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First record of the Carboniferous fusuline genus *Parawedekindellina* in a Palaeotethyan area (Cantabrian Zone, NW Spain)

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ABSTRACT

A fusuline species of the genus *Parawedekindellina* Safonova has been found in the Fito Formation of the Carboniferous of the Cantabrian Zone (NW Spain). Representatives of this genus had only previously been recorded from the Arctic and the Ural palaeobiogeographic provinces, and therefore the new species from Spain is the first record of the genus from the Palaeotethyan province. This finding is interpreted as evidence of temporary connections between the Ural and the Palaeotethys provinces.

Keywords: Fusulinoideans, *Parawedekindellina*, Pennsylvanian, palaeobiogeography, Cantabrian Zone.

RESUMEN

Se ha descubierto una especie de *Parawedekindellina* en la Formación Fito, unidad litoestratigráfica del Carbonífero (Pensilvánico) de la Zona Cantábrica. Hasta el momento, sólo se habían descrito representantes de este género en regiones pertenecientes a las provincias paleobiogeográficas del Ártico y los Urales. Por tanto, este hallazgo amplía la distribución de *Parawedekindellina* a la provincia del Paleotethys y demuestra la existencia de conexiones, al menos temporales, entre dos provincias biogeográficas del Pensilvánico.

Palabras clave: Fusulinoideos, *Parawedekindellina*, Pensilvánico, paleobiogeografía, Zona Cantábrica.

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1. INTRODUCTION

During the Pennsylvanian, fusulinoidean foraminifera were distributed throughout the equatorial and subequatorial seas. However, provincialism existed, causing fusulinoidean species, and even some genera, to be restricted to specific areas. Pioneering investigations on such fusulinoidean provincialism were published by Miklukho-Maklay (1963), Solovieva (1974; and *in* Ivanova *et al*., 1979, p. 128-129) and in a number of papers by Ross (1967, 1973, among others), and Ross & Ross (1985, 1987, also among other contributions). The latter emphasized that, contrary to the mostly cosmopolitan shelf faunas in the early Carboniferous, a strong provincialism developed during mid- to late Carboniferous in response to palaeogeographic and climatic variations. According to Ross & Ross (1985), episodic dispersals occurred, probably during maximum glacioeustatic sea level highstands. Immigrants then became isolated and evolved independently in new regions, resulting in the significantly different stratigraphic ranges of a few of widespread genera.

A refined scheme of the fusulinoidean biogeographic provinces was presented by Rui Lin *et al*. (1991) for the late Moscovian (Middle Penssylvanian). These authors estimated that the fusulinoideans thrived on shallow marine environments situated from 30º S to a northern latitude close to 40 º N. Within this belt, Rui Lin *et al*. (1991) separated the Midcontinent-Andean, Arctic, Ural and Tethyan (= Palaeotethyan herein) provinces. They pointed out that common elements in the assemblages of the adjacent provinces indicated that some communication existed, at least sporadically.

This paper shows the evidence of the migration of the Arctic and Uralian genus *Parawedekindellina* to the Cantabrian Zone, northern Spain (Lotze, 1945) (Fig. 1), a region that during the Carboniferous belonged to the Palaeotethyan biogeographic province (Villa *et al*., 2002).

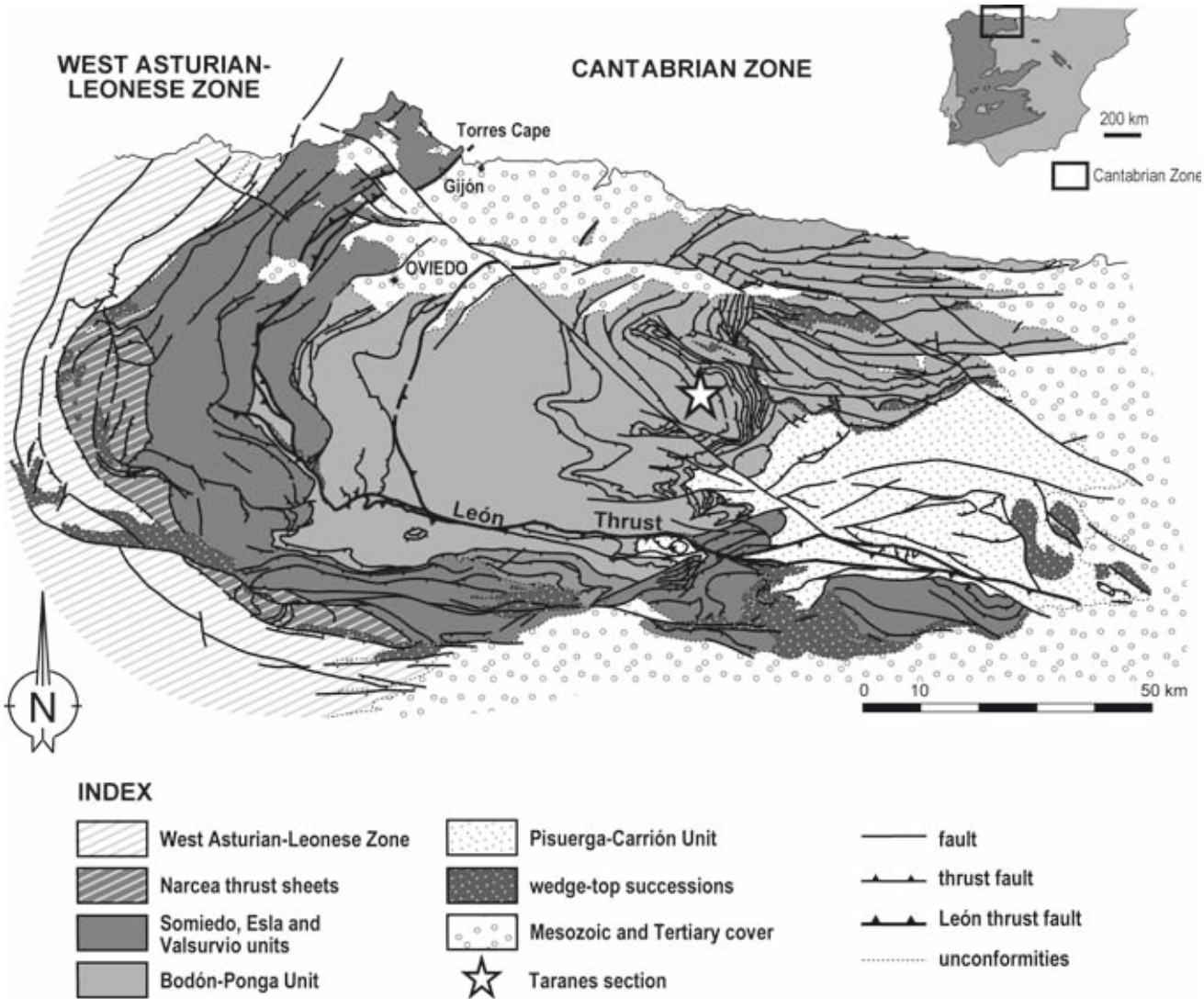

Figure 1. Sketch of the Cantabrian Zone and location of the Taranes section in the Bodón-Ponga Unit (Alonso *et al*., 2009).

2. THE MID-PENNSYLVANIAN PALAEOBIOGEOGRAPHIC PROVINCES OF EURASIA

The fusulinoidean content of Pennsylvanian rocks evidence that three of the four palaeobiogeographic provinces established by Rui Lin *et al*. (1991) are represented in Eurasia: the Arctic, Ural and Palaeotethyan provinces (Fig. 2).

During the late Carboniferous, the Arctic province comprised the north and northwestern margin of Pangea, which Rui Lin *et al*. (1991) have placed in the warm temperate latitudinal climatic zone. Probably as a consequence of this relatively higher latitude, it exhibits a reduced fusulinoidean diversity. Assemblages are dominated by species belonging to *Fusulinella*, *Wedekindellina*, *Pseudostaffella* (*Neostaffella*) and *Pseudoendothyra* genera, whereas the representatives of *Fusulina* and *Beedeina* (typical Moscovian forms in the other provinces) are absent or scarcely represented (Rui Lin *et al*., 1991). The latter genus, *Beedeina*, appears to be somewhat more abundant in the Moscovian formations from Kap Jungersen, North Greenland (Davydov *et al*., 2001).

The Ural province coincides with the Uralian region, which extended from Arctic Russia to the Donets Basin. During the Pennsylvanian, this area constituted a subtropical marine passageway linking the northern Pangea coast with the Palaeotethys ocean. Fusulinoidean faunas are abundant and diverse. Assemblages from the northern part of this province (North Timan, Timan-Petchora, and Arctic Russia) show characteristics that are transitional to those of the Arctic province. The presence of *Wedekindellina*-like forms, which are common in the Arctic province, is the most distinct feature in this respect.

The Palaeotethyan province was the most extensive of the three Eurasian provinces. It occupied a circumequatorial belt, situated from 15º S to 15º N (Rui Lin *et al*., 1991), that extended laterally in the Palaeotethys ocean from present southwestern Europe to eastern Asia. In this province, fusulinoidean assemblages of Moscovian age show probably one of the highest diversities in the history of the fusulinoideans. Most of the known assemblages occur only in the northern margin of the Palaeotethys, and the absence of these faunas in southern similar palaeolatitudes is interpreted as having been caused by cooler conditions due to the proximity of the Gondwana glaciation (Kalvoda, 2002). During mid-Pennsylvanian, the Palaeotethyan and Ural provinces shared the same genera and diversity; however, some taxa that are common in the Palaeotethyan province become progressively rarer towards the north of the Ural province. This is the case of the genus *Verella*, common in the Palaeotethys, present in the South and Central Urals, and rare in the North Urals (Ivanova, 2008).

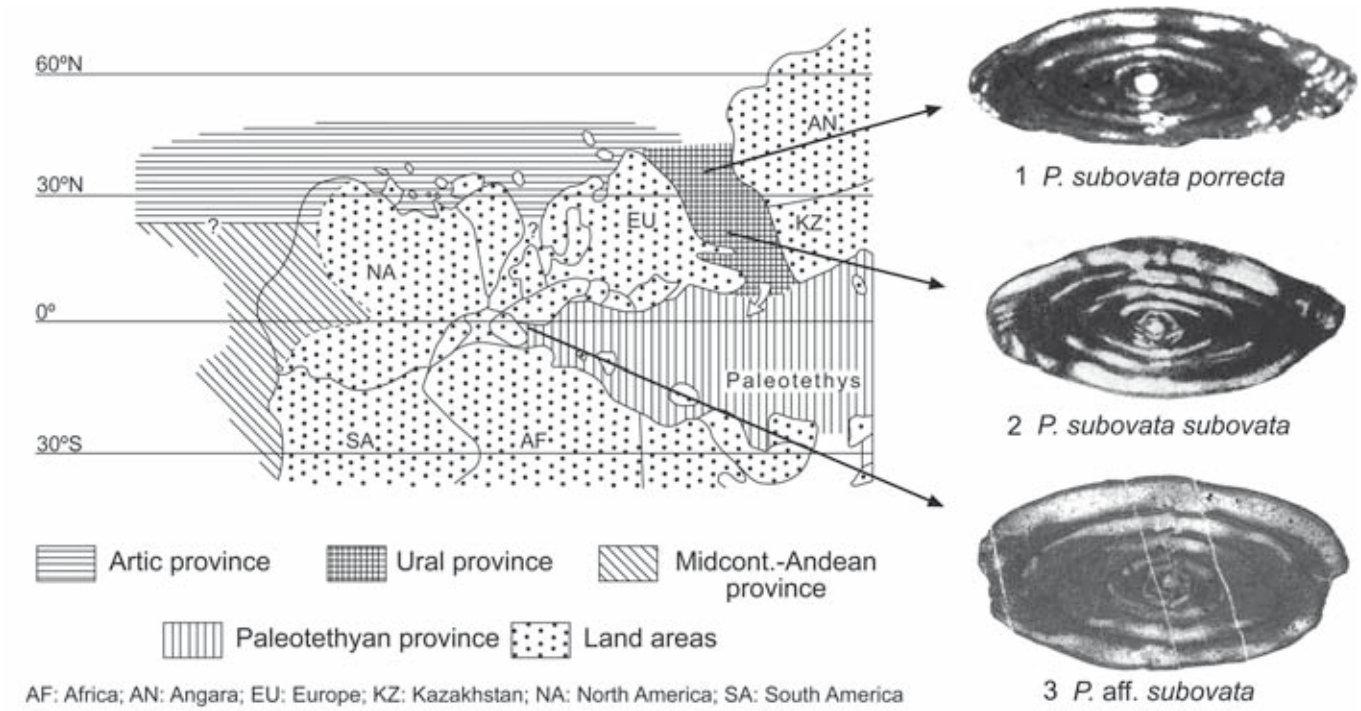

Figure 2. Reconstruction of the Pennsylvanian palaeobiogeograhic provinces, according to Rui Lin *et al*. (1991, slightly modified). 1 *Parawedekindellina subovata porrecta* Remizova (North Timan). 2 *Parawedekindellina subovata subovata* (Safonova) (Russian Platform). 3 *Parawedekindellina* aff. *subovata* (Cantabrian Zone).

3. *PARAWEDEKINDELLINA*, A TYPICAL URALIAN GENUS

The genus *Parawedekindellina* (type species: *P. kamensis* Safonova, 1951) was introduced by Safonova in Rauzer-Chernousova *et al*. (1951). It includes fusulinoideans exhibiting a small ovoid or short fusiform test with few volutions (frequently, no more than 4-4.5), straight septa, sometimes slightly undulated at the poles, and narrow and weakly developed chomata that towards the poles merge with axial fillings. The wall is three-layered in the inner whorls and four-layered in the outer whorls, where it shows a thin but clear non-porous diaphanotheca.

Parawedekindellina species bear a remarkable similarity to other Arctic and Uralian forms such as some of the smaller species belonging to *Wedekindellina* Dunbar & Henbest *in* Cushman, 1933, as well as to species assigned to *Nipperella* Solovieva, 1984. From the former, *Parawedekindellina* is distinguished from *Wedekindellina* by having a smaller size, fewer volutions, a shorter shell, and by lacking pores piercing its four-layered wall. *Nipperella*, except for having weaker axial fillings and more pointed polar ends, shows fewer conspicuous differences from *Parawedekindellina*. This has been noted by Wilde (2006), who pointed out that the specimens assigned to *Parawedekindellina uralica* by Solovieva (1984) have the same generic characteristics as others assigned in the same paper to *Nipperella*. For this reason, Wilde considers that "*Nipperella* is inadequately described as a genus and is, thus, unrecognizable" (Wilde, 2006, p. 39).

As mentioned above, species belonging to *Parawedekindellina* have been described from diverse localities situated in the European part of Russia, such as the Kama River basin in the eastern part of the Russian Platform (Rauzer-Chernouzova *et al*., 1951), the Yugorsky Peninsula (Solovieva, 1984), the Kolguev Island (Davydov, 1994, *fide* Davydov *et al*., 2001), Northern Timan (Remizova, 1995, 2004), and the Middle and South Urals (Ivanova, 2008). Additionally, Kulagina *et al*. (2009) illustrated two wedekindellinid specimens from the Basu River section (South Urals) that were assigned to *Wedekindellina uralica* (Dutkevich), a species that other authors (Rauzer-Chernousova *et al*., 1951; Solovieva, 1984) consider as belonging to *Parawedekindellina*. Note that, except for the findings of Ivanova (2008) and Kulagina *et al*. (2009), which represent the southernmost occurrences so far known, the rest of the localities mentioned above correspond to the northern areas of the Ural palaeobiogeographic province. Regarding its stratigraphic position (Fig. 3), the genus *Parawedekindellina* ranges from the lower Podolian to the Kasimovian (Remizova, 2004).

In addition to these Ural province occurrences, *Parawedekindellina* species could also be distributed in the Arctic province. Rui Lin *et al*. (1991) and Groves *et al*. (1994) described from the Ellesmere Island of the Canadian Arctic Archipielago abundant fusulinoidean specimens, very close or identical to *Parawedekindellina uralica*, which these authors assigned to the genus *Wedekindellina*. However, as these specimens do not show porosity piercing the wall, it seems that they would be better assigned to *Parawedekindellina.* Other Arctic occurrences have been recorded from Spitsbergen (Arctic Norway) by Davydov & Nilsson (1999). *Parawedekindellina* might also occur in Midcontinent and western North America. According to G.P. Wahlman (pers. comm., 2015), fusulines with small elongate fusiform to inflated-fusiform shells, plane septa, and varying secondary deposits occur in lower Desmoinesian strata of that province. Those species have been previously assigned to *Wedekindellina*, but need further study to determine if some species should be reassigned to *Parawedekindellina*.

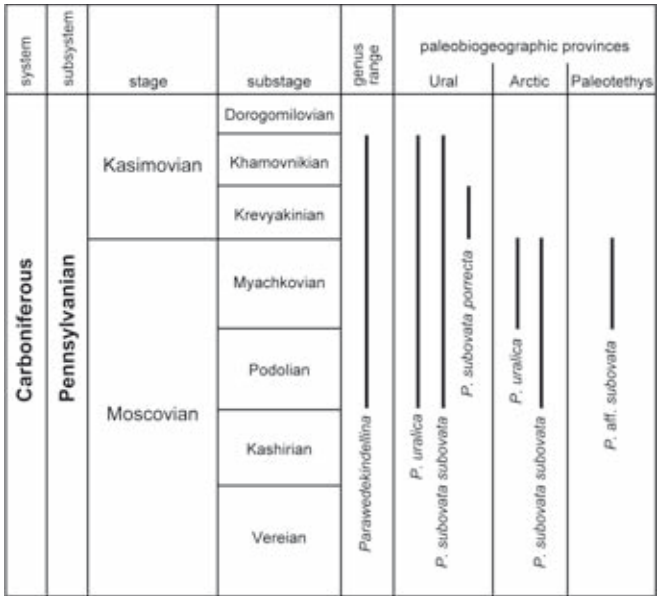

Figure 3. Stratigraphic range of the *Parawedekindellina* species mentioned in this paper.

4. PRESENCE OF *PARAWEDEKINDELLINA* IN THE CANTABRIAN ZONE

As already pointed out by Rui Lin *et al*. (1991), the Carboniferous palaeobiogeographic provinces were not fully isolated, but connections occurred recurrently. It must be noted, however, that in the northern hemisphere most frequent fusulinoidean migrations seem to have taken place from south to north (Groves *et al*., 2007; Villa & Wahlman, 2007; Davydov, 2014), which suggests that migrations

were easier during warming episodes. By contrast, the cases of northern genera that colonized southern areas (and therefore, moved from cooler to warmer waters) seem to have been less frequent.

Parawedekindellina, a typical northern fusuline genus, has recently been found in the upper Moscovian strata of the eastern Bodón-Ponga Unit (Alonso *et al*., 2009) of the Cantabrian Zone, representing the first record in an area that during the Carboniferous belonged to the Palaeotethyan biogeographic province. Two specimens were recovered from a limestone bed of the lower part of the Fito Formation (van Ginkel, 1965) in the Taranes section (Bahamonde *et al*., 2015). On the basis of the rest of the fusuline specimens identified from this bed (see below), an early Myachkovian age can be estimated. No other wedekindellinid fusulines have been recorded so far in the Cantabrian Zone, nor is there any evidence of a possible immediate ancestor of this form in older Cantabrian Zone strata. Therefore, this finding represents apparent evidence for a probable migration from the Ural province to the Palaeotethys, that is, from a northern to a southern area.

Which cause could have led to such a migration? The *Parawedekindellina* specimens occur in the limestone unit labeled Fi 8 in Bahamonde *et al*. (2015, p. 217, fig. 7), lower Myachkovian in age, which laterally correlates with the uppermost part of the Escalada 2 Formation. The latter is a carbonate platform (developed during a significant 3rd-4th-order transgressive interval) that resulted from the vertical stacking of discrete carbonate units accumulated during 5th-order transgressions (*op. cit*.). It might be interpreted that these marine transgressions were the result of the ice-sheets waning during interglacial episodes. In that scenario, sealevel rise would open marine dispersal corridors, thereby enabling the migration of *Parawedekindellina* into the Cantabrian Zone. The Myachkovian age of the bed yielding *Parawedekindellina* indicates that this occurrence coincides with one of the major warming events detected during the Pennsylvanian (Davydov, 2014).

5. SYSTEMATIC PALAEONTOLOGY

Family **Fusulinidae** von Möller, 1878

Subfamily Wedekindellininae Kahler & Kahler, 1966

Genus *Parawedekindellina* Safonova *in* Rauzer-Chernousova *et al*., 1951

Type species *Parawedekindellina kamensis* Safonova *in* Rauzer-Chernousova *et al*., 1951

Parawedekindellina aff. *subovata* (Safonova *in* Rauzer-Chernousova *et al*., 1951)
(Fig. 4)

Material. One axial section (FIT25.5/3) and one parallel section.

Measurements (specimen FIT25.5/3). Length: 1.40 mm. Diameter: 0.72 mm. L/D: 1.94. Number of volutions: 5. Diameter of the 4th whorl: 0.50 mm. Proloculus diameter: 80 μm. Wall thickness (4th whorl): 22 μm.

Description. Test small sized, showing a flattened ovoid shape in outline and broad and rounded polar ends. Chomata very low (their height is about one third of the chamber height), extending to the polar region, where

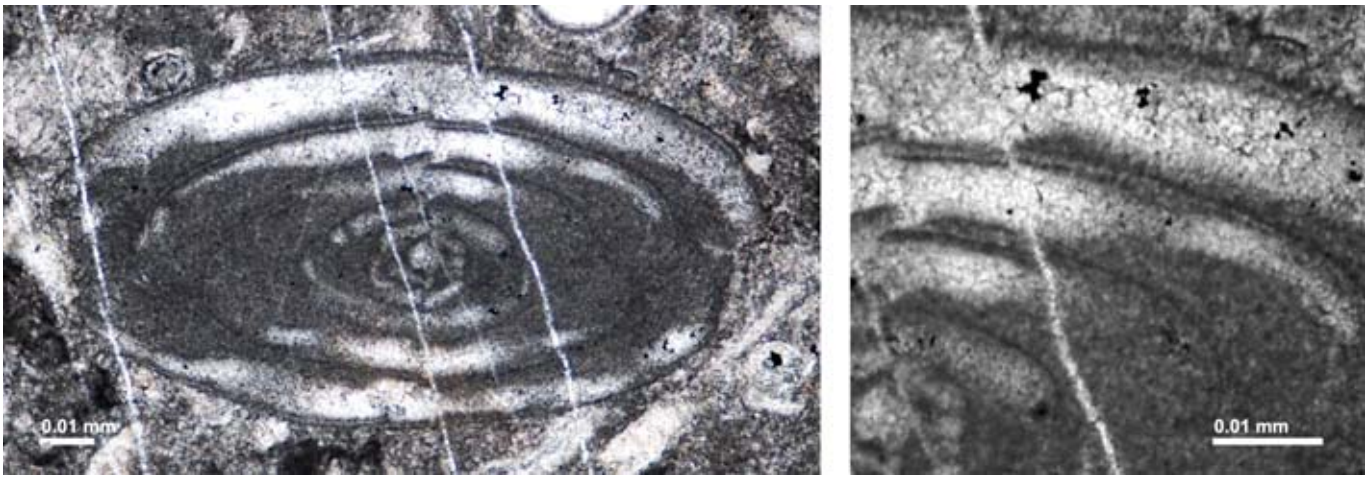

Figure 4. Left: axial section of *Parawedekinellina* aff. *subovata* (Safonova, *in* Rauzer-Chernousova *et al*., 1951) from the lower Myachkovian strata of the Fito Formation in the Taranes section. Right: enlargement of the same specimen to show its wall microstructure.

they merge with thick axial fillings. These last deposits fill or nearly fill the whole chamber in the axial region. In the first two volutions the wall consists of three layers (tectum, primatheca and outer tectorium), a discontinuous diaphanotheca appearing in the third volution; in the fourth volution, the wall is four-layered, exhibiting tectum, thin inner and lower tectoria, and a thin but very distinct diaphanotheca, which is also present in the outer whorl.

Discussion. This species resembles *Parawedekindellina subovata* (Safonova, 1951), which has been described from the Podolian and Myachkovian horizons of the Russian Platform (Kama River basin). The Cantabrian form, however, differs from the Russian species in having more rounded polar ends, a smaller L/D ratio, and somewhat looser spire. Differences in the shape of the polar ends and the L/D ratio also hold for the Northern Timan subspecies *P. subovata porrecta* Remizova, 1995.

Accompanying fusuline microfauna (Fig. 5). *Beedeina* cf. *paradistenta* Safonova, *Fusulinella* aff. *pseudobocki ovoides* Rauzer-Chernousova, *Fusulina* sp., *Putrella* sp., *Pseudostaffella* (*Quasistaffella*) sp., *Pseudostaffella* (*Neostaffella*) ex gr. *ozawai* (Lee & Chen), *Ozawainella* ex gr. *angulata* Chen.

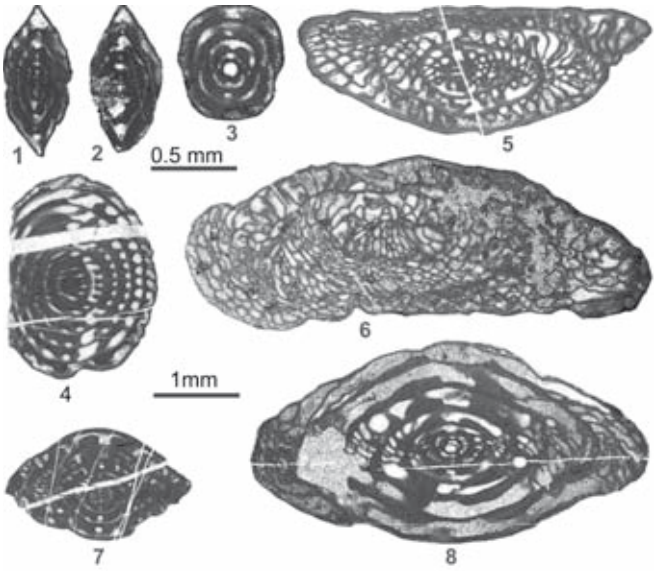

Figure 5. Other fusuline species yielded by the stratigraphic bed containing *Parawedekindellina*. **1-2)** *Ozawainella* ex gr. *angulata* Chen. **3)** *Pseudostaffella* (*Quasistaffella*) sp. **4)** *Pseudostaffella* (*Neostaffella*) ex gr. *ozawai* (Lee & Chen). **5)** *Putrella* sp. **6)** *Fusulina* sp. **7)** *Beedeina* cf. *paradistenta* Safonova. **8)** *Fusulinella* aff. *pseudobocki ovoides* Rauzer-Chernousova. Scale bar representing 0.5 mm indicate magnification of Figs 1-3.

Stratigraphic data and age. Middle part of the Fito Formation, Taranes section, Bodón-Ponga Unit of the Cantabrian Zone. Upper Moscovian (lower Myachkovian).

6. CONCLUDING REMARKS

- The Pennsylvanian fusuline assemblages of the Cantabrian Zone, in NW Spain, show the characteristics of the Palaeotethys biogeographic province of Rui Lin *et al.* (1991).
- *Parawedekindellina*, a fusuline genus regarded as a typical component of the Uralian and Arctic assemblages, has been recently found in lower Myachkovian strata of the Cantabrian Zone, representing the first record of this genus in an area belonging to the Palaeotethys province.
- This new occurrence of *Parawedekindellina* suggests that during the Myachkovian there was a highstand connection between the seas of the Ural and Palaeotethys provinces and a north-to-south fusuline migration.
- Neither ancestors, nor descendants of *Parawedekindellina* have been so far recorded in the Cantabrian Zone, which reinforces the idea of a temporary connection between faunal provinces during a glacioeustatic highstand.

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REFERENCES

Alonso, J.L., Marcos, A. & Suárez, A. 2009. Paleogeographic inversion resulting from large out of sequence breaching thrusts: The León Fault (Cantabrian Zone, NW Iberia). A new picture of the external Variscan Thrust Belt in the Ibero-Armorican Arc. *Geologica Acta*, 7, 451-473; doi:10.1344/105.000001449.

Bahamonde, J.R., Merino-Tomé, O., Della Porta, G. & Villa, E. 2015. Pennsylvanian carbonate platforms adjacent to deltaic systems in an active marine foreland basin (Escalada Fm., Cantabrian Zone, NW Spain). *Basin Research*, 27, 208-229; doi:10.1111/bre.12068.

Cushman, J.A. 1933. Foraminifera, their classification and economic use. *Special Publications Cushman Laboratory for Foraminiferal Research*, 4, 1-349.

Davydov, V. 2014. Warm water benthic foraminifera document the Pennsylvanian-Permian warming and cooling events. The record from the Western Pangea tropical shelves. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 414, 284-295; doi:10.1016/j.palaeo.2014.09.013.

Davydov, V. & Nilsson, I. 1999. Fusulinids from the Middle-Upper Carboniferous boundary beds on Spitsbergen, Arctic Norway. *Palaeontologia Electronica*, 2, 45 p.; http://paleo-electronica.org.

Davydov, V.I., Nilsson, I. & Stemmerik, L. 2001. Fusulinid zonation of the Upper Carboniferous Kap Jungersen and Foldeadal Formations, southern Amdrup Land, eastern North Greenland. *Bulletin of the Geological Society of Denmark*, 48, 31-77.

Ginkel, A.C. van 1965. Carboniferous fusulinids from the Cantabrian Mountains (Spain). *Leidse Geologische Mededelingen*, 34, 1-125.

Groves, J.R., Nassichuk, W.W., Rui Lin & Pinard, S. 1994. Middle Carboniferous fusulinacean biostratigraphy, northern Ellesmere Island (Sverdrup Basin, Canadian Arctic Archipielago). *Bulletin of the Geological Survey of Canada*, 469, 1-55.

Groves, J.R., Kulagina, E.I., & Villa, E. 2007. Diachronous appearances of the Pennsylvanian fusulinid *Profusulinella* in Eurasia and North America. *Journal of Paleontology*, 81, 227-237.

Ivanova, E.A., Solovieva, M.N. & Shik, E.M. (in collaboration with Arendt, Y.A., Kuznetsov, Y.I., Lazarev, S.S., Morozova, I.P., Nikitina, T.A., Rosovskaya, S.E., Semenova, E.G. Fissunenko, O.P., Shestakova, M.V. & Shcherbakova, M.V.). 1979. The Moscovian stage in the USSR and throughout the world. In: *The Carboniferous of the World* (eds. Wagner, R.H., Higgins, A.C. & Meyen, S.V.). Yorkshire Geological Society, Occasional Publication nº 4, 117-146.

Ivanova, R.M. 2008. *Fusulinids and algae of the Urals Middle Carboniferous (zonal stratigraphy, paleobiogeography, paleontology)*. Rossiiskaya Akademiya Nauk, Urlaskoe Otdelenie, Institut Geologii i Geokhimii, 1-203 (in Russian).

Kahler, F. & Kahler, G. 1966. *Fusulinida (Foraminiferida), Teil 2. Fossilium Catalogus, I: Animalia, Pars 112*. Uitgeverij Dr. W. Junk, 's-Gravenhage, 255-538.

Kalvoda, J. 2002. *Late Devonian-Early Carboniferous Foraminiferal fauna: zonations, evolutionary events, paleobiogeography and tectonics implications*. Folia, Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, 1-213.

Kulagina, E.I., Pazukhin, V.N. & Davydov, V.I. 2009. Pennsylvanian biostratigraphy of the Basu River section with emphasis on the Bashkirian-Moscovian transition. In: *The Carboniferous Type Sections in Russia and Potential Global Stratotypes* (ed. Puchkov, V.N.). Proceedings of the International Field Meeting "The historical type sections, proposed and potential GSSP of the Carboniferous in Russia", Institut of Geology, Bashkirian Academy of Sciences, Ufa, Russia, 42-63.

Lotze, F. 1945. Zur Gliederung der Varisziden der Iberischen Meseta. *Geotecktonic Forschungen*, 6, 78-92.

Miklukho-Maklay, A.D. 1963. *Upper Paleozoic of Central Asia*. Izdatelstvo Leningradskogo Universiteta, 1-328 (in Russian).

Möller, V. von 1878. Die spiral-gewundenen Foraminiferen des russischen Kohlenkalks. *Mémoires de l'Academie Imperiale de Science, VII Série*, 25, 1-47.

Rauzer-Chernousova, D.M., Gryzlova, N.D., Kireeva, G.D., Leontovich, G.E., Safonova, T.P. & Chernova, E.I. 1951. Middle Carboniferous fusulinids of the Russian Platform and adjacent regions. *Akademiya Nauk SSSR, Institut Geologicheskikh Nauk, Ministerstvo Neftianoy Promyschlennosti SSSR*, 1-229 (in Russian).

Remizova, S.T. 1995. Foraminifera and biostratigraphy of the Upper Carboniferous from Northern Timan. *Rossiskaya Akademiya Nauk, Uralskoye Otdelenie, Komi Nauchnyi Tsentr, Institut Geologii, Syktyvkar*, 1-128.

Remizova, S.T. 2004. Fusulinoida from Timan: evolution, biostratigraphy and paleobiogeography. *Rossiskaya Akademiya Nauk, Uralskoye Otdelenie, Komi Nauchnyi Tsentr, Institut Geologii, Ekaterinburg*, 1-200.

Ross, C.A. 1967. Development of Fusulinid (Foraminifera) faunal realms. *Journal of Paleontology*, 41, 1341-1354.

Ross, C.A. 1973. Carboniferous Foraminifera. In: *Atlas of Paleobiogeography* (ed. Hallam, A.). Elsevier, New York and London, 127-133.

Ross, C.A. & Ross, J.R.P. 1985. Carboniferous and Early Permian biogeography. *Geology*, 13, 27-30; doi:10.1130/0091-7613(1985)13<27:CAEPB>2.0.CO;2.

Ross, C.A. & Ross, J.R.P. 1987. Biostratigraphic zonation of Late Paleozoic depositional sequences. In: *Timing and depositional history of eustatic sequences: Constraints on seismic stratigraphy* (eds. Ross, C.A. & Haman, D.). Cushman Foundation for Foraminiferal Research, Special Publication 24, 151-168.

Rui Lin, Ross, C.A. & Nassichuk, W.W. 1991. Upper Moscovian (Desmoinesian) fusulinaceans from the type section of the Nansen Formation, Ellesmere Island, Arctic Archipielago. *Bulletin of the Geological Survey of Canada*, 418, 1-121.

Solovieva, M.N. 1974. Paleobiogeographical zonation of the open seas of the Middle Carboniferous Epoch (according to Fusulinacea). *Izvestia Ademiya Nauk SSSR, ser. geol*, 11, 123-127 (in Russian).

Solovieva, M.N. 1984. Lower boundary of the Upper Carboniferous based on foraminiferal fauna of the Yugorsky peninsula. In: *Verkhniy Karbon SSSR*. Trudy Mezhvedomstvennogo Statigraficheskogo Komiteta, Akademiya Nauk SSSR, Ministerstvo Geologii SSSR, 13, 121-155.

Villa, E. & Wahlman, G.P. 2007. Late Middle to Late Pennsylvanian fusulinoidean paleobiogeography. In: *Proceedings of the XVth International Congress on Carboniferous and Permian Stratigraphy, Utrecht* (ed. Wong, T.E.). Royal Netherlands Academy of Arts and Sciences, Amsterdam, 497-511.

Villa, E., Dzhenchuraeva, A., Forke, H.C. & Ueno, K. 2002. Distinctive features of Late Carboniferous fusulinoidean faunas from the western Paleo-Tethyan realm. In: *Carboniferous and Permian of the World* (eds. Hills, L.V., Henderson, C.M. & Bamber, E.W.). Canadian Society of Petroleum Geologists Memoir, 19, 609-615.

Wilde, G.L. 2006. Pennsylvanian-Permian Fusulinaceans of the Big Hatchet Mountains, New Mexico. *Bulletin of the New Mexico Museum of Natural History and Science*, 38, 1-331.