C. R. Palevol 1 (2002) 205–211

S1631068302000313/FLA

General Palaeontology / Paléontologie générale
(Biostratigraphy / Biostratigraphie)

Discovery of radiolaria and conodonts in the Carboniferous–Permian of San Salvador Patlanoaya (Puebla, Mexico); biostratigraphic implications

Martial Caridroit[a,*], Aude Lamerandt[a], Jean-Marie Dégardin[a], Antonio Flores de Dios[b], Daniel Vachard[a]

[a] *UFR des sciences de la Terre, Upresa 8014 du CNRS, université des sciences et technologies de Lille, 59655 Villeneuve d'Ascq cedex, France*

[b] *Escuela regional de ciencias de la Tierra, universidad autónoma de Guerrero, A.P. 197, Taxco, Guerrero, Mexico*

Received 14 January 2002; accepted 24 June 2002

Presented by Jean Dercourt

Abstract – New identifications of radiolaria and conodonts allow clarifying the biostratigraphy of the Pennsylvanian and Permian deposits in San Salvador Patlanoaya (Puebla State, Mexico). The radiolaria are sometimes relatively common in the series, but weakly diversified and endemic. Among the conodonts, *Streptognathodus bellus* is characteristic of the Late 'Virgilian' sensu Baars, probably coeval with the Early Wolfcampian sensu Thompson or Wilde, the Bursumian of Ross & Ross or the Orenburgian–Asselian stage or substage of Russia (sensu Davydov). San Salvador Patlanoaya is a key-section for the Pennsylvanian–Permian boundary in Mexico. ***To cite this article: M. Caridroit et al., C. R. Palevol 1 (2002) 205–211.*** © 2002 Académie des sciences / Éditions scientifiques et médicales Elsevier SAS

Pennsylvanian / Permian / biostratigraphy / conodont / radiolaria / Mexico

Résumé – Des découvertes de radiolaires et de conodontes permettent de préciser la stratigraphie du Pennsylvanien et du Permien à San Salvador Patlanoaya (État de Puebla, Mexique). Les radiolaires sont parfois fréquents, mais ils sont peu diversifiés et relativement endémiques. Parmi les conodontes, *Streptognathodus bellus* caractérise une biozone réduite, mais discutée, du Virgilien sommital, du Wolfcampien inférieur, du Bursumien ou de l'Orenburgien–Assélien. La coupe de San Salvador Patlanoaya est la première coupe mexicaine, où le passage du Carbonifère au Permien est clairement identifié et caractérisé paléontologiquement. ***Pour citer cet article : M. Caridroit et al., C. R. Palevol 1 (2002) 205–211.*** © 2002 Académie des sciences / Éditions scientifiques et médicales Elsevier SAS

Pennsylvanien / Permien / biostratigraphie / conodontes / radiolaires / Mexique

Version abrégée

Le Paléozoïque supérieur du Mexique est très parcellaire et disséminé au sein de nombreuses microplaques [7, 17, 20]. Il est bien représenté dans la coupe de San Salvador Patlanoaya (Puebla). Ses macrofaunes et microfaunes carbonatées ont déjà été inventoriées [5, 6, 19, 21–23]. Cette note expose les résultats d'une étude des conodontes et des radiolaires du Pennsylvanien et du Permien inférieur. Les radiolaires n'étaient connus que dans quelques intercalations jaspoïdes [19, 20] ; les conodontes n'avaient été signalés qu'une seule fois [5]. La formation, ou mieux, le groupe de Patlanoaya repose en discordance angulaire sur le Paléozoïque inférieur métamorphique du groupe d'Acatlán. Les séries s'étagent du Tournaisien inférieur (peut-être du Dévonien supérieur) au Permien moyen (éventuellement supérieur).

*Correspondence and reprints.
E-mail address: Martial.Caridroit@univ-lille1.fr (M. Caridroit) ; Daniel.Vachard@univ-lille1.fr (D. Vachard).

Trois niveaux de récoltes précédentes [19], Pp04, Pp15 et Pp24, nous ont livré des radiolaires. De surcroît, l'échantillon Pp24 a fourni des conodontes. Les passées radiolaritiques de Pp04 offrent des associations dominées par *Latentifistula* ex gr. *impella* (Ormiston & Lane, 1976) sensu Caridroit, 2000 [8]. Ce radiolaire ne permet malheureusement pas de préciser l'âge des dépôts, mais confirme qu'ils peuvent appartenir au Pennsylvanien moyen. Sur le terrain, les séries radiolaritiques passent, en effet, en continuité à des calciturbidites desmoinésiennes et missouriennes précoces, constituées par une alternance de *floatstones* bioclastiques gris et d'argilites brunes à crinoïdes. On retrouve les *Latentifistula* ex gr. *impella* au sommet de ces calciturbidites, dans Pp 15, daté du Missourien supérieur par des fusulinidés [19]. Cette série est surmontée par des calcaires de plate-forme légèrement sableux, à la partie supérieure desquels avaient été caractérisés le Wolfcampien, puis le Léonardien à grands fusulinidés *Paraskinnerella* (= *Parafusulina* sensu lato) [19]. À la partie inférieure, en revanche, le niveau Pp 24 a révélé des radiolaires *Entactinia* spp. et *Latentifistula* spp. et surtout des conodontes, dont *Streptognathodus bellus* Chernyk & Ritter, 1997 [9]. Celui-ci est caractéristique d'une période actuellement controversée en Amérique du Nord. Elle fut longtemps incluse dans le Wolfcampien inférieur [18, 19, 25, 26] du Sud des États-Unis (New Mexico, Texas). Son équivalent fut plutôt attribué, dans le 'mid-continent', à un Virgilien prolongé [1–4]. Il semble plus judicieux de désigner l'intervalle local par Bursumien [10, 11, 13, 16, 24] et de le supposer équivalent partiel de l'Orenburgien et de l'Assélien [10, 11]. Cela voudrait dire que la limite Carbonifère–Permien passe au milieu de cet étage [24]. L'attribution de l'Orenburgien au Carbonifère terminal ou au Permien basal, selon des critères biostratigraphiques, fut d'ailleurs discutée dans les régions-types de l'Oural. Cette datation infirme toutefois l'hypothèse selon laquelle les séries rouges continentales sous-jacentes au niveau à *Streptognathodus bellus* seraient équivalentes de la Powwow Formation, et constitueraient l'écho de la suture marathonienne [15, 19]. Ces découvertes soulignent l'intérêt de la coupe de San Salvador Patlanoaya pour la connaissance du Paléozoïque supérieur du Mexique, et confirment l'individualité du Bloc Mixtèque (*Mixteco Terrane*) par rapport à la province Grandienne du Texas au Pennsylvanien/Permien inférieur. Enfin, trois résultats importants intéressent la paléoécologie des radiolaires : (**a**) la quasi-exclusivité des ordres Entactinaria et Latentifistularia, (**b**) l'absence des Albaillellaria, principal groupe d'intérêt stratigraphique en Téthys, (**c**) la difficulté de reconstituer les caractères généraux, notamment la paléobathymétrie, des environnements de dépôt ne contenant que des radiolaires comme Pp04, ou à alternances de calcaires et de niveaux siliciclastiques, comme Pp15 ou Pp24.

1. Introduction

The San Salvador Patlanoaya section is located in the southern part of the Puebla State (Mexico), south of Izucar de Matamoros (Fig. 1). This section is very important to understand the Carboniferous/Permian stratigraphy in central Mexico, especially in the Mixteco Terrane [7, 17]. The sedimentary succession,

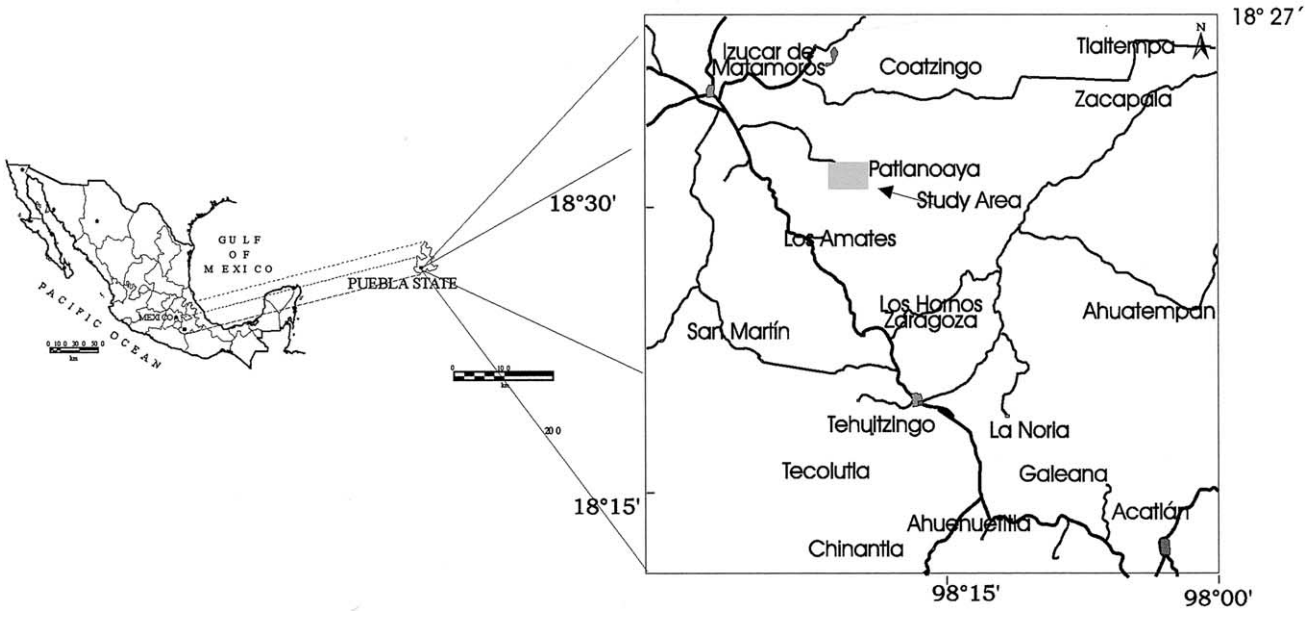


Fig. 1. Location sketch maps of San Salvador Patlanoaya (Puebla, Mexico).

Fig. 1. Cartes de localisation de San Salvador Patlanoaya (Puebla, Mexique).

containing numerous fossiliferous limestone beds, rests unconformably upon the metamorphic basement of Acatlán [5, 6, 19–21, 23]. It is in fact a group, lithostratigraphically speaking, deposited from Early Tournaisian (may be Late Devonian) to Middle (may be Late) Permian [6, 20]. The Carboniferous–Permian outcrops have been discovered by Vazquez-Echeverría in 1986 [21]. The initial studies have described the macropalaeontological content: brachiopods, goniatites and terrestrial plants [6, 12, 22, 23]. Recently, the biostratigraphy was clarified by accurate studies of fusulinids [19, 20].

Due to the biostratigraphic and palaeobiogeographic importance of this section, we attempt to: (**a**) establish a precise age of a radiolaritic series, only calibrated as Late Mississippian to Middle Pennsylvanian; (**b**) investigate new micropalaeontological components of Late Missourian and Early Wolfcampian samples.

2. Occurrences of radiolaria and conodonts

This note deals with the radiolaria and the conodonts extracted of three samples of San Salvador Patlanoaya. Previously sampled by A. Flores de Dios in 1995, already lithologically described and located [19], these fossiliferous samples are Pp04, Pp15 and Pp24 (Fig. 2).

Pp04 is a chert located in a sequence of green shales and greyish radiolaritic cherts; PP15 is a calciturbidite, at the top of alternations of grey bioclastic calciturbidites and brown claystones with crinoids; Pp24 is situated at the base of dark grey neritic limestones overlying the continental red beds of an alluvial fan (Fig. 2).

The methods of extraction are similar for the three samples, and all the microfossils have been extracted by etching with 5% hydrofluoric acid.

All illustrated specimens and other investigated material are housed in the collections of the laboratory of Palaeozoic Palaeontology and Palaeogeography (LP3) of the university of Lille (France); the field samples are emplaced in the laboratory of geology of the UNAM (Universidad Autónoma de Mexico, Mexico).

3. Biostratigraphic implications

Although rich in specimens, the radiolarian assemblage of Pp04 is too poor in genera (principally due to the absence of Albaillellaria) to allow a dating. Only two indirect indications can be used: (**a**) the radiolaritic deposits are superimposed to Osagean (= Late Tournaisian) deposits constituted by shelf sandy limestones

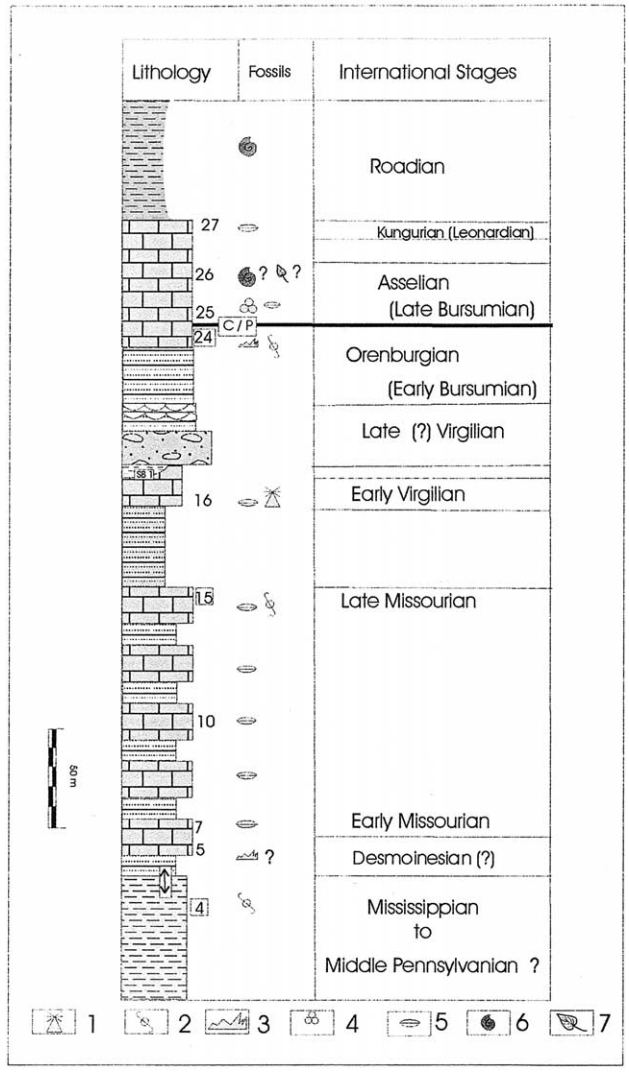


Fig. 2. Idealised column of the Late Pennsylvanian–Early Permian in San Salvador Patlanoaya (Puebla, Mexico). **SB1**: important sequence boundary; **C/P**: Carboniferous–Permian boundary; double arrow: continuity between the radiolaritic sequences and the calciturbidites. Symbols: **1**, dasyclads; **2**, radiolaria; **3**,conodonts; **4**, smaller foraminifers; **5**, fusulinids; **6**, ammonoids; **7**, terrestrial plants.

Fig. 2. Log schématique du passage du Pennsylvanien terminal au Permien inférieur à San Salvador Patlanoaya (Puebla, Mexique). **SB1** : limite de séquence importante ; **C/P** : limite Carbonifère–Permien ; la double flèche indique la continuité de dépôt entre les passées radiolaritiques et les calciturbidites. Symboles : **1**, dasycladales ; **2**, radiolaires ; **3**, conodontes ; **4**, petits foraminifères ; **5**, fusulines ; **6**, ammonoïdés ; **7**, végétaux terrestres.

with brachiopods; this drastic change of lithology can correspond to a relatively long gap; (**b**) inversely, a progressive passage is visible in the field (Fig. 2) between the radiolaritic series and the calciturbiditic deposits, dated as Early Missourian [19] and may be Late Desmoinesian [5]. Consequently, the radiolaritic

lower sequence can be Middle Pennsylvanian, possibly Atokan and/or Early Desmoinesian, but alternatively can correspond to a condensed sequence from Mississippian to Middle Pennsylvanian (Fig. 2).

Radiolarian assemblages of Pp15 are not indicative. The level is well dated by the fusulinids *Triticites* and *Kansanella*. This dating shows, inversely, that *Latentifistula* ex gr. *impella,* principally known in the Visean, is still present in the Late Missourian.

The conodont *Streptognathodus bellus* Chernyk & Ritter, 1997 [9] (Figs. 3.1 and 3.2) provides the most interesting biostratigraphic data about the Latest Carboniferous deposits. This discovery has three consequences (Fig. 2).

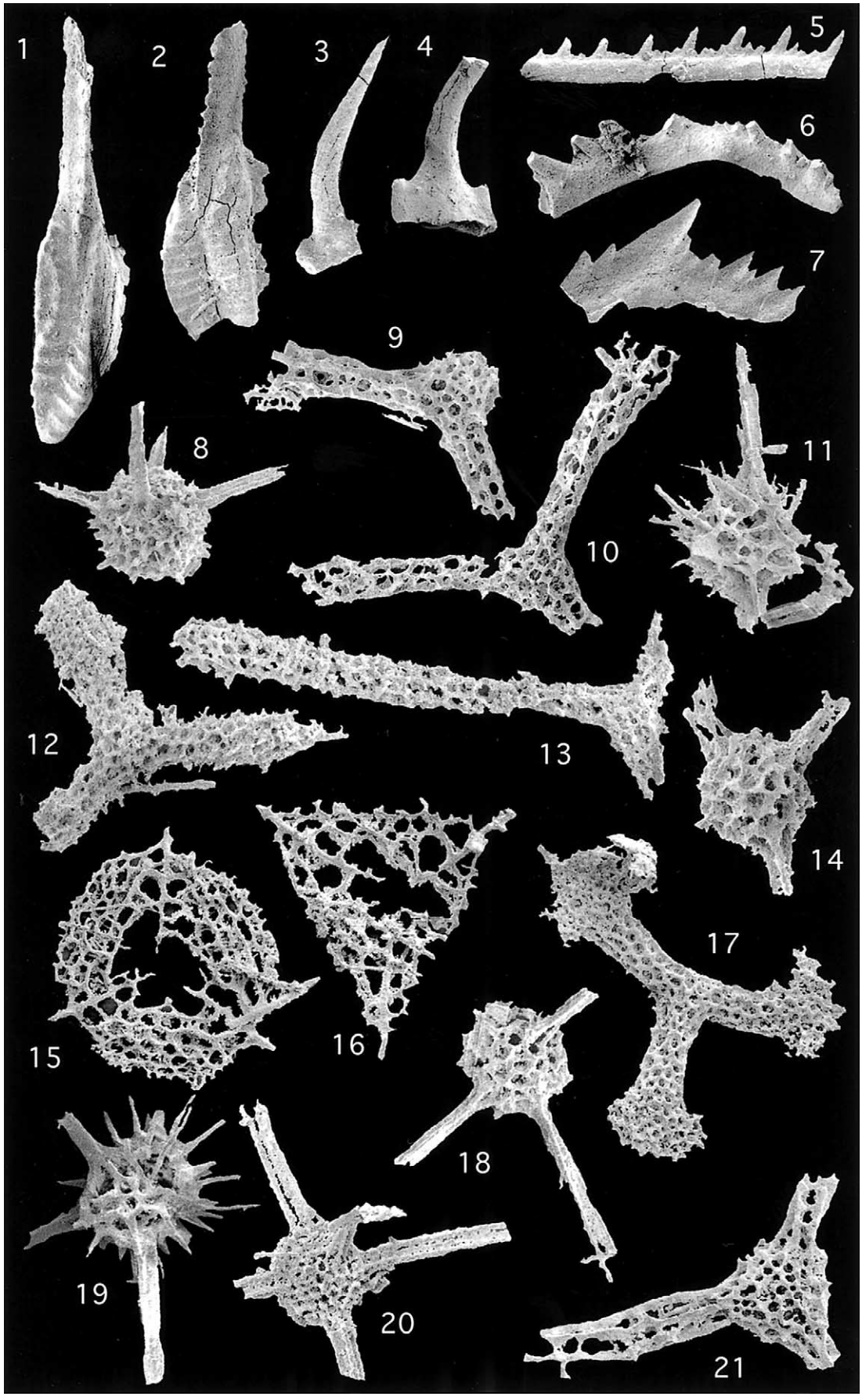
– (1) The siliciclastic series of alluvial fan and green shales, interpreted previously as an equivalent of the Powwow Formation of the Wolfcampian, are older, since they are located between limestones with *Streptognathodus bellus* (Latest Virgilian [4]) and limestone with several species of *Triticites*, Early Virgilian in age [19]. The eroded sequence boundary (SB1: Fig. 2) at the top of the limestones with *Triticites* is therefore not indicative of the Marathonian orogeny [15], as previously indicated [19].

– (2) The Virgilian of the Mid-Continent authors [1–4] is controversial [13] and can partly correspond to some Early Wolfcampian deposits of Thompson or Wilde [18, 25, 26]. The designation of this period by Bursumian seems to be more justified in North America [10, 11, 16, 24]. It can be paralleled with an Orenburgian/Asselian interval [10, 11], i.e. the Carboniferous–Permian boundary crosses through the Bursumian [24]. Nevertheless, Orenburgian, as the biozone of *Bosbytauella = Ultradaixina* was also interpreted as the base of Permian. Our investigations in New Mexico (Krainer, Vachard and Lucas, work in progress) confirm that Bursumian and Orenburgian–Asselian are coeval. This age is also demonstrated by the presence in Pp25, of *Rugosochusenella gregaria* (Lee, 1931) and a '*Pseudofusulina*' sp. [19], similar to some Orenburgian/Asselian *Rugosofusulina* of Russia.

– (3) In fact, Pp25 is typically an Early Permian level, yielding the smaller foraminifers *Geinitzina* sp., *Pseudovermiporella* sp. and '*Arenovidalina'* cf. *novospolovi* Baryshnikov [19]. Consequently, in San Salvador Patlanoaya, the Carboniferous boundary is situated just between our samples Pp24 and Pp25 (Fig. 2). Similarly, in the Aidaralash stratotype (southern Urals), the last beds with *Streptognathodus bellus* are topped by the first strata with Permian microfossils [14]. Despite of this continuity at its base, the Early Permian limestone series of San Salvador Patlanoaya is incomplete in its upper part, since its beds are rich in large fusulinids of the genera *Skinnerella* and *Paraskinnerella (= Parafusulina* sensu lato) [19], of Middle Leonardian age. This Middle Leonardian is actually correlated with the Kungurian [10], therefore the Sakmarian and the Artinskian (i.e. the major part of the Wolfcampian) can be absent in San Salvador Patlanoaya.

Fig. 3. Main microfossils from San Salvador Patlanoaya (Puebla, Mexico). **1**, **2**: *Streptognathodus bellus* Chernykh & Ritter, 1997. Bursumian (Orenburgian). Sample Pp24. 1: x 102. 2: × 94. **3**: *Lonchodus* sp. Bursumian (Orenburgian). Sample Pp24. × 77. **4**: *Ligonodina* sp. Bursumian (Orenburgian). Sample Pp24. × 96**. 5**: *Hindeodella* sp. Bursumian (Orenburgian). Sample Pp24. × 104. **6**: *Lonchodina* sp. Bursumian (Orenburgian). Sample Pp24. × 149. **7**: *Bryantodus* sp. Bursumian (Orenburgian). Sample Pp24. × 113. **8**: *Entactinia parva* Won, 1983. Middle Pennsylvanian (?). Sample Pp04. × 214. **9**, **10**, **12**, **13**: *Latentifistula* ex gr. *impella* (Ormiston & Lane, 1976) sensu Caridroit, 2000 [8]. **9**, **10**: Middle Pennsylvanian (?). Sample Pp04. **9**: × 145. 10: × 155. **12**, **13**: Late Missourian. Sample Pp15. **12**: × 146. **13**: × 157. **11**: *Entactinia tortospira* Won, 1983. Middle Pennsylvanian (?). Sample Pp04. × 120. **14, 18**–**20**: *Entactinia* spp. **14**: Late Missourian. Sample Pp15. × 182. **18**–**20**: Bursumian (Orenburgian). Sample Pp24. **18**: × 158. **19**: × 130. **20**: × 159. **15**, **16**: *Ruzhencevispongus* sp. Bursumian (Orenburgian). Sample Pp24. **15**: × 76. **16**: × 103. **17**: *Latentifistula* aff. *texana* Nazarov & Ormiston, 1985. Bursumian (Orenburgian). Sample Pp24. × 101. **21**: *Latentifistula* aff. *triacanthophora* Nazarov & Ormiston, 1983. Bursumian (Orenburgian). Sample Pp24. × 167.

Fig. 3. Principaux microfossiles de San Salvador Patlanoaya (Puebla, Mexique). **1**, **2** : *Streptognathodus bellus* Chernykh & Ritter, 1997. Bursumien (Orenburgien). Échantillon Pp24. **1** : × 102. **2** : × 94. **3** : *Lonchodus* sp. Bursumien (Orenburgien). Échantillon Pp24. × 77. **4** : *Ligonodina* sp. Bursumien (Orenburgien). Échantillon Pp24. × 96. **5** : *Hindeodella* sp. Bursumien (Orenburgien). Échantillon Pp24. × 104. **6** : *Lonchodina* sp. Bursumien (Orenburgien). Échantillon Pp24. × 149. **7** : *Bryanthodus* sp. Bursumien (Orenburgien). Échantillon Pp24. × 113. **8** : *Entactinia parva* Won, 1983. Pennsylvanien moyen (?). Échantillon Pp04. × 214. **9**, **10, 12**, **13** : *Latentifistula* ex gr. *impella* (Ormiston & Lane, 1976) sensu Caridroit, 2000 [8]. **9**, **10** : Pennsylvanien moyen (?). Échantillon Pp04. **9** : × 145. **10** : × 155. **12**, **13** : Missourien supérieur. Échantillon Pp15. **12** : × 146. **13** : × 157. **11** : *Entactinia tortospira* Won, 1983. Pennsylvanien moyen (?). Échantillon Pp04. × 120. **14, 18**–**20** : *Entactinia* spp. **14** : Missourien supérieur. Échantillon Pp15. × 182. **18**–**20** : Bursumien (Orenburgien). Échantillon Pp24. **18** : × 158. **19** : × 130. **20** : × 159. **15**, **16** : *Ruzhencevispongus* sp. Bursumien (Orenburgien). Échantillon Pp24. **15** : × 76. **16** : × 103. **17** : *Latentifistula* aff. *texana* Nazarov & Ormiston, 1985. Bursumien (Orenburgien). Échantillon Pp24. × 101. **21** : *Latentifistula* aff. *triacanthophora* Nazarov & Ormiston, 1983. Bursumien (Orenburgien). Échantillon Pp24. × 167.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21

4. Palaeoecological and palaeogeographic implications

The three radiolaritic assemblages reveal: (**a**) the significant absence of Albaillellaria and (**b**) a general weak biodiversity (with only two orders, three genera and very few species). The radiolarian assemblages are almost exclusively composed of representatives of the order Latentifistularia (Figs. 3.9, 3.10, 3.12, 3.13, 3.15–3.17, 3.21), constituted by a small sphere associated with three to five spines. The associated second order is the Entactinaria, forms with two concentrical shells including an initial spicule (Figs. 3.8, 3.11, 3.14, 3.18–3.20). Pp04 and Pp24 yielded also undetermined sponge spicules. Pp04 and Pp15 contain *Latentifistula* ex gr. *impella* (Ormiston & Lane, 1976) sensu Caridroit, 2000 [8] (Figs. 3.9–3.10, 3.12, 3.13). This species is generally Late Tournaisian to Visean, but its range is modified in America, since the sample Pp15 contains Late Missourian fusulinids [19].

Palaeoecological reconstructions based on radiolaria are not conclusive. The cherts are not truly oceanic. The palaeodepths of the deposits are questionable, and might be estimated, from 20–50m for Pp24 (due to the assemblage with *Tubiphytes* and '*Arenovidalina*' [19], both photophile microfossils), to 200–500 m for Pp04 (due to the complete absence of neritic organisms within the faunistic assemblage).

The palaeogeographic data are relatively puzzling. The observed *Streptognathodus*, and especially *S. bellus*, exhibit similarities with southern Urals faunas, as well as the fusulinids [19]. Radiolarian assemblages show few relationships with the assemblages from the USA, where the Albaillellaria are present. In fact, the series of San Salvador Patlanoaya and the whole Mixteco Terrane is completely atypical in North America. The South-American series are less known, but further investigations may permit more accurate comparisons. Therefore, San Salvador Patlanoaya constitutes an excellent test-area for the Pangea A and Pangea B models.

5. Conclusions

The radiolaritic beds of Patlanoaya contain numerous representatives of the orders Latentifistularia and Entactinaria, but no Albaillellaria.

Late Missourian radiolaria are not characteristic, and only dated by their association with index-fusulinids.

The Latest Carboniferous (Orenburgian) is identified thanks to the conodont *Streptognathodus bellus*. The Bursumian corresponding to the Orenburgian/Asselian is consequently present in San Salvador Patlanoaya. The Carboniferous/Permian boundary is located between the samples Pp24 and Pp25 (Fig. 3).

The particularity of the Patlanoaya Group, and its affinity with southern Urals sequences, is confirmed. This series is completely atypical in southern North America.

No comparison with other Mexican or Texan series is really possible, as previously indicated [20]. The palaeogeography of the Mixteco Terrane between Laurasia and Gondwana remains enigmatic, and constitutes a challenge for the Pangea A and Pangea B reconstructions.

Acknowledgements. This note is a contribution to the program Ecos-Nord Mexique M00U01.

References

[1] D.L. Baars, C.G. Maples, S.M. Ritter, C.A. Ross, Redefinition of the Pennsylvanian–Permian boundary in Kansas, mid-continental USA, Int. Geol. Rev. 34 (1992) 1021–1025.

[2] D.L. Baars, C.A. Ross, S.M. Ritter, C.G. Maples, Proposed repositioning of the Pennsylvanian–Permian boundary in Kansas, Kansas Geol. Surv. Bull. 230 (1994) 5–10.

[3] D.L. Baars, S.M. Ritter, C.G. Maples, C.A. Ross, Redefinition of the Upper Pennsylvanian Virgilian Series in Kansas, Kansas Geol. Surv. Bull. 230 (1994) 11–16.

[4] J.E. Barrick, P.H. Heckel, A provisional conodont zonation for Late Pennsylvanian (late Late Carboniferous) strata in Midcontinent region of North America, Newsl. Carboniferous Stratigraphy 18 (2000) 15–22.

[5] P. Brunner, Microfacies y microfósiles de las rocas carbonatadas del Paleozoico de San Salvador Patlanoaya, Revista Sociedad Mexicana Paleontología, 1, Puebla, México, 1987, pp. 98–112.

[6] P. Brunner, A.B. Villaseñor, A. Martínez, Estudio bioestratigráfico de las rocas del Paleozoico en Izucar de Matamoros, Puebla, Instituto Mexicano del Petróleo, Subdirección de Tecnología de Exploración, Proyecto C 5015 (1988) 1–36 (unpublished).

[7] M.F. Campa, P.J. Coney, Tectonostratigraphic terranes and mineral resource distributions in Mexico, Can. J. Earth Sci. 20 (1983) 1040–1051.

[8] M. Caridroit, Radiolaires du Paléozoïque. Paléontologie. Applications à la biostratigraphie, la tectonique et la géodynamique, Habilitation à diriger des recherches, University Lille-1, France, 2000, pp. 489 (unpublished).

[9] V.V. Chernykh, S.M. Ritter, *Streptognathodus* (conodonta) succession at the proposed Carboniferous–Permian boundary stratotype section, Aidaralash Creek, Northern Kazakhstan, J. Paleontol. 71 (3) (1997) 459–474.

[10] V.I. Davydov, Fusulinid biostratigraphy and the correlation of Moscovian–Guadalupian North American, Tethyan and Boreal (Russian Platform/Uralian) standards, Permophiles 29 (1996) 47–52.

[11] V.I. Davydov, The terminal stage of the Carboniferous: Orenburgian versus Bursumian, Newsl, Carboniferous Stratigraphy 19 (2001) 58–64.

[12] C. Esquivel-Macías, W.I. Ausich, B.E. Buitrón-Sánchez, Flores de Dios A., Pennsylvanian and Mississippian pluricolumnal assemblages (class Crinoidea) from southern Mexico and a new occurrence of a column with a tetralobate lumen, J. Paleontol. 74 (6) (2000) 1187–1190.

[13] S.G. Lucas, G.L. Wilde, B. The, ursum Formation stratotype, Upper Carboniferous of New Mexico, and the Bursumian stage, Permophiles 36 (2000) 7–10.

[14] Permophiles, Stratigraphic detail C/P GSSP, Aidaralash Creek, Permophiles 30 fold out. (1997).

[15] C.A. Ross, Paleozoic evolution of southern margin of Permian basin, Geol. Soc. Am. Bull. 97 (1986) 536–554.

[16] C.A. Ross, J.R.P. Ross, The need for a Bursumian stage, Uppermost Carboniferous, North America, Permophiles 24 (1996) 3–6.

[17] R.L. Sedlock, F. Ortega-Gutiérrez, R.C. Speed, Tectonostratigraphic terranes and tectonic evolution of Mexico, Geological Society of America, special paper 278 (1993) 253.

[18] M.L. Thompson, American Wolfcampian fusulinids, University of Kansas, Paleontological Contributions, Protozoa, Article 5 (1954) 1–226.

[19] D. Vachard, A. Flores de Dios, B. Buitrón, M. Grajales, Biostratigraphie par fusulines des calcaires carbonifères et permiens de San Salvador Patlanoaya (Puebla, Mexique), Géobios 33 (1) (2000) 5–33.

[20] D. Vachard, A. Flores de Dios, J. Pantoja, B. Buitrón, M. Grajales, Les fusulines du Mexique, une revue biostratigraphique et paléogéographique, Géobios 33 (6) (2000) 655–679.

[21] A. Vasquez-Echeverría, Descubrimiento de una nueva localidad de rocas marinas del Paleozoico al suroeste del Estado de Puebla, 24 Congreso Nacional de la Asociación de Geologos Petroleros Mexicanos (1986) 1–19 PEMEX, Departamento Exploración Zona Centro.

[22] M.P. Velasco de León, B.E. Buitrón, Algunos Crinoides (Echinodermata–Crinoida) del Misisípico-Pensilvánico de San Salvador de Patlanoaya, Estado de Puebla, Revista Sociedad Mexicana Paleontología 5 (1992) 71–81.

[23] A.B. Villaseñor, A. Martínez, B. Contreras, Bioestratigrafía del Paleozoico superior de San Salvador Patlanoaya, Puebla, México, Revista Sociedad Mexicana Paleontología 1 (1987) 396–413.

[24] B.R. Wardlaw, V.I. Davydov, Preliminary placement of the international Lower Permian working standard to the Glass Mountains, Texas, Permophiles 36 (2000) 11–14.

[25] G.L. Wilde, Fusulinid evidence for the Pennsylvanian–Permian boundary, Proceeding First I.C. White Memorial Symposium, The age of the Dunkard, West Virginia Geol. and Economic Survey (1975) 123–141.

[26] G.L. Wilde, Practical Fusulinid zonation: the species concept, with Permian Basin emphasis, West Texas Geol. Soc. Bull. 29 ((7)) (1990) 5–15 28-34.