# Asteroid Fossils from the Upper Jurassic of South-Central Montana

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Jay A. Gunderson

Montana Bureau of Mines and Geology

*Cover image: Photo of sea star by Jay Gunderson, MBMG*

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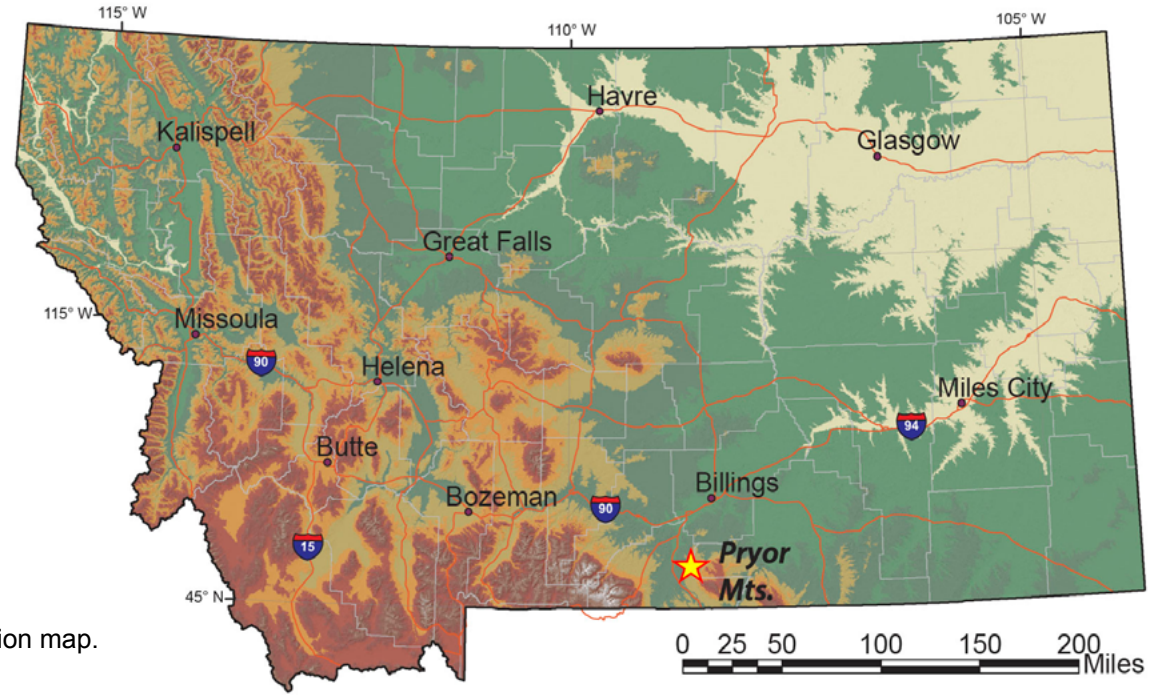



Fig. 1. Location map.

## ABSTRACT

Numerous sea star (Asteroidea) fossils have been discovered in the Upper Jurassic (Oxfordian) Swift Formation of Montana; these are the first Jurassic sea stars reported in Montana. More than 20 reasonably complete, partial, or fragmented sea stars are concentrated in a 200 $m^2$ area along a single bedding plane of medium-grained, glauconitic, coquinoid sandstone. The quality of the fossils varies widely, but as a collection could provide valuable taxonomic and phylogenetic data for the study of post-Paleozoic sea stars.


## INTRODUCTION

Sea star (starfish) fossils are exceedingly rare and generally poorly preserved, because their hard parts are easily disarticulated. The small calcareous plates, or ossicles, that form their endoskeleton are almost always scattered by shallow-water currents and wave action prior to being preserved. Thus, any information that can be added to this limited data set is important.

Asteroidea fossils are known to exist in Jurassic rocks of Great Britain and continental Europe, but few have been found in Jurassic rocks of North America. Whitfield (1877) described three poorly preserved specimens (*Asterias? dubium*) from Jurassic sandstone of the Black Hills, South Dakota. Logan (1900) found a specimen (*Asterias dubium*) in a thin bed of sandy limestone within "purplish clay" in the Freeze-Out Hills of south-eastern Wyoming. A well-preserved specimen subsequently named *Eokainaster pewei* (Blake, 1981) was discovered in the Jurassic Sundance Formation of the Owl Creek Mountains in central Wyoming (Miller and Unklesbay, 1943). Blake (1981) refers to a "University of Wyoming" collection of three specimens preserved in limestone from the upper part of the Redwater Shale Member of the Sundance Formation in Wyoming. Finally, the beautifully preserved "Kaycee specimen" was recently discovered (2005) in shale and glauconitic sandstone of the Redwater Shale Member near Kaycee, Wyoming (Connely and Talbot, 2008). All of the Wyoming specimens have been assigned to the genus *Eokainaster* (Blake, 1981; Connely and Talbot, 2008).

During the summer of 2010, several asteroid fossils were discovered in the Upper Jurassic (Oxfordian) Swift Formation of Montana and appear to be the first sea star fossils reported from Jurassic rocks of Montana. The discovery of numerous Jurassic sea star fossils at one locality should provide significant new data. The purpose of this report is simply to document the occurrence so that paleontologists with asteroid expertise can locate the fossils.

## OCCURRENCE

The sea star fossils occur in the Upper Jurassic Swift Formation, a sequence of interbedded glauconitic sandstone and shale (Cobban, 1945), on the western flank of the Pryor Mountains in south-central Montana (fig. 1). They are located on public land; surface access is managed by the U.S. Bureau of Land Management Field Office in Billings, Montana.

The Swift Formation marks the last major regression of the Sundance Sea, which covered a large part of the western interior of the United States during Middle to Late Jurassic time (169–157 mya) (Imlay, 1980; Johnson, 1992). In south-central Montana, the lower part of the Swift is composed mainly of glauconitic mudstone and siltstone. The upper Swift is mostly medium- to coarse-grained glauconitic sandstone deposited in shallow water (<100 m deep) along the western margin of the Sundance Sea (Brenner and Davies, 1973). Age-equivalent rocks to the south and east (i.e., basinward) in Wyoming and South Dakota are fine-grained sandstone and shale of the Redwater Shale Member of the Upper Sundance Formation. Typical fauna of the Swift Formation includes the crinoid *Petracrinus*, the belemnite *Pachyteuthis*, and the bivalves *Camptonectes, Tancredia, Grammatodon, Meleagrinella, Mytilus, Ostrea, Trigonia,* and *Pleuromya* (Imlay, 1956). In places, *Ostrea* and *Camptonectes* are so abundant that the units are essentially coquinoid limestone and sandstone (Brenner and Davies,

1973; Imlay, 1956). The ammonites *Cardioceras* and *Quenstedtocera* found in the lower Swift place its age as Oxfordian (Imlay, 1956).

At the "Pryor Mountain" site, the Swift Formation is approximately 47 m (150 ft) thick, composed of a basal unit of 15 m of glauconitic shale and fine-grained sandstone; a middle unit of 25 m of cliff-forming medium-grained, cross-bedded sandstone; and an upper unit of 7 m of calcareous, glauconitic sandstone and shale (Imlay, 1954). Individual sandstone beds are cross-bedded, rippled, and variably fossiliferous. Coquinoid beds of bivalve shells are most often in the basal and uppermost units.

The sea star fossils occur about 40 m above the basal contact of the Swift Formation at or near the top of the cliff-forming sandstones. More than 20 specimens are embedded in a single 10- to 30-cm-thick bed of flaggy, coquinoid sandstone within a 10 m x 20 m area (fig. 2). Sea star fossils include whole or nearly whole specimens, disassociated arms, and other fragments. The quality of the fossils varies widely. Some sea stars are well preserved and show considerable detail of ambulacral and marginal plates; others are eroded, fractured, or partially obscured by the coquina's coarse sand grains and fossil hash. No sea star specimens or fragments were found outside of the small area despite exposure of the same apparent bedding plane over several hundred square meters. The coquinoid sandstone is overlain by 4–5 m of cross-bedded, fine-grained sandstone devoid of fossils.

Individual sea stars were informally identified by "site number (S)" and "specimen number" (e.g., S2-1 refers to site 2, specimen 1), where a "site" is an exposed bedding face that may contain multiple specimens (figs. 2, 3). Most exposed bedding faces are planar, but others are somewhat undulating or hummocky as a result of primary deposition, breakage subparallel to bedding, and/or weathering. Between sites, the bedding plane is obscured by a thin veneer of talus and other debris. Each bedding exposure (site) and each fossil within sites were marked, measured, and photographed so they can be easily relocated. No specimens were removed.

## DISCUSSION

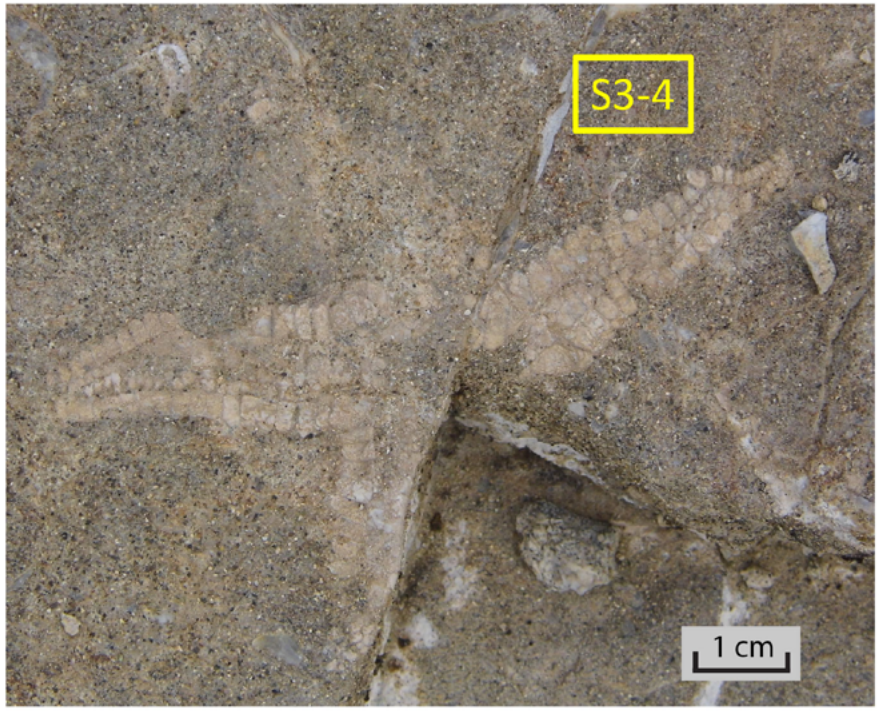
Sea star fossils are extremely rare in the Mesozoic of North America, so reporting any discovery is important. The Pryor Mountain site is unique and deserves further study because of the large amount of fossil material present.

Detailed morphologic descriptions of each fossil are beyond the scope of this report, but several of the sea stars are similar in size and shape to *Eokainaster pewei*. These individuals have relatively small central disks, short triangular and straight-sided arms, and stout marginal plates (fig. 4). *Eokainaster* occurs in age-equivalent strata of Wyoming. Other specimens appear to differ in size and shape. They are larger with long, slender arms. For example, the first specimen to be discovered has a large central disk and arm lengths of 40–50 mm [fig. 5 (S2-1)]. Several small isolated "arms" may be the disassociated tips of these long, slender arms. The narrow arm tips also look different from the short, stocky *Eokainaster* arms. Thus, it is possible that the location contains more than one sea star species.

The concentration of asteroid fossils in a small area is remarkable. New specimens have been found on nearly every one of the author's dozen or so visits to the site. As recently as April 2015, four additional specimens were located; it is very likely that more sea star fossils will be discovered at the Pryor Mountain site. Perhaps none will match the quality of the Wyoming specimens, but the apparent presence of more than one species and the density of asteroid specimens could be important in better understanding the phylogeny and taxonomy of post-Paleozoic sea stars.


Fig. 2. Sea star fossils occur along a single bedding plane of the Swift Formation. Numbers (and flags) mark individual bedding faces or "sites."


Fig. 3. Site 1 bedding face showing locations of individual sea star specimens within fractured coquinoid sandstone.

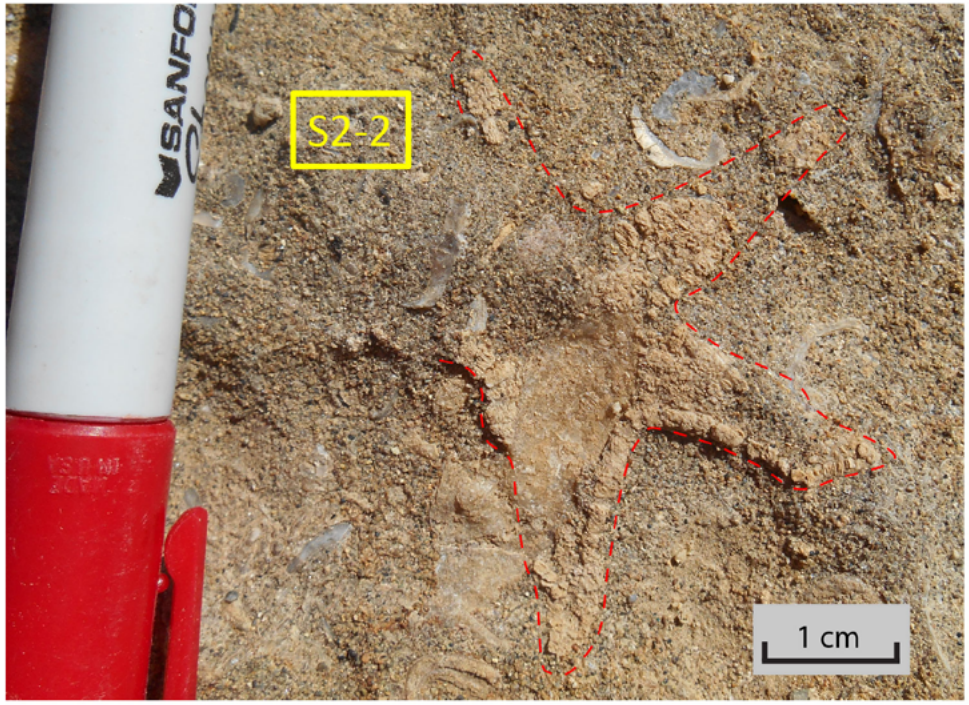
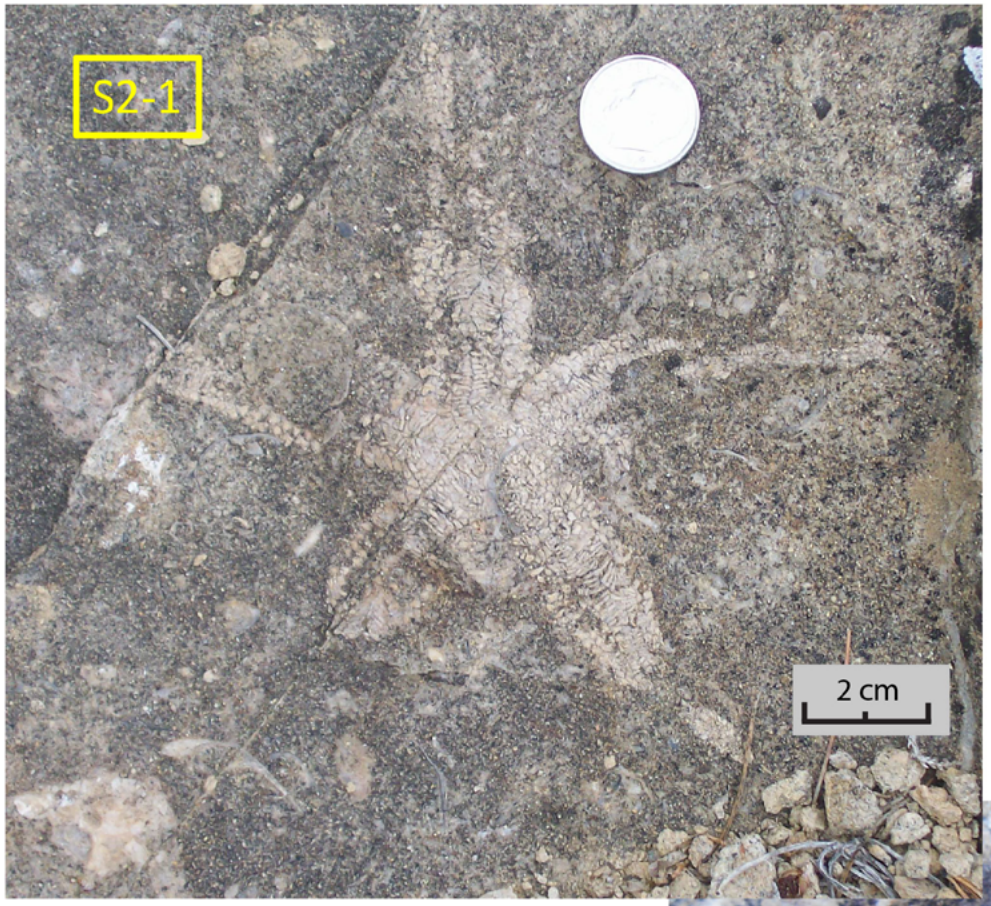
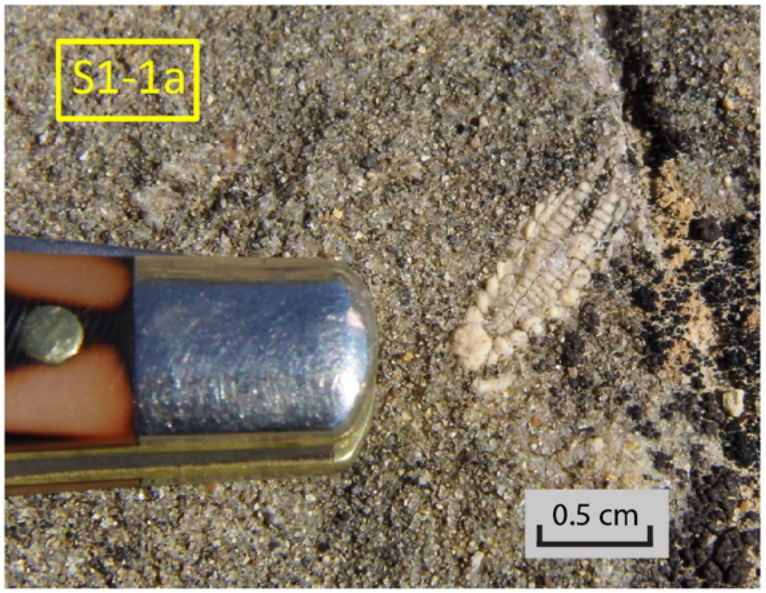




Fig. 4. Several sea stars appear similar to Eokainaster found in Jurassic rocks of Wyoming.



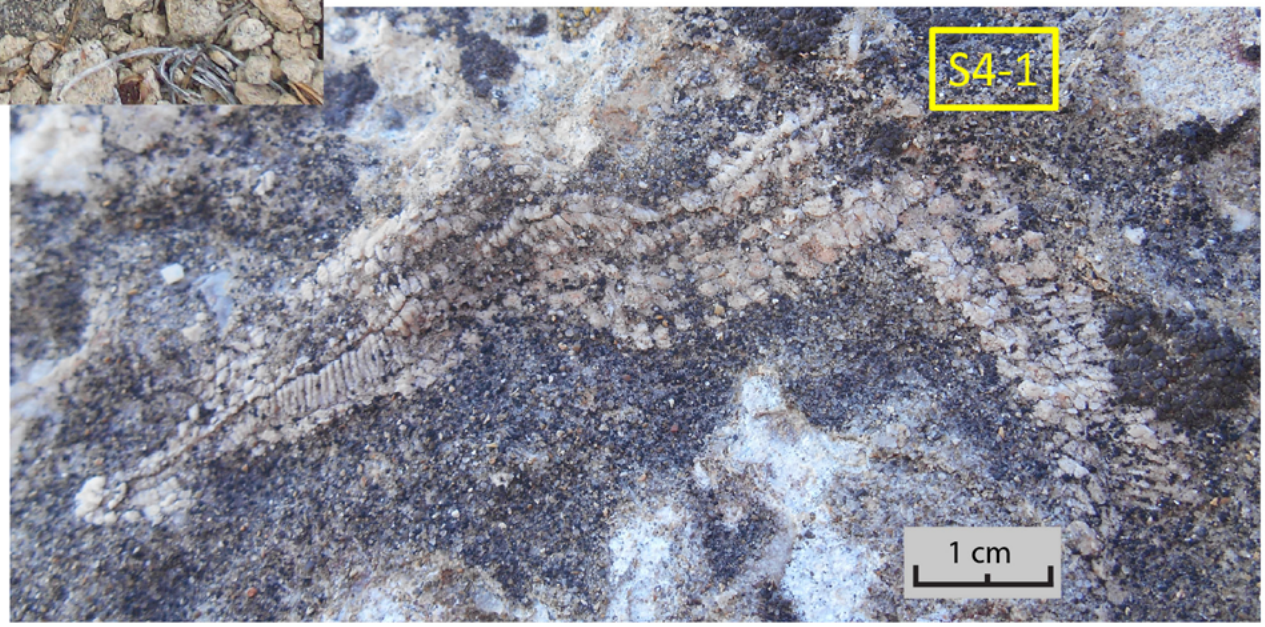




Fig. 5. Some sea star specimens have long, slender arms and small arm tips with large terminal ossicles. Specimen S1-1a and other small “arms” may be distal tips of larger sea stars (compare S1-1a with the tip of S4-1).

## ACKNOWLEDGMENTS

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Swift Formation (foreground) overlain by Jurassic Morrison and Cretaceous Kootenai Formations (near ridge) and Lower Cretaceous shale (far ridge). View looking west toward the Beartooth Mountains. Photo by Clay Schwartz, MBMG.