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PALEONTOLOGY

A PRELIMINARY ACCOUNT ON DEVONIAN TRILOBITES FROM ARMENIA

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Abstract

We here report and illustrate Middle and Late Devonian trilobites found in the sedimentary sequences of southwestern Armenia, represented by an unidentified proetid pygidium and a few phacopids, including the species *Omegops* cf. *accipitrinus* (Phillips, 1841). The Late Devonian stratigraphic and paleobiogeographic distribution of *Omegops accipitrinus* and related species is reviewed. The paleoecological preference of *Omegops* for shallow marine shelves is compatible with the previously established paleoenvironmental significance of the thick Upper Devonian sequences of the South Armenian Block.

Keywords: Trilobita; Phacopida; Middle and Late Devonian; South Armenian Block; Armenia.

Introduction

Trilobites were relatively abundant and diverse in marine Devonian habitats, a time of dynamic long-term climate change (Becker et al., 2016) that triggered significant biodiversity changes and major biotic crises (Sepkoski, 1996; Bond and Grasby, 2017). In particular, the Late Devonian period is important for the development of trilobites because the main groups of reduced sight or blind taxa arose at that time, especially in deeper offshore environments in which cephalopod-rich limestones were accumulated. This important development was followed by a severe drop in diversity that resulted to one of the highest extinction rates in the Late Palaeozoic (Lerosey-Aubril and Feist, 2012; Crônier et al., 2013; Crônier and François, 2014; Bault et al., 2021). Nevertheless, in sedimentary sequences that accumulated in shallow-water near-shore environments, the trilobite record is existent but remains scarce due to relatively few studies dealing with them. The present paper contributes to the systematic study of few Devonian trilobites found in shallow-water sequences from southwestern Armenia (Fig. 1), represented by an unidentified proetid pygidium and a few phacopids.

Geological setting

In southwestern Armenia crop out Devonian sedimentary sequences, which are reknown for their fossil richness. The famous German geologist Hermann Abich, considered as the « father of Caucasian geology », was the first to describe in 1858 some of these Devonian outcrops. They are essentially composed of marly and sandy biogenic limestones, rich in brachiopods, and contain some shaly and sandy intercalations. These outcrops continue in Nakhichevan and are part of a small microcontinent, the South-Armenian Block (SAB), which was part till the Permian of a huge platform of the northern Gondwana margin, extending from the Anatolide-Tauride to the Iranian plates; the SAB was detached and individualized during the Triassic and Jurassic (Sosson et al., 2010). Thus, during the Late Devonian it was part of a huge platform that was positioned at the southern hemisphere tropical carbonate development zone (Brock and Yazdi, 2000).

The Devonian sequences of Armenia and Nakhichevan were studied systematically after the World War II, as part of extensive mapping projects of the ex-USSR republics. The Devonian sequences in Armenia were described and stratigraphically individualized based on their brachiopod content thanks to the groundbreaking studies of Abrahamyan (1957, 1964) and Arakelyan (1964). Grechishnikova et al. (1982) and Rzhonsnitskaya and Mamedov (2000) applied Abrahamyan's zonal scheme in Nakhichevan, by improving and complementing it for some intervals. A subsequent step forward was achieved by the integration of this brachiopod zonation with the conodont study carried out by Aristov (1994) in Nakhichevan.

Trilobite content

The study of Devonian outcrops in the Lesser Caucasus (Armenia and Nakhichevan) began with the works of Abich (1858) and Bonnet (1947). A more comprehensive Devonian stratigraphic scheme (see Grechishnikova et al., 1983) was developed based on a number of local biostratigraphic schemes established from brachiopod studies (Rzhonsnitskaya, 1948; Mamedov, 1961, 1962, 1974, 1979; Arakelyan, 1964; Abrahamyan, 1974). In the Lesser Caucasus, several trilobite families have been reported by Levitskiy (1983, 1986) from the upper Emsian to the Givetian: Proetidae (*Proetus*, *Cornuproetus*), Dechenellidae (*Dechenella*), Aulacopleuridae (*Otarion*), Phacopidae (*Phacops*), Calmoniidae (*Alcaldops*, *Heliopyge*, *Neocalmonia*), Odontopleuridae (*Radiaspis*), and Scutelluidae (*Scutellum*, *Paralejurus*). *Phacops*, *Scutellum*, and *Proetus* are the most diverse and abundant genera. Several Eifelian trilobites were assigned by Levitskiy (1983) especially to *Phacops (Geesops) deresiensis* Levitskiy, 1983 (upper Eifelian), *Phacops (Geesops) crassus* Levitskiy, 1983 (upper Eifelian), *Phacops (Geesops) caucasius* Levitskiy, 1983 (upper Eifelian), *Phacops (Geesops) araraticus* Levitskiy, 1983 (Upper Eifelian) among phacopids; and, *Proetus (Proetus) prox* Richter and Richter, 1956 (upper Eifelian) and *Proetus (Proetus) caucasius*

Levitskiy, 1983 among proetids; and subsequently by Levitskiy (1986) to *Geesops dagnaensis* (Levitskiy, 1986) (upper Emsian-lower Eifelian), *Alcaldops dagnaensis* Levitskiy, 1986 (middle Eifelian), *Neocalmo niairina* Levitskiy, 1986 (upper Eifelian), and *Otarion armeniacus* Levitski, 1986 (upper Eifelian). With an updated taxonomy, some phacopids were reassigned (see Lemke, 2018): *Geesops araraticus* (Levitskiy, 1983), *Geesops caucasius* (Levitskiy, 1983).

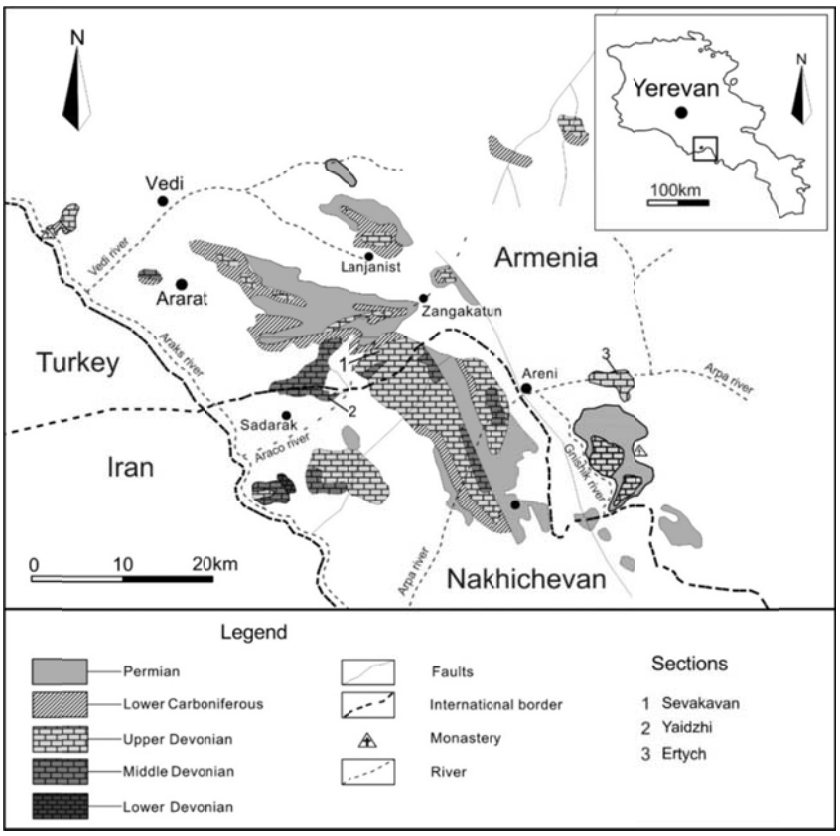

Fig.1. Simplified geological map of the south-western part of Armenia and the north-eastern part of the Nakhichevan area showing the Sevakavan, Ertych, and Yaidzhi sections.

Previously, in the published fauna reported from Armenia, some Middle and Upper Devonian trilobites have been cited but without illustrations by Arakelyan et al. (1975) with *Asteropyge aff. punctata* Sten. and *Scutellum armenicum* Max. (determ. from Maximova) from Givetian (p. 22), *Scutellum* ex. gr. *cristatum* Pusch (determ. from Maximova) from the Frasnian (p. 23), *Phacops accipitrinus* (Phill.) and *Phacops bergicus* (Drev.) (determ. from Z.A. Maximova) from the lower Tournaisian (p. 27). There is no record of trilobites in the Famennian. Nevertheless, the fossil record from the lower Tournaisian is misidentified and should be assigned to the uppermost Famennian.

By comparison with other areas from the northern peri-gondwanian margin, such as Morocco (Crônier and Feist, 1997; Crônier and Clarkson, 2001; Crônier

et al., 2013; Bault et al., 2021), the trilobite remains from Armenia are rare. They seem to be more numerous in closely related areas, such as Iran, where *Trimerocephalus shotoriensis*, *Omegops cf. cornelius*, *Omegops tilabadensis*, *Phacops granulatus*, and *Rabienops* aff. *wedekindi* have been reported.

Systematic palaeontology (by C. Crônier)

The illustrated specimens were coated with ammonium chloride before being photographed with the use of a digital camera Nikon and, they are deposited at the Geological Museum of the Institute of Geological Sciences of the National Academy of Sciences of Armenia, Yerevan (IGSNASRAGM/PS), unless otherwise stated. The prefix PS indicates the Laboratory of Paleontology and Stratigraphy. The morphological terminology follows Chlupáč (1977) and Crônier et al. (2011).

Order PHACOPIDA Salter, 1864
Superfamily PHACOPOIDEA Hawle and Corda, 1847
Family PHACOPIDAE Hawle and Corda, 1847
Subfamily PHACOPINAE Hawle and Corda, 1847
Genus *Omegops* Struve, 1976

Type species. Calymene accipitrina Phillips, 1841, Upper Devonian Pilton Beds, England.

Remarks. The main characters of *Omegops* were presented by Struve (1976), i.e., a reduced intercalating ring as a narrow flat band, 15-16 dorso-ventral files with a maximum of 7 lenses, a distinct postocular pad, a marginulate lateral border, and coarse tubercles on glabella.

Omegops cf. *accipitrinus* (Phillips, 1841)

Fig. 2a-d, k

See Richter and Richter (1933) for previous synonymies

1933 *Phacops (Phacops) accipitrinus accipitrinus* (Phillips, 1841): Richter and Richter, p. 5-12, pl. 1, figs. 1-4, 7 [non Fig. 5-6 = *Phacops (Omegops) accipitrinus belgicus* Drevermann 1902; non Fig. 8 = *Phacops (Omegops) accipitrinus insolatus* Struve, 1976].

cf. 1937 *Phacops (Phacops)* cf. *accipitrinus* (Phillips, 1841): Weber, p. 114, pl. 1, figs. 1-5.

1939 *Phacops (Phacops) accipitrinus accipitrinus* (Phillips, 1841): Richter and Richter, p. 20, pl. 2, fig. 4.

non 1943 *Phacops (Phacops) accipitrinus accipitrinus* (Phillips, 1841): Richter and Richter, p. 130-131, pl. 1, fig. 2 [= *Phacops (Omegops) accipitrinus insolatus* Struve, 1976].

1955 *Phacops (Phacops) accipitrinus accipitrinus* (Phillips, 1841): Goldring, p. 46-47.

1966 *Phacops (Phacops) accipitrinus* (Phillips, 1841): Chlupáč, p. 103-104, pl. 21, figs. 3-5, 12, text-fig. 32.

non 1966 *Phacops (Phacops) accipitrinus* (Phillips, 1841): Chlupáč, p. 103-104, pl. 21, figs. 1-2 [= *Phacops (Omegops) accipitrinus insolatus* Struve, 1976].

1969 *Phacops (Phacops) accipitrinus* (Phillips, 1841): Pillet and Lapparent, p. 329-330, pl. 39, figs. 2-7, 9-18.

1972 *Phacops (Phacops) accipitrinus* (Phillips, 1841): Alberti, p. 4-21, figs. 1-11.

1974 *Phacops accipitrinus* (Phillips, 1841): Levitskiy, p. 54-56, pl. 1, figs. 10-22, text-fig. 3b.

1976 *Phacops (Omegops) accipitrinus accipitrinus* (Phillips, 1841): Struve, p. 439, pl. 2, fig. 8.

non 1977 *Phacops (*subg.*?) accipitrinus* (Phillips, 1841): Chlupáč, p. 76, pl. XXXII, figs. 8-9 [= *Phacops (Omegops) accipitrinus insolatus* Struve, 1976].

1998 *Phacops (Omegops) accipitrinus accipitrinus* (Phillips, 1841): Farsan, p. 25-26, pl. 2, figs. 1-2.

Studied material. The studied material is represented by an isolated cephalon. This material comes from Abrahamyan's collection stored at the IGSNASRAGM/PS, unfortunately without mention of locality. The studied specimen is almost complete, partially exfoliated. Because of the cephalic shape and ornamentation this specimen is assigned to an Upper Famennian Phacopid trilobite, i.e., *Omegops* (Struve, 1976), a common genus for this time interval.

Diagnosis. See Richter and Richter, 1933

Remarks. A detailed description of the studied taxa was presented by Richter and Richter (1933) and then completed by Struve (1976). *Omegops accipitrinus* is characterized by a smooth postocular area adaxially and covered with few tubercles abaxially, up to five lenses in a dorso-ventral file (with 56–70 lenses recorded), divergent axial glabellar furrows (about 45–60°), and two small granules on the reduced preoccipital ring. According to available data (illustration from Salter, 1864; pl. 1, figs 10, 14 with a reassignment by Richter and Richter, 1933, description from Richter and Richter, 1933), the pygidial morphology of *Omegops accipitrinus* shows that the pygidium has six pleural ribs.

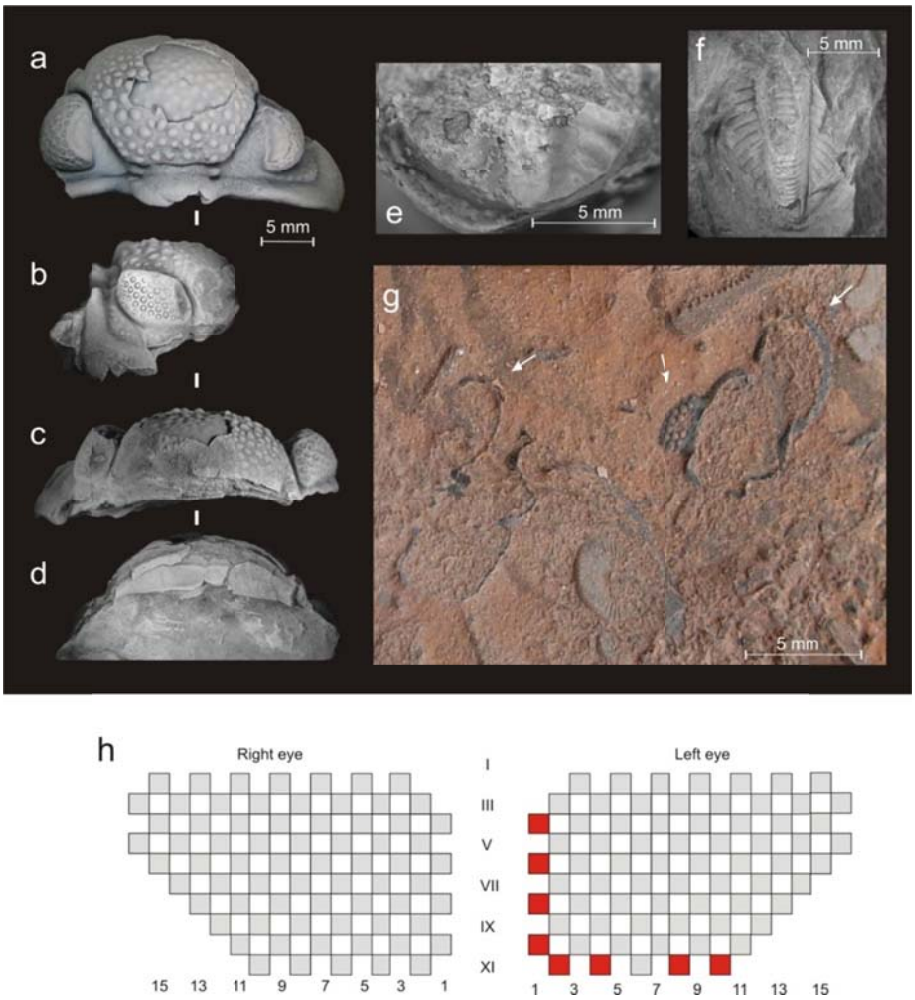

Fig.2. (a-b) *Omegops* cf. *accipitrinus* (Phillips, 1841), undetermined locality; cephalon in dorsal view (a), in lateral view (b), in frontal view (c) and in ventral view (d). (e) Trilobite, poorly preserved isolated pygidium, Sevakavan section, upper Famennian, J5.2. (f) Trilobite, isolated pygidium assigned to Proetida, within micritic limestones, Ertych section, Frasnian, J6.3, N 39° 44' 04.2' E 45° 15' 15.4''. (g) Trilobites, cephala in section, near Yaidzhi, along the road, with crinoids and solitary corals, Givetian, J5.4, N 39° 45' 25.1'' E 44° 53' 15.3''. (h) Schematic representation of visual surfaces in *Omegops* cf. *accipitrinus* (Phillips, 1841), following the method of Thomas (1998). Front of visual surface is left; numbers below drawing denominate individual dorso-ventral files, counting from the front (1-15); roman numerals denote successive horizontal rows; numbers in boxes indicate a surface having that lens present in all visual surfaces.

Our specimen fits rather well with this description in having 16 dorso-ventral files with a maximum of five lenses (with 70 lenses recorded in two visual surfaces), few tubercles on postocular area. Unfortunately, the postero-

lateral border is not well preserved and prevents us to observe small granules and pits.

Ghobadi Pour et al. (2018) described *Omegops tilabadensis* Ghobadi Pour et al. 2018 from the Famennian of Iran (Alborz). *Omegops tilabadensis* differs from *O. accipitrinus* by a more reduced eye with up to 48 large lenses arranged in up to four lenses in the vertical files, a postocular pad with up to eight coarse tubercles and a pygidium with five pleural ribs.

Ghobadi Pour et al. (2018) suggested the existence of two geographically isolated *Omegops* lineages which diverged in pre-Strunian time according to small but constant differences in the pygidial morphology, i.e., between the Middle East and Northwest China (Junggar) with taxa exhibiting four to five pygidial pleural ribs and West Europe and North African with taxa having six and more pygidial pleural ribs. The occurrence of *Omegops* cf. *accipitrinus* in the south Armenian Block does not match with this pattern (Fig. 3). Only a complete specimen exhibiting a pygidium with pleural ribs could resolve such a trend. Farsan (1998) assigned some Afghan specimens to *Omegops accipitrinus*. However, according to Ghobadi Pour et al. (2018), these specimens were not properly described and they reassigned them, with doubt, to *Omegops tilabadensis.*

Crônier and François (2014) commented on a distinct bathymetrical gradient in the distribution of the Famennian phacopid taxa, with *Omegops* restricted to shallow-water deposits influenced by current activity (previously reported by Chlupáč 1977), along both the South Laurussia and North Peri-Gondwana margins. *Omegops* is invariably present in an *Omegops* association established by Crônier and François (2014). This association is encountered in late Famennian shallow water clastic limestones, of probable lower shoreface to upper offshore origin. The *Omegops* dominated association spreads out during a phase of relative sea-level lowstand and is known from the lower shoreface to upper offshore domain. This pattern, established by Crônier and François (2014), is consistent with the fossil record in Armenia, where *Omegops accipitrinus* is a component of a benthic fauna with abundant brachiopods that inhabited a limestone substrate rich in bioclasts within a shallow shelf setting. Almost all documented *Omegops* occurrences, except the North peri-Gondwanan ones, were confined to the tropics and subtropics. All phacopid genera became extinct at the end-Famennian (Hangenberg event). In this regard, the Famennian is noted for its taxonomic turnovers and for its decline in phacopid diversity.

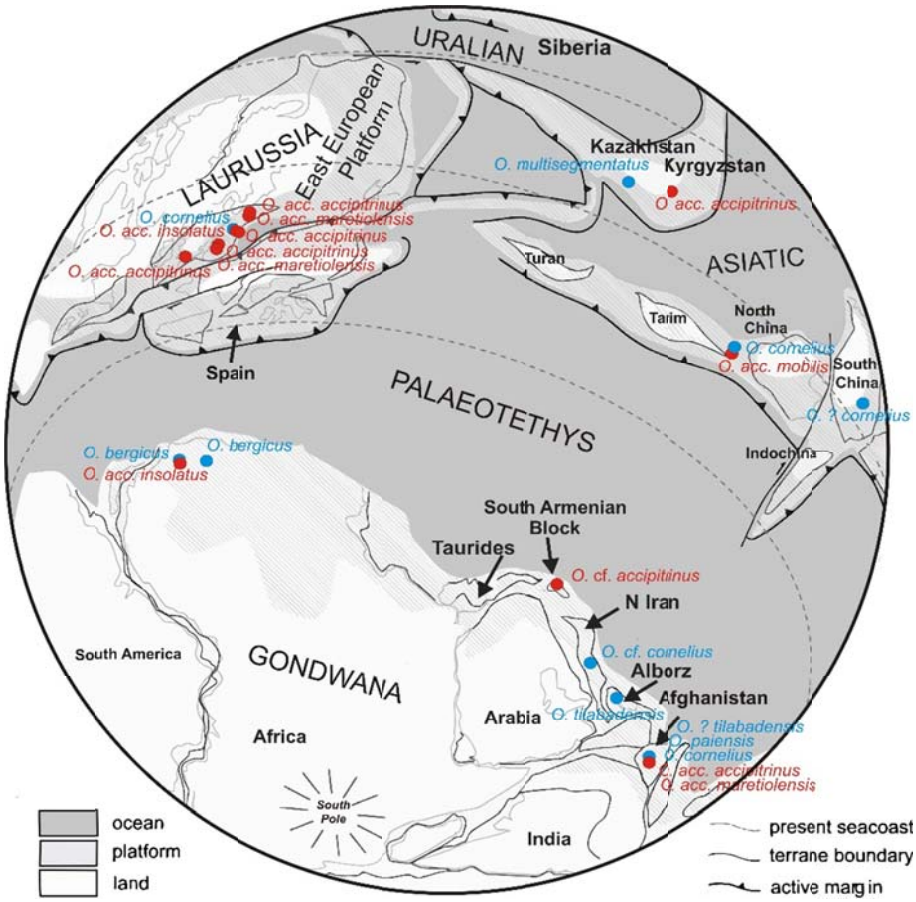

Fig.3. Late Devonian palaeogeographic reconstruction of the Palaeotethys Ocean and its margins showing *Omegops* occurrences. Modified from Grigoryan et al., 2019; based on the maps of Stampfli et al., 2002.

Undetermined phacopid

Fig.2e

Material. One poorly preserved pygidium coming from the latest Famennian of Sevakavan section, southwestern Armenia; a section rich in brachiopods (fig.2j).

Remarks. The absence of complete and better-preserved specimens prevents an accurate assignment. Pygidium apparently sub-lenticular. Length (excluding articulating half ring)/width ratio about 47% rather wide. Its maximum width in front of the mid length (sag.). Posterior outline apparently rounded. Pygidial axis not well-preserved, long (sag.), narrow, and convexe. Axial rings not distinct due to poor preservation. Four preserved pleural ribs. Pleural furrows rather wide shallower posteriorly. Interpleural furrows no distinct. Pygidium apparently lacks any sculpture.

Undetermined phacopid
Fig.2i

Material. Sections of several cephala displayed naturally in section of a very hard bioclastic limestones of Givetian with crinoids, brachiopods.

Remarks. Because of the cephalic outline and visual surface with lenses, theses specimens are assigned to Phacopid trilobites.

Order PROETIDA Fortey and Owens, 1975

Proetida, family undetermined
Fig.2f

Material. One poorly preserved pygidium found within a micritic limestone. Unfortunately, no cephalon is available. From the Frasnian interval of the Ertych section, southwestern Armenia.

Remarks. The absence of complete and better-preserved specimens prevents an accurate assignment. Pygidium sub-parabolic. Its maximum width in front of the mid length (sag.). Length (excluding articulating half ring)/width ratio about 90% very long. Posterior outline rounded. Pygidial axis long (sag.) up to (90%) of the pygidial length, narrow, and strongly convex. Numerous axial rings defined by narrow furrows. Numerous pleural ribs. Pleural furrows relatively deep and thin. Interpleural furrows not distinct. Pygidium apparently with small tubercles on pleural ribs.

Conclusion

The present paper contributes to the systematic study of few poorly preserved Devonian trilobites collected in 2016 from shallow-water sequences cropping out in southwestern Armenia and a rather well-preserved specimen found in the collections of the Geological Museum (IGS, NAS RA, Yerevan). New occurrences come from several different sections rich in brachiopods. According to brachiopods, the age of the newly collected trilobites ranges between the Frasnian and the late Famennian. The relatively well-preserved phacopid trilobite found in the Geological Museum is assigned to *Omegops* cf. *accipitrinus* taking into account its cephalic shape and doublure, thus becoming an additional report for a worldwide distribution (Chlupáč, 1975; Crônier and François, 2014; Feist, 2019), and is compatible with the presence of a shallow water shelf environment during the Late Devonian.

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ՀԱՅԱՍՏԱՆԻ ԴԵՎՈՆՅԱՆ ՏՐԻԼՈԲԻՏՆԵՐԻ ՆԱԽՆԱԿԱՆ ԳՆԱՀԱՏՈՒՄ

Կրոնիեր Կ., Սերոբյան Վ., Գրիգորյան Ա., Վիտտ Ս., Դանելիան Տ.

Ամփոփում

Սույն հոդվածում մենք հաղորդում և պատկերազարդում ենք հարավ-արևմտյան Հայաստանի նստվածքային առաջացումներում հայտնաբերված միջին և ուշ դևոնյան տրիլոբիտներ, որոնք ներկայացված են անհայտ պրոետիդային պիգիդիումով և մի քանի ֆակոպիդներով, ներառյալ *Omegops* cf. *accipitrinus* տեսակը (Ֆիլիպս, 184: Տրված է ակնարկ *Omegops accipitrinus*-ի և հարակից տեսակների շերտագրական և հնակենսաաշխարհագրական տեղաբաշխման վերաբերյալ ուշ դևոնյան շրջանում: Պալեոէկոլոգիական առումով *Omegops*-ը հիմնականում բնորոշ է ծանծաղ ծովային շելֆերին և համա-

հունչ է Հարավ Հայկական բլոկի վերին դևոնի հղոր շերտերի նախկինում հաստատված հնաէկոլոգիական իրավիճակին:

ПРЕДВАРИТЕЛЬНАЯ ОЦЕНКА ДЕВОНСКИХ ТРИЛОБИТОВ АРМЕНИИ

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Резюме

В данной статье мы сообщаем и иллюстрируем трилобиты среднего и позднего девона, обнаруженные в осадочных отложениях юго-западной Армении, представленые неидентифицированным проэтидным пигидием и несколькими факопидами, включая вид *Omegops* cf. *accipitrinus* (Phillips, 1841). Дан обзор стратиграфического и палеобиогеографического распространения *Omegops accipitrinus* и родственных им видов в позднем девоне. *Omegops* в палеоэкологическом отношении преимущественно характерен мелководным морским шельфам и согласуется с ранее установленным палеоэкологическим значением мощных толщ верхнего девона Южно-Армянского блока.