Biostratigraphy of the Cambrian–Ordovician boundary beds at Kopet-Dagh, Iran

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ABSTRACT: A continuous succession comprising upper Cambrian (Furongian) to Lower Ordovician (Tremadocian) conodont biozones is reported for the first time from the Kopet-Dagh Region of northeastern Iran. Seven biostratigraphical units are recognized, including the *Proconodontus tenuiserratus* and *Proconodontus posterocostatus* zones; these two lowermost biostratigraphical units are defined by euconodont species which have not been previously reported from Iran and temperate latitude peri-Gondwana. The conodont diversity and abundance decreased significantly above the *Eoconodontus notchpeakensis* Zone; the conodont faunas of the succeeding *Cordylodus proavus*, *Cordylodus lindstromi* (*sensu lato*) and *Cordylodus angulatus* zones are characterised by oligotaxic to monotaxic associations dominated by species of *Cordylodus*. In the absence of diagnostic conodont species, the position of the lower boundary of the Ordovician System in the Kalat Valley Section can be placed somewhat below the first occurrence of the early planktonic graptolite *Rhabdinopora flabelliformis*, which approximately coincides with the onset of black shale deposition.

INTRODUCTION

The main objective of this paper is to review the available information on the conodont biostratigraphy of the Cambrian–Ordovician boundary beds in the Kuh-e Saluk Mountains, south of the city of Bojnurd, in the North Khorosan Province, northeastern Iran (Fig. 1a, b). This area was mapped (1: 250000) by Bolourchi and Mehr Parto (1987); however, the coverage of the Lower Palaeozoic rocks in this map is not adequately shown. Ahmadzadeh-Heravi (1983) proved the existence of the continuous succession from the Upper Cambrian to the Silurian exposed along the road connecting Bojnurd and Esfaraen, south of the Pelmis Pass and also presented the first and only published report on the occurrence of the Cambrian and Early Ordovician conodonts in the area.

The studied section, which is here referred as the Kalat Valley is situated on the western side of the Kalat stream, about 39 km south of Bojnurd. Geographical coordinates of the zero point at the base of the first limestone bed are 37°13′36″N; 57°23′2″E, altitude 1620 m. The underlying beds are covered by allochthonous, strongly weathered argillite and therefore cannot be observed. No formal lithostratigraphical subdivision can be applied to the Cambrian (Furongian) and Lower Ordovician deposits of Kopet-Dagh at present. Ghavidel-Syooki (2001) assigned this part of the succession to the

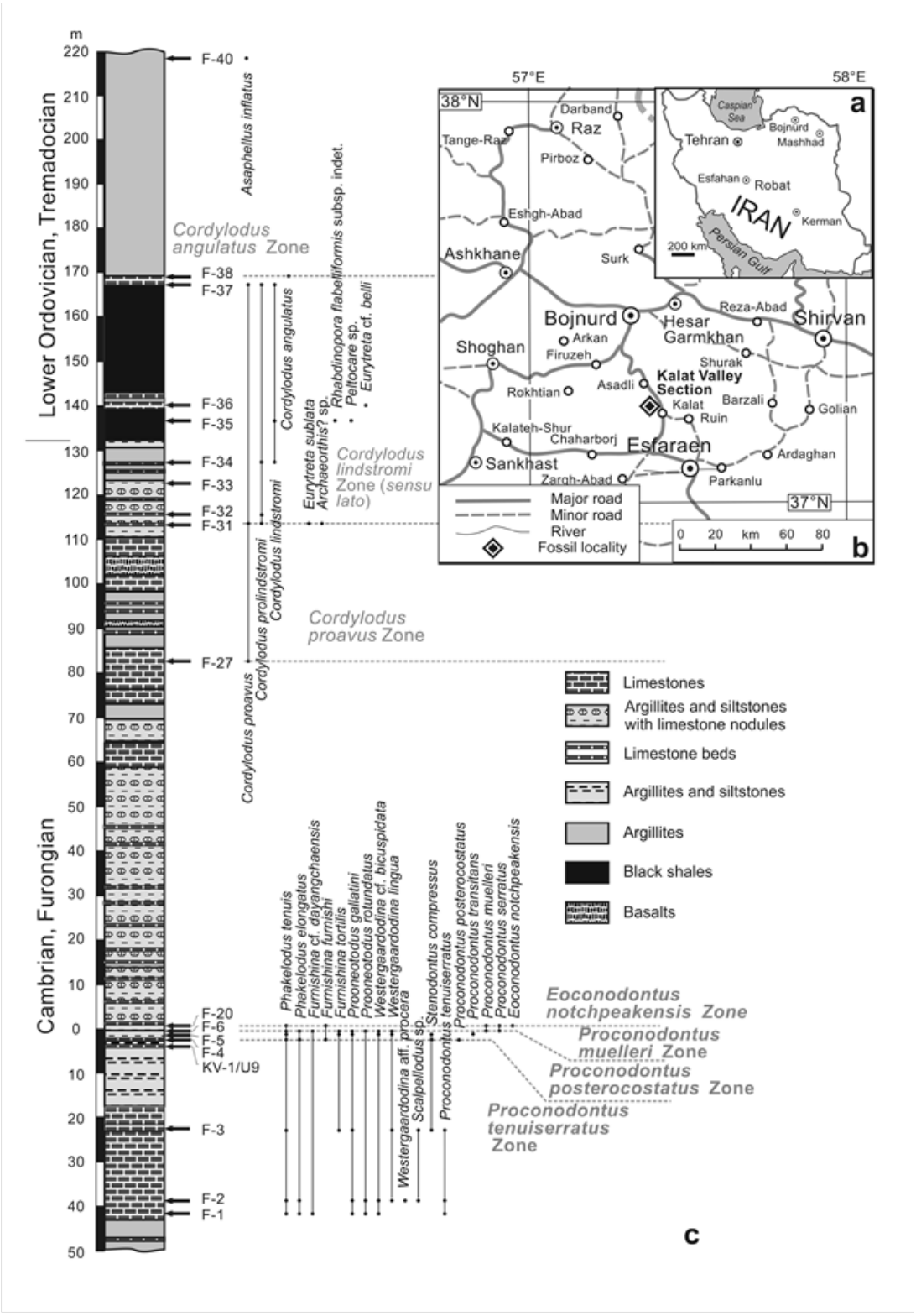

Figure 1. —a, simplified map of Iran showing location of Bojnurd situated north of the Kalat Valley Section; b, geographical map of the vicinity of Bojnurd showing geographical position of the Kalat Valley Section west of the road connecting Bojnurd and Esfaraen; c, stratigraphic column of the terminal Cambrian and Lower Ordovician (Tremadocian) deposits exposed in the Kalat Valley Section, showing position of sampled fossiliferous horizons and stratigraphic distribution of conodonts and selected species of brachiopods, trilobites and graptolites.

Lashkarak Formation; however, this formation was defined in Central Alborz within a completely different tectonostratigraphical unit. Moreover, as demonstrated by Ghobadi Pour et al. (2011), the Lashkarak Formation, as originally defined by Gansser & Huber (1962), is confined to Middle and Upper Ordovician deposits.

The Cambrian–Ordovician boundary beds in the Kalat Valley section comprise a monotonous succession of mostly siliciclastic sediments, which were deposited in the outer shelf environment, with some limestone units representing mostly shell beds formed by bioclasts transported across the shelf during occasional strong storm events. Carbonate nodules in argillites are relatively common in the Cambrian part of the observed succession, but completely disappear in the Tremadocian. Only the lowermost part of the studied section, corresponding to the *Proconodontus tenuiserratus* Zone, contains a significant amount of carbonates. The autochthonous benthic faunas are dominated by low diversity trilobite associations, while disarticulated shells of the rhynchonelliform brachiopods usually are displaced offshore. The lingulate brachiopods are relatively common and moderately diverse within the interval from the *Proconodontus tenuiserratus* to *Eoconodontus notchpeakensis* Zone, but decrease markedly in abundance and diversity up sequence.

CONODONT BIOSTRATIGRAPHY

The conodont yield in the studied samples is very low. Among 17 productive samples the content of conodont elements usually does not exceed 20 specimens per standard 1. 5 kg sample, and fewer than half of the sampled limestone horizons were productive for conodonts. Nevertheless, it is still possible to build conodont based biostratigraphical framework for the late Furongian to Tremadocian of the Kopet-Dagh Region, which is comparable to the conodont zonal schemes of the Cold Domain *sensu* Zhen and Percival (2003), and in particular, to the Baltoscandian province (Kaljo et al. 1986; Szaniawski and Bengtson 1998; Bagnoli and Stouge 2014). Seven successive conodont zonal assemblages can be recognised in the terminal Cambrian to Early Ordovician (lower Tremadocian) sedimentary succession of the Kalat Valley section. These include the *Proconodontus tenuiserratus* and *Proconodontus posterocostatus* zones, two lowermost biostratigraphical units defined by euconodont species, which have not been previously reported from Iran.

Proconodontus tenuiserratus Zone

The zone spans a 30. 6 m thick interval in the lowermost part of the measured section. In addition to the eponymous species, *Stenodontus compressus* Chen and Gong, 1986 is the only other euconodont in the assemblage, which is otherwise dominated by proto- and paraconodonts, including *Phakelodus tenuis* Müller, 1959, *Phakelodus elongatus* Müller, 1959, *Furnishina dayangchaensis* Chen & Gong, 1986, *Furnishina tortilis* Müller, 1959, *Furnishina furnishi* Müller, 1959, *Prooneotodus gallatini* Müller, 1959, *Prooneotodus rotundatus* (Druce and Jones, 1971), *Scalpellodus* sp., *Westergaardodina* cf. *bicuspidata* Müller, 1959, *Westergaardodina ligula* Müller, 1959, *Westergaardodina procera* Müller and Hinz, 1991.

Proconodontus posterocostatus Zone

Conodonts of this zone recovered from a condensed interval, which is only 2. 75 m thick. In addition, eponymous species of the associated assemblage includes *Proconodontus transitans* Szaniawski and Bengtson, 1998, which appears in the upper part of the unit (Fig. 1c), and proto- and paraconodonts

Phakelodus tenuis, *Phakelodus elongatus*, *Furnishina tortilis*, *Furnishina furnishi*, *Prooneotodus gallatini*, *Westergaardodina* cf. *bicuspidata* and *Westergaardodina ligula*, all of which are transitional from the *Proconodontus tenuiserratus* Zone.

***Proconodontus muelleri* Zone**

This zone is only 0. 15 m thick in the studied transect. It is defined by the first appearance of eponymous taxon and *Proconodontus serratus* Miller, 1969, while taxonomic composition of the proto- and paraconodont taxa ranges unchanged from the underlying unit. A condensed interval, corresponding to the *Proconodontus posterocostatus* and *Proconodontus muelleri* zones, is closely followed by the termination of more or less continuous carbonate sedimentation, while influx of fine siliciclastic sediments significantly increased since the beginning of *Eoconodontus notchpeakensis* Zone. These together with basalt volcanism, which is evident from the overlying deposits, may suggest a development of extensional tectonic regime in the area and related subsidence of the basin about that time.

***Eoconodontus notchpeakensis* Zone**

This zone is defined by the first appearance of the eponymous species, which co-occurs with transitional eoconodont taxa, including *Proconodontus muelleri* Miller, 1969 and *Proconodontus serratus.* The diversity and abundance of proto- and paraconodonts, which are represented by only two species (Fig. 1c) decreased considerably.

Conodont diversity and abundance decreased significantly up sequence. In the middle and upper parts of the Kalat Valley section, the conodont elements occur in a few horizons separated by thick barren intervals, yet successive appearance of *Cordylodus proavus* Müller, 1959, *Cordylodus lindstromi* Druce and Jones, 1971 and *Cordylodus angulatus* Pander, 1856, have been documented. All these species are the index-taxa of globally recognised conodont zones. Species of *Cordylodus* are the only common conodonts within that stratigraphical interval. They tend to form oligotaxic to monotaxic associations. A similar decline in diversity of the conodont fauna at the time of proliferation of *Cordylodus* species is also evident in the terminal Cambrian–early Ordovician (Tremadocian) conodont successions of other parts of Iran, and in particular from the Alborz Region (Müller 1973; Jahangir 2014) and the Tabas Region of Central Iran (Ghaderi et al. 2009).

THE CAMBRIAN–ORDOVICIAN BOUNDARY IN THE KALAT VALLEY SECTION

Only two conodont species, *Cordylodus lindstromi* and *Cordylodus prolindstromi* Nicoll, 1991, occur within transitional Cambrian–Ordovician boundary interval in the Kalat Valley section; however, their application for precise definition of the system boundary in the studied section is rather limited. Nevertheless, black shales just below the first documented occurrence of *Cordylodus lindstromi* (Fig. 1c; sample F-36) contain the biostratigraphically informative early planktonic graptolites. These graptolites occur in association with a few obolid brachiopods and the olenid trilobite *Peltocare* sp. probably representing a new species. Although the graptolite material from Kalat is not identified with certainty[, the regularity of the mesh is more suggestive of a subspecies close to *Rhabdinopora flabelliformis flabelliformis* (Eichwald, 1840) rather than *R. f. parabola* (Bulman 1954) or *R. f. canadensis* (Lapworth 1898), in which the mesh is less regular. If this is accepted, the age of these graptolites is likely to be close to that of "Assemblage 2" of Cooper *et al*. (1998 fig. 3) that is early but not earliest Tremadocian. Thus the lower boundary of the Ordovician System in the Kalat section may be close or somewhat below the first unit of the black graptolitic argillites, which contain the early planktonic graptolite *Rhabdinopora*

flabelliformis subsp. indet. It is probably the best approximation in definition of the system boundary presently achievable in Iran. Occurrence of *Rhabdinopora flabelliformis* subsp. indet. in the Kalat Section allows direct correlation with the GSSP section in Green Point, Newfoundland, where this graptolite appears just above the Cambrian – Ordovician boundary defined by FAD of *Iapetognathus fluctivagus*. A worldwide graptolite and conodont based correlation of the Green Point section was discussed in great details in the publication by Cooper et al. (2001) and there is no reason to repeat it here. In Baltica, Avalonia (Britain), western North America, North China and parts of Gondwana (Erdtmann, 1986, 1988; Buatois et al. 2006) the beginning of the Tremadocian Stage (upper *Cordylodus lindstromi* to *Cordylodus angulatus* zones) coincided with the extensive deposition of black shales and substantial sea-level rise.

In spite of a low diversity, the micromorphic acrotretide brachiopods also are of some value for biostratigraphical subdivision and correlation of the Cambrian–Ordovician boundary beds due to scarcity of other fossils. The members of *Quadrisonia→Eurytreta* lineage are particularly illustrative in that respect. Shells of *Quadrisonia* occur on the Kalat Valley section in the *Proconodontus tenuiserratus* Zone, but they require further study. *Eurytreta sublata* Popov, in Koneva and Popov 1988, is a geographically widespread taxon, which in Malyi Karatau (Karatau-Naryn terrane, Kazakhstan) is confined to the *Cordylodus proavus* Zone (Holmer et al. 2001), and in Laurentia (Utah) it ranges from the *Cordylodus proavus* to *Cordylodus intermedius* Zone (Popov et al. 2002). In Kopet-Dagh (Fig. 1c; sample F-31) this species co-occurs with *Cordylodus prolindstromi* at the base of the *Cordylodus lindstromi* Zone (*sensu lato*). *Eurytreta* cf. *belli* (Davidson, 1868) as revised by Sutton et al. (2000) appears in the Kalat Valley section together with *Cordylodus lindstromi* just above the black shale unit with *Rhabdinopora* (Fig. 1c). This brachiopod taxon is widespread globally within *Cordylodus lindstromi* and *Cordylodus angulatus* zones (Popov and Holmer 1994; Holmer et al. 2001, 2005; Popov et al. 2002).

The continuous character of sedimentation across the Cambrian–Ordovician boundary in the Kopet-Dagh Region is in sharp contrast with the sedimentary succession of the Alborz Region in northern Iran, where this interval corresponds to a widespread hiatus on top of '*Cruziana'* sandstones originally deposited in shoal complexes (Kebria-ee Zadeh et al. 2015), while the conodont record between the *Cordylodus proavus* and *Paltodus deltifer* zones is missing (Müller 1973; Jahangir et al. 2014). The trilobite species *Asaphellus inflatus* Lu, 1962, which usually occurs at the base of the Ordovician succession in Eastern Alborz (Ghobadi Pour 2006), appears in the Kalat Valley Section within the *Cordylodus angulatus* Zone, well above the base of the Ordovician System (Fig. 1c, sample F-40).

DISCUSSION AND CONCLUSIONS

The Kalat Valey section shows the most complete succession of conodont biozones, and includes the earliest euconodont species yet documented in Iran. The earliest euconodont taxa yet known in Alborz Region and in Central Iran are *Proconodontus muelleri* and *Proconodontus serratus* (Müller, 1973; Ghaderi et al. 2009; Jahangir 2014). Both appear in the middle part of the Furongian euconodont biostratigraphical succession of the Tropical Domain, e. g., Laurentia and Australasian segment of Gondwana (Druce and Jones 1971; Miller 1980; Miller et al. 2003). The early Furongian euconodont record is poor and incomplete in the faunas of the Cold Domain confined to the peri-Gondwanan Oaxaquia terrane (Landing 2007), Alborz and Central Iran (Jahangir 2014) and Baltica (Müller and Hinz 1991; Szaniawski and Bengtson 1998; Bagnoli and Stouge 2014). The Furongian conodont succession of Kopet-Dagh where *Proconodontus muelleri* and *Proconodontus serratus* zone are now documented represents a noticeable exception. Yet the Furongian faunas of Kopet-Dagh are characterised by a

proliferation of paraconodont taxa, while a few cosmopolitan euconodont species are of low diversity and abundance; these can be taken to indicate cold water faunas, and taken as the evidence that the region was located deep within temperate latitudes already in the Furongian. The first signs of a possible extensional tectonic regime in the Kopet-Dagh, as indicated by basin subsidence and associated volcanism, were already evident in the late Furongian, but if it was the first sign of rifting, or if the Kopet-Dagh remained an integral part of Gondwana Domain later through the Ordovician is not yet clear.

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REFERENCES

AHMADZADEH-HERAVI, M., 1983. Brachiopods and conodonts from the Lower Palaeozoic sediments at southern Bojnurd city. *Journal of Technology and Science, Tehran University*, 45: 1–24. [In Persian.]

BAGNOLI, G. and STOUGE, S., 2014. Upper Furongian (Cambrian) conodonts from the Degerhamn quarry road section, southern Öland, Sweden. *GFF*, 136: 436–458.

BLOURCHI, M. H. and MEHR PARTO, M., 1987, Geological map of Bojnurd. *Geological survey of Iran, Quadrangle map of Iran 1: 250. 000 Series*, No. J-3.

BUATOIS, L. A., ZEBALLO, F. J., ALBANESI, G. L., ORTEGA, G., VACCARI, E. and MÁNGANO, M. G. 2006. Depositional Environments and Stratigraphy of the Upper Cambrian-Lower Ordovician Santa Rosita Formation at the Alfarcito area, Cordillera Oriental, Argentina: Integration of biostratigraphic data within a sequence stratigraphic framework. *Latin American Journal of Sedimentology and Basin Analysis*, 13: 65–95.

BULMAN, O. M. B., 1954. The graptolite fauna of the Dictyonema shales of the Oslo region. *Norsk Geologisk Tidsskrift*, 33: 1–40.

CHEN, J. and GONG, W., 1986. Conodonts. In Chen, J., Ed., *Contributions to Dayangcha International Conference Camibrian/Ordovician Boundary*, 93–223. Beijing, China Prospect Publishing House.

COOPER, R. A., MALETZ, J., WANG, H. and ERDTMANN, B. –D., 1998, Taxonomy and evolution of earliest Ordovician graptolites: Norsk Geologisk Tiddskrift, 78: 3–32.

COOPER, R. A., NOWLAN, G. S. and WILLIAMS, S. H., 2001. Global Stratotype Section and Point for base of the Ordovician System. *Episodes*, 24: 19–28.

DAVIDSON, T. 1868. On the earliest forms of Brachiopoda hitherto discovered in the British Palaeozoic rocks. *Geological Magazine*, **5**: 303–316. DRUCE, E. C. and JONES, P. J., 1971. Cambro–Ordovician conodonts from the Burke River Structural Belt, Queensland. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin*, 110: 1–159.

EICHWALD, E. 1840. *Ueber das silurische Schichtensysstem in Esthland*. Akademie der St. Petersburg, 240 pp.

ERDTMANN, B. -D. 1986, Early Ordovician eustatic cycles and their bearing on punctuations in early nematophorid (planktic) graptolite evolution. In Walliser, O. H., Ed., *Lecture Notes in Earth Sciences, Volume 8: Global Bioevent*s: 139–152.

ERDTMANN, B. -D. 1988. The earliest Ordovician nematophorid graptolites: taxonomy and correlation. *Geological Magazine*, 125: 327-348.

GANSSER, A. and HUBER, H. 1962. Geological observations in the Central Elburz, Iran. *Schweizerische Mineralogische und Petrographische Mitteilungen*, 42: 593–630.

GHADERI, A., AGHANABATIL, A., HAMDI, B. and MILLER, J. F., 2009. Biostratigraphy of the first and second member of type section of the Shirgesht Formation in north of Tabas with special emphasis on conodonts. *Journal of Earth Scinces Iran*, 67: 150–163. [In Persian.]

GHAVIDEL-SYOOKI, M. 2001. Palynostratigraphy and Paleobiogeography of the Lower Paleozoic sequence in the northeastern Alborz Range (Kopet-Dagh Region) of Iran. In: Goodman, D. K. and Clarke, R. T., Eds., *Proceedings of the IX International Palynological Congress, Houston, Texas, U. S. A, 1996,* 17–35. American Association of Stratigraphic Palynologists Foundation.

GHOBADI POUR, M. 2006. Early Ordovician (Tremadocian) trilobites from Simeh-Kuh, Eastern Alborz, Iran. In Bassett, M. G. and Deisler, V. K. (eds). *Studies in Palaeozoic palaeontology*. *National Museum of Wales Geological Series*, 25, 93–118.

GHOBADI POUR, M., POPOV, L. E., KEBRIA-EE ZADEH, M. R. and BAARS, C., 2011c. Middle Ordovician (Darriwilian) brachiopods associated with the *Neseuretus* biofacies, eastern Alborz Mountains, Iran. *Memoirs of the Association of Australasian Palaeontologists*, 42: 263–283.

HOLMER, L. E., POPOV, L. E., KONEVA S. P. and BASSETT, M. G. 2001. Cambrian – early Ordovician brachiopods from Malyi Karatau, the western Balkhash Region, and northern Tien Shan, Central Asia. *Special Papers in Palaeontology*, 65: 1–180.

HOLMER, L. E., POPOV, L. E., STRENG, M. and MILLER, J. F. 2005. Lower Ordovician (Tremadocian) lingulate brachiopods from the House and Fillmore Formations, Ibex Area, Western Utah, USA. *Journal of Palaeontology*, 79: 884–906.

JAHANGIR, H., GHOBADI POUR, M. and ASHOURI, A. -R., 2014 (1392). Palaeobiogeography of conodonts from the Alborz Mountains through Cambrian–Ordovician transition. *Paleontology (Iran)*, 1(2): 137–148. [In Persian.]

KALJO, D., BOROVKO, N., HEINSALU, H., KHAZANOVICH, K., MENS, K., POPOV, L., SERGEYEVA, S., SOBOLEVSKAYA, R. & VIIRA, V., 1986. The Cambrian-Ordovician boundary in the Baltic–Ladoga clint area. *Eesti NSV Teaduste Akadeemia Toimetised. Geoloogia*, 35: 97–108.

KEBRIA-EE ZADEH, M. -R., GHOBADI POUR, M, POPOV, L. E., BAARS, C., and JAHANGIR, H., 2015. First record of the Ordovician fauna in Mila-Kuh, eastern Alborz, northern Iran. Estonian Journal of Earth Sciences. *Estonian Journal of Earth Sciences*, 64. [In press.]

KONEVA, S. P. and POPOV, L. E., 1988. Acrotretides (inarticulate brachiopods) from the Cambrian–Ordovician boundary beds of the Malyi Karatau Range (south Kazakhstan). *Ezhegodnik Vsesoiuznogo Paleontologicheskogo Obshchestva*, 31: 52–72. [In Russian.]

LANDING, E., WESTROP, S. R. and KEPPIE, J. D., 2007. Terminal Cambrian and lowest Ordovician succession of Mexican West Gondwana: biotas and sequence stratigraphy Of the Tinu Formation. *Geological Magazine*, 144: 909–936.

LAPWORTH, C., 1898. *An Intermediate Textbook of Geology. 13th edition*. Edinburgh and London.

LU, Y., 1962. Early Ordovician trilobites. *In*: Wang Yu, Ed., *A handbook of index fossils of Yangtze District,* 42–47, Beijing: Science Press. [In Chinese.]

MATTHEW, G. F., 1901. New species of Cambrian fossils from Cape Breton. *New Brunswick Natural History Society, Bulletin*, 4: 269–286.

MILLER, J. F., 1969. Conodont fauna of the Notch Peak Limestone (Cambro-Ordovician) House Range, Utah. *Journal of Paleontology*, 43: 413–439.

——, 1980. Taxonomic revisions of some Upper Cambrian and Lower Ordovician conodonts with comments on their evolution. The University of Kansas, *Paleontological Contribution*, 99: 1–44.

MILLER, J. F., EVANS, J. D., LOCH, R. L., ETHINGTON, J. H., HOLMER, L. E. and POPOV, L. E., 2003. Stratigraphy of the Sauk III interval (Cambrian-Ordovician), western Millard County, Utah, and Central Texas. *BVU Geology Studies*, 47, 23–118.

MÜLLER, K., 1959. Kambrische Conodonten. *Zeitschrift Deutschen Geologische Gesellschaft*, 111: 434–485.

——, Late Cambrian and Early Ordovician conodonts from northern Iran. *Reports of Geological Survey of Iran*, 30: 1–77.

MÜLLER, K. J. and HINZ, I., 1991. Upper Cambrian conodonts from Sweden. *Fossils and Strata*, 28: 1–153.

NICOLL, R. S., 1991. Differentiation of Late Cambrian–Early Ordovician species of *Cordylodus* with biapical basal cavities. *BMR Journal of Australian Geology and Geophysics*, 12: 223–244.

——, 1994. Seximembrate apparatus structure of the Late Cambrian coniform conodont *Teridontus nakamurai* from the Chatsworth Limestone, Georgina Basin, Queensland. *AGSO Journal of Australian Geology and Geophysics*, 15: 367–379.

PANDER, C. H., 1856. *Monographie der fossilen Fische des silurischen Systems der russisch–baltischen Gouvernments*. St Petersburg: Akademie der Wissenschaft, 91 pp.

POPOV, L. E., and L. E. HOLMER. 1994. Cambrian-Ordovician lingulate brachiopods from Scandinavia, Kazakhstan, and South Ural Mountains. *Fossils and Strata*, 35: 1–156.

POPOV, L. E., HOLMER, L. E. and MILLER, J. F., 2002. Lingulate brachiopods from the Cambrian-Ordovician boundary beds of Utah. *Journal of Paleontology*, 76: 211–228.

SUTTON, M. D., BASSETT, M. G. and CHERNS, L., 2000. Lingulate brachiopods from the Lower Ordovician of the Anglo-Welsh basin. Part 2. *Monographs of the Palaeontographical Society, London*, 154, 61–114.

SZANIAWSKI, H. and BENGTSON, S. 1998. Late Cambrian euconodonts from Sweden. [In: Szaniawski, H., Ed., Proceedings of the Sixth European Conodont Symposium (ECOS VI)], *Palaeontologia Polonica*, 58: 7–29.

ZHEN, Y. Y. and PERCIVAL, I. G., 2003. Ordovician conodont biogeography–reconsidered. *Lethaia*, 36: 357–369.