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1 **First record of a non-paleotropical intejocerid cephalopod from** 2 **Darriwilian (Middle Ordovician) strata of central Spain**

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11
12 **Running Header:** peri-Gondwana intejocerid

13
14 **Abstract.**—The order Intejocerida is an enigmatic, short lived cephalopod taxon, known
15 previously only from Early–Middle Ordovician beds of Siberia and the USA. Here, we
16 report a new genus, *Cabaneroceras* n. gen., and a new species of *C. aznari* n. sp. from
17 Middle Ordovician strata of central Spain. This finding widens the paleogeographic range of
18 the order toward high-paleolatitudinal areas of peri-Gondwana. A curved conch,
19 characteristic for the new genus, was previously unknown from members of the Intejocerida.

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21 UUID: <http://zoobank.org/21f0a09c-5265-4d29-824b-6b105d36b791>
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Introduction

Intejocerids are a unique group of cephalopods, previously known only from Siberia (Balashov 1960, 1962, 1968) and North America (Flower, 1964, 1968; VanCamp Gil, 1988). The most conspicuous characters of intejocerids are their long septal necks, and their large siphuncles, which are filled with heavy lamellar deposits and which form a coral-like radial pattern in cross section. Like other cephalopods with long septal necks and heavy endosiphuncular deposits, intejocerids were relatively large for their time with conch diameters reaching more than 100 mm. The isolated, several decimeter long steinkerns of the specimens described herein occur exclusively and in relative high abundance at a single locality in the northern Ciudad Real province where they are found as the weathered residue of the soft mudstone of the Navas de Estena Formation. The steinkerns are often superficially eroded and parts of the phragmocone, such as septa and outer shell are not preserved. This obstructed the correct identification of these remains as cephalopods, which were originally interpreted as remains of hexactinellid dictyospongids (Gutiérrez-Marco et al., 2013, p. 596, fig. 4c, 2015a, p. 130, fig. 20A). Here, we identify and describe these fossils for the first time in detail.

Geological setting

The examined material comes from three nearby localities in the central part of the Mounts of Toledo area, central Spain, two of them situated within the Cabañeros National Park (‘Los Medianiles’ and ‘Naval delchorro’, see Gutiérrez-Marco et al., 2013, 2015a) and the third immediately adjacent to same (‘Cuesta de Valderuelo’ section, see Reyes-Abril et al., 2010;

Gutiérrez-Marco and Sá, 2017) (Fig.1). This area belongs to the southern part of the Central Iberian Zone of the Iberian Massif, where large outcrops of Paleozoic fossiliferous rocks have been known since the middle half of the XIX century, including early reports and illustrations of Middle Ordovician cephalopods both from the Portuguese (Sharpe, 1849) and Spanish parts (Verneuil and Barrande, 1855).

All studied specimens come from a relatively narrow (5–45 m) stratigraphic interval of fossiliferous mudstones located at the lower third of the Navas de Estena Formation. The formation is a thick (up to 800 m) Darriwilian succession of massive dark mudstones and siltstones, partly with noduliferous horizons. The Navas de Estena Formation (Fm) stratigraphically overlies the Lower Ordovician sandstone group comprising the Armorican Quartzite (Floian age) and the transitional Marjaliza beds (Floian–Dapingian ages).

From north to south, the fossiliferous localities in the Navas de Estena Fm are as follows:

Locality 'Navadelchorro'.—About 10,000 m to the south of Los Navalucillos (province of Toledo), east of Posturero's house on the left bank of the La Calanchera stream (lat. 39° 34' 28" N, long. 4° 39' 13. 7" W). From this locality (Fig. 1.2a) came a single limonitic siphuncle (MGM-8196O), from mudstone beds c. 100 m above the base of the Navas de Estena Formation.

Locality 'Cuesta de Valderuelo'.—Located c. 5,600 m to the SE from Navas de Estena, province of Ciudad Real (lat. 39° 27' 33" N, long. 4° 28' 31" W). This locality corresponds to the bed NE-III A of the section (Reyes-Abril et al., 2010), from which some brachiopods (Reyes-Abril et al., 2010) and ichnofossils (Gutiérrez-Marco and Sá, 2017) were described and illustrated. The locality (Fig. 1.2b) is about 120–135 m above the base of the Navas de Estena Formation, in the

70 southwestern flank of the Navas de Estena syncline. A single siphuncle preserved in shale was
71 found at Cuesta de Valderuelo (MGM-81970).

72
73 *Locality 'Los Medianiles'.*—About 8,700 m to the ENE of Horcajo de los Montes, province of
74 Ciudad Real, in the northern bank of the La Chorrera stream south of Sierra de Valdefuertes (lat.
75 39° 21' 42,2" N, long. 4° 33' 41" W). From this locality (Fig. 1.2c) we have recovered about 90
76 fragments of isolated steinkerns of intejocerid siphuncles. Only few specimens of this collection
77 occurred strictly *in situ*, ca. 80–85 m above the base of the Navas de Estena Formation. The
78 majority of specimens have been collected on a labor field which gently dips south from the
79 narrow outcropping area in the northern flank of La Chorrera Syncline.

80
81 All three localities contain an assemblage of trilobites, brachiopods, mollusks, ostracods and
82 echinoderms, detailed by Gutiérrez-Marco et al. (2013, 2015a) for assemblages from Cabañeros
83 National Park (see also: Reyes-Abril et al. 2010; Gutiérrez-Marco and Sá, 2017) for the Cuesta
84 de Valderuelo section. The occurrence of the graptolite *Didymograptus artus* Elles et Wood, plus
85 some trilobites and brachiopods of regional biochronological significance indicate an early
86 Oretanian age to the assemblage according with the Bohemo-Iberian regional scale (Gutiérrez-
87 Marco et al., 2015b, 2017), equivalent to an early mid Darriwilian age at the global
88 chronostratigraphy (Bergström et al., 2009).

90 **Materials**

The available material consists of isolated steinkerns of siphuncles, partly with impressions of septal necks as moulds within the sediment. The steinkerns consist of massive limonite and limonitic mudstone. No original calcareous material is preserved. Preserved parts of septa and septal necks are silicified. Internal characters of the siphuncles can be traced along pattern of differences in the compactness of the limonite. The cross-sections of the specimens are often slightly diagenetically deformed, which is indicated by the similarly deformed endosiphuncular lamellae. Imprints of bryozoan epizoans occur on the silicified shelly surface of the septal necks and on the surface of the steinkern itself (Figs 2.8, 3.2) (specimen MGM-8181O).

Repositories and institutional abbreviations.—The material described herein is deposited at the Museo Geominero of Madrid (prefixed numbers MGM) which belongs to the Instituto Geológico y Minero de España / IGME (Spanish Geological Survey).

Systematic paleontology

Order Intejocerida Balashov, 1960

Family Padunoceratidae Balashov, 1960

Genus *Cabaneroceras* new genus

Type species.—*Cabaneroceras aznari* n. sp., by monotypy.

Diagnosis.—As for the type species by monotypy.

Occurrence.—Mounts of Toledo, Navas de Estena Formation, central Spain.

Etymology.—The name refers to the Cabañeros National Park in Spain. All currently known specimens of this genus are from this territory or its immediate surroundings (Valderuelo section).

Remarks.—The placement of the new genus within the Padunoceratidae is justified by the occurrence of branching, irregularly shaped lamellar endosiphuncular deposits and the holchoanitic septal necks. *Cabaneroceras* n. gen. differs from other Intejocerids in having a curved conch, a relatively large angle of expansion and relatively shallow concave siphuncular segments. The endosiphuncular lamellae of *Cabaneroceras* n. gen. are relatively widely spaced, similar to *Evenoceras*, from which they differ in forming an irregularly spaced ventral endosiphontube.

Cabaneroceras aznari new species

Figures 2–4,

Holotype.—MGM-81830 (Figs 2.1, 2.5, 2.6, 4.4), Navas de Estena Formation, about 100 m above the base. Lower mid Darriwilian, *Didymograptus artus* graptolite zone, ‘Los Medianiles’ site in the northern flank of the La Chorrera syncline, northeast of Horcajo de los Montes, province of Ciudad Real, central Spain.

Diagnosis.— Slightly curved brevicones with marginal siphuncle. Siphuncle at concave margin of conch curvature with slightly compressed or circular cross-section with angle of expansion of

138 c. 8–12°. Ventral margin of siphuncle slightly flattened. Siphuncle diameter c. three to four times
139 that of septal distance. Siphuncular segments slightly concave. Septal necks holchoanitic.
140 Endosiphuncular deposits longitudinally subdivided into c. 25 irregularly spaced radially
141 arranged lamellae separated by narrow, folded blades as interspaces. Lamellae laterally
142 downcurved toward the ventral side forming an endosiphuncular tube with an irregularly
143 compressed semicircular shape in cross section at ventral side of siphuncle.

144

145 *Occurrence.*—As for genus, by monotypy.

146

147 *Description.*—The holotype is a fragment of a siphuncle, slightly diagenetically laterally
148 compressed with a dorso-ventral diameter of 46–73 mm, a width of 38–60 mm at a length of 135
149 mm, expanding with an angle of 11.5° dorso-ventrally. The siphuncle is slightly curved with the
150 ventral side less curved than the dorsal side. Traces of the septa and septal necks are visible on
151 the steinkern only on the dorsal side of the holotype indicating a slightly concave shape of the
152 siphuncular segments and an at least holchoanitic length of the septal necks that ranges over the
153 entire height of chamber. The former position of the septa is visible around the surface of the
154 holotype as rounded ridges. These ridges are oblique toward the growth axis with an angle that is
155 c. 20° from the angle perpendicular to the growth axis and slopes toward the dorsal
156 (antisiphuncular) side of the conch. In places where the steinkern exposes the inner surface of
157 siphuncular deposits (which is the outer surface of the siphuncle), a number of c. 25 lamellae are
158 visible as broad bands divided by thin (<1 mm) longitudinal grooves. In cross-section, these
159 lamellae are visible, reaching into a depth of up to 20 mm of the siphuncle, where they are
160 radially arranged and irregularly folded leaving a central space or tube filled with massive

limonite. The central tube is eccentrically positioned within the siphuncle with a ventral contact to the siphuncular wall and irregularly compressed, with semicircular cross-section.

Specimen MGM-8184O (Fig. 2.4) is a part of a steinkern of a siphuncle with a maximum diameter of 71 mm; it has a slightly compressed cross section with particularly well preserved holochroanitic septal necks; at its ventral side it is in a contact to the outer shell, which in its best-preserved parts smooth. Details of potential ornamentation are probably not visible due to preservation.

Etymology.—The name was given in honour of Alejandro Aznar, the owner of the private property of the type locality, supporter of the 11th International Symposium on the Ordovician System, Spain, 2011 and producer of the fine Rioja wine "Marqués de Riscal".

Materials.—Seventeen paratype specimens (MGM-8180O – MGM-8189O, MGM-8191O – MGM-8195O, MGM-8198O, and MGM-8199O) were available for closer examination. Fourteen additional, less valuable or more incomplete specimens, were deposited in the same collection MGM-8196O – MGM-8197O, MGM-8200O – MGM-8206O, and MGM-8225O – MGM-8230O.

Remarks.—The material of *Cabaneroceras aznari* n. sp., described above, consists exclusively of fragments of siphuncles. Many of the specimens are also diagenetically slightly deformed. This fragmentary preservation constraints the diagnosis of this new species to the preserved internal characters. However, the erection of a new species and genus is justified, because the

known internal features are unique (see discussion of *Cabaneroceras* n. gen.) and unknown in this combination from any other padunoceratid cephalopod.

Discussion

Little can be said about the taphonomy and depositional history of the material. The now limonitic mineralogy of the steinkerns probably represents a primary deposition and burying under deoxidized conditions with pyrite (FeS) as replacement of organic rich spaces, and later oxidation and dissolution of the calcareous deposits. Alternatively, massive pyrite may have preferentially replaced the shelly material rich in in organics (e.g. nacre), while carbonate poor in organics may have been replaced by crystalline pyrite (pers. comm. D. Evans). The local presence of bryozoan epizoans, which covered parts of already broken septa and outer surfaces of the septal necks is evidence of a relatively complex depositional history with potential secondary reworking.

The massive limonitic parts of the siphuncles are interpreted by us as originally organic rich shelly material, and in contrast, the less massive, more porous limonitic spaces are interpreted as representing areas originally filled with porous calcareous endosiphuncular deposits. This results in a reconstruction of a pattern with a number of radially arranged lamellae and elongated endoconic cells or compartments that were divided by folded interspaces or endosiphoblades (sensu Flower, 1964, see Fig. 4), a reconstruction which is consistent with siphuncular features of better-preserved material of intejocerids, specifically with *Evenoceras* Balashov, 1960 (Balashov, 1960, pl. 28, fig 1; VanCamp, Gil 1988, fig. 14. 6). The siphuncles described herein differ from all other known intejocerids in having a wider angle of expansion, and in being

slightly curved, which justifies the erection of a new genus and probably would be adequate to suggest a new family if more complete material would be available.

Conclusions

Our interpretation and systematic classification of the cephalopod siphuncles collected from the Navas de Estena Formation has two main consequences: (1) The known paleogeographic range of the Intejocerida now widens from restricted to low paleolatitude Siberia and Laurentia toward high latitude peri-Gondwana; (2) the known morphological diversity of the Intejocerida widens significantly from originally restricted to slender orthoconic forms, to now also including slightly curved brevicones. Notably, distinct groups of curved brevicones are known also from other predominantly hemi-holochoantic higher cephalopod taxa, such as the Piloceratidae of the Bisonocerida (comp. Evans and King 2012) and Cyrtendoceratidae of the Endocerida (Teichert 1964).

The intejocerids reported herein also add to the known diversity of Ordovician cephalopods from the Iberian Peninsula. Currently, this includes member of the Ascoceridae, Ellesmerocerida, Endocerida, Orthocerida, Lituitida, and Tarphycerida (see: Babin and Gutiérrez-Marco, 1992; Sá and Gutiérrez-Marco, 2009 for previous compilation). With the exception of two tarphycerid species, most of the previously published taxa are based on poorly preserved material occurring as incomplete moulds and casts in siliceous mudstones and sandstones. The absence of critical internal structures in many of these specimens does not allow for a taxonomic identification at genus or species level and many taxa are in need of a revision. Hopefully, the recent reappraisal of early Paleozoic peri-Gondwanan cephalopod faunas from elsewhere (e. g. Kröger et al., 2012;

Evans et al., 2013, 2015; Bogolepova et al., 2014; Niko and Sone, 2014, 2015; Aubrechtová, 2015; Cichowolski et al., 2015, 2018; Ghavidel-Syooki et al., 2015; Rolet and Plusquellec, 2016; Aubrechtová and Turek, 2018; Manda and Turek, 2018; Ebbestad et al., 2019; Fang et al., 2019) will stimulate future research on the Iberian cephalopods.

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References

- Aubrechtová, M., 2015, A revision of the Ordovician cephalopod *Bactrites sandbergeri* Barrande: Systematic position and palaeobiogeography of *Bactroceras*: *Geobios*, v. 48, p. 193–211.

- 251 Aubrechtová, M. and Turek, V., 2018, Lituitid cephalopods from the Middle Ordovician of
252 Bohemia and their paleobiogeographic affinities: *Bulletin of Geosciences*, v. 93, p. 401–
253 417.
- 254 Babin, C. and Gutiérrez-Marco, J.C., 1992, Intéret paléobiogéographique de la présence du genre
255 *Trocholites* (Cephalopoda, Nautiloidea) dans le Dobrotivá (Llandeilo) inférieur d'Espagne:
256 *Neues Jahrbuch für Geologie und Paläontologie Monatshefte*, v. 1992, p. 519–541.
- 257 Balashov, E.G., 1960, Novye ordovikskie nautiloidei SSSR [New Ordovician nautiloids of the
258 USSR]: *Novye Vidy Drevnikh Rastennyi i Besposvonochnykh SSSR*, v. 2, p. 123–137.
259 [in Russian]
- 260 Balashov, E.G., 1962, Nautiloidei ordovika sibirskoi platformy [Nautiloids of the Ordovician of
261 the Siberian Platform]: *Izdatel'stvo Leningradskogo Universiteta*, 205 p. [in Russian]
- 262 Balashov, E.G., 1968, Endoceratoidei ordovika SSSR [Ordovician Endoceratoidea of the USSR]:
263 *Izdatel'stvo Leningradskogo Universiteta*, 170 p. [in Russian]
- 264 Bergström, S.M., Chen, X., Gutiérrez-Marco, J.C. and Dronov, A.V., 2009, The new
265 chronostratigraphic classification of the Ordovician System and its relations to major
266 regional series and stages and $\delta^{13}\text{C}$ chemostratigraphy: *Lethaia*, v. 42, p. 97–107.
- 267 Bogolepova, O. K., Kröger, B., Falahatgar, M. and Javidan, M., 2014, Middle Ordovician
268 cephalopods from the Abarsaj area, northern Iran: *GFF*, v. 136, p. 34–37.
- 269 Cichowolski, M., Waisfeld, B.G., Vaccari, N.E. and Marengo, L., 2015, The nautiloid Family
270 *Eothinoceratidae* from the Floian of the Central Andean Basin (NW Argentina and South
271 Bolivia): *Geological Journal*, v. 50, p. 764–782.
- 272 Cichowolski, M., Uriz, N.J., Alfaro, M.B. and Galeano Inchausti, J.C., 2018, Ascocerid
273 cephalopods from the Hirnantian? – Llandovery stages of the southern Paraná Basin

274 (Paraguay, South America, first record from high paleolatitudes: *Journal of Paleontology*,
 275 v. 93(1), p. 1–11.

276 Ebbestad, J.O.R., Polechová, M., Kröger, B. and Gutiérrez-Marco, J.C., 2019, Late Ordovician
 277 molluscs of eastern Anti-Atlas, Morocco, *in* Hunter, A.W., Álvaro, J.J., Lefebvre, B., van
 278 Roy, P. and Zamora, S., eds., *The Great Ordovician Biodiversification Event: Insights*
 279 *from the Tafilalt Biota, Morocco*. The Geological Society, London, Special Publication,
 280 v. 485, doi: 10.1144/SP485.9.

281 Evans, D.H. and King, A.H., 2012, Resolving polyphyly within the Endocerida: The
 282 *Bisonocerida* nov., a new order of early Palaeozoic nautiloids: *Geobios*, v. 45, p. 19–28.

283 Evans, D.H., Ghobadi Pour, M. and Popov, L.E., 2013, Review of Early to Mid Ordovician
 284 orthoconic cephalopods from Iran: *Bulletin of Geosciences*, v. 88, p. 21–44.

285 Evans, D.H., Ghobadi Pour, M., Popov, L.E. and Jahangir, H., 2015, An early Silurian
 286 (Aeronian) cephalopod fauna from Kopet-Dagh, north-eastern Iran: including the earliest
 287 records of nonOrthocerid cephalopods from the Silurian of Northern Gondwana: *Bulletin*
 288 *of Geosciences*, v. 90, p. 479–507.

289 Fang, X., Burrett, C., Li, W., Zhang, Y., Zhang, Y., Chen, T. and Wu, X., 2019, Dynamic
 290 variation of Middle to Late Ordovician cephalopod provincialism in the northeastern
 291 peri-Gondwana region and its implications: *Palaeogeography, Palaeoclimatology,*
 292 *Palaeoecology*, v. 521, p. 127–137.

293 Flower, R.H., 1964, *Nautiloid shell morphology*: New Mexico Bureau of Mines and Mineral
 294 *Resources Memoir*, v. 13, p. 1–79.

295 Flower, R.H., 1968, Part I. The first great expansion of the actinoceroids. Part II. Some
 296 additional Whiterock cephalopods: New Mexico Bureau of Mines and Mineral Resources
 297 Memoir, v. 19, p. 1–120.

298 Ghavidel-Syooki, M., Evans, D.H., Ghobadi Pour, M., Popov, L.E., Álvaro, J.J., Rakhmonov,
 299 U., Klishevich, I.A. and Ehsani, M.H., 2015, Late Ordovician cephalopods, tentaculitides,
 300 machaeridians and echinoderms from Kuh-e Faraghan, High Zagros, Iran: *Alcheringa*, v.
 301 39, p. 530–549.

302 Gutiérrez-Marco, J.C. and Sá, A.A., 2017, Primer registro del icnogénero *Phycodes* en el
 303 Ordovícico Medio de los Montes de Toledo (Zona Centroibérica, España): *Boletín de la*
 304 *Real Sociedad Española de Historia Natural, Sección Geológica*, v. 110 (for 2016), p. 43–
 305 48.

306 Gutiérrez-Marco, J.C., Rábano, I., Sá, A.A., García-Bellido, D.C. and Sarmiento, G.N., 2013,
 307 Patrimonio paleontológico del Ordovícico Medio del Parque Nacional de Cabañeros
 308 (Castilla-La Mancha), *in* Vegas, J., Salazar, A., Díaz-Martínez, E. and Marchán, C., eds.,
 309 Patrimonio geológico, un recurso para el desarrollo. Cuadernos del Museo Geominero, v.
 310 15, p. 591–599.

311 Gutiérrez-Marco, J.C., Rábano, I., Sá, A.A., Baeza Chico, E., Sarmiento, G.N., Herranz Araújo,
 312 P. and San José Lancha, M.A. de., 2015a, Geodiversidad e itinerarios geológicos en el
 313 Parque Nacional de Cabañeros [Geodiversity and geological routes in the Cabañeros
 314 National Park], *in* Amengual, P. and Asensio, B., eds., *Proyectos de investigación en*
 315 *parques nacionales: 2010-2013*. Organismo Autónomo Parques Nacionales, Serie
 316 *investigación en la red*, v. 7, p. 105–142.

317 Gutiérrez-Marco, J.C., Sá, A.A., Rábano, I., Sarmiento, G.N., García-Bellido, D.C., Bernárdez,
 318 E., Lorenzo, S., Villas, E., Jiménez-Sánchez, A., Colmenar, J. and Zamora, S., 2015b,
 319 Iberian Ordovician and its international correlation: *Stratigraphy*, v. 12(3-4), p. 257–263.
 320 Gutiérrez-Marco, J.C., Sá, A.A., García-Bellido, D.C. and Rábano, I., 2017, The Bohemo-Iberian
 321 regional chronostratigraphic scale for the Ordovician System and palaeontological
 322 correlations within South Gondwana: *Lethaia*, v. 50(2), p. 258–295.
 323 Kröger, B. and Lefebvre, B., 2012, Palaeogeography and palaeoecology of early Floian (Early
 324 Ordovician) cephalopods from the Upper Fezouata Formation, Anti-Atlas, Morocco:
 325 *Fossil Record*, v. 15, p. 61-75.
 326 Manda, S. and Turek, V., 2018, Silurian tarphycerid *Discoceras* (Cephalopoda, Nautiloidea,
 327 systematics, embryonic development and paleoecology: *Journal of Paleontology*, v. 92, p.
 328 412–431.
 329 Niko, S. and Sone, M., 2014, Actinocerid cephalopods from the Ordovician of Myanmar, and
 330 their paleobiogeographic implications for northern Gondwana: *Paleontological Research*,
 331 v. 18, p. 94-104.
 332 Niko, S. and Sone, M., 2015, Gondwanan nautiloid cephalopods from the Ordovician of
 333 Myanmar: *Paleontological Research*, v. 19, p. 288–294.
 334 Reyes-Abril, J., Villas, E. and Gutiérrez-Marco, J.C., 2010, Orthid brachiopods from the Middle
 335 Ordovician of the Central Iberian Zone (Spain): *Acta Palaeontologica Polonica*, v. 55, p.
 336 285–308.
 337 Rolet, J. and Plusquellec, Y., 2016, Découverte d'un nautiloïde cyrtocône dans les grès
 338 ordoviciens de Bréhec (Massif Armoricain): *Bulletin de la Société Géologique et*
 339 *Minéralogique de Bretagne [D]*, v. 14, p. 3–14.

340 Sá, A.A. and Gutiérrez-Marco, J.C., 2009, Cefalópodos del Ordovícico Medio de la Formación
 341 Valongo, norte de Portugal: *Geogaceta*, v. 47, p. 9–12.
 342 Sharpe, D., 1849, On the geology of the neighbourhood of Oporto, including the Silurian coal
 343 and slates of Valongo: *Quarterly Journal of the Geological Society*, 5, p. 142–153.
 344 Teichert, C., 1964, Endoceratoidea, *in* Moore, R.C., ed., *Treatise on Invertebrate Palaeontology*,
 345 Part K, Mollusca 3. Geological Society of America and the University of Kansas Press,
 346 Boulder, Colorado, p. K160–K189.
 347 Vancamp Gil, A., 1988, Whiterock (lower Middle Ordovician) cephalopod fauna from the Ibex
 348 area, Millard County, western Utah: *New Mexico Bureau of Mines and Mineral*
 349 *Resources Memoir*, v. 44, p. 27–41.
 350 Verneuil, E. de and Barrande, J., 1855, Descriptions des fossiles trouvés dans les terrains silurien
 351 et dévonien d’Almaden, d’une partie de la Sierra Morena et des montagnes de Tolède:
 352 *Bulletin de la Société Géologique de France* [2^e série], v. 12, p. 964–1025.
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Figures and Figure Captions

Figure 1. Details of fossil localities and stratigraphy of the occurrences of *Cabaneroceras aznari* n. sp., Middle Ordovician, central Spain. **(1)** General location of the studied area in the Iberian Peninsula (arrowed). Grey area corresponds to the Neoproterozoic basement and Paleozoic rocks affected by the Variscan Orogeny (Iberian Massif). **(2)** Geological sketch map of a part of the central Mounts of Toledo region showing the position of the localities yielding *Cabaneroceras aznari* n. gen , n. sp. (type locality in c). **(3)** Stratigraphic log of a part of the Navas de Estena Formation with the range of the new taxon.

Figure 2. Siphuncular fragments of *Cabaneroceras aznari* n. sp., from Navas de Estena Formation, Middle Ordovician, central Spain: **(1)** holotype, MGM-8183O, adapical view. **(2)** specimen MGM-8182O, adapical view. **(3)** specimen MGM-8184O, adapical view. **(4)** specimen MGM-8184O, dorsal view. **(5)** holotype, ventral view. **(6)** holotype, lateral view. **(7)** MGM-8186O, lateral view. **(8)** specimen MGM-8181O, ventral view, note horizontal traces of bryozoan overgrowth (see details in Fig. 2b). **(9)** specimen MGM-8198O, lateral view. **(10)** specimen MGM-8187O, lateral view. Scale bars = 10 mm, for specimens **1–8** and **9–10**, respectively. All the specimens were whitened with MgO before photography.

Figure 3. Details of siphuncular fragments of *Cabaneroceras aznari* n. sp., from Navas de Estena Formation, Middle Ordovician, central Spain. **(1)** Longitudinal cross section of steinkern of siphuncular fragment of *Cabaneroceras aznari* n. sp., specimen MGM-8199O. Dark area is

377 massive limonite and probably originally was calcareous endosiphuncular deposit. **(2)** Detail of
378 traces of bryozoan epizoans on specimen MGM-8181O (marked with arrow). Scale bars = 10
379 mm. Specimen in **2** was whitened with MgO before photography.

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381 **Figure 4.** Camera lucida drawings of cross section view of siphuncle steinkerns of
382 *Cabaneroceras aznari* n. sp. from Navas de Estena Formation, Middle Ordovician, central Spain.
383 The radial structures are interpreted here as either interspaces between folded siphuncles, or as
384 endosiphoblades (sensu Flower, 1964). All figured specimens are arranged in a position with
385 assumed ventral side down. Note the different orientation and grade of diagenetic compression,
386 which reflects the original position in the sediment: **(1)** specimen MGM-8188O. **(2)** specimen
387 MGM-8189O. **(3)** specimen MGM-8182O. **(4)** holotype, specimen MGM-8183O. **(5)** Specimen
388 MGM-8180O. Scale bar = 10 mm.

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