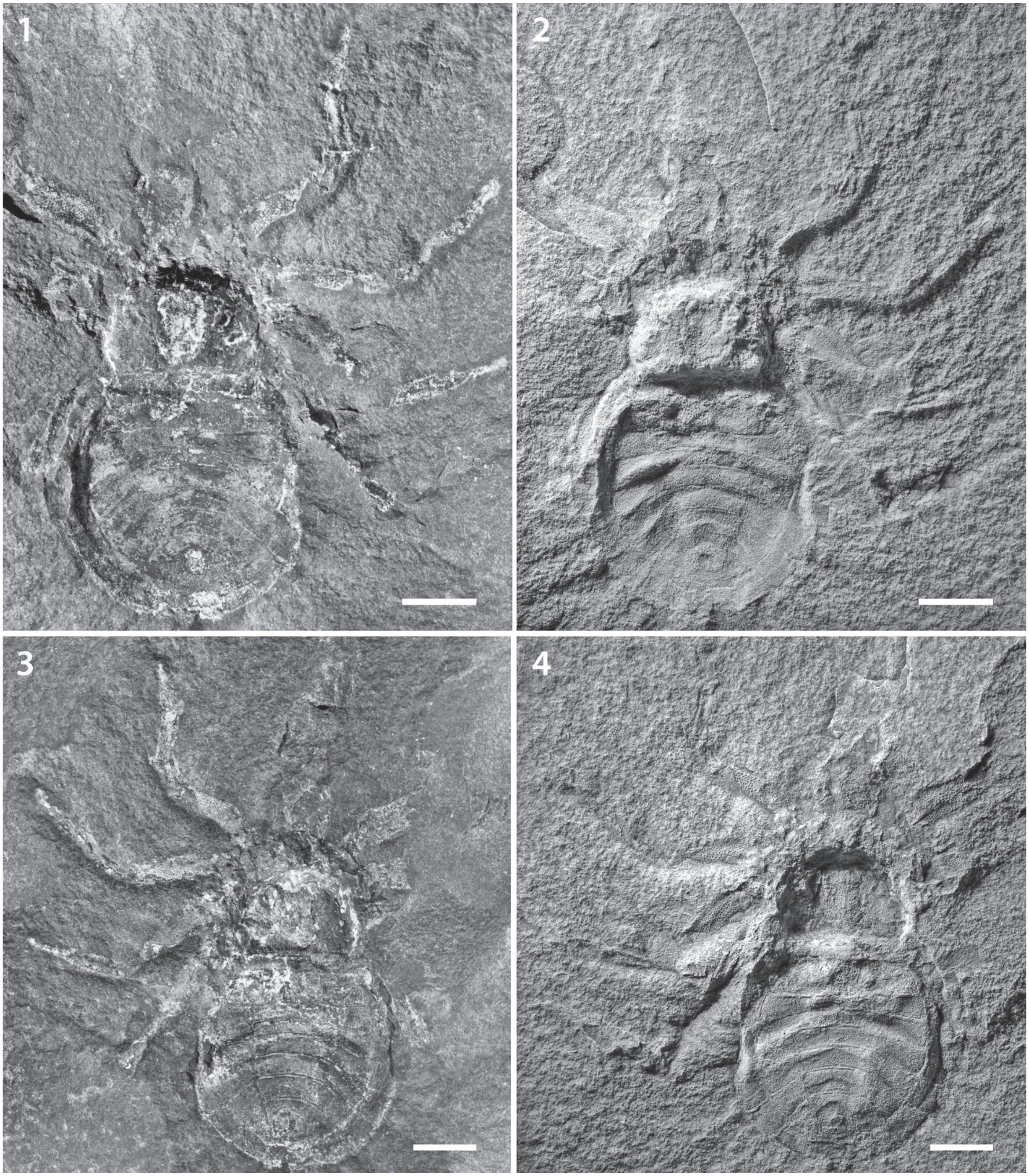

FIGURE 3—*Anthracomartus* sp., Upper Pennsylvanian (Virgilian), specimen KUMIP 197185. *1, 2,* photographs of part; *3, 4,* photographs of counterpart; *1, 3,* dry; *2, 4,* whitened with ammonium chloride. Scale bars=5 mm.

Figures 3–6

ARACHNID, FELDMAN et al., 1993, fig. 4C.

Description.—Cuticle surface finely tuberculate on all sclerotized parts. Body length 22 mm. Carapace subquadrate, but flattened and lateral margins incomplete; median area depressed (Figs. 3.4, 4.1); maximum preserved length 7.2 mm, width 10.4 mm (specimen 156097). Pedipalp short; legs of normal length and robustness for the genus (see Fig. 4). Preserved walking leg I–III lengths c. 19 mm; leg IV c. 13.5 mm (~19 mm by extrapolation). Smooth opisthosomal margin, nearly circular, slightly wider than long (17.2 mm × 16.8 mm in 197185; 16.4 mm × 15.8 mm in 156097), with the greatest

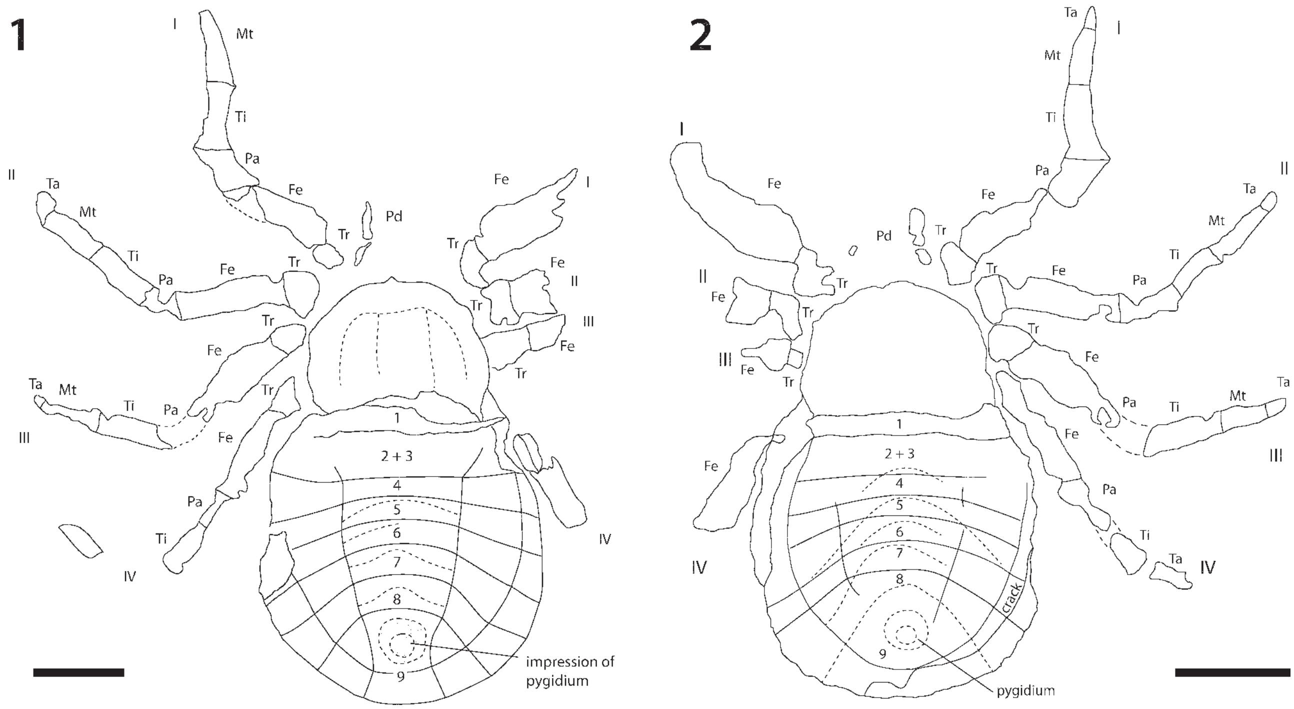

FIGURE 4—*Anthracomartus* sp., Upper Pennsylvanian (Virgilian), specimen KUMIP 197185. *1,* explanatory drawing of part; *2,* explanatory drawing of counterpart. Dashed lines on opisthosomas=sternite boundaries. Scale bars=5 mm.

width mid-length. Tergites divided longitudinally into five plates; median plates wider than laterals. Tergite 1 not visibly articulated in specimen. Tergites 2 and 3 merged as a diplotergite. Curvature of tergites increases towards the posterior region. Visible ventral sternites show broadly chevron-shaped anterior borders, especially posteriorly; pygidium ~2 mm in diameter.

Remarks.—A reexamination and description of Karsch's (1882) type material by Dunlop and Rößler (2002) validated the genus *Anthracomartus*, and suggested that many anthracomartid genera originally described by carapace features (Petrunkevitch, 1956) represent taphonomic variation, and would be referred under *Anthracomartus* following a redescription of specimens from poorly diagnosed genera. Dunlop and Rößler (2002) listed only two recognizable species under *Anthracomartus*: *A. voelkenianus*, Karsch, 1882 and *A. granulatus*, Frič, 1904. The two species were differentiated on the grounds that *A. granulatus* is shorter and wider than *A. voelkelianus*, with clear granulation. More recently, Garwood and Dunlop (2011) recognized the following species in *Anthracomartus*: *A. bohemica* (Frič, 1901), *A. carcinoides* (Frič, 1901), *A. elegans* (Frič, 1901), *A. granulatus* Frič, 1904, *A. hindi* Pocock, 1911, *A. janae* (Opluštil, 1986), *A. kustae* (Petrunkevitch, 1953), *A. minor* Kušta, 1884, *A. nyranensis* (Petrunkevitch, 1953), *A. palatinus* Ammon, 1901, *A. planus* (Petrunkevitch, 1949), *A. priesti* Pocock, 1911, *A. radvanicensis* (Opluštil, 1985), *A. triangularis* Petrunkevitch, 1913, *A. trilobitus* Scudder, 1884, and the type species *A. voelkelianus* Karsch, 1882.

Our specimens have an opisthosoma which is almost circular in outline. In this respect they do not resemble *A. elegans*, *A. trilobitus*, *A. planus*, *A. radvanicensis* and *A. triangularis*, all of which have opisthosomas longer than wide (Petrunkevitch, 1913, 1949, 1953; Opluštil, 1985). Moreover, all of the specimens of *A. trilobitus* lack appendages and are preserved as dorsal body surfaces which are more coarsely pustulose than our specimens (Petrunkevitch, 1913), and the surface of *A. radvanicensis* also appears to be more coarsely pustulose than our specimens. Our specimens show the chevron-shaped ventral sternites typical of *A. hindi* and *A. priesti* (Pocock, 1911; Garwood and Dunlop, 2011), and *A. minor* (Kušta, 1884; Petrunkevitch, 1953). The broad angle is closer to *A. priesti* rather than the sharper angle seen in *A. hindi*. The median carapce depression.

Numerous specimens of *A. bohemica* and *A. carcinoides* were redescribed by Petrunkevitch (1953) from the Nýřany locality in Bohemia. *A. granulatus* was considered lost (Dunlop and Rößler, 2002), but has been rediscovered (Selden and Pillola, 2009) and awaits redescription. Of the remaining species, only the type *A. voelkelianus* has been redescribed recently; the remainder are in need of modern restudy because the published descriptions suggest that their specific differences could be due to taphonomy rather than taxonomy. Our specimens most resemble those from Mazon Creek, Illinois (Beall, 1997, fig. 11.8), which have yet to be described. So, we consider that, at present, it would be unwise to refer them to a species pending a future taxonomic study of these and, preferably, all American trigonotarbids.

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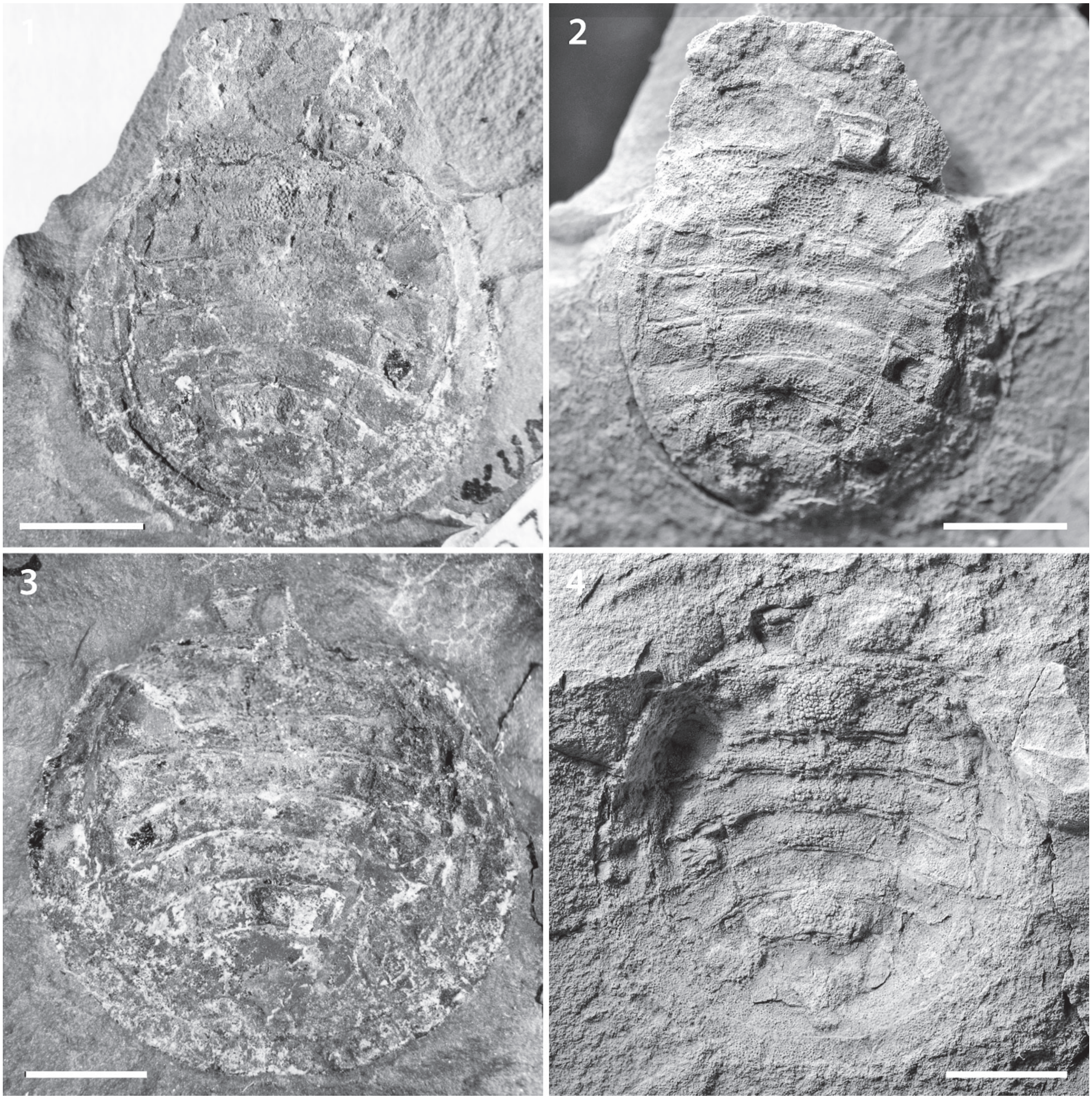

FIGURE 5—*Anthracomartus* sp., Upper Pennsylvanian (Virgilian), specimen KUMIP 156097. *1, 2,* photographs of part; *3, 4,* photographs of counterpart; *1, 3,* dry; *2, 4,* whitened with ammonium chloride. Scale bars=5 mm.

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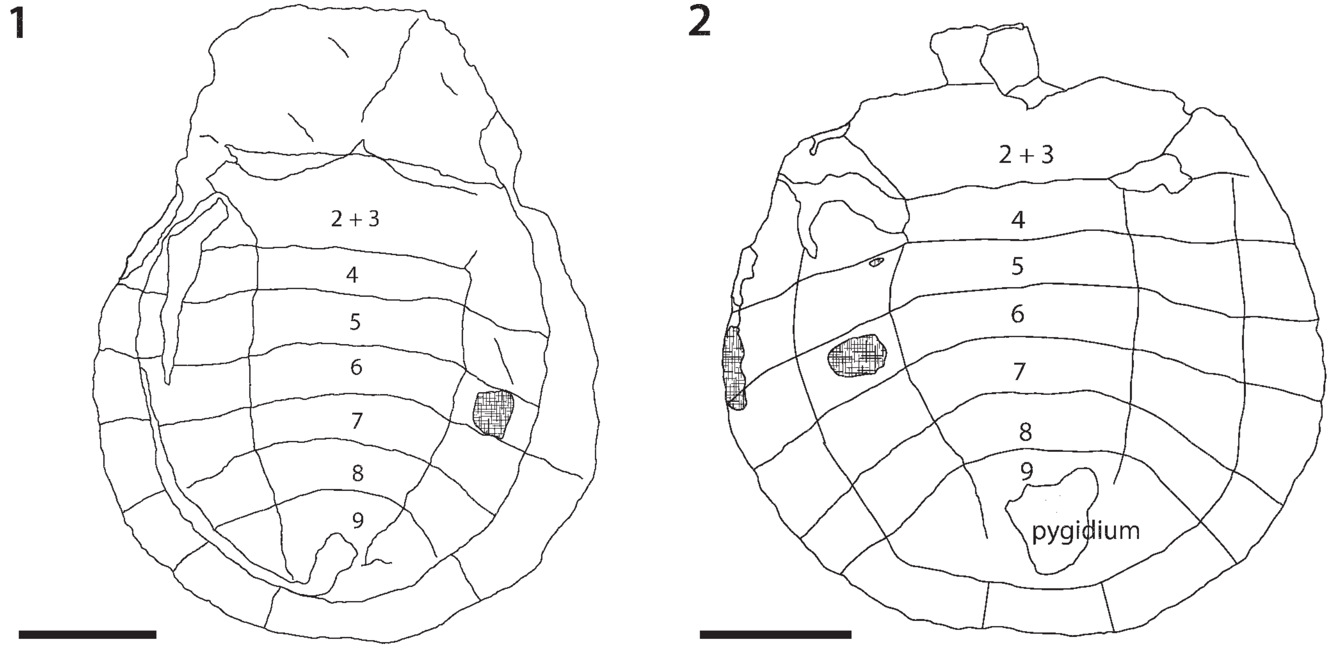

FIGURE 6—*Anthracomartus* sp., Upper Pennsylvanian (Virgilian), specimen KUMIP 156097. *1,* explanatory drawing of part; *2,* explanatory drawing of counterpart. Scale bars=5 mm.

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