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The KALKOWSKY Project - Chapter II
Wobbly ooids in a stromatolite from the Yacoraite Formation (Argentina)

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Abstract: Eccentric ooids are described from a brackish Maastrichtian paleolake in NW Argentina. The first report of such atypical coated grains was from marine Upper Jurassic strata in SE Poland. Because their growth pattern is not likely to be confused with that of other "eccentric" ooids, such as asymmetric ooids, hiatus ooids, half-moon ooids, or "broken" ooids, it is suggested here to name them "wobbly ooids".

Key-words:

- ooid;
- microbial carbonates;
- Salta;
- Argentina;
- Maastrichtian

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Résumé : *Le Projet KALKOWSKY - Chapitre II. Ooïdes bancals dans un stromatolithe de la Formation Yacoraite (Argentine).-* Nous décrivons des ooïdes excentriques formés dans un paléolac saumâtre d'âge maastrichtien du Nord-Ouest de l'Argentine. Des grains cortiqués de ce type avaient déjà été signalés dans des couches sédimentaires marines du Jurassique supérieur du Sud-Est de la Pologne. Parce que le mode de croissance de ces ooïdes argentins ne peut être confondu avec celui d'autres ooïdes excentriques, tels que les ooïdes asymétriques, les ooïdes hiatals, les ooïdes en demi-lune ou les ooïdes brisés, nous proposons ici de les dénommer "ooïdes bancals".

Mots-clefs :

- ooïde ;
- carbonates microbiens ;
- Salta ;
- Argentine ;
- Maastrichtien

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1. Introduction

Mere petrographic analysis of thin sections shows that much can still be learned from microbial carbonates (GRANIER & LAPOINTE, 2021); this is the central idea behind the concept of the KALKOWSKY Project. The present paper documents a new case of eccentric ooids sensu GASIEWICZ (1984a, 1984b). The latter described similar atypical coated grains from the marine Upper Jurassic of SE Poland whereas the material presented here comes from the lacustrine Yacoraite Formation (Maastrichtian to Danian) of NW Argentina.

2. Material and general setting

The material studied was collected by one of us (P.L.) accompanied by three IFP colleagues (namely Bernard COLLETTA, Jean LETOUZEY, and Roland VIALY) on October 11, 1988, from a quarry site in Puesto Viejo (Province of Jujuy, Argentina). This quarry is today operated by Lafarge Holcim (Fig. 1). A short section of the Yacoraite Formation (Fig. 2) was measured and sampled at one quarry face (NW), ca. 24°30'36.8"S 64°56'20.9"W (Fig. 2).

Figure 1: A) Location map of the Province of Jujuy, Argentina. **B)** Map of the southeastern corner of the Province of Jujuy. **C)** Location of the section in the Lafarge Holcim quarry at Puesto Viejo. **D)** Panoramic view of the lower quarry and its face in October 1988.

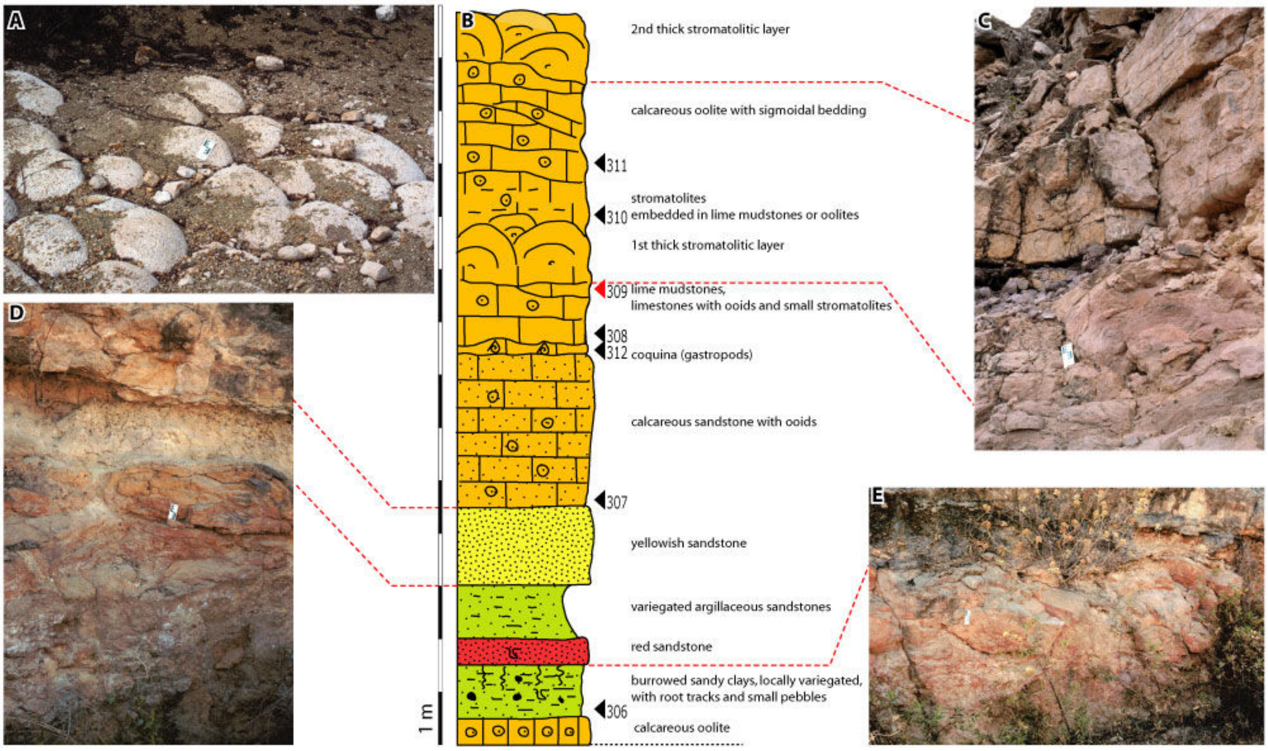

Figure 2: A) Stromatolitic domes capping the section; **B)** schematic lithologic log of the quarry section (Yacoraite Formation) with the location of the sampling points; **C)** first thick stromatolitic layer (8.5-10 m) overlain by oolitic facies; **D)** the yellowish sandstone (3-4.5 m) overlying a variegated argillaceous sandstone; **E)** the red sandstone (1.5-2 m) overlying variegated sandy clays.

Two petrographic thin sections were prepared from a piece of rock labelled ARA 309 that comprises a stromatolitic facies in its lower part and an oolitic to bothryoidal facies in its upper part. The first thin section (ARA 309: Fig. 3.A) is probably lost and the second thin section (AG 309 B) was prepared from an offcut of the first.

3. Description of ARA 309 and comparison with Gasiewicz's material

The microfacies observed in thin sections ARA 309 (Fig. 3) and AG 309 B (Fig. 4) are:

1) a bindstone fabric made of relatively thick layers with spongiostromate, either micritic or spongious, fabrics in the lower part (Fig. 3.A). The thin section was cut in a stromatolitic column the growth of which is determined by variation in volume of the spongious layers and, to a minor extend, by trapping of some allochems, mostly ooids;

2) a grain-supported texture with bothryoids floating in a grainstone matrix made of radial-concentric ooids in the upper part.

Small benthonic foraminifers (*e.g.*, Méndez & Viviers, 1973; Carignano, 2012), including some with milioline chamber arrangement (Figs. 3.E, 4.D-H), are commonly found as nuclei of small ooids. Other common microfossils are ostracods (*e.g.*, Méndez & Viviers, 1973; Carignano, 2012), which obviously cannot be taxonomically identified in thin sections. Locally present in the area, charophytes (*e.g.*, Musacchio, 1972, 2000; Carignano, 2012) were not observed in the studied sample, nor remains or dental plates of fossil fishes (*e.g.*, Cione *et al.*, 1985; Cónsole Gonella *et al.*, 2012). Largest macrofossils comprise gastropod (*e.g.*, Cónsole Gonella *et al.*, 2012; Fig. 4.F, .H) and mollusk shells. The fossiliferous assemblage, including the lack of echinoderm or bryozoan remains, and the architectural diversity of the coated grains do not point to hypersaline conditions in the Salta basin for this short time interval. Altogether, these features suggest that the environmental conditions were those of a paleolake with brackish water rather than those of a "carbonate shallow sea" (*e.g.*, Marquillas *et al.*, 2005). Fine angular quartz sand is locally common suggesting episodic terrigenous influx from wadis (ephemeral streams). It is worth highlighting that this environmental interpretation of a quiet-water Argentinian paleolake does not fit with the Bahamian setting that Gasiewicz (1984a, 1984b) conceived for his Upper Jurassic marine ooids, an environmental interpretation that one cannot agree upon either. This topic should not be discussed further without accessing the original Polish material studied, a goal that is out of the scope of this paper.

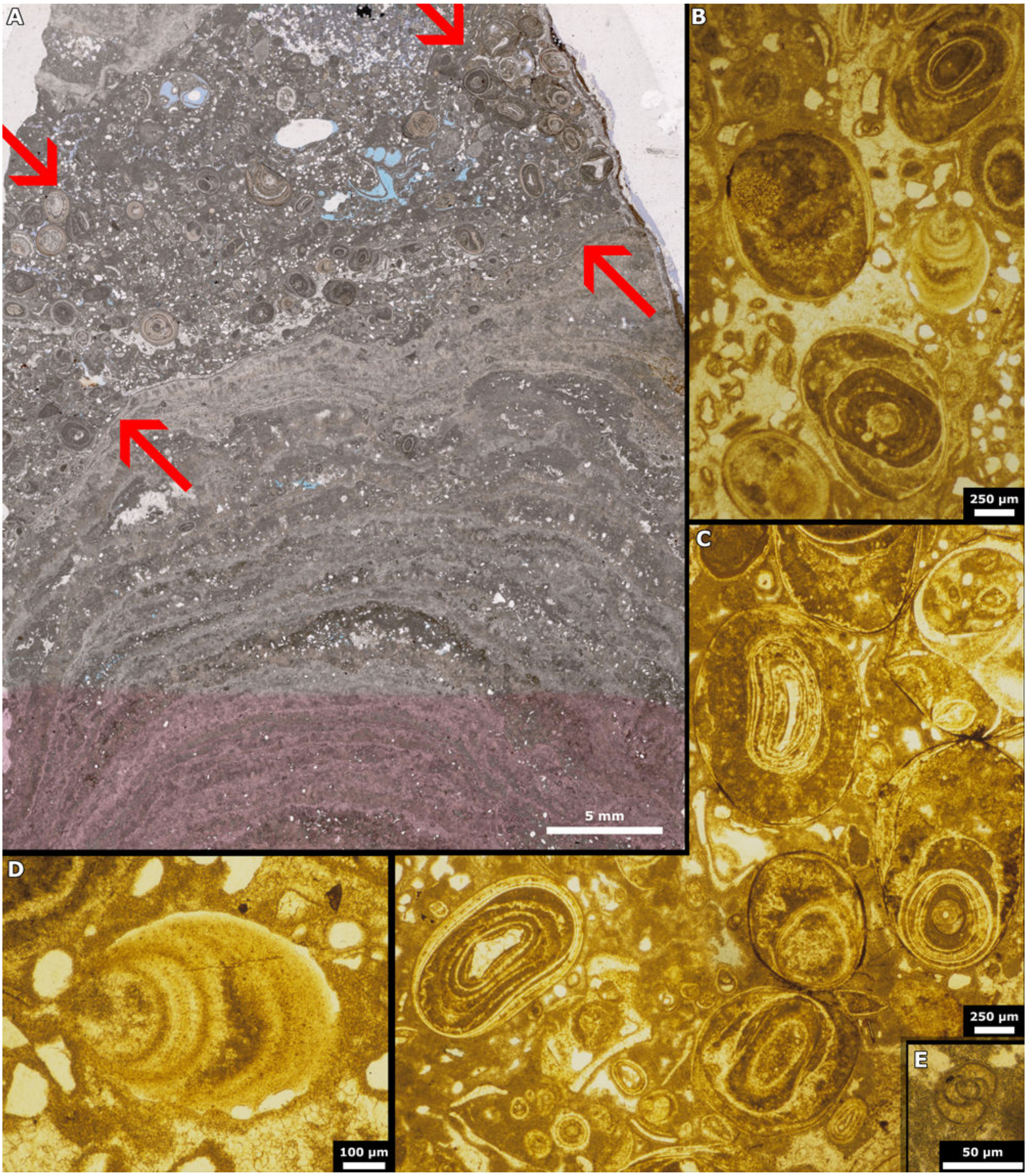

Figure 3: Thin section ARA 309 from the Maastrichtian of Puesto Viejo: **A)** scan of the petrographic thin section. The stromatolitic layers with eccentric ooids are framed by red arrows; **B-C)** various eccentric ooids; **D)** detail of B; **E)** small benthic foraminifer. Scale bars: **A)** 5 mm; **B-C)** 250 µm; **D)** 100 µm; **E)** 50 µm.

In sample ARA 309, ooids are confined to few stromatolitic layers at the top of a microbial column (Fig. 3.A). These ooids, ovoid in shape and matching the characteritics of the eccentric ooids as defined by GASIEWICZ (1984a, 1984b: "ekscentryczne ooidy"), commonly reach a maxImum length of 1 mm, which is almost twice the dimension given for GASIEWICZ's ooids. Similarly they consist of layers made either of yellowish "fibrite" (a neologism for "fibrous calcite", *i.e.*, "material with one large and two small dimensions" (FOLK, 1974)) or of dark micrite (= microcrystalline calcite). Micrite and fibrite layers are alternating more or less regularly within the ooid cortex. The fibrite forms roughly isopachous crusts of palisade crystals, whereas the micrite forms clearly anisopachous crusts, *i.e.*, genuine micritic bumps.

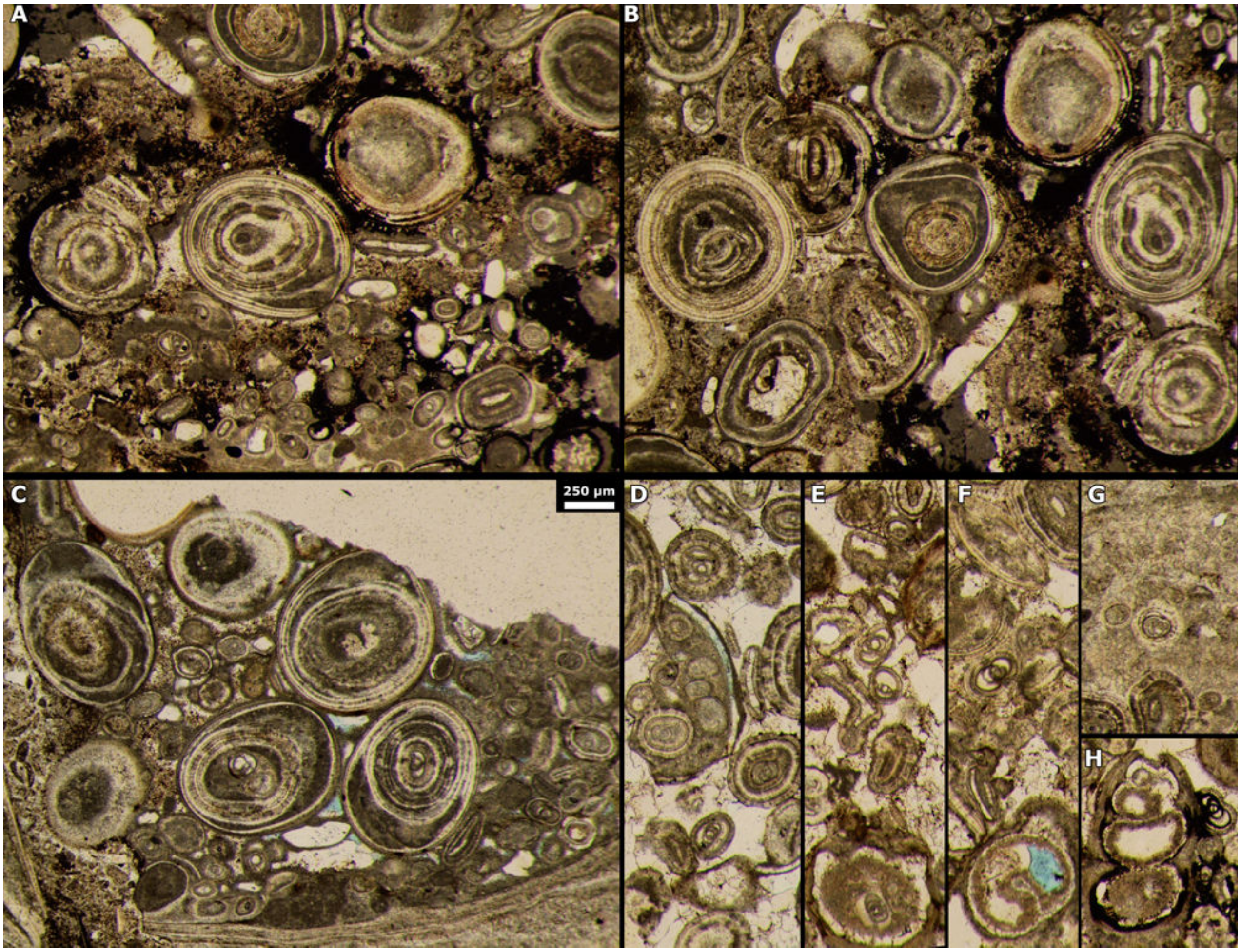

Figure 4: Thin section AG 309 B from the Maastrichtian of Puesto Viejo: **A-C)** various eccentric ooids; **D-H)** small benthic foraminifers with gastropods (in F and H). A single 250 µm scale bar is used for all photos.

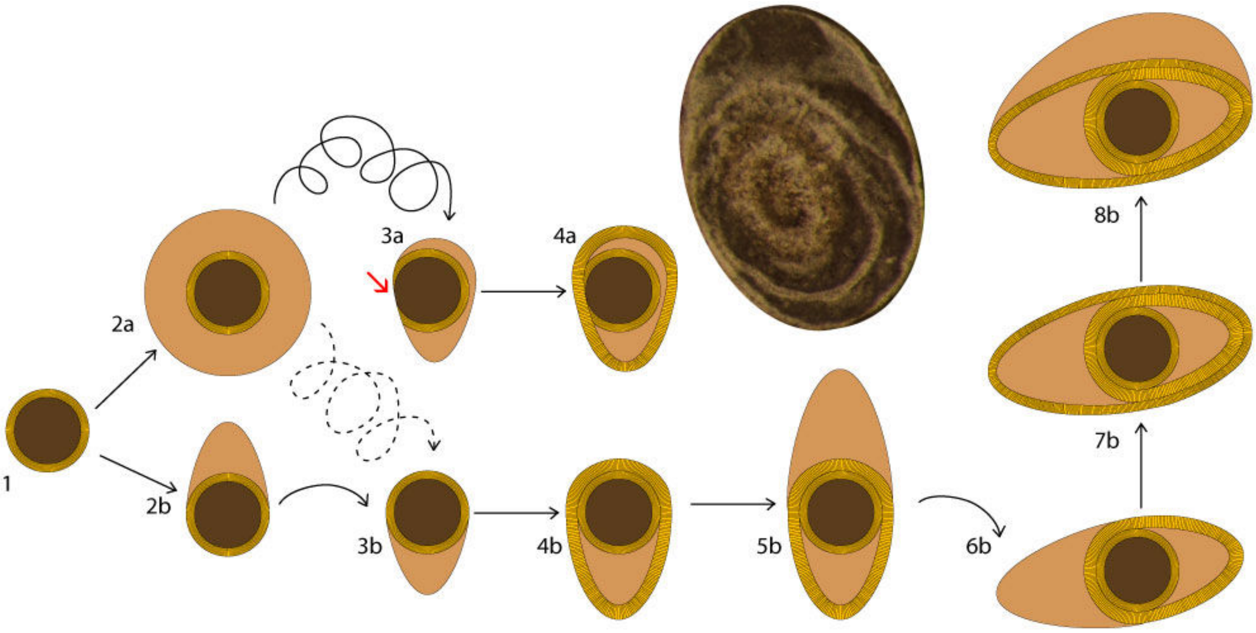

Figure 5: Tentative models for the growth of Argentinian eccentric ooids. 1) nucleus with an isopachous fibrite crust. Option a: 2a) thick isopachous micrite crust; 3a) partial abrasion of the micritic crust and the underlying fibrite crust (red arrow: truncation of the fibrite crust); 4a) new isopachous fibrite crust. The end product is a hiatus ooid *sensu* BERG (1944). Option b (our favorite model): 2b) micrite bump (anisopachous crust) growing in an upward direction; 3b) tilting of the ooid; 4b) new isopachous fibrite crust; 5b) new micrite bump growing in an upward direction; 6b) tilting of the ooid; 7b) new isopachous fibrite crust; 5b) new micrite bump growing in an upward direction. The shortcut transition with abrasion from 2a to 3b is highly improbable.

4. The wobbly ooid hypothesis

The maximum thickness of the micritic bumps always shifts from one bump to the next. Consequently, the center of mass of the ooid changed with each addition of a new micritic bump. Such coated grains should not be confused with other "eccentric" ooids, such as asymmetric ooids (*e.g.*, BERG, 1944, Fig. 26; FREEMAN, 1962, Fig. 6), hiatus ooids (*e.g.*, BERG, 1944, Fig. 27), half-moon ooids, or even "broken" ooids. Therefore, it is suggested here to call them "wobbly ooids". In Argentinian stromatoids described in a previous paper (GRANIER & LAPOINTE, 2021), "spongiostromate, either micritic or spongious, fabrics" are the key to the differential growth of the stromatolitic column whereas the contribution of thin fibrite crusts can be neglected. It is suggested here that the microbial consortium responsible for the micritic bumps comprises some phototrophic species. This hypothesis is taken into consideration in our favorite model (Fig. 5) to tentatively explain the growth of Argentinian eccentric ooids. Accordingly, the growth of each new micritic bump is assumed to have been in an upward direction. Contrary to GASIEWICZ's model (1984a, 1984b), our favorite model (Fig. 5) does not necessarily imply any significant abrasion, suspension, saltation, or traction. However, it should be noted that this model cannot explain all atypical features observed in the studied material (*e.g.*, Fig. 3.D).

The architecture of the wobbly ooids vaguely resembles that of some cave pearls recently documented by MELIM and SPILDE (2021: Figs. 7.B, 8.A) but they should not be confused with these because the latter are commonly larger (up to 14 mm) than the former. The dimensions of these cave pearls range within the pisolite category. Additionally, cave pearls are characterized by low-Mg calcite (MELIM & SPILDE, 2021), a mineralogy that is consistent with their concretionary growth in place during vadose diagenesis, whereas Argentinian ooids and bothryoids are primarily made of high-Mg calcite (GRANIER & LAPOINTE, 2021).

5. Conclusion

Both the peculiar ooids from the Maastrichtian Yacoraite Formation in NW Argentina and ooids described from the Upper Jurassic strata in SE Poland correspond to a distinct class of eccentric ooids: "wobbly ooids". They are not likely to be confused with asymmetric ooids, hiatus ooids, half-moon ooids, or "broken" ooids. Althought they are found in contrasting types of environments, lacustrine with brackish water for the first and marine with normal sea water for the second, these ooids are both markers of quiet water settings. It is assumed that transitions from fibrite cortical layers to micrite bumps probably correspond to changes in the microbial consortia. The eccentricity varied during growth due to repeated shifting of the center of mass of the ooids mostly related to the asymmetric growth of micrite bumps of their cortices.

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Bibliographic references

BERG G. (1944).- Vergleichende Petrographie oolithischer Eisenerze.- *Archiv für Lagerstättenforschung*, Berlin, Heft 76, p. 7-128 (6 Pls.).

CARIGNANO A.P. (2012).- Sistemática y paleoecología de Foraminifera (Protista) y Ostracoda (Crustacea) del Cretácico Superior-Paleoceno de Argentina en ambientes marino transicionales y continentales.- PhD thesis, Naturalis, Facultad de Ciencias Naturales y Museo, La Plata, 236 p. http://naturalis.fcnym.unlp.edu.ar/id/20120423001223

CIONE A., PEREIRA S.M., ALONSO R. & ARIAS J. (1985).- Los bagres (Osteichthyes-Siluriformes) de la Formación Yacoraite (Cretacico tardio) del Noroeste Argentino. Consideraciones biosgeograficas y bioestratigraficas.- *Ameghiniana*, Buenos Aires, vol. 21, no. 2, p. 294-304.

CÓNSOLE GONELLA C.A., GRIFFIN M., CIONE A., GOUIRIC CAVALLI S. & ACEÑOLAZA F.G. (2012).- Paleontología de la Formación Yacoraite (Maastrichtiano-Daniano) en el ámbito de la Subcuenca de Tres Cruces, Cordillera Oriental de la provincia de Jujuy, Argentina.- Relatorio de la XIII Reunión Argentina de Sedimentología (16-19 de mayo de 2012), Salta, p. 45-56.

FOLK R.L. (1974).- The natural history of crystalline calcium carbonate: Effect of magnesium content and salinity. *Journal of Sedimentary Petrology*, Tulsa - OK, vol. 44, no. 1, p. 40-53.

FREEMAN T. (1962).- Quiet water oolites from Laguna Madre, Texas.- *Journal of Sedimentary Petrology*, Tulsa - OK, vol. 32, no. 3, p. 475-483.

GASIEWICZ A. (1984a).- Górnojurajskie ooidy o niewspółśrodkowych powłokach.- *Kwartalnik Geologiczny*, Warszawa, t. 28, no. 1, p. 93-106.

GASIEWICZ A. (1984b).- Eccentric ooids.- *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, Jarhgang 1984, Heft 4, p. 204-211.

GRANIER B.R.C. & LAPOINTE Ph. (2021).- The KALKOWSKY Project - Chapter I. Ooid - stromatoid relationship in a stromatolite from the Maiz Gordo

Fm (Argentina).- *Carnets Geol.*, Madrid, vol. 21, no. 9, p. 193-201. https://doi.org/10.2110/carnets.2021.2109

MARQUILLAS R.A., PAPA C. del & SABINO I.F. (2005).- Sedimentary aspects and paleoenvironmental evolution of a rift basin: Salta Group (Cretaceous-Paleogene), northwestern Argentina.- *International Journal of Earth Sciences (Geologische Rundschau)*, vol. 94, p. 94-113.

MELIM L.A. & SPILDE M.N. (2021).- The rise and fall of cave pearl pools: Highly variable growth, recrystallization and demise of a mine pearl site.- *Sedimentology*, vol. 68, no. 5), 29 p.

MÉNDEZ I. & VIVIERS M.C. (1973).- Estudio micropaleontológico de sedimentitas de la Formación Yacoraite (Provincias de Salta y Jujuy). *In*: Actas del quinto Congreso Geológico Argentino, Ciudad de Villa Carlos Paz, Córdoba (22-28 de octubre de 1972).- Asociación Geológica Argentina, Buenos Aires, vol. 3, p. 467-470.

MUSACCHIO E.A. (1972).- Charophytas de la Formación Yacoraite en Tres Cruces y Yavi Chico, Jujuy, Argentina.- *Revista de la Asociación Paleontológica Argentina*, Buenos Aires, vol. 9 no. 3, p. 223-237.

MUSACCHIO E.A. (2000).- Biostratigraphy and biogeography of Cretaceous charophytes from South America.- *Cretaceous Research*, vol. 21, no. 2-3, p. 211-220.