FIELDIANA
Geology

Published by Field Museum of Natural History

Volume 37, No. 5 February 24, 1978

Ordovician *Receptaculites camacho* n. sp. from Argentina

MATTHEW H. NITECKI
CURATOR, FOSSIL INVERTEBRATES
FIELD MUSEUM OF NATURAL HISTORY

and

GERALD G. FORNEY
AMERADA HESS CORP.
WILLISTON, N.D.

ABSTRACT

An Early Ordovician green alga, *Receptaculites camacho* n. sp., from the San Juan Formation in Talacasto Gorge, San Juan Province, Argentina is a probable ancestor of *Receptaculites oweni* of the Galena-Kimmswick (Caradocian?) of North America. Analogy with recent calcareous green algae suggests that *R. camacho* inhabited warm, shallow, marine water. A paleomagnetic reconstruction of mid-Ordovician continental configurations places the North and South American localities of *R. oweni* and *R. camacho* in tropical latitudes. The major global oceanic currents for Middle Ordovician are inferred.

INTRODUCTION

Receptaculitids are an order of Paleozoic green algae related to Siphonales, Siphonocladales, and Dasycladales. Receptaculitids are common in North America, but are poorly known from South America. Ahlfeld and Branisa (1960) and Branisa (1965) illustrated a Devonian *Receptaculites bolivianus* from Bolivia, where it is an index fossil and a zone marker. The Ordovician specimen described in this paper was illustrated by Camacho (1966) as *Receptaculites* sp. Silurian receptaculitids have been found by geologists working in the Argentine Precordillera (Camacho, pers. comm.).

Distribution of Argentine and Bolivian receptaculitids has been discussed by Byrnes (1968), Holland (1971), and Nitecki (1972). Byrnes and Holland suggested that Devonian receptaculitids were

Library of Congress Catalog Card Number: 77-20539
US ISSN 0096-2651

Publication 1277

restricted to a zone of 15 degrees north and south of the paleoequator, but did not include the South American taxa on their map. Nitecki (1972) included the South American occurrences on a map of receptaculitid distribution.

The apparent scarcity of South American receptaculitids may be due to the lack of paleontological exploration. In the 19th century, European and North American receptaculitids were described by students of fossil sponges, but no South American occurrences were known. There has been no active search for receptaculitids in South America, although with an increased number of field studies, more will certainly be found.

The fossil described here adds new information on the paleogeographic distribution of Ordovician receptaculitids and on the possible ancestry of the well-known North American *Receptaculites oweni*.

LOCATION AND STRATIGRAPHY

Early Ordovician carbonate rocks are found throughout the eastern Precordillera of Argentina. Narrow bands of limestone extend southward for almost 500 km. from Cerro Totora (LaRioja Province) to west of Mendoza City, with their greatest thickness between Jachal-Huaco and the city of San Juan (Cuerda, 1973).

Harrington (1957) found abundant fossils in the upper part of the San Juan Formation, and lists over 25 species of crinoids, bryozoans, corals, brachiopods, gastropods, cephalopods, and the trilobite*Proetiella tellecheai*. Harrington (1957) considers the zone of*P. tellecheai* to be Upper Llanvirnian, since the San Juan Formation at Huaco is conformably overlain by shales with supposed Llandeilian graptolites. More recent graptolite collections (including*Paraglossograptus etheridgei* and *Glyptograptus austrodentatus*) known from Llanvirnian of Australia suggest a Lower Llanvirnian age for the San Juan Formation (Cuerda, 1973). The revised and correct name of *Paraglossograptus etheridgei* is *P. tentaculatus*. It was originally described from Levis Shale of Quebec from beds apparently corresponding to the European *D. hirundo* Zone, that is, late Arenigian. This is in good agreement with Serpagli's strong conodont evidence of the age of San Juan. Conodonts from the San Juan Formation 50 km. north of Huaco include North Atlantic Lower Ordovician forms such as *Oistodus, Scandodus,* and *Cordylodus* (Hünicken, 1971). Serpagli (1974) considers the upper 200 m. of the

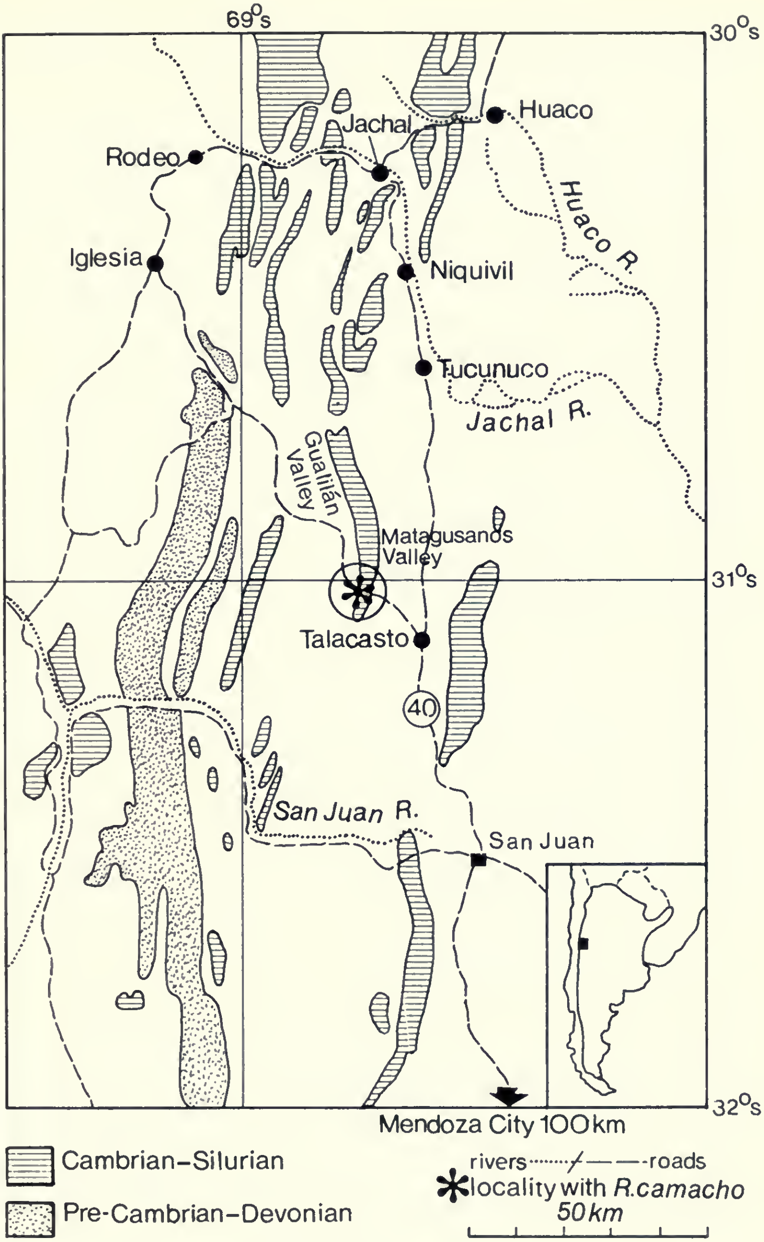

FIG. 1. Central Argentine Precordillera showing outcrop pattern of undifferentiated rocks of Lower Paleozoic age. The Quebrada de Talacasto locality with *Receptaculites camacho* is indicated by an asterisk in a circle (modified from Padula et al., 1967, fig. 4).

San Juan Formation to be of Arenigian age. Serpagli's locality is 50 km. northwest of San Juan.

Talacasto Gorge (Quebrada de Talacasto), where *Receptaculites camacho* is found, is one of the best-studied Lower Paleozoic sections in the Argentine Precordillera (Padula et al., 1967; Marchese, 1972). The gorge is located in San Juan Province about 55 km. north-northwest of the city of San Juan (fig. 1). The section of Ordovician to Middle Devonian strata extends from east to west along the highway from Talacasto to Rodeo, and between the Matagusanos and Gualilan valleys. Our locality (fig. 1) is about 2 km. east of locality 2 of Padula and others (1967, fig. 4).

The total thickness of the San Juan Formation at Talacasto Gorge is unknown because the base of the Paleozoic section is bounded by a fault. The formation (fig. 2) is divisible into a lower, 300 m. thick member, consisting of 0.5 to 3 m. thick beds, and an upper, 50 m. thick member, with beds ranging from 0.2 to 1 m. in thickness (Marchese, 1972). The textures and sedimentary structures of the upper member suggest deposition in shallower water than the lower member (Marchese, 1972).

The fauna associated with *R. camacho* includes the trilobite *Proetiella tellecheai*, the gastropod *Maclurites avellanedae*, the nautiloid cephalopod *Lituites* sp., the brachiopod *Orthis* sp., and other, unidentified, fossils (Baldis, pers. comm.).

According to Baldis (pers. comm.), the San Juan Formation at Talacasto Gorge is unconformably overlain by the Silurian (Wenlock-Ludlow) Los Espejos Formation (fig. 2) which consists of 350 m. of fossiliferous green sandstones interbedded with shales.

Receptaculites oweni Hall, 1861

Receptaculites oweni is a very common, conspicuous North American Ordovician fossil. Although it is well-known to American geologists, it has received little study. *R. oweni* is the largest receptaculitid known; specimens over 30 cm. in diameter are common. In the midwestern United States, *R. oweni* is restricted to the Galena and Kimmswick Formations where it is an excellent horizon marker. Outside this region, its distribution is less precisely known, and work in progress indicates that fragmentary material is often misidentified. While other species have been assigned to *R. oweni*, the reverse is also true, and at least 10 different names have been

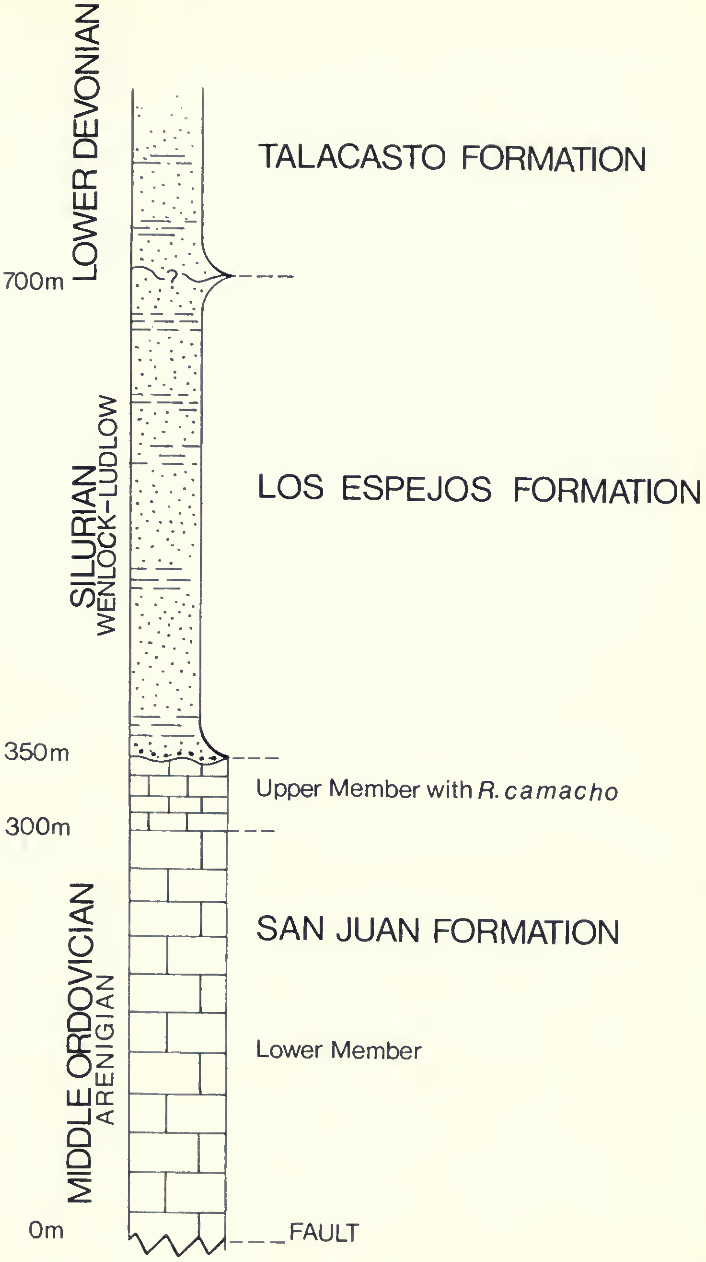

FIG. 2. Stratigraphic section of the lower part of the Quebrada de Talacasto succession (Baldis, pers. comm.).

given to this taxon. Preliminary examination reveals that specimens from Colorado, Nevada, New Mexico, Texas, Wyoming, Manitoba, Northwest Territories, Ontario, Saskatchewan, and the Canadian Arctic appear similar to *R. oweni*. However, the identification of *R. oweni* in Kentucky, Maryland, New Jersey, Pennsylvania, Alberta, and Quebec, is in question. These fossils appear to be *R. occidentalis*, which differs from *R. oweni* in the size of thallus, length of branches, and in the complexities of lateral heads. If the fossils reported from these localities are *R. oweni*, then the species ranges into the Ashgillian. Until more information is available, we consider *R. oweni* to be restricted to the Galena-Kimmswick of Caradocian (?) age. However, the topmost part of the Galena Group may be Ashgillian in age.

Although *R. oweni* is found chiefly in limestone, it is also common in dolostone. In the field, it is easily recognized by its large size, short but relatively thick branches, and disc-like preservation. Although complete specimens have never been illustrated, we have such entire individuals in our collections. These show that *R. oweni* was globose, rather than disc-like, without holdfast, and suggest that this form rested directly on the substrate.

Receptaculites camacho n. sp.

The fossil from Talacasto Gorge is a very large *Receptaculites* 22 cm. in diameter (fig. 3). Although its large size and flat shape could easily cause it to be mistaken for *R. oweni* and although not all the skeletal elements are well-preserved, it represents a distinct new species. The single specimen consists of a complete upper part of the thallus and portions of its sides. The thallus is circular in outline with the central area and margin of the fossil somewhat elevated. This is a distorted form of preservation frequently found in North American *Receptaculites oweni*. The central nucleus, representing the growing, distinctly mamillary tip is very pronounced and somewhat elevated. The branches are very short, with irregular bases, relatively thin shafts, and heads consisting of thin, small stellate structures just below relatively thin plates. The heads and shafts are poorly preserved and the head elements appear fused and heavily calcified. Small knobs are found on the outer surface of individual plates. Horizontal and vertical elements of the stellate structures are distinct on portions of the surface. These structures are not observed together, indicating that the elements of the stellate structures were in two planes.

FIG. 3. *Receptaculites camacho* from Quebrada de Talacasto, Holotype, Field Museum of Natural History, PP 19881.

The following characters are shared by *R. camacho* and *R. oweni*: very large thallus; preserved part has a circular, disc-like outline; somewhat elevated nucleus is centrally located; branches are characteristically very short; calcification of bases and heads of laterals forms a double wall structure; and a thin outer plate is present.

R. camacho differs from *R. oweni* as follows: lateral shaft is much thinner (the shaft of *R. camacho* is five times thinner than the shaft of *R. oweni);* stellate structure of *camacho* consists of four small ribs, apparently not fused together; and a small central protuberance is present on the plate.

This comparison shows that *R. oweni* and *R. camacho* are morphologically very similar taxa. The characters generally used to differentiate receptaculitid species, such as calcification, formation of walls, and length of branches, indicate that these are very closely related forms that could be placed in the same subgenus. Since *R. camacho* is stratigraphically older than *R. oweni*, the conclusion that *R. camacho* is an ancestral stock of *R. oweni* seems very reasonable.

PHYTOGEOGRAPHY OF RECENT DASYCLADACEAN ALGAE

Data on the distribution of extant algae are based either upon the study of small planktonic forms, or upon attached near-shore forms. The pattern of distribution of planktonic algae gives us information about oceanic currents, and about the physical conditions of the near and surface waters from which the plankton was transported. The pattern of distribution of near-shore benthonic algae, however, indicates the distribution of conditions suitable for their establishment and growth. This is particularly true for long-lived organisms which spend all of their lives (including reproductive phases) in one place. On a global scale, recent marine algal floras are differentiated into northern and southern, and tropical and non-tropical realms. Like the terrestrial plants, species of benthonic algae are geographically restricted.

While the vertical and horizontal distribution of living red algae is now being studied (Adey and Macintyre, 1973; Adey and Vassar, 1975), the distribution of calcareous green algae, particularly Dasycladales, has received little attention. Both intensity and color of light are important in the bathymetric distribution of green calcareous algae. Chlorophyta cannot tolerate deep or muddy water because they require light frequencies that cannot penetrate deep or muddy water. Calcified algae have a greater ability to tolerate exposure to light than uncalcified forms. Green "naked" uncalcified *Acetabularia* cannot tolerate an intensity of light as high as heavily calcified forms, and when exposed to strong light it bleaches and loses much of its chlorophyll. Therefore, calcified individuals can inhabit shallower and more intensely illuminated waters. The usefulness of benthonic calcareous algae as depth indicators in paleoenvironmental studies is discussed by Riding (1975).

Apart from water depth, the geographic distribution of algae is mainly controlled by water temperature. The algal floras of the tropical Atlantic and Indian Oceans are very similar. These floras are not continuous around the southern, non-tropical projections of

South Africa and South America. Such a distribution may be a result of extinction, migration, and currents. The most common view today is that Pleistocene climatic variations caused this distribution. However, Pleistocene climatic changes cannot explain the distribution of the living dasycladaceous genera *Bornetella, Helicoryne, Dasycladus,* and *Acetabularia*. *Bornetella* and *Helicoryne* are cosmopolitan in the tropics, but are absent from the Caribbean; *Dasycladus* is found in the Mediterranean, Caribbean, and Australia; *Acetabularia* is found on both sides of Panama, across the equator (including Australia), and in the Mediterranean. Neither the closing or opening of the Isthmus of Panama, nor the movement of cold or warm Pleistocene currents alone can explain this distribution. Even more difficult to explain is the distribution of the dasycladaceous alga *Batophora oerstedii* found not only in the warm, quiet marine waters of lagoons in the Gulf of Mexico and in the Caribbean, but also in lakes in New Mexico 500 miles from the nearest marine locality! Although modern Dasycladales are generally restricted to the marine tropics, they are also found outside the tropical sea belt. This pattern suggests that the importance of Pleistocene changes upon the distribution of marine algae may have been exaggerated.

PALEOECOLOGY OF ORDOVICIAN RECEPTACULITIDS

The ecology of Ordovician receptaculitids is known from 1) calathids of the southwestern United States, 2) receptaculitids from the southern Appalachians, and 3) *Receptaculites oweni* from the Upper Mississippi Valley.

1. Calathids, best known in the Lower Ordovician mounds of western Texas, are definite reef builders, with long thalli and thick holdfasts. They are a major component of algal bioherms that range in size from small mounds one-half meter long, to structures more than 15 m. long. The bioherms are calcitic mudstones bound by possible blue-green algae, by archaeoscyphian sponges, and by calathid receptaculitids. In the reefs, calathids are beautifully preserved in growth position. The size of calathids in each mound is related to the size and rate of growth of the mound, indicating that these algae were long-lived with a life span probably measured in decades.

2. The receptaculitids of the Appalachian region occur either in association with organic reefs or are found in the inter-reef facies.

Those in reefs have bulky thalli, often with holdfasts, and were unquestionably sessile. Like the long-lived Texas calathids, Appalachian reef receptaculitids formed "thickets" and acted as frame builders to produce boundstone (Alberstadt et al., 1974).

3. Although holdfast is not known in *Receptaculites oweni,* the heavy calcification and large size suggest that it was a benthonic form. Even in incomplete specimens, the individual branches are articulated, and there is only rare evidence of abrasion or extensive transport.

R. oweni is an abundant fossil and it is usually found in rocks of a consistent lithology. The lithology and faunal associations of receptaculitid localities in Illinois, Wisconsin, Iowa, and Missouri indicate moderate to high energy, shallow bioturbated subtidal and shoal environments. These shallow environments were, however, probably many miles from the nearest shorelines of the widespread epeiric seas. However, the facts controlling the dispersal of the genus remain still poorly understood.

PALEOGEOGRAPHY OF ORDOVICIAN RECEPTACULITIDS

Reconstruction of Ordovician continental positions is helpful in our understanding of the latitudinal distribution of the Ordovician members of the genus *Receptaculites.*

For post-Permian time the continental reconstructions are based on data derived from the magnetic anomalies of the oceanic crust, geographic fits, and paleomagnetic determinations; for pre-Permian time the information on the relative positions of continental plates is much more difficult to obtain. Apparent polar wandering paths for well-defined plates can be used, but other sources are required to fix absolute positions on the globe and the relative positions of the various plates to one another.

Several reconstructions of continental positions are available for the Ordovician. Smith et al. (1973, text-fig. 13) present a Cambrian to Lower Ordovician map; Whittington and Hughes (1973, text-fig. 2) offer a modification of it; Barnes and Fåhraeus (1975, figs. 4 and 5) published an Early and Late Ordovician continental reconstruction based in part on the map of Smith et al.

Our reconstruction and sutures are based upon McKerrow and Ziegler, 1972, and upon Smith and Hallam, 1970, and the shape of the Siberian plate is from McKerrow (pers. comm.). Unlike Barnes

TABLE 1. SELECTED ORDOVICIAN PALEOMAGNETIC POLE POSITIONS FROM EUROPE AND NORTH AMERICA (Van der Voo, pers. comm.).

Location	Age	Pole Position	Reference
EUROPE:			
Aberdeenshire, Scotland	MO 470	11°N 189°E	Sallomy and Piper, 1973
Girvan, Scotland	LO 510?	11°N 168°E	Nesbitt, 1967, p. 49
Lake District, England	UO 445	9°N 176°E	Briden and Morris, 1973, p. 38
Lake District, England	UO 445	28°N 188°E	Briden and Morris, 1973, p. 41
Wales	UO 435	2°N 182°E	McElhinny, 1973, no. WE 3.5
Wales	MO 470	16°N 179°E	McElhinny, 1973, no. WE 3.2
Norway	UO 440	14°N 180°E	Piper, 1974, p. 383
	Mean Pole	13°N 180°E	
NORTH AMERICA:			
New York, USA	MO	36°N 114°E	McElhinny and Opdyke, 1973, p. 3,697
New Jersey, USA	UO-LS 435	35°N 126°E	Proko and Hargraves, 1973, p. 185
	Mean Pole	36°N 120°E	

and Fåhraeus, we have omitted New Zealand from our map because evidence is not available on its position.

No paleomagnetic data are available to place China and Mexico on an Ordovician map. Smith et al. attach China to Siberia while Barnes and Fåhraeus attach it to Australia. China is not relevant to our interpretation, therefore it is left out of our Figure 4.

Our reconstruction of Middle Ordovician continental positions (fig. 4) is based on newer European, North American, and Australian paleomagnetic studies and on older studies from Siberia. McElhinny and Embleton (1974) based a new path of apparent polar wander for the southern continents on the Gondwana reconstruction of Smith and Hallam (1970). When their southern continents are reassembled, the individual polar tracks converge for much of the Paleozoic. For Gondwana, the Cambrian and Ordovician south pole centers (with respect to Africa) in the Mediterranean just east of Tunisia. This pole is used to position Gondwanaland in our Figure 4. A new pole for the Ordovician Gondwana (McElhinny and Embleton, 1974) places Argentina in a latitude lower than any of the other maps.

The new Ordovician mean poles for North America and Europe (table 1) are based on a re-evaluation by Van der Voo (pers. comm.) using reliability criteria of Van der Voo and French, 1974. The mean pole position for Europe differs only slightly from previous values of 7°N 180°E (Smith et al., 1973, p. 10), or 10°N 176°E (McElhinny, 1973), but the North American mean pole differs considerably from previous determinations. The position of North America in the reconstruction of Smith et al. (1973, fig. 14) is based on a Cambrian pole at 7°N 140°E. McElhinny (1973) stated that this North American Ordovician pole (28°N 192°E) was questionable. The pole used to position North America in Figure 4 is the mean of values obtained by Proko and Hargraves (1973) and McElhinny and Opdyke (1973).

All these values are based on samples from rocks that can be proved to have been heated at least 300° C which makes them questionable (Bergström, pers. comm.). Bergström's (unpublished) data from thermally unaffected Arenigian and Llanvirnian limestones from the Baltic Shield give a pole position for the Baltic Shield during Arenigian time of 34°N 47°E. This, according to Bergström, fits well with sedimentological and faunal data, and suggests that the Baltic limestones in Early and Middle Ordovician time were cold water sediments, not tropical.

Continental positions in Figure 4 indicate that *R. oweni* and *R. camacho*, like Devonian receptaculitids (Byrnes, 1968), were tropical plants. In North America, *R. oweni* was restricted to latitudes between 20°N and 20°S, while the South American locality of *R. camacho* was at 15°S. The earliest occurrence of *R. camacho* in South America suggests that the descendents of this species migrated eastward to North America, where they evolved into *R.*

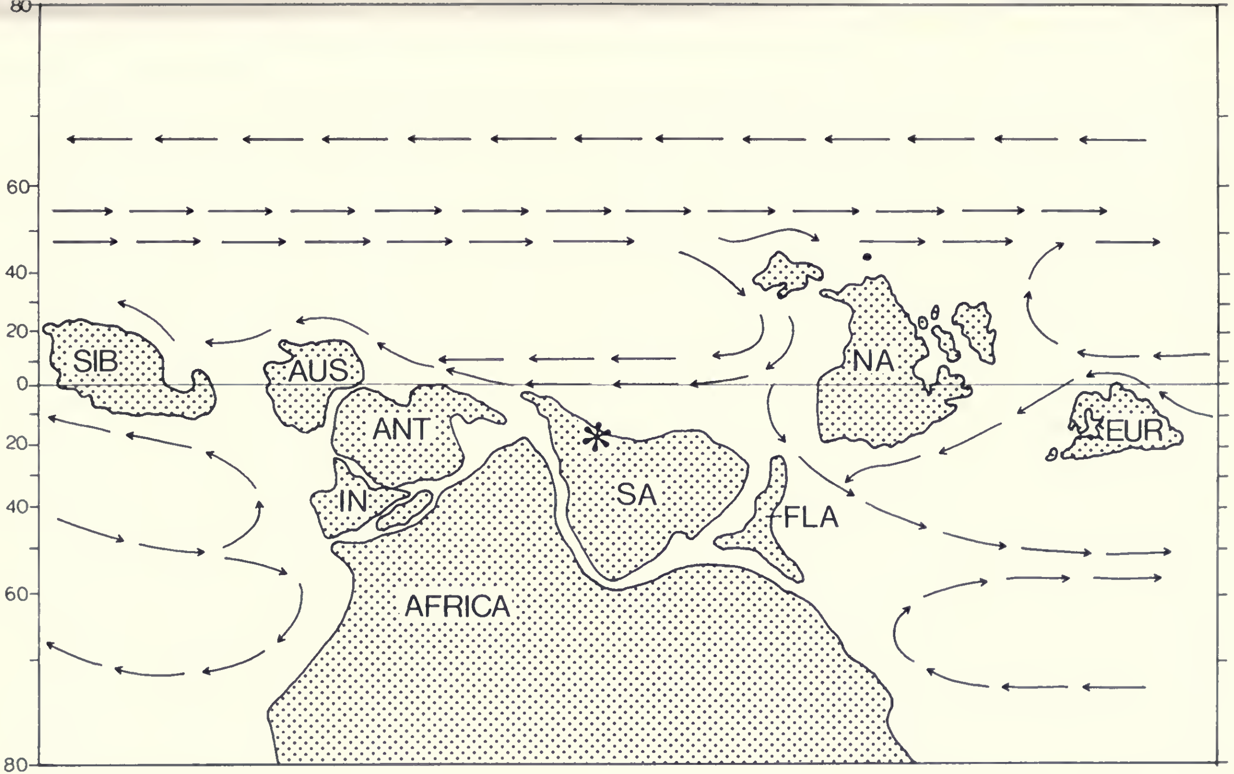

FIG. 4. Map of Middle Ordovician continental positions and oceanic currents. Continental positions based on paleomagnetic data in Table 1, and in McElhinny (1973). Geometric fits of plates based on maps in Smith and Hallam (1970) and McKerrow and Ziegler (1972). Position of *R. camacho* is indicated by an asterisk.

oweni. A single subgenus possibly consisting of these two species was distributed over a large area and in deep water, just as some modern genera of Dasycladales are distributed.

Middle Ordovician ocean currents have been drawn (fig. 4), by analogy with the present day ocean currents. Today, surface ocean currents usually are broadly aligned along the direction of major wind belts. If continents were not exposed, zonal ocean currents would simply circle the globe. This is seen today in latitudes without exposed land, and the Antarctic Circumpolar Current is such a zonal current.

However, when north to south land barriers are present, the circumglobal zonal currents are deflected and produce gyres. Modern wind belts cause two gyres, one in each hemispheric ocean basin: an anticyclonic gyre (5 to 45 degrees latitude) and a cyclonic gyre (45 to 65 degrees latitude). Figure 4 shows zonal currents when no interfering land masses are present, and gyres when land masses interfere with and deflect zonal currents. We assume that the Ordovician wind belts had approximately the present position. There is evidence that the length of day was about 10 per cent shorter in the Devonian than it is today (Mazzullo, 1970). The faster rotation of the earth during that time would tend to move the dry belts and wind belts slightly closer to the equator, but this would be unnoticed on the scale of our map.

SYSTEMATICS

Receptaculites camacho n. sp. Figure 3.

Name.—Named for Professor H. H. Camacho, Buenos Aires University, who provided the specimen described here.

Definition.—Large, flattened globose *Receptaculites*; branches very short and small; bases of branches irregular, heavily calcified, forming an inner wall; shaft of lateral short and thin (in adult rarely over 5 mm. in length); thin, small, four-ribbed stellate structures in two planes; plates thin with central knobs.

Holotype.—A single, upper part of thallus, PP 19881 (shown in fig. 3), deposited in Field Museum of Natural History.

Stratigraphic position and locality.—San Juan Formation, Talacasto Gorge, Argentine Precordillera.

CONCLUSION

We know nothing of the method of dispersal of receptaculitids, and it is clear that the living relatives (Dasycladales) are not now inhabiting the ecological niches formerly occupied by receptaculitids. Dasycladales live in wide geographic areas, and their distribution is largely temperature controlled. It appears, however, that we can infer the receptaculitid environment. *R. oweni* and *R. camacho* are closely related, and because the North American occurrence of *R. oweni* is stratigraphically restricted (Galena and Kimmswick Formation), and because the lithologic character of enclosed rock is very similar, we propose that the earlier South American occurrence represents, nevertheless, a similar environment. This environmental interpretation indicates environmental similarities, but no conclusion about the relative positions of the continents could be based solely on the distribution of receptaculitids. Our conclusions about continental positions are independent of the distribution of *Receptaculites* and are based on tectonic and paleomagnetic data. Thus this new distributional pattern of *Receptaculites* supports but does not explain the posited relative positions of North and South America in the Ordovician time.

ACKNOWLEDGEMENTS

We are grateful to H. H. Camacho for providing the specimen from Argentina; B. A. J. Baldis for stratigraphic and geographic information; R. Van der Voo for paleomagnetic data; C. S. Scotese for computer graphics; and C. R. Barnes, S. M. Bergström, and our colleagues at Field Museum for reading the manuscript. Richard Roesner prepared the drawings. Research has been supported by National Science Foundation grant DEB 77-11129.

REFERENCES

Adey, W. H. and I. Macintyre

1973. Crustose coralline algae: a re-evaluation in the geological sciences. Bull. Geol. Soc. Amer., **84**, pp. 883-904.

Adey, W. H. and J. M. Vassar

1975. Colonization, succession and growth rates of tropical crustose coralline algae (Rhodophyta, Cryptonemiales). Phycologia, **14**, no. 2, p. 55-69, 14 text-figs.

AHLFELD, F. and L. BRANISA

1960. Geologia de Bolivia. La Paz, Instituto Boliviano del Petroleo, 245 pp., 12 pls., 90 text-figs., map.

ALBERSTADT, L. P., K. R. WALKER, and R. P. ZURAWSKI

1974. Patch reefs in the Carters Limestone (Middle Ordovician) in Tennessee, and vertical zonation in Ordovician reefs. Bull. Geol. Soc. Amer., **85**, no. 7, pp. 1,171-1,182, 10 text-figs.

BARNES, C. R. and L. E. FÂHRAEUS

1975. Provinces, communities, and the proposed nektobenthonic habit of Ordovician conodontophorids. Lethaia, **8**, no. 2, pp. 133-149.

BRANISA, L.

1965. Los fósiles guias de Bolivia. Index fossils of Bolivia. I. Paleozoico. Servicio Geologico de Bolivia, Bull. 6, 282 pp., 80 pls.

BRIDEN, J. C. and W. A. MORRIS

1973. Palaeomagnetic studies in the British Caledonides - III. Igneous rocks of the Northern Lake District. England. Geophys. Jour. Roy. Astr. Soc., **34**, no. 1, pp. 27-46.

BYRNES, J. G.

1968. Notes on the nature and environmental significance of the Receptaculitaceae. Lethaia, **1**, no. 4, pp. 368-381, 5 text-figs.

CAMACHO, H. H.

1966. Invertebrados fósiles. Buenos Aires, Univ. Buenos Aires, 707 pp., 121 pls.

CUERDA, A. J.

1973. Reseña del Ordovicico Argentino. Ameghiniana, **10**, no. 3, pp. 270-312.

HARRINGTON, H. J.

1957. Ordovician formations of Argentina, pp. 1-59. *In* Harrington, H. J. and A. F. Leanza, Ordovician trilobites of Argentina, Univ. Kansas, Dept. Geol., Spec. Pub. 1, 276 pp.

HOLLAND, C. H.

1971. Silurian faunal provinces? pp. 61-76. *In* Middlemiss, F. A. ed., Faunal provinces in space and time, Geol. Jour. Spec. Issue., **4**.

HÜNICKEN, M. A.

1971. Sobre el hallazgo des conodontes en las calizas de la Formacion San Juan (Ordovicico, Llanvironiano) Quebrado Potrerillos, Sierra de Yanson, Depto. Jachal (Prov. de San Juan). Ameghiniana, **8**, no. 1, pp. 37-51.

MAZZULLO, S. J.

1970. Length of the year during the Silurian and Devonian periods: new values. Bull. Geol. Soc. Amer., **82**, pp. 1,085-1,086.

MCELHINNY, M. W.

1973. Palaeomagnetism and plate tectonics. Cambridge, Cambridge Univ. Press., 358 pp. 144 text-figs.

McElhinny, M. W. and B. J. J. Embleton

1974. Australian palaeomagnetism and the Phanerozoic plate tectonics of eastern Gondwanaland. Tectonophysics, **22**, pp. 1-29.

McElhinny, M. W. and N. D. Opdyke

1973. Remagnetization hypothesis discounted: a paleomagnetic study of the Trenton Limestone, New York State. Bull. Geol. Soc. Amer., **84**, no. 11, pp. 3,697-3,708, 8 text-figs.

McKerrow, W. S. and A. M. Ziegler

1972. Palaeozoic oceans. Nature, Phys. Sci., **240**, pp. 92-94.

Marchese, H. G.

1972. Sedimentologia de la Formacion San Juan (Ordovicico) y del conglomerado "basal" de la Formacion Los Espejos (Silurico?) en la Quebrada de Talacasto, Prov. de San Juan, Republica Argentina. Rev. Assn. Geol. Argentina, **27**, no. 2, pp. 215-222.

Nesbitt, J. D.

1967. Palaeomagnetic evidence for the Ordovician geomagnetic pole position. Nature, **216**, pp. 49-50.

Nitecki, M. H.

1972. The paleogeographic significance of receptaculitids. 24th Int. Geol. Congr., Rept., Sec. 7, pp. 303-309, 2 text-figs.

Padula, E. L., E. O. Rolleri, A. R. G. Mingramm, P. C. Roque, M. A. Flores, and B. A. Baldis

1967. Devonian of Argentina, pp. 165-199. *In* Oswald, D. H., ed., International symposium on the Devonian system, Calgary, 1967, **2**, Calgary, Alberta Soc. Petrol. Geol.

Piper, J. D. A.

1974. Sulitijelma Gabbro, Northern Norway: a paleomagnetic result. Earth Planetary Sci. Letters, **21**, no. 4, pp. 383-388.

Proko, M. S. and R. B. Hargraves

1973. Paleomagnetism of the Beemerville (New Jersey) alkaline complex. Geology, **1**, no. 4, pp. 185-186, 2 text-figs.

Riding, R.

1975. *Girvanella* and other algae as depth indicators. Lethaia, **8**, no. 2, pp. 173-179.

Sallomy, J. T. and J. D. A. Piper

1973. Palaeomagnetic studies in the British Caledonides - II. The younger gabbros of Aberdeenshire, Scotland. Geophys. Jour. Roy. Astr. Soc., **34**, no. 1, pp. 13-26.

Serpagli, E.

1974. Lower Ordovician conodonts from Precordilleran Argentina (Province of San Juan). Soc. Paleontol. Ital., Boll., **13**, no. 1-2, pp. 17-98.

Smith, A. G., J. C. Briden, and G. E. Drewry

1973. Phanerozoic world maps, pp. 1-42. *In* Hughes, N. F. ed., Organisms and continents through time. Spec. Paper in Palaeontol., Paloeontol. Assn., London, **12**.

SMITH, A. G. and A. HALLAM
1970. The fit of the southern continents. Nature, **225,** pp. 139-144.

VAN DER VOO, R. and R. B. FRENCH
1974. Apparent polar wandering for the Atlantic-bordering continents: Late Carboniferous to Eocene. Earth Sci. Rev., **10,** pp. 99-119.

WHITTINGTON, H. B. and C. P. HUGHES
1973. Ordovician trilobite distribution and geography, pp. 235-240. *In* Hughes, N. F., ed., Organisms and continents through time. Spec. Paper Palaeontol., Palaeontol. Assn., London. **12.**