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Cosmopolitan myodocope ostracods from the Silurian of Uzbekistan, Central Asia

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Abstract – Four species of myodocope ostracods are documented from the Silurian Ludlow Series of the Aburtkan gorge on the southern slope of Dzhalpak Mountain, Uzbekistan: namely, *Parabolbozoë bohemica* (Barrande, 1872), *Bolbozoë anomala* Barrande, 1872, *Silurocypridina calva* Perrier, Vannier and Siveter, 2011 and *Richteria migrans* (Barrande, 1872). These species have a palaeogeographically widespread trans-oceanic distribution, which supports the notion that Silurian myodocopes signify the earliest zooplanktonic ostracods. *Richteria migrans* (Barrande, 1872), in particular, provides a precise intercontinental biostratigraphic marker that identifies rocks of the upper Gorstian to upper Ludfordian stages.

Keywords: Ludlow Series / Myodocopa / Ostracoda / palaeobiogeography / plankton / Silurian

Résumé – Les ostracodes myodocopes cosmopolites du silurien Asie centrale. Quatre espèces d’ostracodes myodocopes sont documentées dans le Silurien (Ludlow) des gorges d’Aburtkan sur le versant sud de la montagne Dzhalpak en Ouzbékistan: *Parabolbozoë bohemica* (Barrande, 1872), *Bolbozoë anomala* Barrande, 1872, *Silurocypridina calva* Perrier, Vannier et Siveter, 2011, et *Richteria migrans* (Barrande, 1872). Ces espèces ont une distribution paléogéographique trans-océanique durant le Silurien. Cette distribution cosmopolite soutient l’idée que les myodocopes siluriens représentent la première faune d’ostracodes zooplanctoniques. *Richteria migrans* (Barrande, 1872), en particulier, est un marqueur biostratigraphique intercontinental précis qui permet de dater les roches du Gorstien supérieur au Ludfordien supérieur.

Mots clés : Ludlow / Myodocopa / Ostracoda / paléobiogéographie / plancton / Silurian

1 Introduction

During the 1980s and 1990s analysis of distributional and facies data of Silurian myodocopes suggested that some species had colonised pelagic niches during that time and therefore represented the earliest known record of zooplanktonic ostracods (Siveter, 1984; Siveter et al., 1987, 1991; Siveter and Vannier, 1990; Vannier and Abe, 1992; see also Perrier et al., 2015). Subsequent studies of Silurian myodocopes have focused on their systematics, habitats, lifestyles, and biostratigraphical and palaeobiogeographical utility (Perrier et al., 2007, 2011, 2014a–c, 2019a–c; Perrier, 2012; Perrier and Siveter, 2013). These studies are underpinned by the discovery of five exceptionally preserved myodocope ostracod species from the Silurian, in the Herefordshire Lagerstätte, Welsh Borderland, UK, which provides precise data on the soft anatomy of ancient representatives of the group (Siveter et al., 2003, 2007, 2010, 2013, 2015, 2018).

Myodocope ostracods were identified in the Silurian of Uzbekistan as early as 1966, when fieldwork by A.I. Kim and E. Mikhailova yielded material from the Ludlow Series at the village of Kanda in the North Nuratau Ridge. Written records of myodocopes from Uzbekistan are few. Brief mentions occur in the unpublished theses of Mikhailova (1972, 2000), which list three species of *Cypridina* Milne-Edwards, 1840 from the
Pridoli Series of the Kyzyl-Kum Hills of the Tamdy-Tau massif and from the Devonian Lochkovian Stage of the Turkestan Range and Zeravshan Range respectively; species under the names *Entomozoe* (*Richteria*) cf. *migrans* (Barrande, 1872) from the Ludlow of the North Nuratau Ridge and *Entomozoe* aff. *subphalanga subphalanga* Polenova, 1970 and *Entomozoe* aff. *tuberosa* (Jones, 1861) from the Lochkovian of the Turkestan range; and a new monotypic polycopid genus from the Lochkovian of the Turkestan range. A few myodocope genera (*Bolbozoe*, *Entomozoe* and *Cypridina*) were also listed in Mikhailova’s (1981) publication on Pridoli ostracods from the Kyzyl-Kum Hills. Fieldwork undertaken by the present authors in 2014 yielded many additional Silurian myodocope specimens and newly recorded species from the locality at Kanda, and these are the basis of the present paper. Our studies recognise four cosmopolitan myodocope species from the Silurian of Uzbekistan, allowing detailed biostratigraphical correlations with other regions.

2 Locality and stratigraphy

The myodocopes were collected from a section outcropping north of the spring at the northern edge of the small hamlet of Kanda, along the side of the Aburtkan gorge on the southern slope of Dzhalpak Mountain. The locality (40°25’40"N, 66°28’05"E; Fig. 1) lies on the southern slopes of the North Nuratau Ridge and is about 10 km east of the small town of Dzjush, and some 100 km north-west of Samarkand. The outcrops in the area of the villages of Kanda, Shaly, Chashma-Zrak and others (the Jalpak and Gavalbet mountains) have been known since the middle part of the 20th century but very little has been published on them. The Silurian rock successions are part of the Merishkor synform and collectively are known as the Merishkor sections (Kim, 1966). They consist of richly fossiliferous carbonate and clastic rocks of mostly Silurian Wenlock Series to middle Carboniferous age that have been uplifted and folded during the late Palaeozoic to form part of the southern Tien Shan fold and thrust belt (see, e.g., Biske and Seltmann, 2010; McCann et al., 2013). The myodocope-bearing rocks are cyclically arranged calcareous siltstones and mudstones which, following the Uzbek regional stratigraphic scheme, are termed the upper member of the Aburtkan beds of the Khotynbulak Formation. Associates of the myodocopes are orthoconic nautilioids, graptolites, rare small brachiopods and plant fragments; ichnofossils are also present.

These deposits are considered to have accumulated in a low energy, open deep-water shelf/shelf slope setting (Mikhailova and Tarasenko, 2015). Graptolites from various outcrops and stratigraphic levels of the upper member of the Aburtkan beds comprise *Pristiograptus* ex gr. *dubius*, *Pristiograptus* cf. *tunescens*, *Saetograptus leintwardinensis*, *Saetograptus chimaera*, *Colo- nograptus* sp., *Monograptus* ex gr. *haupi*, *Bohemograptus bohemicus*, *Bohemograptus bohemicus tenius*, *Neo diversograptus nilssoni*, *Linograptus* sp. and *Lobograptus simplex* and *Lobograptus progenitor* (T.N. Koren of VESEGI, St Petersburg; unpublished list of graptolite taxa sent to Uzbek...
3 Material and methods

The bivalved carapace of Silurian myodocopes is presumed to have been weakly calcified in life with a probable ligamentum dorsal connection. The myodocopes in our collections occur as internal and external moulds. Due to intense weathering in what is a hot desert area the ostracods are poorly preserved. Among several hundred specimens collected, 71 were firmly identified and are considered in the present paper. Many of the moulds preserve an adductor muscle scar/spot sub-centrally, corresponding to the site of attachment of the adductor muscle. The surface of the carapace may be smooth or have a range of types of ornament, including reticulation, corrugation and punctuation. Some valves show post-mortem diageneric features, such as “rosettes”, similar to features described from Silurian myodocopes of European areas (Siveter et al., 1987).

Rock matrix was removed from the specimens mechanically using fine needles. Casts of external moulds of all of the ostracods recovered were made with silicone rubber (Silcoset 105) using the technique of Siveter (1982). Specimens occurring as internal moulds and casts were coated with a thin layer of ammonium chloride and photographed using a Leitz Aristophot mounted with a Canon EOS 5D camera following the methods of Siveter (1990). Morphological terminology used here follows that of Siveter et al. (1987) and Perrier (2012).

The four central Asian Silurian myodocope species reported on here, are also present in the UK and have been fully revised by Perrier et al. (2019a). Perrier et al. (2019a) presents full synonymies of these four species. Repositories for the figured ostracods are: Université Claude Bernard Lyon 1, France (FSL), University of Brest, France (LPB), Národní Museum, Prague, Czech Republic (NM-L) and The Polish Academy of Science, Warsaw, Poland (ZPAL). All the newly described and figured material is deposited in Oxford University Museum of Natural History (OUMNH).

4 Systematic palaeontology

Class OSTRACODA Latreille, 1802 (nom. correct Latreille, 1806)
Subclass MYODOCOPA Sars, 1866

Order MYODOCOPIDA Sars, 1866
Suborder MYODOCOPINA Sars, 1866
Superfamily BOLBOZOOIDEA sensu BOLBOZOACEA
Bouček, 1936
Family BOLBOZOIDAE Bouček, 1936

Genus Bolbozoe Barrande, 1872

Type species. – Bolbozoe anomalum Barrande, 1872; subsequent designation by Bassler and Kellett, 1934. Ludlow Series, Silurian, Prague, Czech Republic.

Other species. – Bolbozoe acuta Perrier et al., 2011, Bolbozoe beccata Perrier et al., 2014c, Bolbozoe largiglobosa Wang and Zhang, 1983, Bolbozoe parvafraga Perrier et al., 2011, Bolbozoe psittaca Perrier et al., 2019a, Bolbozoe rugosa Perrier et al., 2011, Bolbozoe sp. nov. A of Perrier et al., 2019a, Bolbozoe sp. nov. B of Perrier et al., 2019a and possibly Bolbozoe jonesi Barrande, 1872.

Stratigraphic and geographic range. – Upper part of the Wenlock Series, Silurian, to Emsian Stage, Devonian; Czech Republic (Perrier et al., 2011), France (Perrier et al., 2011), Sardinia (Gnoli et al., 2009), China (Wang, 2009), Australia (Perrier et al., 2014c), Wales (Perrier et al., 2019a) and Poland (Perrier et al., 2019b).

Bolbozoe anomalum Barrande, 1872 (Figs. 2D, 2H, 2I, 3C, 3G, 3K, 3O and 3S) 2019a Bolbozoe anomalum Barrande, 1872; Perrier et al.: pl. 3, figs. 1–18 (see p. 26 for full synonymy).

2019b Bolbozoe anomalum Barrande, 1872; Perrier et al.: pl. 2A and 2B.

2019c Bolbozoe anomalum Barrande, 1872; Perrier et al.: fig. 7C.

Type material. – Lectotype (designated Príbyl, 1988: 119), a right valve, NM-L 23572 (ex. CE1194); Barrande, 1872: pl. 24, figs. 29 and 30; Perrier et al., 2011: pl. 1, fig. 1. Paralectotype (designated Príbyl, 1988: p. 119), a left valve, NM-L 13993; Barrande, 1872: pl. 24, figs. 27 and 28; Perrier et al., 2011: pl. 1, fig. 2.

Type locality. – Lochkov suburb of Prague, Czech Republic.

Type horizon. – Požáry Formation, Pridoli Series, stratigraphical division e2 of Barrande, 1872 (Kříž, 1992).

Material. – Twelve valves from the outcrop at Kanda.

Description. – Adult valve sub-ovoidal, slightly tapering posteriorly. Anterior third of valve mostly occupied by a large hemispherical bulb forming c. 20–25% of valve area; bulb-centre lies just above valve mid-height and well above other surface areas of valve. Maximum valve length is just above bulb mid-height; maximum valve height is at mid-length and maximum valve width is at central part of bulb. A deep, narrow sulcus surrounds the bulb posteriorly and ventrally. An adductor muscle scar occurs at mid-length within the sulcus. Ridges and furrows typical of the muscle scar pattern of the species are not visible in the Uzbek material. In adults, rostrum is very small, in some cases beak-like or absent. Early ontogenetic stages are more rounded in valve outline and the bulb is relatively larger than in adults.

Remarks. – Though the Uzbek material is poorly preserved its features are diagnostic of B. anomalum. It differs from other smooth species of Bolbozoe by its rounded shape (B. psittaca is elongated; Perrier et al., 2019a), its tiny rostrum (B. beccata has been prominent beak-like rostrum; Perrier et al., 2014c) and
the lack of a well-developed caudal process (present in B. acuta; Perrier et al., 2011, 2019a).

Stratigraphic and geographic range.—Ludlow Series, North Nuratau Ridge, Uzbekistan. Also known from the upper part of the Wenlock to at least the middle part of the Pridoli Series. Occurs in the Czech Republic, France, Sardinia (Perrier et al., 2011), Wales and England (Perrier et al., 2019a), and Poland (Perrier et al., 2019b). If B. jonesi is conspecific with B. anomala the range of the species would extend into the Lochovian Series, Lower Devonian (see Perrier et al., 2011).

Genus Parabolbozoe Přibyl, 1988

Type species.—Bolbozoe bohemica Barrande, 1872; by monotypy. Ludlow Series, Silurian, Prague, Czech Republic.

Other species.—Parabolbozoe armoricana Perrier et al., 2011 and Parabolbozoe britannica Perrier et al., 2019a.

Stratigraphic and geographic range.—Upper part of the Wenlock to Ludlow or Pridoli Series. Known from the Czech Republic (Perrier et al., 2011), France (Perrier et al., 2011), Sardinia (Gnoli et al., 2009), Wales and England (Perrier et al., 2019a), and Poland (Perrier et al., 2019b).

Parabolbozoe bohemica (Barrande, 1872) (Figs. 2E–2G, 3B, 3F, 3J, 3N and 3R)

2019a Parabolbozoe bohemica (Barrande, 1872); Perrier et al.: pl. 6, figs. 1–13; pl.7, figs. 1–10 (see p. 31 for full synonymy).

2019b Parabolbozoe bohemica (Barrande, 1872); Perrier et al.: figs. 2D and 2E.

2019c Parabolbozoe bohemica (Barrande, 1872); Perrier et al.: fig. 7J.

Type material.—Lectotype (designated Bouček, 1936: 63). A left valve, NM-L 23658 (ex. CE1193). Barrande, 1872: pl. 27, fig. 19 (in reverse); Perrier et al., 2011: pl. 3, fig. 1.

Type locality.—Praha-Malá Chuchle, Vyskočilka, Czech Republic.

Type horizon.—Kopanina Formation, Ludlow Series (stratigraphical division e2 of Barrande, 1872; horizon with the trilobite “Cromus” beaumonti).

Material.—Eight valves from the outcrop at Kanda.

Description.—Adult valve is sub-ovoid in lateral outline, gently curved dorsally and ventrally, posteriorly tapering...
slightly. Bulb is large, anterodorsal, has centre above valve mid-height, extends posteriorly to almost line of maximum valve height and ventrally to below valve mid-height; outline is sub-circular, with a slight indentation opposite the rostrum. Rostrum is large, hook-like, generally with a pointed end. Rostral incisure is well developed, below which the valve has a forward pointing projection. Caudal process is not preserved in the Uzbek material. Maximum valve length is at about the level of end of rostrum; maximum valve height is at about valve mid-length; maximum valve width is at the crest of the bulb. A narrow, fairly deep sulcus flanks the bulb posteriorly and ventrally, is widest dorsally and at its mid-length is the site of the adductor muscle scar. In posterior one-third of valve a narrow S-shaped sulcus skirts around dorsal and anterior base of caudal process and projects forward near valve ventral margin. Adductor muscle scar prominent, consisting sub-parallel, radiating and alternating ridges and furrows arranged in a double series feather-like pattern. In the Uzbek specimens, faint remains of reticulation covers external valve surface. During ontogeny, size of bulb becomes relatively smaller and valve shape changes from almost circular to ovoid and density of reticulation decreases.

**Remarks.** – Though poorly preserved the Uzbek specimens show the reticulation characteristic of *P. bohemica*. 

![Fig. 3. Lateral views of four species of Silurian myodocopes from the North Nuratau Ridge, Uzbekistan (A–D), France (E–H), the UK (I–L), Poland (M–P) and the Czech Republic (Q–T). A, E, I, M, Q: *Richteria migrans*: A: left valve (OUMNH CY.00066); E: left valve (FSL 705029a); I: right valve, image reversed (OUMNH 35481); M: left valve (ZPAL O.63/6); Q: left valve (FSL 705002a). B, F, J, N, R: *Parabolbozoe bohemica*: B: left valve, image reversed (OUMNH CY.00074); F: right valve (FSL 710420); J: left valve, image reversed (OUMNH 35087); N: right valve (ZPAL O.63/5); R: left valve, image reversed (FSL 710759). C, G, K, O, S: *Bolbozoe anomala*: C: right valve (OUMNH CY.00070); G: right valve (OUMNH 35467); O: left valve, image reversed (ZPAL O.63/24); S: right valve (NM-L 23572, lectotype). D, H, L, P, T: *Silurocypridina calva*: D: right valve of a carapace (OUMNH CY.00076); H: left valve, image reversed (FSL 710652); L: right valve (OUMNH 35382); P: right valve (ZPAL O.63/11); T: left valve, image reversed (FSL 710772). All images are photographs except E and Q which are SEM images. A, F–N, R, T: silicone casts; B–E, O–Q, S: internal moulds. All scale bars: 500μm.](image-url)
*P. armoricana* has corrugate ornament (Perrier et al., 2011, 2019a) and *P. britannica* is corrugated and pitted (see Perrier et al., 2019a).

Stratigraphic and geographic range. – Ludlow Series, North Nuratau Ridge, Uzbekistan. Also known from the upper part of the Wenlock and lower part of the Ludlow Series. Occurs in the Czech Republic, France, Sardinia (Perrier et al., 2011), England and Wales (Perrier et al., 2019a) and Poland (Perrier et al., 2019b).

Suborder ENTOMOZOCOPINA Gründel, 1969

Superfamily ENTOMOZOIDEA sensu ENTOMOZOACEA Přibyl, 1950

Family ENTOMOZOIDEA Přibyl, 1950

Genus *Richteria* Jones, 1874

Type species. – *Cypridina serrato-striata* Sandberger, 1845; subsequent designation by Kegel, 1934: 413. Lower Famennian, Upper Devonian of Germany.

Stratigraphic and geographic range. – *Richteria* is known from the Silurian and Devonian. Supposed records of its occurrence in younger and older strata (all the unrevised “Entomis” species, see Bassler and Kellett, 1934) lie outside the scope of the present study and have not been confirmed by the present authors. The genus is known from Europe (Czech Republic, Germany, Poland, Belgium, France, Italy, U.K.; Perrier et al., 2007, 2019a-c), Arctic Russia (Perrier et al., 2014a), Central Asia, and China (Perrier et al., 2007).

*Richteria migrans* (Barrande, 1872) (Figs. 2A–2C, 3A, 3E, 3I, 3M and 3Q)

1981 Entomozoë; Mikhailova, p. 130, fig. 3.

2019a *Richteria migrans* (Barrande, 1872); Perrier et al.: pl. 12, figs. 1–3, 11 and 12 (see p. 39 for full synonymy).

2019b *Richteria migrans* (Barrande, 1872); Perrier et al.: fig. 2F.

2019c *Richteria migrans* (Barrande, 1872); Perrier et al.: fig. 7L.

Type material. – Lectotype (subsequently designated by Přibyl, 1950: 11). An incomplete right valve; Národní Museum, Prague, on slab NM-L 22944. Barrande, 1872: pl. 24, figs. 12–14; Bouček, 1936: text-fig. 2a; Perrier et al., 2007: text-figs. 6a–6b.

Type locality. – Former Dvorce quarry (today Podolí swimming pool), Podolí district of Prague.

Type horizon. – Kopanina Formation, Ludlow Series.

Material. – Forty-two valves from Kanda.

Description. – Valve large, bean-shaped in lateral outline. Greatest length is slightly above mid height; greatest height is at the adductor sulcus. Dorsal margin shorter than valve length. Preadductorial and postadductorial areas very slightly curved dorsally; ventral, anterior and posterior margins convex. Anterior valve margin shows a faint notch in some large specimens. Adductorial sulcus long, deep, crescent shaped, extends two-thirds of valve height from in front of mid length near dorsal margin to below the preadductorial node. A simple elliptical adductor muscle scar is present at the slightly widened ventral extremity of the sulcus. Preadductorial node is generally uninornamented but can be weakly ribbed and less developed in some specimens. External valve surface has up to 25 longitudinal ribs, including in some specimens short, intercalated and bifurcated ribs. The alignment of ribs is not disturbed by the adductorial sulcus. Ribs merge posteriorly, converge on a triangular smooth area anteriorly and curve slightly away from the valve margin ventrally. Conjoined open valves are consistently connected along dorsal margin, but there is no evidence for presence of hinge structure.

Remarks. – The specimens of *R. migrans* are the best preserved among the Uzbek myodocopes, notably showing the typical entomozoid ribbed ornament. Morphological comparison with material from other regions (see Figs. 3A, 3E, 3I, 3M and 3Q), resolves the specimens recorded as *Entomozoea* (Richteria) cf. *migrans* (Barrande, 1872) by Mikhailova (1972, 2000) as conspecific with *R. migrans*.

Superfamily CYPRIDINOIDEA sensu CYPRIDINACEA Baird, 1850

Family CYPRIDINIDAE Baird, 1850

Genus *Silurocypridina* Perrier et al., 2011

Type species. – *Silurocypridina retroreticulata* Perrier et al., 2011 from the Silurian of France.

Other species. – *Silurocypridina variostriata* Perrier et al., 2011 and *Silurocypridina calva* Perrier et al., 2011.

Stratigraphic and geographic range. – Silurian (upper Ludlow or Pridoli Series); France, Czech Republic, England, Wales and possibly Germany and Sweden (Perrier et al., 2007, 2014a, 2019a-c).

*Silurocypridina calva* Perrier et al., 2011 (Figs. 2J, 2K, 3D, 3H, 3L, 3P and 3T)

1929a *Silurocypridina calva* Perrier et al., 2011; Perrier et al.: pl. 17, figs. 1–5 and 8–11 (see p. 49 for full synonymy).

1929b *Silurocypridina calva* Perrier et al., 2011; Perrier et al.: fig. 2L.

1929c *Silurocypridina calva* Perrier et al., 2011; Perrier et al.: fig. 7T.

Type material. – Holotype, a three-dimensionally preserved left valve (LPB 18926). Perrier et al., 2011: pl. 5, figs. 8 and 9.

Type locality. – Les Chevrières, near St Denis-d’Orques, Sarthe, France.

Type horizon. – Le Val Formation is in the upper part of the Ludlow Series or lower part of the Pridoli Series, and currently cannot be further resolved.

Material. – Nine valves from the outcrop at Kanda.

Description. – Valve dome-like, with sub-ovoid lateral outline; hinge short. Rostrum well developed, is about 10%–20% of valve length, protrudes distinctly forward beyond anteroventral margin of valve. Rostral incisure well developed, rounded to angular in lateral outline. Adductor muscle scar is small, subcentral, crescent-shaped and convex anteriorly. Valves smooth. During ontogeny valve shape changes from almost circular to sub-ovoid.

Remarks. – *S. calva* is known to display considerable variation in valve outline and shape of the rostrum. The morphology of the rostrum, the crescent-shaped muscle scar and
lack of ornament assign the Uzbek material to *S. clava*. Other species of *Silarocypridina* are reticulate (*S. retroreticulata*) or corrugate (*S. variostriata*; Perrier *et al.*, 2011, 2019a).

Stratigraphic and geographic range.—Ludlow Series, North Nuratau Ridge, Uzbekistan. Also known from the Silurian of the Czech Republic, France, Poland, England, Wales and possibly Sardinia (Perrier *et al.*, 2011, 2019a–c).

5 Discussion

5.1 Palaeogeographical position and significance

Central Asia in general contains a collage of structurally complex terranes whose relationships and geological history are intricate and controversial (McCann *et al.*, 2013; Kröner, 2015). The assignment of the region of Uzbekistan in question to a particular terrane/palaeocontinental area and its palaeogeographic position during the Silurian is very conjectural and has elicited a wide range of opinions. Several studies have treated the area of the North Nuratau Ridge of Uzbekistan as part of an “Alai Terrane Group”, whose position during the Silurian is considered problematic but which is generally accepted to have accreted with a “Kazakh” (micro) continent during the Carboniferous. Biske and Seltmann’s (2010) tectonic synthesis and palaeogeographic reconstruction of pertinent areas of central Asia during Devonian times placed Kyzylkum-Alai, Merishkor-Ulan and several other “microcontinents” within a “Turkestanian Ocean” positioned in subtropical latitudes between the Baltic plate and the Kazakh continent. Heubeck’s (2001) reconstruction shows a broadly similar plate configuration. McCann *et al.*’s (2013) synthesis of the Ordovician-Carboniferous tectono-sedimentary evolution of the North Nuratau region allies its position in the Silurian to the carbonate (–clastic) dominated Alai microcontinent positioned astride the equator in the Turkestian Ocean and opposite the Kazakh continent some 20 degrees to the north.

Interestingly, various Upper Silurian non-myodocope benthic ostracod associations are similar in shelf facies over a large area of Uzbekistan, from the Turkestian-Nuratau mountain region to the Kyzyl-Kum hills (Mikhailova, 1981, 2000 and unpublished analyses). Such occurrences would link the supposed palaeogeographically close Kyzylkum-Alai and Merishkor-Ulan microplates of various authors. Furthermore, such ostracod faunas are compositionally closest to faunas of the western and eastern slopes of the northern and central Urals, as well as the western slope of the southern Urals (Abramova, 1976; Mikhailova, 1981).

Fossils have not yet proved decisive in determining the palaeogeographical positioning of the many central Asian terranes (see Cocks and Torsvik, 2002, 2013; Forrey and Cocks, 2003; Torsvik and Cocks, 2013). On balance of the available evidence we tentatively regard the Uzbek region/palaeocontinent as a small microcontinent positioned in mid-latitudes between the Baltica plate and the Kazakhstan supercontinent (see Abramova, 1976; Mikhailova, 1981).

5.2 Biostratigraphical significance

The biostratigraphic control using graptolites recorded by T.N. Koren (unpublished written information given to Uzbek geologist S. Piven; typed records stored in the Uzbekistan Geological Survey, Tashkent) from various outcrops and stratigraphic levels of the upper member of the Aburtkan beds narrows down the biostratigraphical age of the present Uzbek ostracod material to the *nilssonii* to *formosus* graptolite biozones of the Ludlow Series (Fig. 4). Based on inter-regional correlation of the myodocope ostracods (see Perrier *et al.*, 2019a, c) that we identify from the locality at Kanda, the Silurian rocks there are most likely of the upper Gorstian (*scanicus/incipiens* Biozone) to upper Ludfordian (*leintwardinensis* and *formosus* biozones). One myodocope species, *R. migrans*, is particularly informative as it is restricted to the Ludfordian in the UK, Germany, Gotland, Arctic Russia, France, Sardinia and Bohemia (Perrier *et al.*, 2014a, 2019a, c). However, its presence in the mid-Gorstian *scanicus Biozone* of Poland (Perrier *et al.*, 2019b) may imply that this species originated earlier. The other three myodocope species found in Kanda are all long-ranging species and thus do not provide additional biostratigraphic control. *B. anomala* is known from strata of the lower Homorian to the upper Pridoli, *P. bohemicus* from strata of the upper Homorian to the uppermost Ludfordian, and *S. calva* from the upper Homorian to the upper Pridoli (Perrier *et al.*, 2019a, c; Fig. 4). The coincidence of the four Uzbek myodocope species corresponds to the assemblage present in the *R. migrans* myodocope biozone of the UK (Perrier *et al.*, 2019a, c), coeval to the *leintwardinensis* graptolite biozone and the *Fungochitina pistilliformis/?chitinozoan biozone* (Steeman *et al.*, 2015; Fig. 4). The *Richteria migrans* Biozone is also recognized in Germany (Perrier *et al.*, 2014a), Gotland (Perrier *et al.*, 2014a), Arctic Russia (Perrier *et al.*, 2014a), France (Perrier *et al.*, 2007), Sardinia (Perrier *et al.*, 2007) and Bohemia (Perrier *et al.*, 2007).

5.3 Palaeoecological significance

The widespread palaeogeographic distribution of *R. migrans*, *B. anomala*, *P. bohemicus* and *S. calva* in southerly tropical to mid latitudes on both sides of the early Palaeozoic Rheic Ocean, was noted by Siveter *et al.* (1991) and Perrier *et al.* (2007, 2011, 2019a). Perrier *et al.* (2014a) expanded the distribution of *R. migrans* to the subtropical region of the palaeo-northern hemisphere, or next to, the Siberia palaeocontinent (Fig. 4). These new Uzbek records at tropical to mid latitudes between the Baltica plate and the Kazakhstan supercontinent (see Abramova, 1976; Mikhailova, 1981) – similar plate configurations (Fig. 4) – constitute additional biostratigraphic control. The occurrence of *R. migrans*, *B. anomala*, *P. bohemicus* and *S. calva* is known from strata of the upper Homerian to the uppermost Ludfordian, and thus does not provide additional biostratigraphic control. *B. anomala*, *P. bohemicus* and *S. calva* are known from the upper Homerian to the uppermost Ludfordian, and thus does not provide additional biostratigraphic control. This species originated earlier. The other three myodocope species found in Kanda are all long-ranging species and thus do not provide additional biostratigraphic control. *B. anomala* is known from strata of the lower Homorian to the upper Pridoli, *P. bohemicus* from strata of the upper Homorian to the uppermost Ludfordian, and *S. calva* from the upper Homorian to the upper Pridoli (Perrier *et al.*, 2019a, c; Fig. 4). The coincidence of the four Uzbek myodocope species corresponds to the assemblage present in the *R. migrans* myodocope biozone of the UK (Perrier *et al.*, 2019a, c), coeval to the *leintwardinensis* graptolite biozone and the *Fungochitina pistilliformis/?chitinozoan biozone* (Steeman *et al.*, 2015; Fig. 4). The *Richteria migrans* Biozone is also recognized in Germany (Perrier *et al.*, 2014a), Gotland (Perrier *et al.*, 2014a), Arctic Russia (Perrier *et al.*, 2014a), France (Perrier *et al.*, 2007), Sardinia (Perrier *et al.*, 2007) and Bohemia (Perrier *et al.*, 2007).
and bivalve dominated associates, as in the case of the occurrence in Uzbekistan. The myodocope-bearing facies typify possible deep shelf environments or topographic lows on the shelf (Siveter et al., 1991; Perrier et al., 2011) and are characterised by the lack of bioturbation, the presence of lamination and by a low diversity mostly pelagic fauna. These facies data, added to the newly extended cosmopolitan distribution suggest that at least these four myodocope species probably possessed a pelagic lifestyle, and this is consistent with the timing of a proposed ecological shift in pioneer pelagic (myodocope) ostracods from benthic to pelagic during the mid-Silurian (see Siveter, 1984; Siveter et al., 1987, 1991; Siveter and Vannier, 1990; Vannier and Abe, 1992; Perrier et al., 2007, 2011, 2015, 2019a, b).

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References

Abramova AI. 1976. Ostracody iz verkhesiluryskikh otlozheniy zapadnogo skloona Yuzhnogo Urals (basseyn Reki Irgizly i M. Ik). (Ostracods from Upper Silurian deposits of the western slope of the Southern Urals: basin of the Irgizly and Little Ik rivers). Biostratigraphy and environment of the Palaeozoic deposits of the Southern Urals and the Eastern Edge of the Russia Platform. BAN USSR, 41–45 [in Russian].

Baird W. 1850. The Natural History of the British Entomostraca. London: The Ray Society, 364 p.

Barrande J. 1872. Système Silurien du centre de la Bohème, 1.

Page 8 of 10
Jones TR. 1874. Uber

Kegel W. 1934. Zur Kenntnis paläozoischer Ostracoden 4. Über die

Kim AI, ed. 1966.

Cocks LRM, Torsvik TH. 2002. Earth geography from 500 to 400

Cocks LRM, Torsvik TH. 2013. The dynamic evolution of the

Mikhailova ED. 1972. Ostracody silura i nizhnego devona Yuzhnogo

Mikhailova ED. 2000. Ostracody silura i nizhnego devona Yuzhnogo

Mikhailova ED. 2000. Ostracody silura i nizhnego devona Yuzhnogo

Polenova EN. 1970. Late Silurian and early Devonian ostracods of the

Pribyl A. 1888. Ostracodes from the Silurian of central Bohemia. 

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Bassler RS, Kellett B. 1934. Bibliographic index of Paleozoic

Biske YS, Seltmann R. 2010. Paleozoic Tian-Shan as a transitional region between the Rheic and Urals-Turkestan oceans. Gondwana Research 17: 602–613.

Bouček B. 1936. Die Ostracoden des böhmischen Ludlows (Stufe εβ).

Neues Jahrbuch für Mineralogie, Geologie und Paläontologie 76: 31–98.

Cocks LRM, Torsvik TH. 2002. Earth geography from 500 to 400 million years ago: a faunal and palaeomagnetic review. Journal of the Geological Society 159(6): 631–644.

Cocks LRM, Torsvik TH. 2013. The dynamic evolution of the Palaeozoic of eastern Asia. Earth-Science Reviews 117: 40–79.

Fortey RA, Cocks LRM. 2003. Palaeontological evidence bearing on global Ordovician–Silurian continental reconstructions. Earth-Science Reviews 61(3-4): 245–307.

Gnoli M, Perrier V, Serventi P. 2009. The state of research on

Gyllenband GTX, Yesson AVM. 2008. A Precambrian pelagic myodocopid ostracod from the Acadian foreland, Maine, USA. Journal of Paleontology 82(3): 480–484.

Gründel J. 1969. Neue taxonomische Einheiten der Unterklass Ostracoda (Crustacea). Neues Jahrbuch für Geologie und Paläontologie 6: 353–61.

Heubeck C. 2001. Assembly of central Asia during the middle and late Paleozoic. Memoirs of the Geological Society of America, 1–22.

Jones TR. 1861. Entomis. In: Howel HH, Geikie A, eds. The geology of the neighbourhood of Edinburgh. Memoirs of the Geological Survey of Great Britain 32: 137.

Jones TR. 1874. Uber Entomis und ein neues Genus Richteria. Neues Jahrbuch für Mineralogie Geologie und Paläontologie (2): 180. [in form of a letter to Prof. Geinitz; title given in the table of contents].

Kegel W. 1934. Zur Kenntnis paläozoischer Ostracoden 4. Über die Gattung Entomis und ihre mittel-devonischen Arten. Jahrbuch der preußischen geologischen Landesanstalt zu Berlin für 1933 54: 409–20.

Kim AI, ed. 1966. Patevoditel’ ekskursyi po tipovom razrezam Ordovika, Silura i Devona Sredney Azii. (Guidebook of field excursions to the standard sections of the Ordovician, Silurian and Devonian of Central Asia). MG UzSSR. Tashkent, 112 p [in Russian].

Kříž J. 1992. Silurian Field Excursions: Prague basin (Barrandian), Bohemia. National Museum of Wales Geological series, 13. Cardiff, 111 p.

Krüner A, ed. 2015. The central Asian Orogenic Belt: Tectonic–palaeogeographic, palaeoecological and palaeobiogeographical significance. Geological Magazine 151: 591–9.

Perrier V, Vannier J, Siveter DJ. 2007. The Silurian pelagic myodocop ostracod Richteria migrants. Transactions of the Royal Society of Edinburgh, Earth Sciences 98: 151–63.

Perrier V, Vannier J, Siveter DJ. 2011. Silurian bolbozooids and eypridinids (Myodocopa) from Europe: Pioneer pelagic ostracods. Palaeontology 54: 1361–91.

Perrier V, Bogolepova OK, Gubanov AP, Siveter DJ, Williams M. 2014a. A pelagic myodocopid ostracod from the Silurian of Arctic Russia. Journal of Micropalaeontology 34(1): 51–57.

Perrier V, Siveter DJ, Williams M, Lane PD. 2014b. An Early Silurian “Herefordshire” myodocop ostracod from Greenland and its palaeoecological and palaeobiogeographical significance. Geological Magazine 151: 591–9.

Perrier V, Siveter DJ, Williams M, et al. 2014c. Myodocope ostracods from the Silurian of Australia. Journal of Systematic Palaeontology 13(9): 727–739.

Perrier V, Siveter DJ, Williams M, Palmer D. 2019a. British Silurian Myodocope Ostracods. Monograph of the Paleontographical Society. London 172(651): 1–99.

Perrier V, Olempska E, Siveter DJ, Williams M, Legiot N. 2019b. Silurian myodocope ostracods from Poland. Acta Palaeontologica Polonica 64(2): 379–397.

Perrier V, Williams M, Siveter DJ. 2015. The fossil record and palaeoenvironmental significance of marine arthropod zooplankton. Earth-Science Reviews 146: 146–62.

Perrier V, Siveter DJ, Williams M, Palmer D. 2019a. British Silurian Myodocope Ostracods. Monograph of the Palaeontographical Society. London 172(651): 1–99.

Perrier V, Olempska E, Siveter DJ, Williams M, Legiot N. 2019b. Silurian myodocope ostracods from Poland. Acta Palaeontologica Polonica 64(2): 379–397.

Perrier V, Williams M, Siveter DJ, et al. 2019c. A high-precision global biostratigraphy of myodocope ostracods for the Silurian upper Wenlock Series and Ludlow Series. Lethaia, https://doi.org/10.1111/let.12357.

Polenova EN. 1970. Late Silurian and early Devonian ostracods of the Altai-Sayan region. Trudy Instituta Geologii Geofiziki, Sibirskoe Otdelenie Akademii Nauk SSSR 127: 1–104.

Pribyl A. 1950. On the Bohemian Ostracoda of the families Entomozoa and Entomoconchida. Bulletin international de l’Académie tchèque des Sciences 1949: 1–27.

Pribyl A. 1888. Ostracodes from the Silurian of central Bohemia. Sborník geologický věd Paleontologie 29: 49–143.
Sadler PM, Cooper RA, Melchin M. 2009. High-resolution, early Paleozoic (Ordovician-Silurian) time scales. *Geological Society of America Bulletin* 121(5-6): 887–906.

Sandberger G. 1845. Die erste Epoche der Entwickelungsgeschichte der Erdkörpers. *Jahrbücher des Vereins für Naturkunde im Herzogthum Nassau* 2: 89–124.

Sars, GO. 1866. Oversigt af Norges marine Ostracoder. *Norske Videnskap-Akademiens Forhandlingar* 1865: 130.

Siveter DJ. 1982. Casts illustrating fine ornament of a Silurian ostracod. In: Bate RH, Robinson E, Sheppard LM, eds. *Fossil and Recent Ostracods*. British Micropalaeontological Society. Chichester: Ellis Horwood, pp. 105–22.

Siveter DJ. 1984. Habitats and modes of life of Silurian ostracods. In: Bassett MG, Lawson JD, eds. *The Autecology of Silurian Organisms*. Special Papers in Palaeontology 32: 71–85.

Siveter DJ. 1990. Photography. In: Briggs DEG, Crowther PR, eds. *Palaeobiology: A synthesis*. Oxford: Blackwell, pp. 505–8.

Siveter DJ, Vannier J. 1990. The Silurian myodocope Entomozoea from the Pentland Hills, Scotland: its taxonomic, ecological and phylogenetic significance and the affinity of bolbozoid Myodocopida. *Transactions of the Royal Society of Edinburgh, Earth Sciences* 81: 71–6.

Siveter DJ, Vannier J, Palmer D. 1987. Silurian myodocopid ostracodes: their depositional environment and the origin of their shell microstructures. *Palaeontology* 30: 783–813.

Siveter DJ, Vannier J, Palmer D. 1991. Silurian myodocopid ostracodes: pioneer pelagic ostracods and the chronology of an ecological shift. *Journal of Micropalaeontology* 10: 157–73.

Siveter DJ, Sutton MD, Briggs DEG, Siveter DJ. 2003. An Ostracode crustacean with soft-parts from the Lower Silurian. *Science* 302: 1749–51.

Siveter DJ, Siveter DJ, Sutton MD, Briggs DEG. 2007. Brood care in a Silurian ostracod. *Proceedings of the Royal Society of London, Series B* 274: 465–9.

Siveter DJ, Briggs DEG, Siveter DJ, Sutton MD. 2010. An exceptionally preserved myodocopid ostracod from the Silurian of Herefordshire, UK. *Proceedings of the Royal Society of London, Series B* 277: 1539–44.

Siveter DJ, Briggs DEG, Siveter DJ, Sutton MD, Joomun SC. 2013. A Silurian myodocope with preserved soft-parts; cautioning the interpretation of the shell-based ostracod record. *Proceedings of the Royal Society of London, Series B* 280(1752): 20122664.

Siveter DJ, Briggs DEG, Siveter DJ, Sutton MD. 2015. A 425-million-year-old Silurian pentastomid parasitic on ostracods. *Current Biology* 25: 1632–1637.

Siveter DJ, Briggs DEG, Siveter DJ, Sutton MD. 2018. A well-preserved respiratory system in a Silurian ostracod. *Biology letters* 14(11): 20180464.

Steeman T, Venniers J, Vandenbroucke TRA, Williams M, Perrier V, Siveter DJ. 2015. Stratigraphy and palynology of the Silurian of the Long Mountain (Wales). *Geological Magazine* 153(1): 95–109.

Torsvik TH, Cocks LRM. 2013. New global palaeogeographical reconstructions for the early Palaeozoic and their generation. In: Harper DAT, Servais T, eds. *Early Palaeozoic Biogeography and Palaeogeography*. Geological Society, London, Memoirs, 38, pp. 5–24.

Vannier J, Abe K. 1992. Recent and early Palaeozoic myodocope ostracodes: functional morphology, phylogeny, distribution and lifestyles. *Palaeontology* 3: 485–517.

Wang S-Q. 2009. Palaeozoic Entomozoaceae and Lepidocoreticulida (Ostracoda) of China. *Fossil Ostracoda of China* 3: 251 [In Chinese, English summary].

Wang S-Q, Zhang X-B. 1983. Ostracodes from Lower and Middle Devonian of the Luofu and other areas, Guangxi Province. *Acta Palaeontologica Sinica* 22: 551–565 [in Chinese, with English summary].

Yakubchuk A. 2017. Evolution of the Central Asian Orogenic Supercollage since late Neoproterozoic revised again. *Gondwana Research* 47: 372–398.

Zalasiewicz JA, Taylor L, Rushton AWA, Loydell DK, Rickards RB, Williams M. 2009. Graptolites in British stratigraphy. *Geological Magazine* 146: 785–850.

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