

# A new occurrence of the genus *Tonkinella* in northern Spain and the Middle Cambrian intercontinental correlation

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## ABSTRACT

The genus *Tonkinella* is a typical polimeroid trilobite in lower Middle Cambrian rocks from Vietnam, Canada, U.S.A., India, Korea, Siberia, China and Argentina. It has recently been found in the Mediterranean region (Iberian Chain, northeastern Spain). In this paper we refer the finding of *Tonkinella* aff. *breviceps* in the Leonian (lower Middle Cambrian) of the Cantabrian Mountains (northern Spain), analysing its stratigraphical position, fossil assemblages, biochronology and utility for intercontinental correlation. The presence of this taxon allows us to make a more accurate correlation between the Middle Cambrian biochronological scales of Laurentia, the Mediterranean area and China.

**KEYWORDS** | Trilobita. *Tonkinella*. Leonian (Middle Cambrian). Biostratigraphy. Correlation. Palaeobiogeography.

## INTRODUCTION

One of the most significant problems in Cambrian correlation is the strong provinciality of the polimeroid trilobites, which are the main faunas used in Cambrian biochronology (Shergold, 1997). This is why studies of the presence of common trilobite species in different biogeographical realms are one of the lines of research encouraged by the International Subcommission on Cambrian Stratigraphy (I.S.C.S.).

The genus *Tonkinella* is one of the most widespread polimeroid trilobite taxa in lower Middle Cambrian rocks. It was defined in Vietnam by Mansuy (1916) and afterwards was found in India, North America, Korea, Siberia, China and Argentina (see Bordonaro and Baldis, 1987; Sundberg, 1994; Bordonaro and Banchig, 1995; Jell and Hughes, 1997). Recently Liñán and

Gozalo (1999) defined *Tonkinella sequei* from the uppermost Lower Cambrian of the Iberian Chain (northeastern Spain), representing the first time *Tonkinella* was found in the Early Cambrian. Moreover, this was the first record of the genus in the Acadobaltic Province.

In this paper *Tonkinella* aff. *breviceps* KOBAYASHI, 1934 is cited from the Upper Leonian (lower Middle Cambrian; Liñán et al., 1993) of the Cantabrian Mountains at the lower Presa del Porma section, "Pu" ("u" stands for the German *untere*, lower) in northern Spain (see Sdzuy, 1995; Gámez Vintaned et al., 2000). The meaning and value of this species as a tool for intercontinental correlation is evaluated. *Tonkinella breviceps* has a wide geographical distribution. It has previously been cited in Kashmir (India: Kobayashi, 1934; Reed, 1934; Jell and Hughes, 1997), Korea (Kobayashi, 1935; Chough et al., 2000),

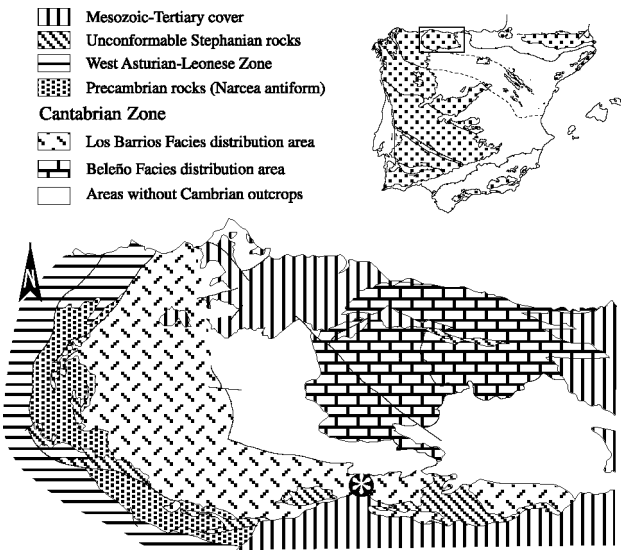


FIGURE 1 | Geological sketch of the Cantabrian Zone showing the Cambrian facies distribution (modified from Sdzuy and Liñán, 1993). The Los Barrios facies records the most complete succession of the Lower-Middle Cambrian carbonate lithological assemblage, while the Beleño facies lacks the reddish, nodular limestones (griotte) of the top of the Láncara Formation. \*: lower Porma section ("Pu").

Alabama, Utah and Nevada (USA: Resser, 1938; Sundberg, 1994), western Newfoundland (Canada: Kindle, 1982; Young and Ludvigsen, 1989) and Siberia (Soloviev, 1989).

**GEOLOGICAL AND STRATIGRAPHIC SETTING OF THE LOWER PRESA DEL PORMA SECTION**

The fossil described here was found at the lower Presa del Porma section ("Pu") in León province (northern Spain), whose UTM coordinates are 30T UN 121548. The section is located in the topographic map sheet at scale 1:50.000 named Boñar (number 104 of the cartography of Servicio Geográfico del Ejército Español). From a geological point of view the studied area is located in the Somiedo-Correcilla Domain, within the Cantabrian Zone. The Middle Cambrian Láncara and Oville Formations which crops out in the area of Presa del Porma were characterised by Sdzuy and Liñán (1993) as representative of the so-called Los Barrios facies (Fig. 1).

The lower Presa del Porma section has been previously studied by Sdzuy (1969, 1995) and Zamarreño (1972). The first author listed the trilobite faunas and showed a biostratigraphic sketch for the upper Láncara Formation and lower Oville Formation, while the second analysed the stratigraphy and sedimentology of the Láncara

Formation. The fossils studied in this paper come from the lowermost visible strata of the Oville Formation (Fig. 2). At this locality, a thickness of 10 m at the boundary between the underlying Láncara Formation and the Oville Formation is covered by soil. The covered interval possibly includes the lowest part of the Oville Formation. The rocks containing *Tonkinella* consist of green shales bearing carbonate nodules and a few levels of very fine green sandstones.

*Tonkinella* aff. *breviceps* has been found at the lower Presa del Porma section in beds containing the following trilobites species: *Eccaparadoxides asturianus* (SDZUY, 1968), *Paradoxides? enormis* SDZUY, 1968, *Acadolenus decorus* SDZUY, 1968 and *Conocoryphe (Parabailiella) matutina* SDZUY, 1968. The age of this assemblage is *Eccaparadoxides asturianus* Zone, which characterises the late Leonian in the Mediterranean biochronology (Gozalo and Liñán, 1995; Sdzuy et al., 1999). A late Leonian age for the specimen of *Tonkinella* aff. *breviceps* cited here is also supported by the first record of *Badulesia tenera* (HARTT in Dawson, 1865), which is found some 4 m above in the same succession. The FAD of this species marks the beginning of the Caesaraugustan Stage (sensu Sdzuy et al., 1996). The Leonian/Caesaraugustan boundary has been correlated with the base of the *Triplagnostus gibbus* or *Ptychagnostus gibbus* Zone by Sdzuy et al. (1999); see also Gozalo et al. (in this issue).

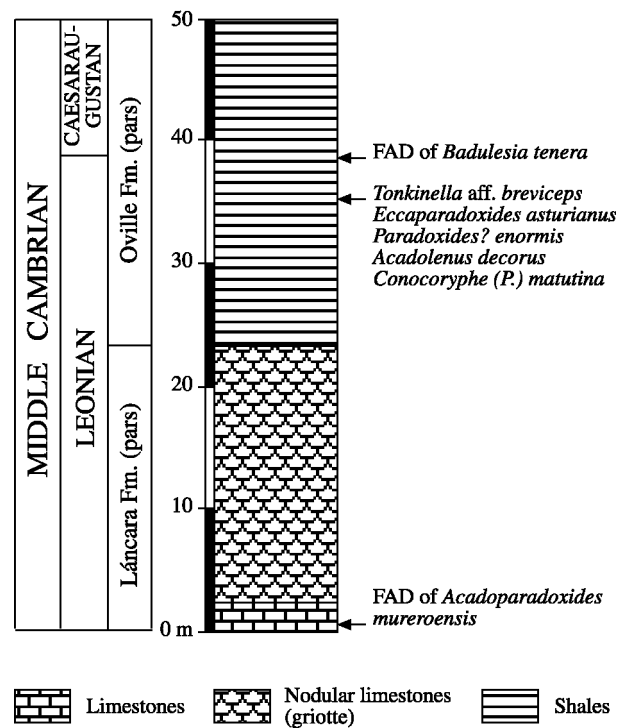


FIGURE 2 | Stratigraphy of the Middle Cambrian at the lower Presa del Porma section ("Pu"). Modified from Sdzuy (1995).

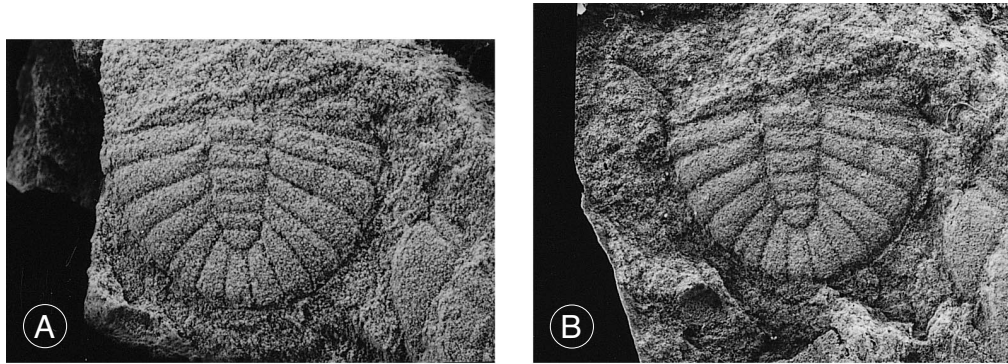


FIGURE 3 | A) Pygidium of *Tonkinella* aff. *breviceps* KOBAYASHI, internal mould, x 5, MPZ 2000/3. B) Latex cast of the external mould, same specimen.

**SYSTEMATIC PALAEOLOGY**

- Order:** Corynexochida KOBAYASHI, 1935
- Family:** Oryctocephalidae BEECHER, 1897
- Subfamily:** Oryctocephalinae BEECHER, 1897

GENUS *Tonkinella* MANSUY, 1916

Type species: *Tonkinella flabelliformis* MANSUY, 1916

*Tonkinella* aff. *breviceps* KOBAYASHI, 1934  
Figure 3

*Material:* A pygidium preserved as inner and outer moulds in green shales from the Oville Formation at the lower Presa del Porma section (“Pu”) in León province (northern Spain). Specimen deposited at the Museo Paleontológico de la Universidad de Zaragoza (Zaragoza, Spain) under reference MPZ 2000/3.

*Dimensions:* Pygidial length is 4.4 mm, axis length 3.1 mm, pygidial width 6.7 mm, axis width 1.55 mm. Posterior pleural segment width is 0.75 mm. Pygidial length is 65% of pygidial width. Posterior pleural segment width is 11% of pygidial width.

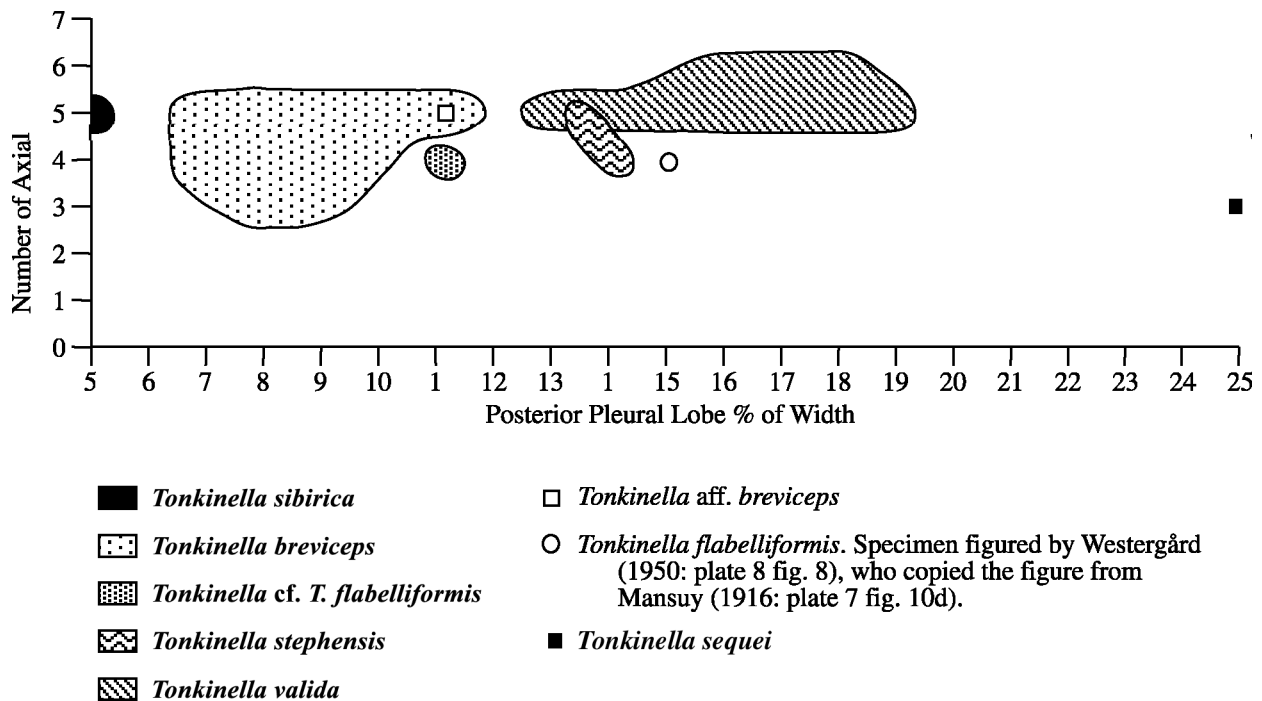


FIGURE 4 | Distribution of *Tonkinella* species based on the number of axial rings and relative width of the posterior pleural segment (modified from Sundberg, 1994).

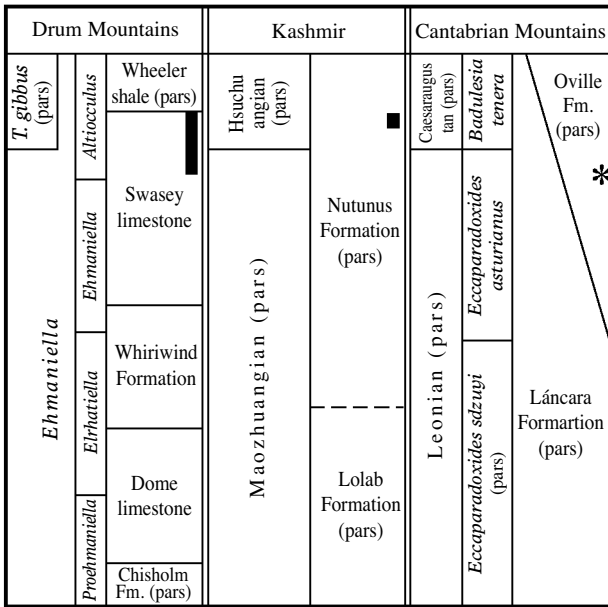


FIGURE 5 | Correlation chart of the main successions containing *Tonkinella* gr. *breviceps* КОБАЯШИ, based on Sundberg (1994), Jell and Hughes (1997), Szzy et al. (1999), and Hughes and Jell (1999). Black rectangle: *Tonkinella breviceps* distribution; \*: *Tonkinella* aff. *breviceps*.

Remarks: *Tonkinella breviceps* has recently been comprehensively described from undistorted limestone specimens by Sundberg (1994). Also, the type material has

been reviewed by Jell and Hughes (1997), who chose the lectotype and refigured the type. Sundberg (1994: p. 35, fig. 23) used the relative width of the posterior pleural segment and the number of axial rings to recognise four groups of pygidia within the genus *Tonkinella*. *T. aff. breviceps* is placed within the *T. breviceps* group (Fig. 4). The pygidium described here shows the same features as the material described and/or figured by Sundberg (1994) and Jell and Hughes (1997), and its size is included within the specific variability.

Although the Spanish pygidium shows the main characteristics of *T. breviceps* pygidia, we prefer to keep our specimen in open nomenclature because we have not yet found any cranidium.

**DISCUSSION: AGE, CORRELATION AND BIOGEOGRAPHY**

According to Whittington (1995), the youngest known oryctocephalid trilobite appears to be a species of *Tonkinella*. The same author interpreted *Tonkinella* species from North America, Vietnam and Siberia as occurring at a similar level. Chang (1988: p. 69) placed the Vietnamese specimens in the Hsuehuangian Stage. Jell and Hughes (1997: text-fig. 4) and Hughes and Jell (1999: fig. 2) placed the Himalayan *Tonkinella* in the same Stage. *Tonkinella* was found at the highest part of the Amgan Stage in

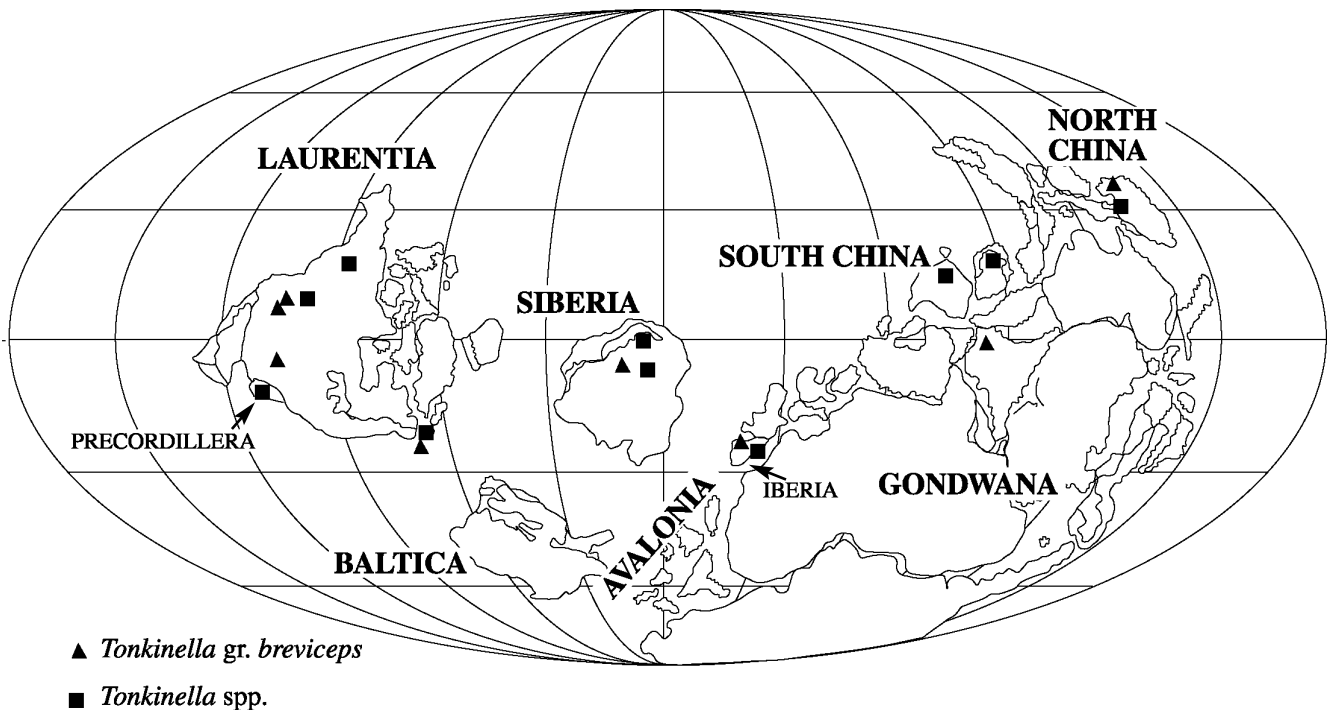


FIGURE 6 | Palaeogeographic reconstruction of the early Middle Cambrian (modified from McKerrow et al., 1992; Argentine Precordillera placed sensu Astini et al., 1996 and Peralta, 2000) and the distribution of *Tonkinella* species.

Siberia (Astashkin et al., 1991: p. 68). Nevertheless, the most continuous record of *Tonkinella* has been found in the Great Basin of North America by Sundberg (1994).

*T. breviceps* appears in the *Altiocculus* Subzone (uppermost *Ehmaniella* Zone) defined by Sundberg (op. cit.), who wrote (p. 11): "As defined here, the *Altiocculus* Subzone also incorporates the upper part of the *Ptychagnostus praecurrens* agnostoid Zone and the majority of the *P. gibbus* agnostoid biozone." The occurrences of this species from other countries are of a similar age (Sundberg, 1994; Jell and Hughes, 1997; Fig. 5).

The level containing *Tonkinella* aff. *breviceps* in Spain can be correlated with the level just below the FAD of *Triplagnostus gibbus* (see above). In consequence, we tentatively correlate the level with *Tonkinella* aff. *breviceps* with the lower part of the *Altiocculus* Subzone, particularly with the levels preceding to the *Triplagnostus gibbus* FAD.

Biogeographically, *Tonkinella* species are widely distributed in lower latitudes at the early Middle Cambrian (Fig. 6), in accordance with the palaeogeographical reconstruction proposed by McKerrow et al. (1992). They appear within the tropical carbonate development zone suggested by Courjault-Radé et al. (1992) for the continental margins of Gondwana. This interpretation is in accordance with Shergold's (1969) idea of considering the oryctocephalid as a tropical fauna. The intercontinental distribution of *Tonkinella* in Laurentia, Siberia and Gondwana may be interpreted as a result of its pelagic habit, at least during a larval phase.

## CONCLUSIONS

In summary, the presence of *Tonkinella* aff. *breviceps* allows us to make a more accurate correlation between the Middle Cambrian biochronological scales of Laurentia, the Mediterranean area and China (Fig. 5). Accordingly, the *Eccaparadoxides asturianus* Zone is an equivalent of the upper part of the *Triplagnostus praecurrens* Zone or lower part of the *Altiocculus* Subzone in the Great Basin (U.S.A.). This new datum is in agreement with the general correlation suggested by Szalay et al. (1999) for the Upper Leonian, and represents the first correlation point between the Spanish and Kashmirian Cambrian.

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## REFERENCES

- Astashkin, V.A., Pegel, T.V., Repina, L.N., Rozanov, A.Y., Shabanov, Y.Y., Zhuravlev, A.Y., Sukhov, S.S., Sundukov, V.M., 1991. The Cambrian System on the Siberian Platform. International Union of Geological Sciences Publication, 27, 133 pp.
- Astini, R.A., Ramos, V.A., Benedetto, J.L., Vaccari, N.E., Cañas, F.L., 1996. La Precordillera: Un terreno exótico a Gondwana. Actas del XIII Congreso Geológico Argentino y III Congreso de Exploración de Hidrocarburos, 5, 293-324.
- Bordonaro, O.L., Baldis, B.A., 1987. *Tonkinella stephensis* (Trilobita) en el Cámbrico Medio de la Sierra del Tontal, Precordillera de San Juan, Argentina, su importancia paleogeográfica. IV Congreso Latinoamericano de Paleontología, Bolivia, Memorias 1, 5-15.
- Bordonaro, O.L., Banchig, A.L., 1995. Trilobites laurénticos en el Cámbrico de la Precordillera Argentina. VI Congreso Argentino de Paleontología y Bioestratigrafía, Actas, 59-65.
- Chang, W.T., 1988. The Cambrian System in Eastern Asia. International Union of Geological Sciences Publication, 24, 81 pp.
- Chough, S.K., Kwon, S.T., Ree, J.H., Choi, D.K., 2000. Tectonic and sedimentary evolution of the Korean peninsula: a review and new view. Earth-Science Reviews, 52, 175-235.
- Courjault-Radé, P., Debrenne, F., Gandin, A., 1992. Palaeogeographic and geodynamic evolution of the Gondwana continental margins during the Cambrian. Terra Nova, 4, 657-667.
- Gámez Vintaned, J.A., Mayoral, E., Gozalo, R., 2000. Lower and Middle Cambrian trace fossils from the Láncara and Oville formations in the area of Presa del Porma (Cantabrian Zone, northern Spain). In: Aceñolaza, G.F., Peralta, S. (eds.). Cambrian from the southern edge. INSUGEO, Miscelánea 6, 91-94.
- Gozalo, R., Liñán, E., 1995. Leonian (early Middle Cambrian) *Paradoxides* biostratigraphy. Beringeria, Special Issue 2, 169-171.
- Gozalo, R., Liñán, E., Palacios, T., Gámez Vintaned, J.A., Mayoral, E. 2003. The Cambrian of the Iberian Peninsula: An overview. Geologica Acta, 1, 103-112.
- Hughes, N.C., Jell, P.A., 1999. Biostratigraphy and biogeography of Himalayan Cambrian trilobites. Geological Society of America, Special Paper, 328, 109-116.
- Jell, P.A., Hughes, N.C., 1997. Himalayan Cambrian Trilobites. Special Papers in Palaeontology, 58, 1-113.
- Kindle, C.H., 1982. The C.H. Kindle collection: Middle Cambrian to Lower Ordovician trilobites from the Cow Head Group, western Newfoundland. Current Research, Geological Survey of Canada, Paper, 82-1C, 1-17.
- Kobayashi, T., 1934. Middle Cambrian fossils from Kashmir. American Journal of Science, 27, 295-302.
- Kobayashi, T., 1935. The Cambro-Ordovician Formations and Faunas of South Chosen. Palaeontology. Part III. Cambrian

- Faunas of South China with a special study on the Cambrian Trilobite Genera and Families. *Journal of the Faculty of Science, Imperial University of Tokyo* (section 2), 4(2), 49-344.
- Liñán, E., Gozalo, R., 1999. Nuevos trilobites del Cámbrico Inferior de Aragón. In: Gámez Vintaned, J.A., Liñán, E. (eds.). 25 años de Paleontología Aragonesa. Homenaje al Prof. Leandro Sequeiros. Zaragoza, Institución "Fernando el Católico", 255-261.
- Liñán, E., Perejón, A., Sdzuy, K., 1993. The Lower-Middle Cambrian stages and stratotypes from the Iberian Peninsula: a revision. *Geological Magazine*, 130(6), 817-833.
- Mansuy, H., 1916. Faunes cambriennes de l'extrême-Orient méridional. *Mémoires du Service Géologique de l'Indochine*, 5(1), 1-48.
- McKerrow, W.S., Scotese, C.R., Brasier, M.D., 1992. Early Cambrian continental reconstructions. *Journal of the Geological Society, London*, 149, 599-606.
- Peralta, S. 2000. An introduction to the geology of Precordillera. In: Aceñolaza, G.F., Peralta, S. (eds.). *Cambrian from the southern edge*. INSUGEO, Miscelánea 6, 14-20.
- Reed, F.R.C., 1934. Cambrian and Ordovician fossils from Kashmir. *Memoirs of the Geological Survey of India, Paleontologica Indica, New Series*, 21, 1-38.
- Resser, C.E., 1938. Fourth contribution to nomenclature of Cambrian fossils. *Smithsonian Miscellaneous Collections*, 97(10), 1-43.
- Sdzuy, K., 1968. Trilobites del Cámbrico Medio de Asturias. *Trabajos de Geología, Universidad de Oviedo* (1967), 1, 77-133.
- Sdzuy, K., 1969. Bioestratigrafía de la griotte cámbrica de Los Barrios de Luna (León) y otras sucesiones comparables. *Trabajos de Geología, Universidad de Oviedo* (1968), 2, 45-58.
- Sdzuy, K., 1995. Acerca del conocimiento actual del Sistema Cámbrico y del Límite Cámbrico Inferior-Cámbrico Medio. In: Gámez Vintaned, J.A., Liñán, E. (eds.). *La expansión de la vida en el Cámbrico. Libro homenaje al Prof. Klaus Sdzuy*. Zaragoza, Institución "Fernando el Católico", 253-263.
- Sdzuy, K., Liñán, E., 1993. Rasgos paleogeográficos del Cámbrico Inferior y Medio del norte de España. *Cuadernos del Laboratorio Xeolóxico de Laxe*, 18, 189-215.
- Sdzuy, K., Liñán, E., Gozalo, R., 1996. The Middle Cambrian Series. In: Liñán, E., Gámez Vintaned, J.A., Gozalo, R. (eds.). *II Field Conference of the Cambrian Stage Subdivision Working Groups. International Subcommission on Cambrian Stratigraphy. Spain, 13-21 September 1996. Field Trip Guide and Abstracts*. Zaragoza, Universidad de Zaragoza, 16-18.
- Sdzuy, K., Liñán, E., Gozalo, R., 1999. The Leonian Stage (early Middle Cambrian): a unit for Cambrian correlation in the Mediterranean subprovince. *Geological Magazine*, 136(1), 39-48.
- Shergold, J.H., 1969. Oryctocephalidae (Trilobita: Middle Cambrian) of Australia. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin*, 104, 1-66.
- Shergold, J.H., 1997. Explanatory notes for the Cambrian Correlation Chart. In: Kaesler, R.L. (ed.). *Treatise on Invertebrate Paleontology, Part O, Revised. Arthropoda 1, Trilobita 1*. Boulder-Lawrence, Geological Society of America-University of Kansas, 303-311.
- Soloviev, I.A., 1989. New Cambrian trilobites from the northern Siberian Platform. *Palaeontological Journal*, 22, 55-63.
- Sundberg, F.A., 1994. Corynexochida and Ptychopariida (Trilobita, Arthropoda) of the *Ehmaniella* Biozone (Middle Cambrian), Utah and Nevada. *Contributions in Science, Natural History Museum of Los Angeles County*, 446, 1-137.
- Westergård, A.H., 1950. Non-Agnostidean Trilobites of the Middle Cambrian of Sweden. I. *Sveriges Geologiska Undersökning, (C)* (1949), 498, 1-33.
- Whittington, H.B., 1995. Oryctocephalid trilobites from the Cambrian of North America. *Palaeontology*, 38(3), 543-562.
- Young, G.A., Ludvigsen, P., 1989. Mid-Cambrian Trilobites from the lower part of the Cow Head Group, Western Newfoundland. *Geological Survey of Canada Bulletin*, 392, 1-49.
- Zamarreño, I., 1972. Las litofacies carbonatadas del Cámbrico de la Zona Cantábrica (NW de España) y su distribución paleogeográfica. *Trabajos de Geología, Universidad de Oviedo*, 5, 1-118.

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