Diversity and Distribution of the Genus *Platypeltoides* (Nileidae) in Morocco

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1. Introduction

In the last two years, we have described two new species of the genus *Platypeltoides* (Nileidae, Trilobita) from the Anti-Atlas region of Morocco have been described. Because new material is still appearing in this area, we have considered to review this subject. The aim of this article is to describe all the species of the genus *Platypeltoides* appeared in the Lower Fezouata Formation (Tremadocian, Lower Ordovician) and distributed in three different locations of the Moroccan Anti-Atlas. Several specimens of this genus and kept in the Museo Geológico del Seminario (Barcelona, Spain), Museo Geominero (Madrid, Spain) and the Natural History Museum (London, UK) are here described and discussed. In this paper, all known species of the *Platypeltoides* genus of Morocco are presented. All them appear in the Zagora region and in the Guelmim area. Three species have already been described: *P. magrebiensis*, *P. hammondi* Corbacho & López-Soriano, 2016 [1] and *P. carmenae* Corbacho et al., 2017 [2]. We left two more in open nomenclature, *Platypeltoides aff. carmenae* and *Platypeltoides* sp. Finally, another species changes its genus: *Asaphellus cuervoae* = *Platypeltoides cuervoae*. Indeed, four species (but possibly two more) of the genus *Platypeltoides* are present in the Lower Ordovician of Morocco.

**Keywords:** Trilobita, *Platypeltoides*, Palaeozoic, Tremadocian, Morocco

1. Introduction

In the last two years, we have described two new species of *Platypeltoides* from the Lower Ordovician (Tremadocian) of the Fezouata Shale of Morocco: *P. hammondi* Corbacho & López-Soriano, 2016 [1] and *P. carmenae* Corbacho et al., 2017 [2]. After obtaining two new species, we have decided to write this article, which is a part of the project that, since 2005, we have been developing on the study of the trilobites of the Ordovician of Morocco, supported by the Museo Geológico del Seminario de Barcelona (Spain) and the Department of Paleontology of the Associació de Perits i Taxadors de Catalunya (Spain), founded by one of the authors (JC).

**Historical Background**

The first geological research done in Morocco was carried out by the French geologist Henri Coquand (1813-1881), who collected and described the first fossils [3]. The presence of Ordovician rocks in the Anti-Atlas zone was firstly mentioned by Neltner [4], specifically in the Tafilalt area. Similarly, it was established the existence of the Ordovician system both in the western (Jbel Tachilla, Tiznit area [5]) and central Anti-Atlas (Foum Zguid area; Bondon in [6]).

A long list of authors have studied the trilobite faunas from the Upper and Middle Ordovician of Morocco: Barthoux [7], Termier [6, 8], Neltner [4], Roch [9], Destombes [10-13], Destombes et al. [14] and Rábano [15], and more recently Vela and Corbacho [16], Corbacho [17], Corbacho and Kier [18], López-Soriano and Corbacho [19], Corbacho and López-Soriano [20], Corbacho and Calzada [21], Corbacho et al. [2, 22], and Fortey and Edgecombe [23]. On the other hand, the studies on the trilobites from the Lower Ordovician of Morocco have been carried out by Pruvost (in [24]), Termier and Termier [25], Hupé (in [26]), Destombes [12, 13,
The described species of the genus *Platypeltoides* in Morocco are: *Platypeltoides magrebiensis*? Rábano, 1990; *Platypeltoides cuervoae* (Corbacho & López-Soriano, 2012); *Platypeltoides hammondi* Corbacho & López-Soriano, 2016; and *Platypeltoides carmenae* Corbacho et al. 2017.

### 2. Materials and Methods

#### 2.1. Origin of the Specimens

The specimens examined in this study originate from Anti-Atlas, Morocco and belong to the Lower Ordovician (Tremadocian), Lower Fezouata Formation. All the sites mentioned in this study have been visited by the first author (JC). The images of the holotypes of the different species from the cited publications are presented. *Platypeltoides magrebiensis?* is also represented by the paratype (MGM902X) conserved in the Museo Geominero of Madrid (Spain) and an authentic specimen (MGSB-JC224) conserved in the Museo Geológico del Seminario of Barcelona (Spain) and *P. cuervoae* two paratypes are also presented (MGSB-JC76 and MGSB-JC77) conserved in the Museo Geológico del Seminario of Barcelona (Spain) and one (NHMUK-it28945) conserved in the Natural History Museum of London (UK).

#### 2.2. Preparation and Treatment of Specimens

All the specimens presented in this study, except the holotype and paratype of *P. magrebiensis*, have been treated with ammonium chloride to highlight their details (the quality of the figures of *P. magrebiensis*? has been improved through the PhotoScape software). A Canon digital camera, model EOS 1100 D, has been used to take the pictures. For the coordinates, a Garmin GPS Foretrex 401 model has been used.

### Table 1. Measurements (mm) of the different species of *Platypeltoides* from Morocco

#### *Platypeltoides magrebiensis?*

| Specimen number | TL | EL | CL | DEC | CW | CW1 | GW | FWG | PW | RW | RL | PL |
|-----------------|----|----|----|-----|----|-----|----|-----|----|-----|----|----|
| MGM901X         | 53 | 8  | 20 | 6   | 33 | 24  | 13 | 18  | 27 | 9   | 14 | 17 |
| MGM902X         | 277| 24 | 98 | 27  | 152| 122 | 41 | 52  | 130| 44  | 64 | 88 |
| MGSB-JC224      | 235| 21 | 78 | 17  | 120| 90  | 50 | 70  | 130| 34  | 60 | 70 |

#### *Platypeltoides hammondi*

| Specimen number | TL | EL | CL | DEC | CW | CW1 | GW | FWG | PW | RW | RL | PL |
|-----------------|----|----|----|-----|----|-----|----|-----|----|-----|----|----|
| MGSB-82122      | 165| 17 | 50 | 20  | 129| 80  | 37 | 50  | 74 | 24  | 42 | 54 |

#### *Platypeltoides carmenae*

| Specimen number | TL | EL | CL | DEC | CW | CW1 | GW | FGW | PW | RW | RL | PL |
|-----------------|----|----|----|-----|----|-----|----|-----|----|-----|----|----|
| NHMUK-it29220   | 220| 25 | 94 | 22  | 180| 112 | 50 | 76  | 124| 33  | 50 | 66 |

#### *Platypeltoides cuervoae*

| Specimen number | TL | EL | CL | DEC | CW | CW1 | GW | FWG | PW | RW | RL | PL |
|-----------------|----|----|----|-----|----|-----|----|-----|----|-----|----|----|
| NHMUK-it28944   | 125| 16 | 44 | 16  | 210| 68  | 30 | 44  | 76 | 24  | X  | X  |
| NHMUK-it28945   | 115| 13 | 37 | 15  | 210| 62  | 28 | 42  | 69 | 17  | 32 | 39 |
3. Systematic Paleontology

The specimens indicated under the entries MGSB are housed in the collections of the Museo Geológico del Seminario de Barcelona (Spain), those indicated under the entries NHMUK are housed in the Natural History Museum of London (UK), and those indicated under the entries MGM are housed in the Museo Geominero de Madrid (Spain).

Order ASAPHIDA Salter, 1864
Suborder ASAPHINA Salter, 1864 emend.
Fortey & Chatterton, 1988
Superfamily CYCLOPYGOIDEA Raymond, 1925
Family NILEIDAE Angelin, 1854
Genus Platypeltoides Pribyl in Prantl & Pribyl, 1949
Type species - Platypeltis croftii Callaway, 1877 from the Tremadocian of Shropshire (England, UK).

Geographical and stratigraphical distribution - The genus Platypeltoides is found in the Upper Cambrian, Tremadocian and Floian of Morocco, United Kingdom, Czech Republic, Sweden, Russia, Kazakhstan, China and Mauritania.

The oldest known species is Platypeltoides marginatus Appolonov & Chugaeva, 1983 from the Upper Cambrian of Kazakhstan. Platypeltoides serus Tjernvik, 1956 from Hunnenberg in Sweden has an early Arenig age because of the occurrence with Ekeraspis armata and is the youngest member of this genus. Furthermore, Platypeltoides sp. is reported from the Arenig of Mauritania [51, 52]. Most species are from the Tremadoc. Outside of Morocco, the following species are known:

Platypeltoides brevis (nomen nudum?) – Shinetons, Shales, Garstorn, Shropshire, UK
Platypeltoides croftii (Callaway, 1877) – Shinetons, Shales, Shropshire, UK
Platypeltoides persicus Mergl, 2006 – Millina Formation, Olesna, Bohemia, Czech Rep.
Platypeltoides primaevus (Lake, 1942) – Tyllan Beds, Porthmadog, Wales, UK
Platypeltoides sibirica Ogienko, 1992 – Siberian Plattform, Russia
Platypeltoides uralicus Antsygin, 2001 – South Ural, Russia
Platypeltoides sp. Mergl, 2006 – Trenice Formation, Holoubkov, Czech Republic

The assignation of the fragmentary cranidium to Platypeltoides, described by Peng, Geyer & Hamadi [53] at the Mifa Formation (Elbur’s Mountains, Iran) is not certain. Platypeltoides has seven thoracic segments whereas Troedssonia has eight. Most of the species from China assigned to Platypeltoides belongs therefore to Troedssonia.

3.1. Platypeltoides magrebiensis Rábano, 1990

1969 Platypeltoides Destombes et al., pag. 152, plate 5, figure 1; plate 4, figure 14
1990 Platypeltoides magrebiensis Rábano, pag. 23, figure 1
2016 Platypeltoides magrebiensis? Corbacho & López-Soriano, pag. 15, plate 2

Diagnosis – This species of the genus Platypeltoides is characterized by its large size, moderate relief, absence of a frontal border and a glabellar tubercle on the cephalon, and because it presents large eyes in the juvenile holaspis. The pygidium is smooth, showing only a poorly defined axial ring and a wide pygidial doublure, whose internal line develops in parallel to the pygidial margin [15].

Material – Three specimens are presented. The holotype n° MGM901X (holaspis) has a total carapace length of 53 mm and the paratype n° MGM902X (false specimen) has a total carapace length of 277 mm; they were used for the description of the species and are kept in the Museo Geominero de Madrid (Spain) [15]. The third specimen, with a total carapace length of 235 mm, belongs to the collection of Joan Corbacho kept in Museo Geológico del Seminario de Barcelona (Spain) under the entry MGSB-JC224 (authentic specimen).

Geographical distribution – Upper part of the Lower Fezouata Formation. The studied locality exposes blue green argilites from the Upper Tremadocian, Lower Ordovician (Figure 1, locality nº1). The locality yielding the new trilobite is located approximately 32 km of the SE of Agdz and 14 km of the south of Tansikht, Dra Valley, Morocco. The coordinates of the excavation were 30° 33’ 58” N - 6° 9’ 55” W - Altitude 860 m.

The following trilobite species also appear in this outcrop: Platypeltoides magrebiensis? Rábano, 1990; Asaphellus stubssi Fortey, 2009; Dikelokephalina brenchleyi Fortey, 2010; Hungioides sp.; Platypeltoides hammondi Corbacho & López-Soriano, 2016; and Asaphellus sp.
3.2. Platypeltoides hammondi Corbacho & López-Soriano, 2016

2016 Platypeltoides hammondi Corbacho & López-Soriano, pag. 13, plate 1

Diagnosis – Large-sized Platypeltoides with long genal spines, large eyes located slightly before of the transversal medium line of the cranidium and a completely smooth pygidium [1].

Material – Only a single individual (holotype) is presented. Total carapace length of 220 mm, is kept in the collections of the Museo Geológico del Seminario de Barcelona (Spain), under the entry MGSB82122. Its total carapace length is 165 mm.

Geographical distribution – The studied locality consists of grey-blue ferruginous sandstones which have been assigned to the Upper part of the Lower Fezouata Formation, Lower Ordovician (Upper part of Tremadocian). The studied site is located approximately 710 km of the SW of Rabat, in the administrative area of Agadir and NW of Assa in Guelmim area; Western Anti-Atlas, Morocco (Figure 1, locality nº 3). The coordinates of the site are N 28º 43’ 31” and W 009º 36’ 31” - Altitude 689 m.

The following trilobite species also appear in this outcrop: Lehua tahirii Corbacho, 2008; Lehua sp. and Megistaspis (E.) hammondi forteyi Corbacho & Vela, 2010; Platypeltoides cuervoae (Corbacho & López-Soriano, 2012); and Parabathycheilus gallicus Dean, 1965.

3.3. Platypeltoides carmenae Corbacho et al., 2017

2017 Platypeltoides carmenae Corbacho et al., pag. 21, plates 1 – 4

Diagnosis – Platypeltoides of large size, with a slightly subtriangular-shaped cephalon and medium-sized genal spines, large eyes located in the transverse median line of the cranidium, a thin anterior border and a slightly subtriangular pygidium with three axial rings and a terminal axial piece [2].

Material – Only a single individual (holotype) is presented. Total carapace length of 220 mm, is kept in the collections of the Natural History Museum of London (UK), under the entry NHMUK-it29220.

Geographical distribution – The studied locality consists of grey-blue ferruginous sandstones which have been assigned to the Upper part of the Lower Fezouata Formation, Lower Ordovician (Upper part of Tremadocian). The studied site is located approximately 710 km of the SW of Rabat, in the administrative area of Agadir and NW of Assa in Guelmim area; Western Anti-Atlas, Morocco (Figure 1, locality nº 3). The coordinates of the site are N 28º 43’ 31” and W 009º 36’ 31” - Altitude 689 m.

The following trilobite species also appear in this outcrop: Lehua tahirii Corbacho, 2008; Lehua sp. and Megistaspis (E.) hammondi forteyi Corbacho & Vela, 2010; Platypeltoides cuervoae (Corbacho & López-Soriano, 2012); and Parabathycheilus gallicus Dean, 1965.

3.4. Platypeltoides cuervoae (Corbacho & López-Soriano, 2012)

2012 – Asaphellus cuervoae Corbacho & López-Soriano, pag. 4, plates 1 - 3
2014 – Asaphellus cuervoae Corbacho & Calzada, pag. 22, plate 1
2018 - Asaphellus cuervoae Lebrun [54], pag. 83, fig. D

Diagnosis – Platypeltoides species of medium size, characterized by large eyes (approximately 30% of the glabellar length), with long and wide genal spines extending perpendicularly from the cephalon and making a 90° angle with the axis (sag.); the spines slightly towards their terminal
part. The other characteristics are typical of the genus Platypeltoides.

**Material** – Four specimens are presented. The holotype, with a length of 125 mm, is kept in the Natural History Museum of London (UK) under the annotation NHMUK-it28944. A paratype, with a length of 115 mm, is kept in the Natural History Museum of London (UK) under the annotation NHMUK-it28945. Two additional paratypes, with a total length of 120 mm and 95 mm, are kept in the collection of Joan Corbacho in the Museo Geológico del Seminario de Barcelona (Spain), under the annotations MGSB-JC76 and MGSB-JC77 respectively.

**Geographical distribution** – The studied locality consists of grey-blue ferruginous sandstones which have been assigned to the Upper part of the Lower Fezouata Formation, Lower Ordovician (Upper part of Tremadocian). The studied site is located approximately 710 km of the SW of Rabat, in the administrative area of Agadir and NW of Assa in Guelmim area; Western Anti-Atlas, Morocco (Figure 1, locality nº 3). The coordinates of the site are N 28º 43’ 31” and W 009º 36’ 31” - Altitude 689 m.

The following trilobite species also appear in this outcrop: *Lehua tahirii* Corbacho, 2008; *Lehua* sp. and *Megistaspis* (E.) *hammondii* Corbacho & Vela, 2010; *Platypeltoides carmenae* Corbacho et al. 2017; and *Parabathycheilus gallicus* Dean, 1965.

**Discussion** – When this species was first described, the extremely long genal spines and other particular characteristics caused us to underestimate the importance of the number of segments, and for this reason it was assigned to the genus *Asaphellus*. With the study of new complete and well-preserved specimens, it has been proven that they only have 7 thoracic segments, so they should be assigned to the genus *Platypeltoides*.

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**3.5. Platypeltoides aff. carmenae Corbacho et al., 2017**

2017 *Platypeltoides aff. carmenae* Corbacho et al., pag. 21

**Diagnosis** – *Platypeltoides* of large size, with a slightly subtriangular-shaped cephalon and medium-sized genal spines, large eyes located in the transverse median line of the cranidium, a narrow border and a subtriangular pygidium with three axial rings and a terminal axial piece [2].

**Material** – A single specimen with a total carapace length of 155 mm is included. It is kept in the collection of Keith Hammond in the Museo Geológico del Seminario de Barcelona (Spain), under the annotation MGSB-KH2b.

**Geographical distribution** – Upper part of the Lower Fezouata Formation. The studied locality exposes blue green argillites from the Upper Tremadocian. The locality yielding the new trilobite is located approximately 21 km al N de Zagora, Dra Valley, Morocco (Figure 1, locality nº2). The coordinates of the site are N 30º30’54” – W 5º45’24” - Altitude 804 m.

The following trilobite species also appear in this outcrop: See figure 6.

**Discussion** – Because only one specimen is available, it is left in open nomenclature.

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**3.6. Platypeltoides sp.**

**Material** – A single specimen with a total carapace length of 56 mm is included. It is kept in the collection of Joan Corbacho in the Museo Geológico del Seminario de Barcelona (Spain), under the annotation MGSB- JC561.

**Geographical distribution** – Upper part of the Lower Fezouata Formation. The studied locality exposes blue green argillites from the Upper Tremadocian. The locality yielding the new trilobite is located approximately 21 km al N de Zagora, Dra Valley, Morocco (Figure 1, locality nº2). The coordinates of the site are N 30º30’54” – W 5º45’24” - Altitude 804 m.

The following trilobite species also appear in this outcrop: *Megistaspis* (E.) *hammondii* Corbacho & Vela, 2010; *Platypeltoides aff. carmenae* Corbacho et al., 2017; *Parabathycheilus gallicus* Dean, 1965; and *Symphysurus angustatus* Boeck, 1838.
**Discussion** – Only one specimen is available. Here we propose that it could be a juvenile specimen because of the large size of its eyes, as it also occurs with the holotype of *P. magrebiensis*, which is a holaspis (Plate 1, fig. b) since the length of their carapaces are almost equal. The small spines that it presents are normal in the juvenile specimens of some species of *Platypeltoides*, that are subsequently lost when arriving at the adult phase of development. For these reasons, it is left in open nomenclature.

**4. Conclusion**

Regarding the diversity of the genus *Platypeltoides*, four described species and two possible new species to be described are included in this report. In Morocco, until 2016, only *Platypeltoides magrebiensis* was recorded in the Zagora region, but this study shows that the distribution of *Platypeltoides* is concentrated both in the Zagora region and in the Guelmim area. All them appear in the Lower Fezouata Formation (Tremadocian), Lower Ordovician. The presence of well developed genal spines in adult specimens is a very particular characteristic of the species *P. hammondi*, *P. cuervoae* and *P. carmenae*; they are the only three species in which this characteristic has been observed in this genus.

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**References**

[1] J. Corbacho, and F. J. López-Soriano (2016) *Platypeltoides hammondi* (Trilobita, Nileidae): A new species from the Upper Tremadoc of the Dra Valley, Morocco. *Batalleria* 23: 11-19.

[2] J. Corbacho, F. J. López-Soriano, U. Lemke, and K. Hammond (2017) *Platypeltoides carmenae*: A new Nileidae (Trilobita) from the Lower Ordovician (Tremadocian) of Guelmim area; Western Anti-Atlas, Morocco. *Batalleria* 25: 20-29.

[3] H. Coquand (1847) Description géologique de la partie septentrionale de l'Empire du Maroc. *Bull. Soc. Geol. France* 4: 1188-1249.

[4] L. Neltner (1929) Etat des connaissances actuelles sur la géologie du Maroc. *C. R. 15ème. Congr. Géol. Int. Pretoria* 2: 550–556.

[5] D. Bigot, and G. Dubois (1931) Sur la présence de l'Ordovicien dans l'Anti-Atlas marocain. *C. R. Acad. Sci. Paris* 193: 282–293.

[6] H. Termier (1936) Etudes géologiques sur le Maroc occidental et le Moyen-Atlas septentrional. *Notes Mém. Serv. Géol. Maroc* 33: 1–156.

[7] J. C. Barthoux (1924) Les massifs de Djebilet et des Rehamna (Maroc). *C. R. Acad. Sci. Paris* 179: 504–506.

[8] H. Termier (1927) Observations nouvelles en Maroc central. *C. R. Somm. Soc. Géol France* 9: 100–102.

[9] E. Roch (1930) Etudes géologiques dans la région méridionale du Maroc occidental. *Mém. Serv. Géol. Maroc* 9: 1–542.

[10] J. Destombes (1963) Quelques nouveaux Phacopina (trilobites) de l’Ordovicien supérieur de l’Anti-Atlas (Maroc). *Notes Serv. Géol. Maroc* 23: 172, 1963.

[11] J. Destombes (1966) Quelques Calymenina (Trilobitae) de l’Ordovicien moyen et supérieur de l’Anti-Atlas (Maroc). *Notes Serv. Géol. Maroc* 26: 33-44.

[12] J. Destombes (1967) Distribution et affinités des genres de trilobites de l’Ordovicien de l’Anti-Atlas (Maroc). *C. R. Somm. Soc. Géol. 4*: 133–134.

[13] J. Destombes (1971). L’Ordovicien au Maroc. Essai de synthese stratigraphique. *Mém. Bur. Rech. Géol. Min.* 73: 237–263.

[14] J. Destombes, H. Hollard, and S. Willefert (1985) Lower Palaeozoic rocks of Morocco. In Hollard, H. (ed.). Lower Palaeozoic Rocks of the World. Volume 4. *Lower Palaeozoic of North-western and West-central Africa*. Wiley, New York, pp. 91-336.

[15] I. Rábano (1990) Trilobites del Museo GeoMinero. I. *Platypeltoides magrebiensis* n. sp. (Asaphina, Nileidae), del Ordovírico inferior del Anti-Atlas central (Marruecos). *Boletín GeoMinero* 101: 21-27.

[16] J. A. Vela, and J. Corbacho (2009) New trilobites from Upper Ordovician of El Kaid Errami (Morocco). *Batalleria* 14: 99-106.
19 J. Corbacho (2011) Upper Ordovician trilobites of Bou Nemrou – El Kaid Errami (Morocco). Batalleria 16: 16-36.

18 J. Corbacho, and C. Kier (2011) Trilobites of a new outcrop of Upper Ordovician in Jbel Tifarjaouine, El Kaid Errami (Morocco), with first mention of genus Corrugatagnostus. Scripta Musei Geologici Seminarii Barcinonensis [Ser. palaeontologica] 10: 7-22.

19 F. J. López-Soriano, and J. Corbacho (2012) A new species of Symphysops from the Upper Ordovician (Lower Ashgill) of Morocco. Batalleria 17: 13-20.

20 J. Corbacho, and F. J. López-Soriano (2013) Chattasiopsis budili: A new Dalmanitidae species from Morocco; Upper Ordovician (Lower Katian). Batalleria 19: 6-12.

21 J. Corbacho, and S. Calzada (2014) Possible dimorphism sexual in Trilobites del Ordovícico inferior. Batalleria 21: 22-26.

22 J. Corbacho, S. Morrison, and A. Ait Addi (2014) Diodiinae carlottae: Una nueva especie de Diodiidae (Trilobita) del Ordovícico superior de Marruecos. Batalleria 21: 13-21.

23 R. A. Fortey, and G. D. Edgecombe (2017) An Upper Ordovician (Katian) trilobite fauna from the Lower Ktaoua Formation, Morocco. Bull. Geosci. 92: 1-12.

24 E. Roch (1939) Description géologique des montagnes à l’Est de Marrakech. Notes Mém. Serv. Géol. Maroc 51: 1-438.

25 G. Termier, and H. Termier (1950) Paléontologie marocaine 2 (4). Invertébrés de l’Ere Primaire. Annélides, arthropodes, échinodermes, conularides et graptolithes. Notes Mém. Serv. Géol. Maroc 79: 1-279.

26 G. Choubert, J. Hindermeyer, and P. Hupé (1955) Découverte du Trémadoc dans l’Anti-Atlas (Maroc). C. R. Acad. Sci. Paris 241: 1592–1594.

27 J. Destombes (1962) Stratigraphie et paléogéographie de l’Ordovícien de l’Anti-Atlas (Maroc): un essai de synthèse. Bull. Soc. Géol. France 7: 453-460.

28 J. Destombes (1972) Les trilobites du sous-ordre des Phacopina de l’Ordovícien de l’Anti-Atlas (Maroc). Notes Mém. Serv. Géol. Maroc 32: 1-114.

29 J. Destombes (2006) Carte géologique au 1/200 000 de l’Anti-Atlas marocain. Paléozoïque inférieur. Cambrien moyen et supérieur-Ordovícien-base du Silurien. Sonnaire général sur les Mémoires explicatifs des cartes géologiques au 1/200 000 de l’Anti-Atlas marocain. Notes Mém. Serv. Géol. Maroc 515 (149 pp.).

30 J. Destombes (2006) Carte géologique au 1/200 000 de l’Anti-Atlas marocain. Paléozoïque inférieur. Cambrien moyen et supérieur-Ordovícien-base du Silurien. Feuille Zagora-Coule du Dra. Mémoire explicatif, Chapitre A [written in 1983]. Notes Mém. Serv. Géol. Maroc 273 (bis, 36 pp.).

31 J. Destombes (2006) Carte géologique au 1/200000 de l’Anti-Atlas marocain. Paléozoïque inférieur. Cambrien moyen et supérieur-Ordovícien-base du Silurien. Feuille Bou Haiara-Zegdou. Mémoire explicatif, Chapitre B [written in 1983]. Notes Mém. Serv. Géol. Maroc 259 (bis, 30 pp.).

32 J. Destombes (2006) Carte géologique au 1/200 000 de l’Anti-Atlas marocain. Paléozoïque inférieur. Cambrien moyen et supérieur-Ordovícien-base du Silurien. Feuille Jbel Saghrodès. Mémoire explicatif, Chapitre C [written in 1983]. Notes Mém. Serv. Géol. Maroc 161 (bis, 41 pp.).

33 J. Destombes (2006) Carte géologique au 1/200 000 de l’Anti-Atlas marocain. Notice explicative. Paléozoïque inférieur. Cambrien moyen et supérieur-Ordovícien-base du Silurien. Feuille Todra-Maître. Mémoire explicatif, Chapitre D [written in 1985]. Notes Mém. Serv. Géol. Maroc 243 (bis, 58 pp.).

34 J. Destombes (2006) Carte géologique au 1/200 000 de l’Anti-Atlas marocain. Paléozoïque inférieur. Cambrien moyen et supérieur-Ordovícien-base du Silurien. Feuille Tafilt-Taouz. Mémoire explicatif, Chapitre E (Anti-Atlas oriental) [written in 1987]. Notes Mém. Serv. Géol. Maroc 244 (bis, 69 pp.).

35 J. Destombes (2006) Carte géologique au 1/200 000 de l’Anti-Atlas marocain. Paléozoïque inférieur. Cambrien moyen et supérieur-Ordovícien-base du Silurien. Feuille Telouet Sud, Ourazzate, Alougoum, Agadir-Tissint. Mémoire explicatif, Chapitre F [written in 1988]. Notes Mém. Serv. Géol. Maroc 138 (bis, 43 pp.).

36 M. Vidal (1996) Biofaciés à trilobites dans l’Ordovícien inférieur de l’Anti-Atlas, Maroc: paléoenvironnements et paléobiogéographie. Université de Rennes 1, Unpublished thesis (142 pp.).

37 M. Vidal (1998) Trilobites (Asaphidae et Raphiphoridae) de l’Ordovícien inférieur de l’Anti-Atlas, Maroc. Palaeontogr. Abt. A 251: 39–77.

38 M. Vidal (1998) Le modèle des biofaciés à trilobites: un test dans l’Ordovícien inférieur de l’Anti-Atlas, Maroc. C. R. Acad. Sci., Paris [Sci. terre planêt.] 327: 327–333.

39 J. A. Vela (2007) Three new species of Lehua from the Lower Ordovician of Dra Valley of Morocco. Scripta Musei Geologici Seminarii Barcinonensis [Ser. palaeontologica] 4: 24-37.

40 J. A. Vela, and J. Corbacho (2007) A new species of Lehua from Lower Ordovician of Dra Valley of Morocco. Batalleria. 13: 78-80.

41 J. Corbacho (2008) Tres nuevas especies del Género Lehua del Ordovícico Inferior del Valle de Dra (Marruecos). Scripta Musei Geologici Seminarii Barcinonensis [Ser. palaeontologica] 5: 3-13.

42 R. A. Fortey (2009) A new giant Asaphid trilobite from the Lower Ordovician of Morocco. Mem. Assoc. Australasian Palaeontol. 37: 9-16.

43 R. A. Fortey (2010) Trilobites of the genus Dikelokephalina from Ordovician Gondwana and Avalonia. Geol. J. 46: 405-415.

44 R. A. Fortey (2011) The first known complete lichakephalid trilobite, Lower Ordovician of Morocco. Mem. Assoc. Australasian Palaeontol. 42: 1-7.

45 J. Corbacho, and J. A. Vela (2010) Giant trilobites from Lower Ordovician of Morocco. Batalleria 15: 3-32.

46 J. Corbacho, and J. A. Vela (2011) Revisión de las especies de Lehua de la región de Zagora (Marruecos). Batalleria 16: 46-49.

47 J. Corbacho, and J. A. Vela (2013) Paramblichias marochii: New genus and species of Lichidiae from the Zagora region (Morocco); Early Ordovician (Florian). Scripta Musei Geologici Seminarii Barcinonensis [Ser. palaeontologica] 14: 3-13.
[48] J. Corbacho, and F. J. López-Soriano (2012) A new asaphid trilobite from the Lower Ordovician (Arenig) of Morocco. *Batalleria* 17: 3-12.

[49] M. Basse (2012) *Fossilium Catalogus I: Animalia. Pars 150. Trilobites Africae: Catalogus typorum.* Margraf Publishers. 311 pp.

[50] U. Lemke (2018) Catalogue of the available names and non available names of the species and subspecies for the Class Trilobita. DOI: 10.13140/RG.2.2.16878.72007

[51] J. Destombes, J. Sougy, and S. Willefert (1969) Révision et découvertes paléontologiques (Brachiopodes, Trilobites et Graptolites) dans le Cambro-Ordovicien du Zemmour (Mauritanie Septentrionale). *Bull. Soc. Géol. France* 11: 185-206.

[52] R. Trompette (2012) Le Precambrien supérieur et le Paléozoïque inférieur de l’Adrar de Mauritanie (bordure occidentale du bassin de Taoudeni, Afrique de l’Ouest), un exemple de sedimentation de craton. *Etude Stratigraphique et Sedimentologique*, Tome 2 (Series 2 et 3).

[53] S. Peng, G. Geyer, and B. Hamdi (1999) Trilobites from the Shahmirzad section, Alborz Mountains, Iran; their taxonomy, biostratigraphy and bearing for international correlation. *Beringeria* 25: 3-66.

[54] Lebrun, P. (2018). *Fossiles du Maroc. Tome I. Gisements emblématiques du 246 Paléozoïque de l’Anti-Atlas. Fossils from Morocco. Volume I. Emblematic 247 localities from the Palaeozoic of the Anti-Atlas.* Les Editions du Piat – Glavenat, 248 304 pp.