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First record of decapod crustaceans (Astacidea, Stenochiridae) from the Gypsum Springs Formation (Jurassic) of Wyoming, USA

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Abstract

Two new genera and species represent the first record of Stenochiroidea Beurlen lobsters from the Gypsum Springs Formation of Bathonian/Bajocian from the Bighorn Basin of Wyoming. They also represent some of the few known Jurassic lobsters from North America and the first Stenochiridae from North America. New taxa include *Gypsonicus wyomingensis* new genus, new species, and *Gracilimanus obscurus* new genus, new species.

Key Words: Lobster, Astacidea, Stenochiridae, Middle Jurassic, North America

Introduction

Decapod crustaceans of Jurassic age are rare in North America. Only eight species in four genera have been described previously; their occurrences have recently been listed by Feldmann *et al.* (2013). Of these, only two species of the lobster genus *Eryma* are known from the United States. Thus, the discovery of two new species of lobsters from Jurassic rocks in Wyoming substantially increases our understanding of the diversity of decapods in North America during that time. The specimens described herein were obtained from the Jurassic Gypsum Springs Formation (Jgs) in the Big Horn Basin of northcentral Wyoming (Fig. 1). The purpose of the present work is to describe the two new species of lobsters, assigned to two new genera, and to comment on the depositional setting in which they occur.

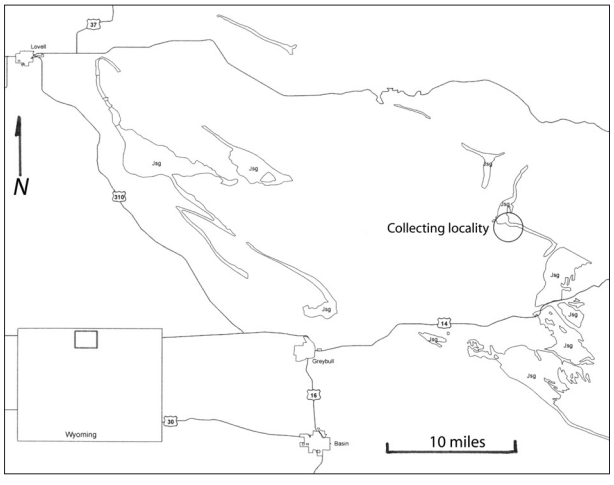

Fig. 1. Gypsum Springs Formation outcrop area map, with fossil collecting locality marked. Inset map of Wyoming (lower left) showing general regional geography for fossil locality.

The Gypsum Springs Formation is a marginal marine unit consisting of interbedded siltstone, limestone, and evaporates. Exposures of the Gypsum Springs occur along the flanks of the Big Horn Basin where the beds have been upturned and exposed due to the uplift of the Big Horn Mountains on the east, the Owl Creek and Bridger Mountains to the south, and the Absaroka Mountains to the west. The Gypsum Springs Formation is unconformably bounded by the Triassic Chugwater Formation below and Jurassic Sundance Formation above. Regionally the formation is extensive and can be found throughout Wyoming, South Dakota, North Dakota, Montana, and Idaho. The Gypsum Springs Formation is Bathonian/Bajocian in age, roughly 169 Ma to 173 Ma (Love, 1939).

The decapod fossils forming the basis for this study were collected from an area on the east side of the Big Horn Basin in an outcrop on the west flank of the Big Horn Mountains. Exposures of the Gypsum Springs are capped by coquina of the Sundance Formation. Small nuculid bivalves are most commonly found in the same layer as the decapod specimens and are abundant.

Depositional setting

The Gypsum Springs Formation consists of three units. These include a basal unit that is composed of massive bedded gypsum interbedded with red siltstone, a middle unit which is interbedded siltstone and fine grained gray limestone, and an upper unit consisting of interbedded claystone, siltstone, and thin evaporites.

During the deposition of the Gypsum Springs Formation, the Bighorn Basin was at latitude 20° to 25° N (Peterson, 1957). The paleoclimate of the Wyoming Shelf area during the Bajocian was very similar to that of the present day Persian Gulf. According to Kocurek and Dott (1983), stable air masses produced very little rainfall in the region even though trade winds are presumed to have passed over the interior seaway. Southerly wind shifts created cyclic storms and high winds caused silt and sand storms possibly lasting for days (Kocurek and Dott, 1983). The red desert soils of the Persian Gulf are modern analogs to the red paleosols and silty red beds found in the Gypsum Springs Formation.

Fig. 2. Rock layers where decapod specimens were found in basal limestone (A) of Middle Unit of Gypsum Springs Formation. Note nodular gypsum at top of lower Unit (below hammer).

The middle unit of the Gypsum Springs Formation, where the decapods were found (Fig. 2), was deposited in a warm, shallow marine environment with near normal salinities (Imlay, 1956, 1957). Skeletal fragments and ooids were concentrated during normal wave action as well as during occasional storms. Thin stringers of gypsum and stromatolitic carbonate layers indicate local periods of increased salinity (Imlay, 1957). An intrabasinal positive feature, Belt Island, became a less prominent feature after deposition of the lower unit enhancing circulation and general deepening of the marine water in northern Wyoming (Peterson, 1958). Deposition proximal to the Sheridan Arch and paleo-shoreline in Wyoming was characterized by minor amounts of gypsum, fossiliferous dolostones, limestones, and claystones (Fig. 3).

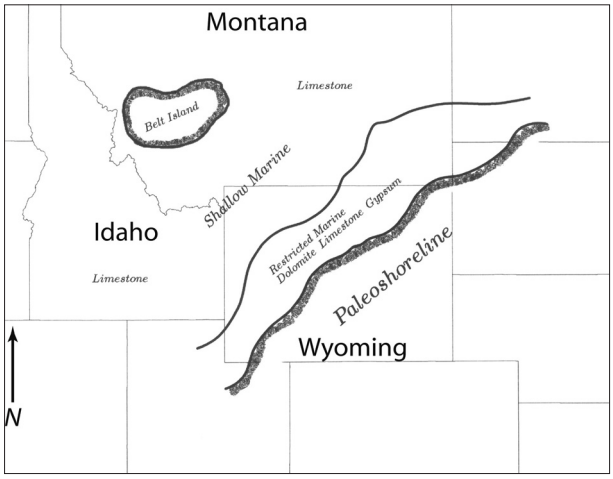

Fig. 3. Generalized paleofacies map of Middle Unit of Gypsum Springs Formation (after Peterson, 1957).

Allochemical carbonates, including ooids, were concentrated to form the thin limestone beds of the middle unit. Indicators of wave reworking include minor cross laminations, minor channeling, bored skeletal fragments, and laterally discontinuous bedding. In the lower half of the middle unit, the thicker limestone beds contain ooids which indicates deposition occurred in shallow, warm, frequently agitated water. Ooids are also indicative of water saturated with respect to calcium carbonate.

Transitions from the thick limestone beds in the lower part of the middle unit to thinly bedded limestone in the upper half of the middle unit indicate a relative deepening of marine water and are analogous to a gradation from proximal to distal storm deposit transitions (Patterson and Kinsman, 1981). Aigner (1982) and Walker and Plint (1992) posited that proximal storm deposits are generally near wave base; are bioclastic-dominated, cross-laminated, and thicker; and are composed of composite beds which can be traced for as far as a few miles. Distal storm deposits are typified by below normal wave base deposits that are mud dominated, thinner, and commonly are single event beds. Distally derived deposits are planar laminated and limited in lateral extent (Aigner, 1982). Claystones within the middle unit indicate that the source area was relatively close and of fairly low relief (Meyer, 1984). Regional deepening of water is recorded not only in north-central Wyoming but is also reflected in strata adjacent to the thrust belt in southern Montana (Peterson, 1957). A shaley limestone with characteristic green stained bedding surfaces with *Isocyprina* sp. can be traced for approximately 120 km (75 miles) (Imlay, 1956). Imlay (1956) correlated these beds along the southern Pryor Mountains north-westward into an oolitic, coquinoidal, pebbly limestone near the middle of the B member of the Piper Formation. The

middle of the B member of the Piper Formation is roughly equivalent stratigraphically to the middle limestone unit of the Gypsum Springs Formation. Continuity and traceability of this green-stained unit possibly indicates a long period of stability over a very large area. The upper half of the Sliderock Member and the entire Rich Member of the Twin Creek Limestone also correlate with the middle unit in the study area. Imlay (1967) interpreted the upper Sliderock Member as indicating a deepening of the marine water and that the Rich Member recorded a dramatic deepening at the end of deposition of the lower unit of the Gypsum Springs Formation. Strata of the southern and eastern regions of the Bighorn Basin were deposited in more restricted water than those strata of the northern and western regions as evidenced by relative dominance of carbonates and a lack of evaporites. Uplift of the Sheridan Arch during the deposition of the uppermost strata of the middle unit is evidenced by the presence of erosion-derived silicification and a conglomerate consisting of chert and limestone clasts near Hyattville, Wyoming.

Systematics

Infraorder Astacidea Latreille, 1802
Superfamily Stenochiroidea Beurlen, 1928
Family Stenochiridae Beurlen, 1928

Stenochirinae Beurlen, 1928, p. 177.

Stenochiridae Beurlen, 1930, p. 326.

Chilenophoberidae Tshudy and Babcock, 1997, p. 259.

Included genera: *Chilenophoberus* Chong and Förster, 1976; *Gypsonicus* Schweitzer and Feldmann new genus; *Palaeophoberus* Glaessner, 1932; *Pseudastacus* Oppel, 1861; *Stenochirus* Oppel, 1862; *Tillocheles* Woods, 1957; questionably *Gracilimanus* Feldmann and Schweitzer new genus.

Diagnosis: The family was recently diagnosed (Karasawa *et al.*, 2013) and that will not be repeated here.

Discussion: The specimens from the Gypsum Springs Formation conform closely to the diagnosis for the family (Karasawa *et al.*, 2013, p. 115). Examination of the new genus and species, based upon a composite of several partial specimens, confirms that the only feature that is not consistent with the current family diagnosis is that the propodus of the cheliped is nodose, rather than unsculptured. The cephalothorax bears cephalic carinae, the cervical groove arises at about midheight and curves smoothly anteroventrally into the antennal groove, the postcervical groove intersects the cervical groove at about midheight, and the branchiocardiac groove is present but relatively indistinct. These same generalizations also hold for the new genus and species questionably assigned to Stenochiridae.

The relatively simplistic groove pattern excludes the specimens from all other families of marine lobsters with the exception of Stenochiridae and Nephropidae. Species of Nephropidae also have more elaborate groove patterns with the exception of *Homarus* Weber, 1795, a taxon that ranges from the Early Cretaceous (Albian) to the Holocene (Feldmann *et al.*, Treatise, submitted). *Homarus* exhibits a smooth carapace and much shorter and more stout, strongly heterochelous first pereiopods than the Gypsum Springs material. The crusher claw of *Homarus* spp. bears molariform denticles whereas the smaller cutter claw has short, sharp denticles. The first pereiopods of the Gypsum Springs lobsters, consistent with placement within Stenochiridae, are much longer than the carapace, are more slender, and bear variable sized denticles. Thus, placement within Stenochiridae is warranted.

The report of stenochirids in the Gypsum Springs Formation represents the first record of Stenochiroidea in North America.

Genus *Gypsonicus* Schweitzer and Feldmann new genus

Type species: *Gypsonicus wyomingensis* Schweitzer and Feldmann new species by original designation and monotypy.

Etymology: The name alludes to the occurrence of the material basis for the genus in the Gypsum Springs Formation. The gender is masculine.

Diagnosis: Carapace with prominent cervical and postcervical grooves both bounded by granular ridges. Postcervical groove of two straight elements with point of inflection at about midlength. Branchiocardiac groove weakly developed. Adductor testis region (χ) a broad swelling. Cephalic region with subrostral and gastroorbital carinae. Branchial region with granular ornamentation dorsally, becoming smooth posteroventrally. Scaphocerite with straight outer margin and rounded inner margin, both with narrow rim. Pereiopod 1 extremely long and slender, with nodose and spinose ornamentation. Pleopods with long, styliform basal element and long, multiarticulate flagellae. Exopod of uropods with diaeresis. Telson appearing to be triangular, narrow.

Discussion: *Gypsonicus* new genus is allied to other genera within Stenochiridae in possession of all the diagnostic characters of the family except with regard to the ornamentation of the first pereiopod. That structure bears nodes and spines on the propodus of *Gypsonicus* new genus whereas other members of the family have unsculptured propodi, where preserved. Long, multiarticulate pleopods are present on one of the specimens under study, USNM 593553. Although not diagnostic of the family, their presence is noteworthy. This form of pleopods has not been reported previously within the superfamily owing to the vagaries of preservation. However, they are present is some astacideans, notably within the Nephropidae. For example, a specimen of *Nephropsis rosea* Bate, 1888, USNM 181773, bears pleopods bearing multiarticulate terminal elements.

Additional characters further confirm the unique character of the new genus. *Chilenophoberus* has an anteriorly branching

Fig. 4. *Gypsonicus wyomingensis* new genus, new species, holotype USNM 593352. 1, entire specimen showing carapace and poorly preserved pleon; 2, cast of carapace, with features marked; a = branchiocardiac groove, b = antennal groove, e = cervical groove, c = postcervical groove, χ = chi swelling or adductor testis muscle attachment site. Scale bars = 1 cm.

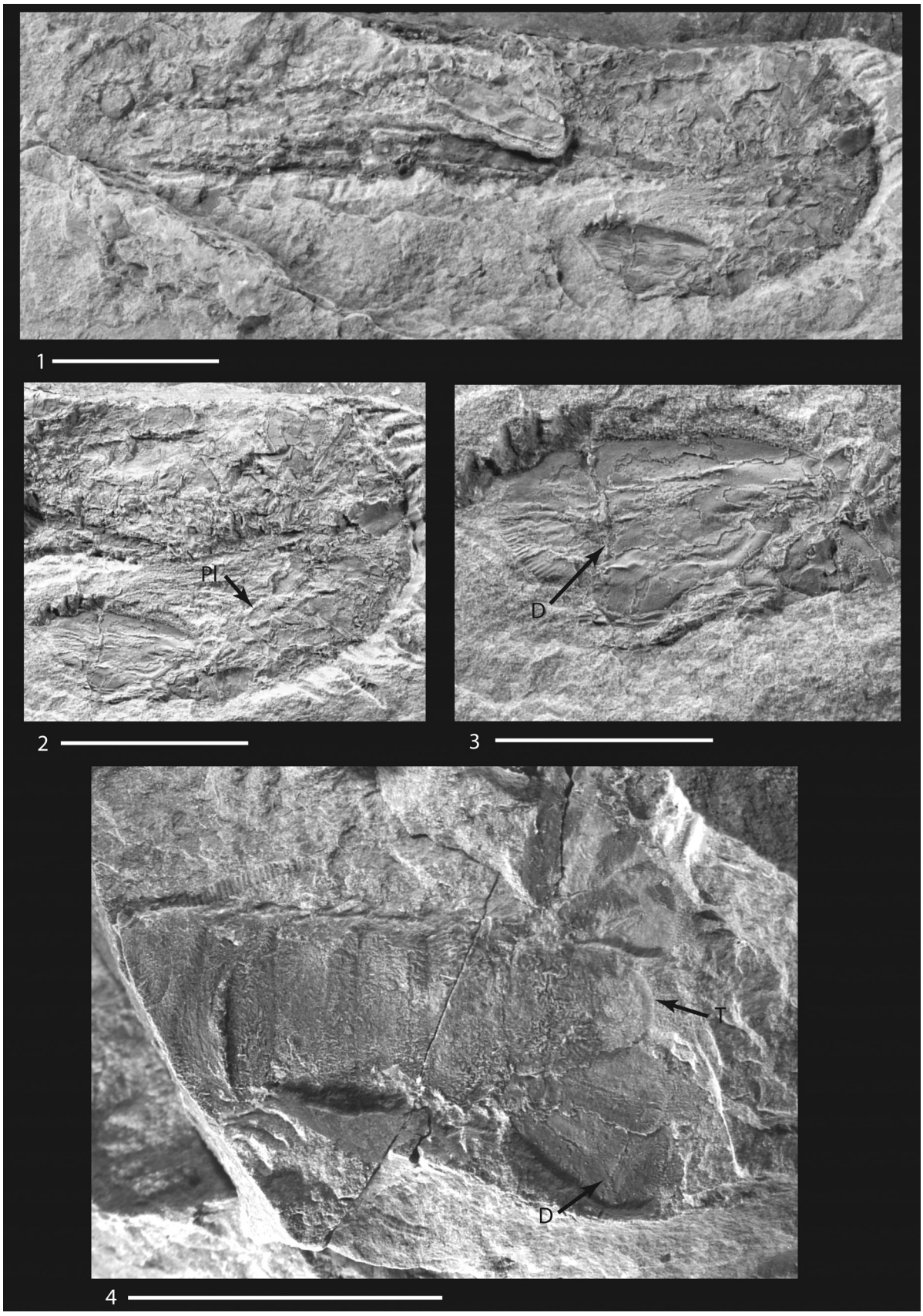

Fig. 5. 1–3. *Gypsonicus wyomingensis* new genus, new species, USNM 593553a, paratype; 1, entire specimen with poorly preserved pereiopods and well−preserved pleon; 2, pleon; 3, enlargement of uropod showing diaresis on exopod. 4, Indeterminate pleon, USNM 593556. D = diaeresis, T = telson, Pl = pleuron (rounded). Scale bars = 1 cm.

gastroorbital groove and a median carina extending across the cephalic and branchial regions, features not seen on *Gypsonicus* new genus. *Palaeophoberus* has a nearly straight postcervical groove and a well defined branchiocardiac groove, and the first pereiopod bears setal pits, but no nodes or spines, both features different from those of *Gypsonicus* new genus. The absence of a postcervical groove and the intersection of the branchiocardiac groove with the cervical groove readily distinguishes *Pseudastacus* from the new genus. Presence of spines on the antennal carina and acicular denticles on the fingers of pereiopod 1 in *Stenochirus* are key characters distinguishing it from *Gypsonicus* new genus. *Tillocheles* has a fusiform area bounded by curved carinae on the gastric area, a semicircular antennal groove, and confluent cervical, postcervical, and branchiocardiac grooves, characters unlike those on *Gypsonicus* new genus. For these reasons, a new genus within Stenochiridae is fully warranted.

Gypsonicus wyomingensis Schweitzer and Feldmann new species

(Figs. 4–8)

Diagnosis: As for genus.

Description: Carapace longer than high, poorly preserved; surface where known with broadly spaced granules becoming smoother in posteroventral area; wrinkled dorsally. Postcervical groove wide, deep, sinuous, intersecting dorsal surface at about 80° angle, extending anteriorly and ventrally in two nearly straight segments with point of inflection at mid length; connecting to well-defined cervical groove below mid height of carapace. Cervical groove curves anteriorly to merge into antennal groove. Cervical and postcervical grooves bounded posteriorly by raised, coarsely granular ridge. Cervical groove bounded anteriorly by raised, coarsely granular ridge. Branchiocardiac groove weak, parallels postcervical groove dorsally to point of inflection at which point it curves posteriorly to nearly parallel dorsal midline. Adductor testis muscle attachment site (χ) circular, large, well developed. Two short gastroorbital ridges. Posterior margin thinly rimmed, perpendicular to dorsal surface, then arcing convexly posteriorly and smoothly curving into ventral margin which is weakly convex. Epistome with narrow, straight anterior margin and two straight, longitudinally sulcate segments extending posterolaterally on either side, smooth.

First pleonal somite with straight tergum and pleuron arcing strongly posteriorly. Terga with subtle transverse ridges or finely wrinkled. Pleura 2–5 appear rounded. Pleopods with long, styliform basal element and long, multiarticulate flagellae. Exopod of uropod wide, flabellate; with complete, distinct diaeresis; outer margin granular or with setal pits; portion distal to diaresis with fluted margin. Telson broad, tapering slightly posteriorly, termination rounded; uropods extend beyond telson.

Antennal flagellae long, basal elements poorly known. Scaphocerite flattened; outer margin straight with narrow, smooth rim; tip acuminate; inner margin convex, with beaded rim. Mandibles long, inflated axially, apparently well-calcified. Third maxilliped pediform, poorly known, much narrower and shorter than pereiopod 1 but about same thickness as pereiopod 2. First pereiopods extremely long, upper and lower margins of elements spinose, outer surface nodose, fingers long, occlusal surfaces with small and large denticles. Pereiopods 2? and 3? slender, long, propodus very long, much longer than high; dactyl short, narrowing to acuminate tip distally; preservation on USNM 593555a suggests possible chelate nature but may be result of superimposition of dactyls of multiple specimens. Pleopods with long, multiarticulate distal elements.

Measurements: Measurements (in mm) on specimens of *Gypsonicus wyomingensis* new genus, new species: USNM 593552, holotype, carapace length, >21; USNM 593553, paratype, carapace length, >11; merus of first pereiopod length, 12.6, carpus of first pereiopod length, 4.1; manus including fixed finger length, 14.1; USNM 593554, paratype, carapace length, >11.

Types: The holotype, USNM 593552, and 8 paratypes, USNM 593553a and b, 593554a and b, 593555a and b, 593556–593560, are deposited in the United States National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA.

Etymology: The trivial name is taken from Wyoming, USA, the state from which the specimens were collected.

Occurrence: The specimens were collected from the middle

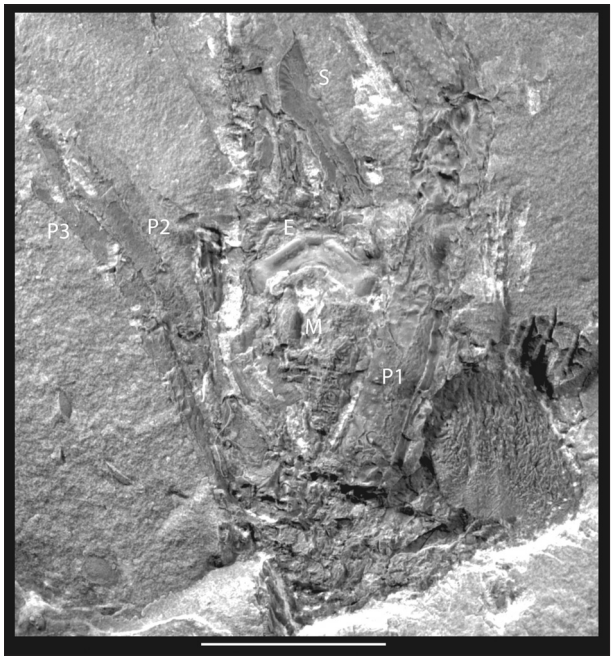

Fig. 6. *Gypsonicus wyomingensis* new genus, new species, USNM 593555a, paratype, ventral view; S = scaphocerite, E = epistome, M = mandible, P1 = pereiopod 1, P2, P3 = pereiopods 2 and 3. Scale bar = 1 cm.

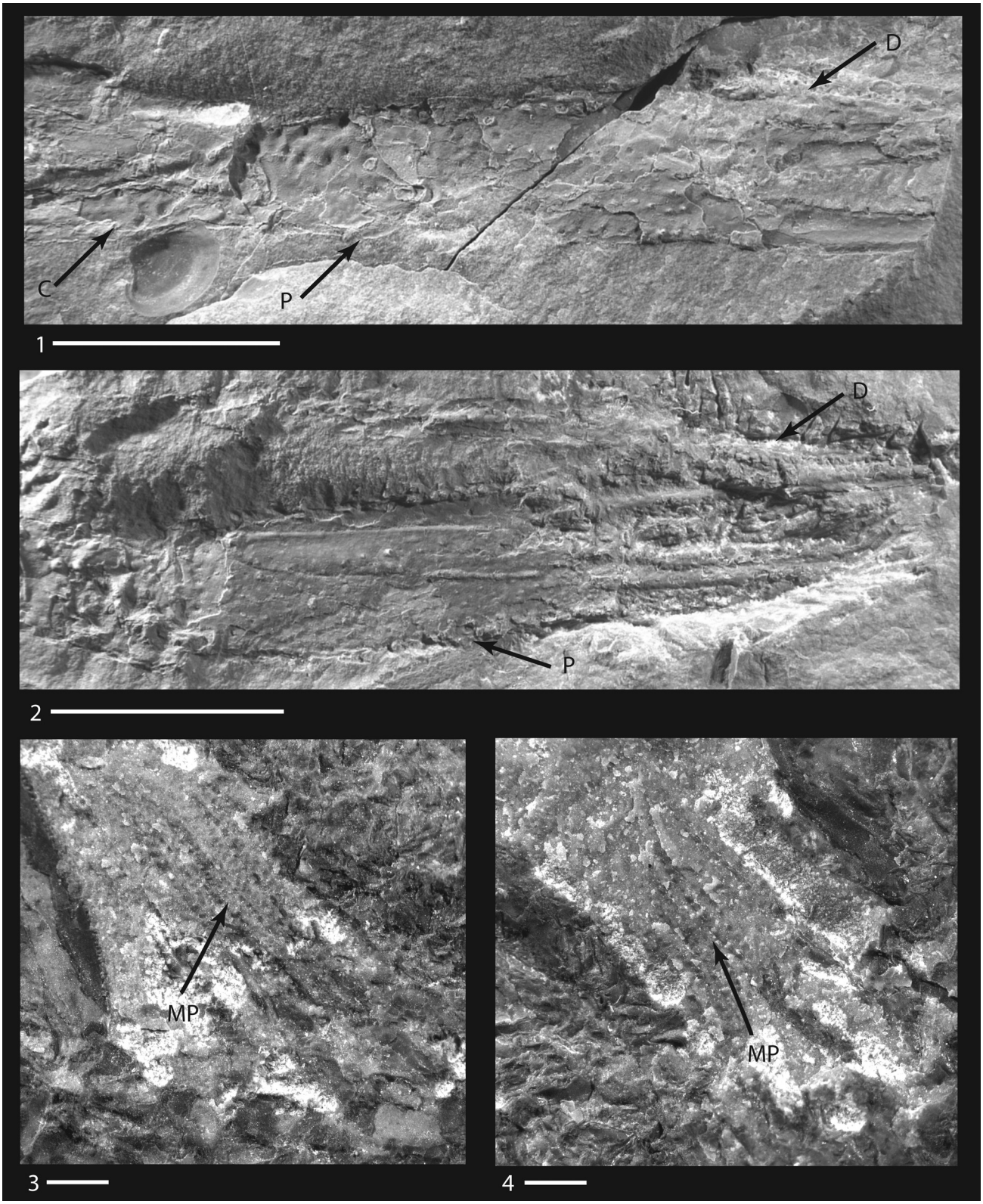

Fig. 7. *Gypsonicus wyomingensis* new genus, new species. 1, USNM 593554a, cheliped; 2, USNM 593557, cheliped; 3, USNM 593553a; 4, USNM 593553b. C= carpus, P = propodus, D = dactylus, MP = multiarticulate pleopods. Scale bars for 1 and 2 = 1 cm, scale bars for 3 and 4 = 1 mm.

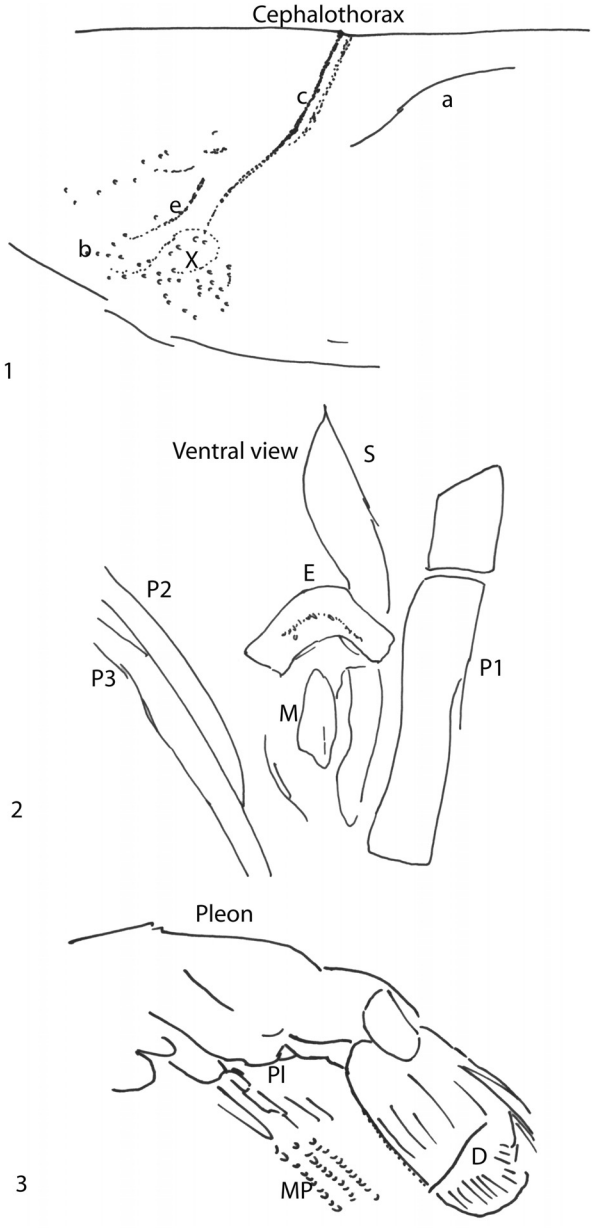

Fig. 8. *Gypsonicus wyomingensis* new genus, new species. A, camera lucida drawing of USNM 593552, a = branchiocardiac groove, b = antennal groove, e = cervical groove, c = postcervical groove, χ = chi swelling or adductor testis muscle attachment site; B, camera lucida drawing of USNM 593555a, S = scaphocerite, E = epistome, M = mandible, P1 = pereiopod 1, P2, P3 = pereiopods 2 and 3; C, camera lucida drawing of USNM 593553a, D = diaeresis, MP = multiarticulate pleopods, Pl = pleopods.

unit of the Gypsum Springs Formation at latitude 44°39'46.54" N, longitude 107°48'38.31"W, Bighorn County, Wyoming.

Discussion: The material basis for *Gypsonicus wyomingensis* new genus, new species, is fragmentary and poorly preserved. As a result, the description is based upon several specimens, each illustrating different parts of the anatomy of the organism. The remains of the carapace and pleon exhibit a wrinkled appearance in several places which appears to be the result of dessication. If this is the case, the deformation would suggest that the cuticle was very thin and, perhaps, weakly calcified. Because many of the specimens are disarticulated, the combination of dismemberment and delicate cuticle would suggest that the specimens represent molts rather than corpses.

Regardless of the state of preservation, the combination of specimens permits a reasonably complete description of the external anatomy. Thus, placement within Stenochiridae is well documented. The carapaces are preserved in lateral aspect which suggests that it was subcylindrical rather than dorsoventrally flattened. The cephalic region is weakly carinate, and the groove pattern is that of stenochirids. The pleon is typical of astacideans and the first pereiopod is chelate. The only point of difference between the Gypsum Springs specimens and the family diagnosis is that the propodi are nodose in the new taxon, whereas the diagnostic character is that the propodus is smooth.

Family Stenochiridae?

Discussion: A single poorly preserved specimen is tentatively referred to Stenochiridae but is recognized as distinctly different from *Gypsonicus wyomingensis* new genus, new species. Presence of a groove pattern consisting of a postcervical groove that extends from the dorsal midline in a smooth arc to midheight where it terminates against the point of origin of the concave forward cervical groove, presence of a distinctly astacidean pleon and uropods, and a chelate first pereiopod that is relatively long and slender are anatomical characters supporting placement within the family. It is noteworthy that Stenochiridae is distinctive among Jurassic decapods in having the relatively simple groove pattern illustrated on both of the Gypsum Springs lobster species. The primary reason for questionable placement within the family is that the quality of preservation is poor enough, particularly in the region of the cephalothorax, that morphological details are sketchy.

Genus *Gracilimanus* Feldmann and Schweitzer new genus

Type species: *Gracilimanus obscurus* new species by original designation and monotypy.

Etymology: The name is a combination of the Latin words *gracilis* = slender, and *manus* = hand, alluding to the form of the first pereiopods. The gender is masculine.

Diagnosis: Carapace with weakly impressed cervical and postcervical grooves. Postcervical groove a weakly concave forward arc terminating at midheight of carapace where the concave forward cervical groove arises. Rostrum long, ensiform, lacking spines. Carapace surface granular. Pleon with triangular pleura terminating in acute tips. First pereiopods isochelous, long, slender, nodose, with long, slender fingers.

Discussion: Several anatomical features distinguish the sole specimen representative of *Gracilimanus* new genus from

Gypsonicus wyomingensis new genus, new species. The carapace grooves appear to be less strongly impressed in *Gracilimanus* new genus, and the pleura are triangular and sharply terminated rather than rounded. This single feature might be taken to represent sexual dimorphism as exhibited in *Glyphea regleyana* (Desmarest, 1822) by Étallon (1858) and *Neoglyphea inopinata* Forest and Saint Laurent (1975) in which the pleura of males are triangular and those of females are rounded. However, the carapace of *Gracilimanus obscurus* new genus, new species is granular whereas that of *Gypsonicus wyomingensis* new genus, new species is punctate and the morphology of the first pereiopods is quite different. Therefore, it seems most reasonable to assign the single specimen to a different genus rather than to suggest sexual dimorphism. More, and better, specimens would be necessary to test this position.

Gracilimanus obscurus Feldmann and Schweitzer new species

(Figs. 9, 10)

Diagnosis: As for genus.

Description: Cephalothorax partially preserved. Postcervical

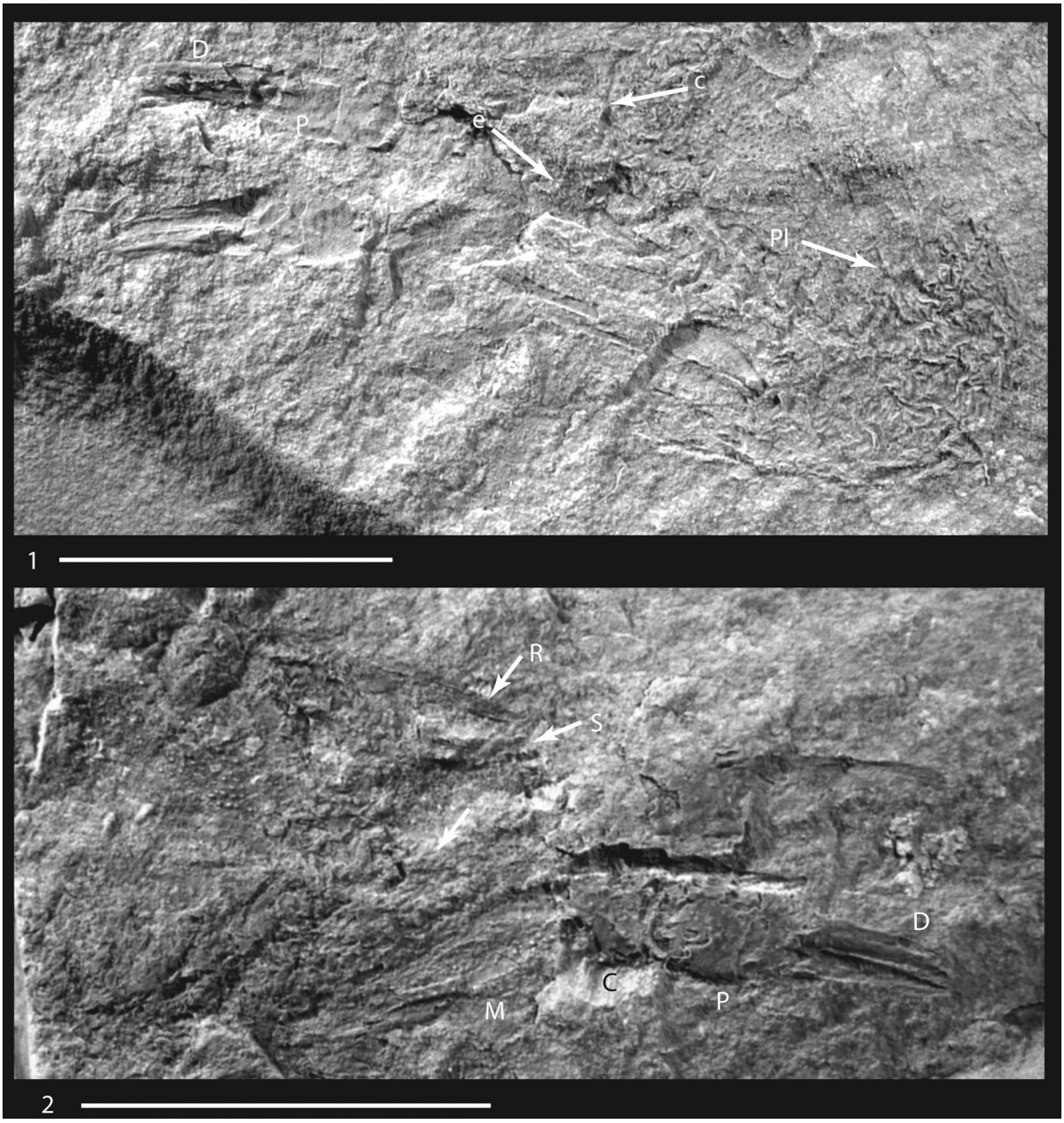

Fig. 9. *Gracilimanus obscurus* new genus, new species, holotype USNM 593562a, b. 1, USNM 593562a, counterpart showing isochelous chelipeds and impression of carapace and pleon; 2, USNM 593562b, part showing chelae. c = postcervical groove, e = cervical groove, D = dactylus, C = carpus, P = propodus, M = merus, Pl = pleuron (triangular), R = rostrum, S = scaphocerite. Scale bars = 1 cm.

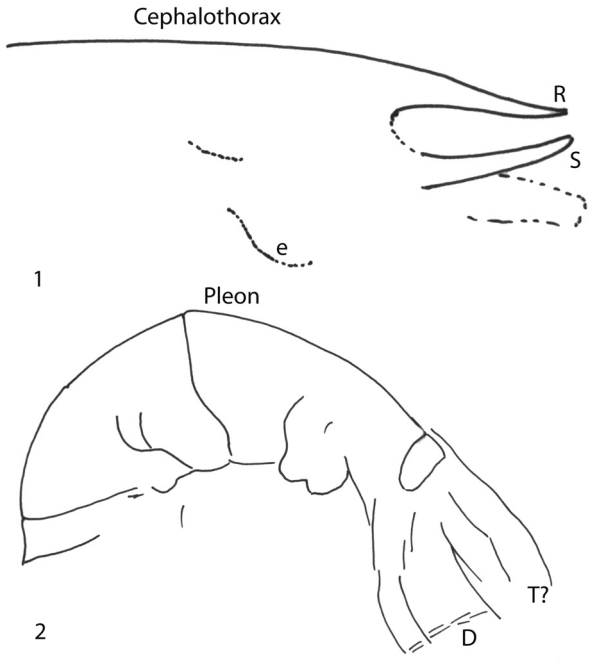

Fig. 10. *Gracilimanus obscurus* new genus, new species. A, camera lucida drawing of USNM 593562b, e = cervical groove, R = rostrum, S = scaphocerite; B, camera lucida drawing of USNM 593562a, D = diaeresis, T = telson.

groove extends from dorsal midline ventrally and anteriorly to about midheight where it terminates at cervical groove which arises at midheight and forms a concave forward arc merging with antennar groove. Rostrum long, slender, ensiform, smooth, upper and lower surfaces lacking spines. Surface of cephalothorax granular.

Pleon with fractured, poorly preserved terga that appear to exhibit a transversely undulatory surface. Preserved pleura are rimmed, triangular with sharp, postero-ventrally directed tips. Uropods and telson incomplete.

First pereiopods long, isochelous, with proximal podomeres crushed. Carpus as long (2.2 mm) as high; outer surface uniformly nodose. Propodus with rectilinear manus, 3.7 mm long, 2.2 mm high; upper surface straight, smooth; lower margin weakly convex, smooth; outer surface nodose. Fixed finger long (3.7 mm), slender, 0.7 mm high proximally, tapering to acute tip, smooth, bearing domed denticles on occlusal surface. Dactylus 1.0 mm high proximally, tapering to acute tip; sulcate and with row of setal pits adjacent to occlusal surface; no denticles evident. Pereiopods 2–5 slender, fragmentary, poorly preserved, terminations not known.

Type: Holotype and sole specimen, USNM 593562a and b, are deposited in the United States National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA.

Etymology: The trivial name alludes to the preservational condition of the specimen which renders description difficult.

Occurrence: The specimen was collected from the middle unit of the Gypsum Springs Formation at latitude 44°39'46.54" N, longitude 107°48'38.31"W, Bighorn County, Wyoming.

Discussion: The bases for comparison of this new species with species in other stenochirid genera is much the same as that for *Gypsonicus wyomingensis* new genus, new species. The points of difference between *G. wyomingensis* new genus, new species and *G. obscurus* new genus, new species have been discussed above.

Fig. 11. USNM 593561, multisegmented pleon of unidentified arthropod. Scale bar = 1 cm.

Indeterminate pleon

(Fig. 11)

Discussion: A single specimen of a pleon, USNM 593561, is also present in the Gypsum Springs assemblage of decapods. The preservation is such that its identity as a pleon of a macruran seems likely, but assignment of it to either of the above named species cannot be done with confidence. Evidence of the form of the pleura is lacking, and the specimen is very small, relative to the specimens of the named species. Thus, it seems best to simply note its presence and await further material to make a more precise identification.

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