Estudios Geológicos
julio-diciembre 2019, 75(2), e112
ISSN-L: 0367-0449
https://doi.org/10.3989/egeol.43586.567

Calcimicrobial-archaeocyath-bearing clasts from marine slope deposits of the Cambrian Mount Wegener Formation, Coats Land, Shackleton Range, Antarctica

Clastos con calcimicrobios y arqueociatos procedentes de depósitos marinos del talud de la Formación cámbrica del Monte Wegener, Coats Land, Cordillera de Shackleton Antártida

M. Rodríguez-Martínez[1], A. Perejón[1], E. Moreno-Eiris[1], S. Menéndez[2], W. Buggisch[3]

[1]Universidad Complutense de Madrid, Departamento de Geodinámica, Estratigrafía y Paleontología, Madrid, Spain. Email: martarm@geo.ucm.es, aparqueo@ucm.es, eiris@geo.ucm.es; ORCID ID: http://orcid.org/0000-0002-4363-5562, http://orcid.org/0000-0002-6552-0416, http://orcid.org/0000-0003-2250-4093

[2]Museo Geominero, Instituto Geológico y Minero de España (IGME), Ríos Rosas, 23, 28003 Madrid, Spain. Email: s.menendez@igme.es; ORCID ID: Silvia Menéndez: http://orcid.org/0000-0001-6074-9601

[3]GeoZentrum Nordbayern. Friedrich-Alexander-University of Erlangen-Nürnberg (FAU). Schlossgarten 5, 91054 Erlangen, Germany.

ABSTRACT

The carbonate clasts from the Mount Wegener Formation provide sedimentological, diagenetic and palaeontological evidences of the destruction and resedimentation of a hidden/unknown Cambrian carbonate shallow-water record at the Coats Land region of Antarctica. This incomplete mosaic could play a key role in comparisons and biostratigraphic correlations between the Cambrian record of the Transantarctic Mountains, Ellsworth-Whitmore block and Antarctic Peninsula at the Antarctica continent. Moreover, it represents a key record in future palaeobiogeographic reconstructions of South Gondwana based on archaeocyathan assemblages.

Keywords: Calcimicrobes; Archaeocyaths; Shackleton Range; Antarctica; Gondwana.

RESUMEN

Los clastos carbonatados de la Formación del Monte Wegener proporcionan evidencias sedimentológicas, diagenéticas y paleontológicas de la destrucción y resedimentación de un registro carbonatadoo cámbrico oculto/no conocido en aguas someras de la región de Coats Land en la Antártida. Este mosaico incompleto podría jugar un papel clave en las comparaciones y correlaciones bioestratigráficas entre el registro cámbrico de las Montañas Transantárticas, el bloque Ellsworth-Whitmore y la Península Antártica del continente antártico. Además, representa un registro clave en las futuras reconstrucciones paleobiogeográficas de Gondwana meridional basadas en asociaciones de arqueociatos.

Palabras clave: Calcimicrobios; Arqueociatos; Cordillera Shackleton; Antártica; Gondwana.

Recibido el 1 de mayo de 2019; Aceptado el 1 de julio de 2019; Publicado online el 10 de diciembre de 2019

Citation / Cómo citar este artículo: Rodríguez-Martínez, M. et al. (2019). Calcimicrobial-archaeocyath-bearing clasts from marine slope deposits of the Cambrian Mount Wegener Formation, Coats Land, Shackleton Range, Antarctica. Estudios Geológicos 75(2): e112. http://doi.org/10.3989/egeol.43586.567.

Introduction and geological setting

The Bruce's Scottish National Antarctic Expedition 1902-1904 sampled the deep sea sediments of the Weddell Sea, Antarctica. Later on, Pirie (1913) first mentioned about the presence of "Archaeocyathinae" from these erratic Cambrian samples. Throughout the twentieth century, different expeditions collected archaeocyaths in the dispersed Cambrian record of the Antarctica continent. The studies of the autochthonous archaeocyathan assemblages from the lower Cambrian Shackleton Limestone (Transantarctic Mountains, Hill, 1964a; Debrenne & Kruse, 1986, 1989), Miaolingian Nelson Limestone (Pensacola Mountains, Debrenne & Kruse, 1989; Wood *et al*., 1992) and Furongian Minaret Formation (Ellsworth Mountains, Debrenne *et al*., 1984) have been essential to infer the likely sources of the abundant and dispersed record of allochthonous archaeocyathan assemblages within Palaeozoic conglomerates as the Whiteout Conglomerates (Ellsworth Mountains, Debrenne, 1992) to Cenozoic deposits as the Polonez Cave and Cape Melville Formations (King George Island, Morycowa *et al*., 1982; Wrona & Zhuravlev, 1996), deep sea gravels (Weddell Sea, Gordon, 1920), and glacial tills and moraines from the Whichaway Nunataks (Hill 1965; Debrenne & Kruse, 1989), Shackleton Range (Stephenson Bastion and Du Toit Nunataks, Höfle & Buggisch, 1995) and the Transantarctic Mountains (Hill, 1964b). In fact, the presence of archaeocyath-bearing clasts in other Palaeozoic records, with unknown Cambrian carbonate platforms, has allowed palaeobiogeographic comparisons between the Antarctica assemblages and others exotic archaeocyaths from South Gondwana localities (Fig. 1), such as the Falkland Islands (Fitzroy Tillite Formation, Stone *et al*., 2012), South Africa (Dwyka Group, Debrenne, 1975), Namibia (Dwyka Group, Perejón *et al*., 2019), and Argentina (El Jagüelito and Sauce Grande Formations González *et al*., 2011, 2013).

The occurrence of archaeocyath-bearing clasts as Cenozoic glacial erratics and as Cambrian marine slope conglomerates of the Cambrian Mount Wegener Formation at the Shackleton Range (Fig. 2) was firstly reported by Buggisch *et al*. (1994a), Höfle & Buggisch (1995) and Buggisch & Henjes-Kunst (1999). The Shackleton Range at the Coats Land region of Antarctica is bounded by the Slessor and Recovery glaciers which drain the East Antarctic Ice Sheet into the Weddell Sea (Fig. 2B). The lithostratigraphic framework of the Shackleton Range has been established after the outstanding work done by a number of geological field expeditions (see Kleinschmidt, 2007) in spite of the great disconnection between outcrops and its complex tectonic structure. In the Shackleton Range, the dispersed rock outcrops mainly consist of medium-high grade amphibolite facies of the Proterozoic Shackleton Range Metamorphic Complex (Clarkson, 1972) and diverse Proterozoic-Cambrian metasedimentary and metavolcanic rocks, where infracrustal and supracrustal rocks are tectonically interleaved. The remaining stratigraphic record, Ordovician red beds and molasses, Permian tillites, Jurassic tuffites and dolerites and Cenozoic tills and moraines occur more or less disconnected into the different tectonostratigraphic units developed during the Ross Orogeny (Buggisch *et al*. 1994b; Buggisch & Kleinschmidt, 1999). In general, the Shackleton Range is interpreted as a collisional orogen as a result of the final amalgamation between East and West Gondwana during late Precambrian-Cambrian times (Tessensohn *et al*., 1999). The Cambrian Mount Wegener Formation is forming part of the Mount Wegener Nappe (Fig. 2C), whose transport to the south and the low-grade metamorphic overprint were around 490 Ma as a result of Ross Orogeny (Buggisch *et al*., 1994b).

Microfacies analysis of carbonate clasts

The analyzed carbonate clasts from the Cambrian marine slope deposits were collected from metaconglomerates and boulders of the Mount Wegener Formation at the southern part of the Read Mountains, from the Swinnerton Ledge, Oldhamia and Trueman Terraces (Fig. 2D) during the EUROSHACK expedition (1993-1994). A total number of 42 thin sections have been analyzed with sedimentological, palaeontological and diagenetic purposes to reconstruct the development and destruction of calcimicrobial-archaeocyath boundstones. The carbonate clasts are accessory to primary components in polymict sandy metaconglomerates and polymict breccias from the Mount Wegener Formation which was deposited in slope to basin environments. The carbonate clasts

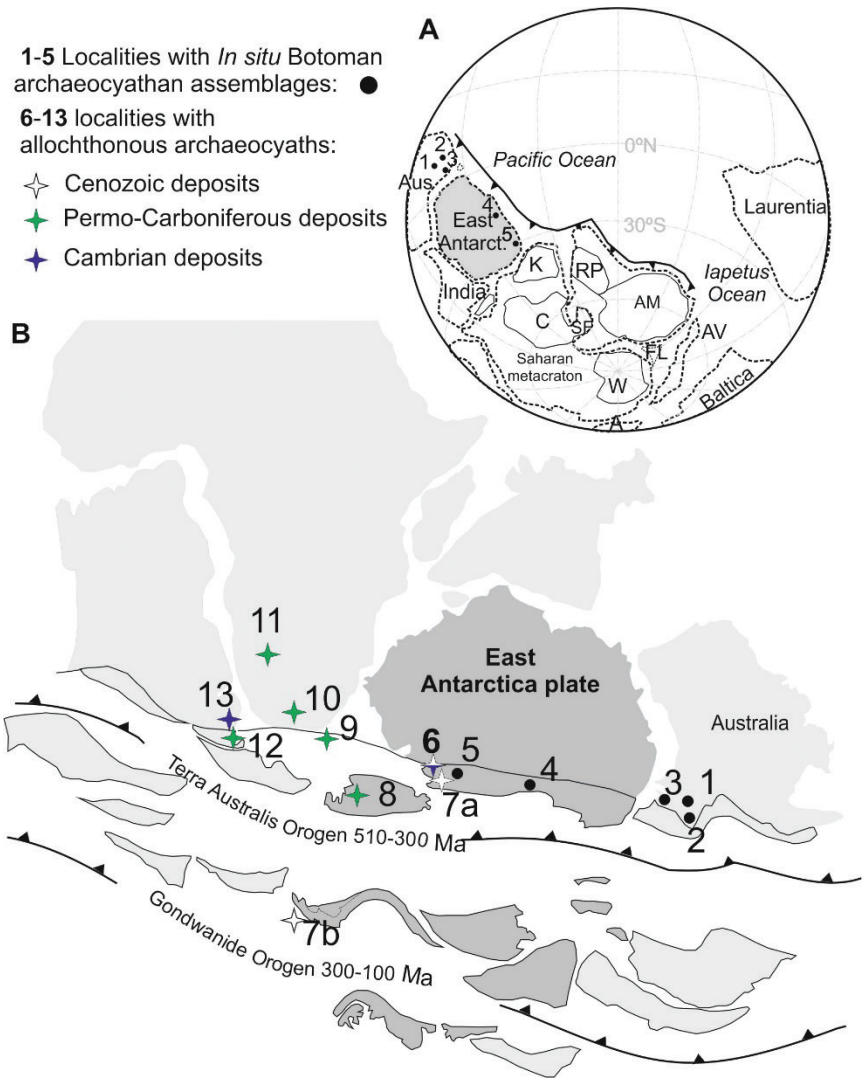

Figure 1.—A. 550-505 Ma palaeogeography of the West Gondwana assembly (simplified from Gray *et al*., 2008), showing the occurrence of *in situ* Botoman archaeocyathan assemblages in Antarctica and Australia localities (1-5), modified from Perejón *et al*. (2019). Abbreviations: Aus, Australia; K, Kalahari craton; C, Congo craton; W, West Africa; RP, Río de la Plata; SF, Sao Francisco; A, Armorica; AM, Amazonia; FL, Florida, AV, Avalonia. B. Mid Cambrian-late Carboniferous of the South Gondwana palaeogeography (rotated and simplified from Boger, 2011), showing the distribution of allocthonous archaeocyaths assemblages from Cambrian to Cenozoic deposits (6-12), modified from Perejón *et al*. (2019). Australia localities: 1, Arrowie Basin; 2, Gnalta Shelf; 3, Stansbury Basin. Antarctica localities: 4, Transantarctic Mountains; 5, Pensacola Mountains; 6, Shackleton Range (this study); 7a, Whichaway Nunataks; 7b, King George Island; 8, Ellsworth Mountains. Argentina localities: 9, Falkland Islands; 12, Sierra Grande; 13, Sierras Australes. Southern Africa localities: 10, main Karoo Basin, South Africa; 11, Aranos Basin, Namibia.

correspond to dolostones and limestones with varied microfacies as silty/sandy mudstone, bioclastic to intraclastic wackestone/packstone, common algal and mud peloidal silty packstone/grainstone, rare ooidal and oncolitic grainstone. The bioclastic to intraclastic wackestone/packstone shows a rich fossil assemblage with trilobites, brachiopods, echinoderms, archaeocyaths and undetermined skeletal remains. Calcimicrobes belonging to *Epiphyton*, *Renalcis* and *Girvanella* groups and archaeocyaths are conspicuous constituents in limestone clasts, forming calcimicrobial boundstone, calcimicrobial-archaeocyathan boundstone and archaeocyathan cementstone. The initial study of pore-filling and fracture cements points out to meteoric to marine-phreatic up to burial diagenesis. The observed low

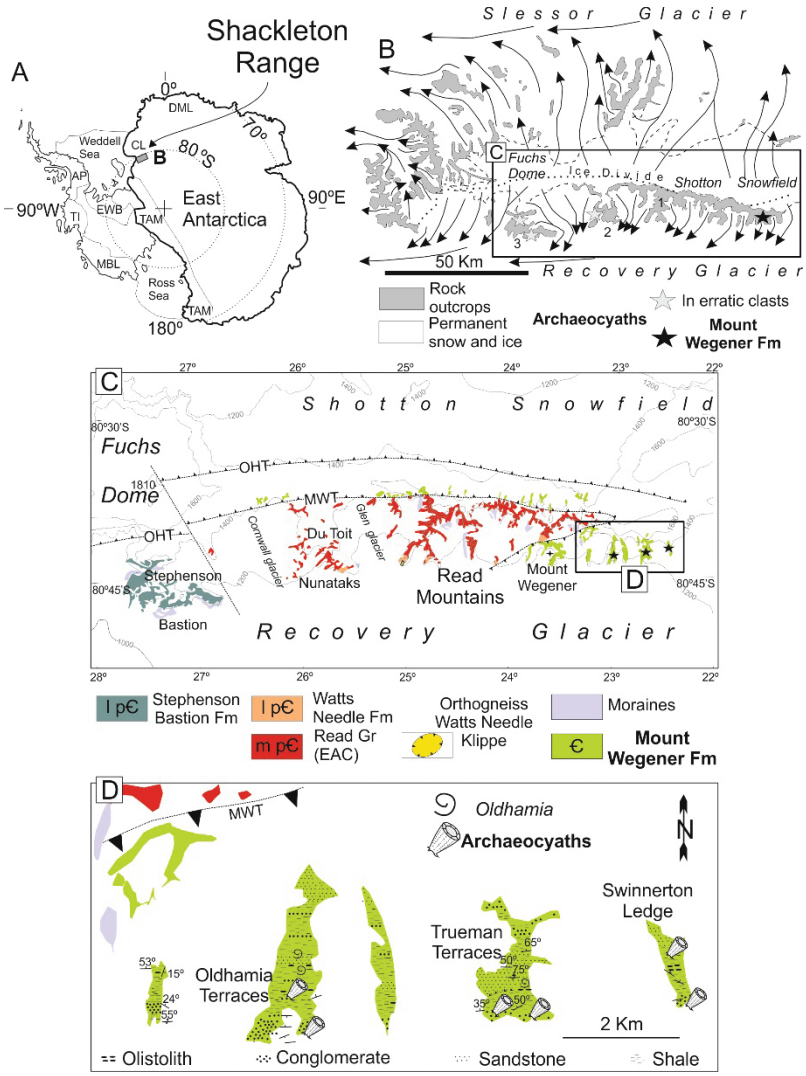

Figure 2.—A. Location of the Shackleton Range at the Antarctica continent. The East Antarctica plate is outlined. The West Antarctic plate was built up by the amalgamation of different terranes (AP, EWB, TI, MBL). AP, Antarctic Peninsula; EWB, Ellsworth-Whitmore Block; TI, Thurston Island, MBL, Marie Byrd Land; DML, Dronning Maud Land; CL, Coats Land; TAM, Transantarctic Mountains. B. Main rock outcrops map of the Shackleton Range, showing the directions of present glaciers and their tributaries, modified from Höfle & Buggisch (1995). Stars point out the location of microbial-archaeocyath-bearing clasts. 1, Read Mountains; 2, Du Toit Nunataks; 3, Stephenson Bastion. C. Detail from B, showing the partial geological map of the southern Shackleton Range, modified from Clarkson *et al*. (1995). OHT, Otter Highlands Thrust; MWT, Mount Wegener Thrust. D. The geological map of the Mount Wegener Formation at the southern part of the Read Mountains, modified from Buggisch & Henjes-Kunst (1999). The occurrence of in situ microbial-archaeocyath-bearing clasts from the Mount Wegener Formation conglomerates is pointed out. MWT, Mount Wegener Thrust.

grade tectonically induced fabrics (achaeocyaths tectonically elongated, mechanical twinning in calcite cements, cataclasite fabrics) were produced during the final emplacement and southwards transport of the Mount Wegener Nappe. The preliminary data from the palaeontological study shows a rich and diverse archaeocyathan assemblage with more than twenty-one genera identified. The 74% of genera belong to the Ajacicyathina Suborder, 9% to Archaeocyathina, 6% to Erismacoscinina, 5% to Loculicyathina, 4% to Dokidocyathina, and 1% to Monocyathida and Putapacyathida Orders.

Concluding remarks

Prof. Dr. Werner Buggisch deceased on 6.04.2019 after a long illness. In the year 2016 we asked Professor Buggisch about the material from the Shackleton Range and about the possibility of studying the calcimicrobial-archaeocyath-bearing clasts. Professor Buggisch responded enthusiastically and sent us all the material he had. Unfortunately, although he was aware of our advances, he died before seeing the first results published. Between 1979 and 1995 he participated in four Antarctic expeditions, thus this work and future publications happen thanks to his tremendous work in Shackleton Range. A brief profile of his work can be seen on the website of the GeoZentrum Nordbayern (https://www.gzn.nat.fau.de/2019/04/09/das-geozentrum-trauert-um-prof-dr-w-buggisch-verstorben-am-6-04-2019/)

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