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The Geology of Patos Island (East Venezuela)

By HANS G. KUGLER[1])

ZUSAMMENFASSUNG

Die zwischen Ostvenezuela und Trinidad gelegene Insel Patos ist ein Gewölbe, das im untern Teil aus neritischem Kalk mit eingelagerten Schiefertonen besteht, die der unteren Kreide und vielleicht noch dem obersten Jura zugeteilt werden müssen. Der obere Teil besteht aus dem Patos-Konglomerat, das durch einen schieferigen Ton in zwei Abschnitte getrennt wird. Das Alter der Mikrofossilien dieses Tones deutet auf Neokom bis Apt, was auch für die Fossilreste der Matrix des Konglomerats zutrifft.

Introduction

The little Island of Patos lies in the Boca Grande at the northern end of the Gulf of Paria, between the Paria Peninsula of Eastern Venezuela and the Island of Trinidad (figure).

At the Treaty of Amiens (1802) Trinidad was ceded to Great Britain, thus also the Island of Patos. However, on 29 February 1942 Patos was returned to the Government of Venezuela (VILA 1964) in connection with the establishment of an international boundary, dividing the Gulf of Paria into a Venezuelan and into a Trinidadian part. The necessity of the establishment of such division was discussed between Dr. Guillermo Zuloaga of Caracas and the author during the Second Venezuelan Geological Congress (26 March to 8 April 1938), and was subsequently submitted to the respective Governments for implementation.

Physiography

Patos is about 2 km long and 450 m wide at its broadest places. The highest point is almost 100 m above sea level and its position is Longitude 61°52′ West and Latitude 10°38′ North. It is situated little more than 6 km ESE from the village Macuro on Paria Peninsula, or about 40 km west of Port-of-Spain in Trinidad. The author visited Patos the first time in November 1931, and subsequently six times (but only during one day each time) particularly during the Second World War when gun-sites had to be selected for the American Navy. At that time a rough, narrow road was built from Port Brion to the east-end of the island, and also from Bahia de los Patos westward to trigonometrical station "Tigre" (see Pl. II).

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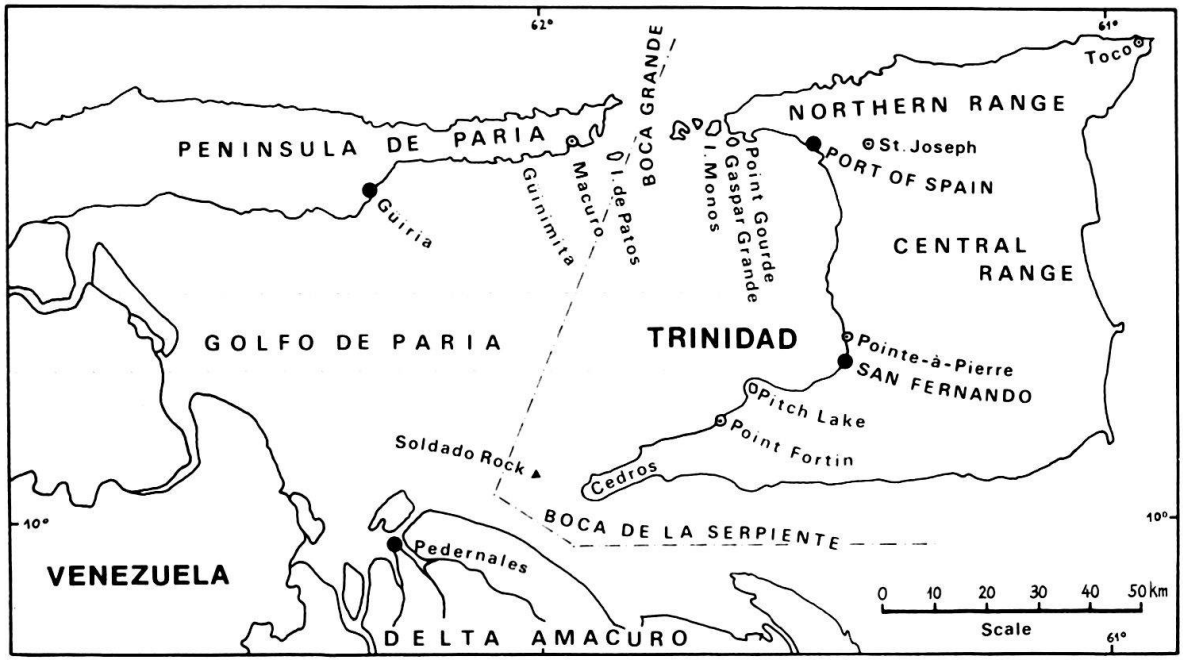

Geographical position of Patos Island.

Patos is an asymmetrical anticline with its axis slightly to the south of the watershed. The axis is gently plunging from east to west and is seemingly interrupted by almost N–S directed cross faults of apparently minor amounts of displacement. The horizontal Laventille Limestone of the crestal region dips gradually, and then steeply to the south. Dip measurements along the coast change from 30 to 60 degrees with an average of about 45 degrees. This dip-slope of the south flank is dissected almost every 150 m by incised dry gullies probably eroded along minor faults. At the southwestern end of the island are two embayments that allow for easy landing of a small boat. North of the anticlinal axis follows a minor syncline, only to be recognized at the northeastern end of the island (see Pl. II). The eastern end, and particularly also the NNW side of the island are formed by vertical, rugged cliffs about 75 m high. Also the west-end of the island is marked by steep cliffs. Huge blocks are lying at the base of the cliffs. A marine terrace exists along the north coast of Patos but not along the south coast (see Pl. II). Large and smaller sink-holes occur almost everywhere in the limestone. These sink-holes are partly filled with hematitic residual soil. The sink-holes communicate with the sea-level, similar to those of the Island Gaspar Grande of the eastern extension of Patos. Gaspar Grande consists likewise of Laventille Formation with sink-holes descending to sea-level, and with large caves adorned with stalactites and stalagmites partly standing in clear sea water in which fishes can be seen below the highest point of the island. Gaspar Grande lies in the sea like a huge sponge of limestone. The same we have to assume for Patos.

Remarks on flora and fauna

On account of the dry climate with a rainfall of less than 120 cm per year, and a possible average annual temperature of 27 °C, one finds on Patos a semi-xerophilous flora besides a small mangrove patch. This flora was partly described by WILLIAMS

(1924). At the landing place, and below the houses of the Coastguard, stands a Baobab tree (*Adansonia digitata* L.) introduced from Africa via Trinidad. This specimen had already a fair size in 1917 when Williams visited the island for the first time. The island is almost covered with bush of less than 5 m height, with the exception of a few hectares of land with sandy soil covered with tall grass extending from the houses of the Coastguard up the slope toward N and NW. The grass appears to be Guinea grass (*Panicum maximum* JACQU.). Among the 9 species of Cactaceae noticed by WILLIAMS are *Opuntia boldinghii*, and *Cephalocereus moritzianus* forming an outstanding part of the bush with its scattered *Agave*, *Tecoma stans*, *Lignum vitae*, *Bursera gummifera*, etc. An extraordinary and rare ground orchid is *Cyrtopodium andersonii* with its large inflorescence of beautiful brown flowers, and with sharp spines at the end of dry leaves covering pseudo-bulbs up to 70 cm length. Unfortunately the undergrowth has been eaten by goats which in the days of R.O. Williams formed a herd of about 100 animals.

At dusk one can observe bats visiting the flowers of a calabash tree (*Crescentia cujete*) near the houses, or Guachero birds (*Steatornis caripensis*) to leave a cave at the west end of the island. J.B. Saunders (private information) observed in August 1962 a good display of the bats *Noctilio leptorinus* fishing in the "Landing Bay" at dusk and in the early night. LANCIN (1963) reported the occurrence of 7 species of lizards and 2 species of snakes on Patos Island.

Laventille Formation

Bibliographic history

CRAIG (1907) has seen the ammonite which R.J.L. GUPPY mentioned from the Laventille Limestone, and considered it to be "a type not earlier than Jurassic", hence not a Goniatitid of Carboniferous age as suggested by GUPPY.

TRECHMANN (1925) suggested a possible Jurassic age for the species of *Nerinea* present in the Picton Limestone Member of the Laventille Limestone.

KUGLER (1936, p. 1442) gave the limestone of Laventille and Patos an Early Cretaceous age, and as far as Patos is concerned stated: "The limestone of this island contains in its lower part subangular pebbles and cobbles of white quartzite and especially of pink sandstone similar to the 'Old Red series' of Venezuela. At present time, this Patos Conglomerate may be considered the oldest formation cropping out in or near Trinidad." [This statement is wrong as far as the stratigraphic position of the Patos Conglomerate is concerned.]

KUGLER (1950, p. 54) tentatively correlated the limestone of Patos with the Laventille Formation to which he attributed a Jurassic age on account of the findings of TRECHMANN. The pink sandstone components of the Patos Conglomerate reminded KUGLER of the sandstone of the Roraima Formation.

KUGLER (1953, p. 31) stated: "Patos is an asymmetric anticline formed of about 80 m of the Picton limestone member which in its upper part carries an increasing number of angular and subangular components ranging from grains to blocks of several cubic meters. This *Patos Conglomerate* (KUGLER 1936) is composed of dominantly pink and crimson colored quartzitic sandstone which already has been compared with the Roraima sandstone. Less common components are: (1) blue crystalline limestone of the Maraval Beds, (2) silty limestone of the Lower Laventille type with *Pteromya*, (3) vein quartz, (4) dense coquina limestone with well preserved small gastropods (a rock type not yet known from Trinidad), (5) oolitic limestone with molluscs and (6) gritty and silty limestone pieces. In the matrix of the 'conglomerate', which would better be called a breccia, a few remains of smaller and larger molluscs were found, as well as a specimen of a branching coral with fine corallites. A few phyllitic shale layers are interbedded in the conglomerate and main limestone mass but their metamorphosis has advanced too far to allow the preservation of foraminifera. There

is little doubt about the off-shore nature of the Patos conglomerate and this may indicate some relationship with the gypsiferous Macuro zone below the Laventille Formation."

SUTER (1951, p. 191) suggested that the Patos Conglomerate may well be the youngest formation of the Northern Range, hence questioned a Lower Cretaceous age.

GONZÁLES DE JUANA, MUÑOZ & VIGNALI (1968, p. 28) dealing with their Güinimita Formation of assigned Barremian–Aptian age stated: "This formation outcrops in some of the most prominent headlands of the southern coast and is characterized by meta-sandstones and meta-conglomerates, associated with reefal, fossiliferous limestones and very low grade phyllites. The *Patos limestone* is considered a part of a reef within this formation, and the *Patos conglomerate* a talus development partly derived from the same reef."

SAUNDERS (1972, p. 459) reported from phyllitic shales north of the Laventille Limestone micromollusks which also occur in shales associated with the limestone. SAUNDERS stated: "The position of the Laventille Limestone has always been a problem and continues to be so", but for several reasons he was inclined to give it an age equivalent to the Toco Formation, hence also of the Güinimita Formation of Barremian–Aptian age. SAUNDERS mentions *Favreina* to be common in the Laventille quarries, on Point Gourde and on the islands to the west. He suggested a correlation of the gypsum outcropping at St. Joseph, and east of Laventille, with the outcropping anhydrite of the Patao Member of the Cariaquito Formation which is underlying the Güinimita Formation.

POTTER (1974, p. 207) could not find a difference between the phyllitic Laventille Shales overlying the Laventille Limestone and the phyllites of the underlying Chancellor Formation from which SAUNDERS mentions a foraminifer of Early Cretaceous age. POTTER, therefore, is inclined to correlate his Chancellor Formation with the Güinimita Formation. In the Chancellor Formation of the Southern Bay of Monos Island he observed a polygenetic conglomerate with quartzite and limestone components.

Laventille Limestone

a) Petrology

A tentative columnar section (Pl. II) through the exposed Laventille Limestone of Patos shows from bottom to top the following sequence:

3. About 80 meters of limestone in thick and thin layers alternating with beds of phyllitic shale, as far as can be judged from a boat facing the vertical cliff of the east end of the island (Pl. I, Fig. 1).

2. About 40 meters of limestone alternating with thin layers of phyllitic shale, together covering about $^2/_3$ of the island. The limestone of the thicker layers is generally muddy, dark blue to dark grey, partly dolomitic, highly jointed with calcite veins, and with fetid odour when broken. At K 4928 this limestone shows shadowy indications of corals. In its nature the limestone is akin to such of Pointe Gourde, or to the lower layers of the main Laventille Quarry at the Eastern Main Road, at the east side of Port-of-Spain. K 10272 is a light grey, dense limestone like the Picton Limestone Member of the top of the Laventille Limestone Formation with its small *Nerinea* sp. (KUGLER 1953, p. 31). Brecciated limestones at the surface are probably sink-hole breccias. Sink-holes filled with red, residual limonitic soil are common, and so is the karren-like, pitted surface of the limestones. Some of the cave breccia is cemented with hematitic clay, grading into "terra rossa" of the surface.

1. About 20 meters of calcareous phyllitic shale, fine bedded with thin layers of silty, dark-grey, brownish weathering limestone. K 10304 is a yellow weathering, thin limestone, full of calcite veins, and, resting on top of the 20 m thick calcareous phyllitic shale, dipping with about 20 degrees toward south.

b) Thickness

The total amount of exposed Laventille Limestone is therefore only about 140 m.

c) Paleontology

Only few molluscan and coral remains were noticed in the Laventille Limestone of Patos. The phyllitic shales proved to be barren. Dr. J.P. Beckmann (private information) investigated thin sections from samples of Laventille Limestone from the Picton Quarry and Laventille Quarry of Laventille Hill, east of Port-of-Spain, as well as of Point Gourde, west of Port-of-Spain. On samples derived from the little Cronstadt Island, south of Point Gourde, J.P. Beckmann made the following observations:

- Picton Quarry, K 7900: *Bankia* ("*Campbelliella*") sp., gastropods.
- Laventille Quarry, B 8017, K 7897, K 11226, K 11225: *Coprolithus salevensis*, *Bankia* ?, gastropods and pelecypods.
- Point Gourde, JS 1888: Coprolites (*Aggregatella* ?, *Favreina* ?).
- Cronstadt, K 11543, JS 1899, 1901, 1902: *Coprolithus salevensis* (abundant), possibly other coprolites. Unidentifiable algae (? Codiacea, rare), pelecypods and crab remains.

d) Age

J.P. Beckmann believes these samples are probably of Latest Jurassic or Early Cretaceous age (Portlandian? to Valanginian?).

Patos Conglomerate Member of the Laventille Formation

Type locality and type section: Both are situated at the western end of Patos. The Patos Conglomerate is separated by the Puerto Brion Shale into a Lower and Upper Patos Conglomerate.

Lower Patos Conglomerate Member

a) Stratigraphic relationships

Bottom of the Lower Conglomerate occurs along the road from Puerto Brion eastward to the top of the island at K 10303, where a flaggy limestone with angular components of phyllite and fossiliferous limestone is resting on the thin limestone K 10304 above the 20 m calcareous phyllitic shale belonging to the main limestone section of the Laventille Formation.

Top of the Lower Patos Conglomerate is at K 10300, between Puerto Brion and Bahia de los Patos. Here the conglomerate is covered by the calcareous phyllitic shale, called the *Puerto Brion Shale*, dipping with 30 degress toward south.

b) Thickness

The thickness of the Lower Patos Conglomerate has been estimated to be about 100 m.

c) Lithology

Following the path from top of the island to Puerto Brion one observes from bottom to top the following rock types: At K 10303 a flaggy limestone with angular pieces of phyllite and fossiliferous limestone. Thin sections of the limestone show an interclast with abundant echinoid spines. Above follows K 10302, a limestone with angular and subangular pebbles, dipping with 15 degrees toward south. The limestone forms lenses in calcareous phyllitic shale, resting on massive dark blue limestone with angular components of phyllite. An alternation of such beds follows up to K 10278 where a component of limestone carries an *actaeonid* gastropod of about 3 cm diameter, which could not be extracted. From this point, and along the road to Puerto Brion, one observes an increase of the size of the components, up to large blocks. Some blocks attain a size of up to 6 m diameter, partly the result of strong jointing of the conglomeratic limestone. A typical example of the components of these large blocks is K 2962, a grey dolomitic knobbly silty limestone with subangular and rounded components up to 50 cm diameter of pink and crimson sandstone, darkgrey fossiliferous limestone, ooidal limestone, clay-iron stones, white vein-quartz pebbles and angular dark phyllite. Of special interest is a block of limestone containing small gastropods. At K 10300, between Puerto Brion and Bahia de los Patos, one observes the conglomeratic limestone to be vertically jointed to such an extent as to obscure the normal inclination of 30 degrees toward SSW indicated by the longer axes of the components.

d) Paleontology

At K 10287, about 200 m NNE from the landing place at Bahia de los Patos. there is an excellent exposure of the Lower Patos Conglomerate. Among the polygenetic components were two stocks of white corals (Pl. I, Fig. 3) in a grey dense limestone matrix, together with angular and rounded pieces of light brown quartzitic sandstone. Dr. John W. Wells who investigated this coral wrote in his letter of April 1955: "This is a new ramose species of *Astrocoenia*, superficially resembling *Stylina harrisoni* of the Lower Cretaceous of Venezuela and Trinidad. Being new its age is uncertain, but in its septal arrangement it has a Cretaceous rather than a Tertiary aspect." This coral shows no signs of reworking. It must be considered to be a penecontemporaneous component of the conglomerate, hence of the same age.

e) Remains of fossils in the components

The above mentioned locality K 10287 can be considered the type locality of the Lower Patos Conglomerate on account of the rich variety of the components containing fossils and the presence of *Stylina* in the matrix. Thin sections of various components show the following remains of fossils: 1. calcareous algae up to one cm diameter in a micrite containing scattered crystals of dolomite; 2. oolitic limestone with grains of rolled algae and echinoderms; 3. limestone with remains of gastropods and bryozoans; 4. angular pieces of light grey limestone with algae and holothuroid-like remains; 5. another component is a brown, noncalcareous, porous weathering sandstone with a few fossil remains which were forwarded to Dr. Erle G. Kauffman of the U.S. National Museum. One of the pelecypods was identified as "*Inoceramus*

sp. aff. *I. trapezoidales* THOMPSON & WILLEY (Bull. brit. antarct. Surv. *29*, 1972, p. 11, Fig. 6d, 6a, b) of probably Lower Aptian age". Dr. Kauffman wondered in a letter of September 1973 why this clam of cool Antarctic water exists in the Caribbean region. Sample K 10287 was designed USNM 163539 (see Pl. I, Fig. 2). Dr. Kauffman reported from the same sample a "poorly preserved external mold of a *Trigoniid* bivalve, gen. indet.". The brown sandstone in which these fossils occur is a greywacke of fine to medium sized angular to subangular quartz grains and about $^1/_3$ of dolomite grains which are responsible for the numerous small holes in the weathered part of the rock. Grains of muscovite and feldspar are also present.

Dr. J.P. Beckmann made the following observations in a limestone from sample K 10287: predominantly mollusks and also echinoderm remains. Among calcareous algae he noticed mainly Dasycladaceae (*Acicularia*, ? *Triploporella* and others). Also some Codiaceae (possibly *Cayeuxia*).

f) Age

This conglomerate is a near-shore deposit, partly almost a coast shingle of Early Cretaceous age (perhaps Neocomian to Aptian according to Beckmann). The Güinimita Formation of GONZÁLES DE JUANA et al. (1968, p. 28) is exposed at the eastern end of Paria Peninsula. It contains a rich fauna of corals, mollusks and foraminifera which can be correlated with the fossils of the limestones of the Cuche and Toco formations of Trinidad, and to which one generally attributes a Barremian to Aptian age (KUGLER & BOLLI 1967, p. 211). GONZÁLES DE JUANA et al. state: "The Güinimita Formation compares lithologically and paleotologically with the Laventille Formation." Unfortunately not one of the mega-fossils found in the Güinimita, Cuche and Toco formations has been noticed in the Laventille Formation.

Puerto Brion Shale Member

Type locality: Between K 10289 and K 10290 of the NW of Bahia de los Patos is the type locality of these slightly phyllitic shales (sample S 72).

a) Stratigraphic relationships

Bottom of the shale is at K 10289, a blue-grey conglomeratic limestone with white calcite veins and vugs, forming the top of the Lower Patos Conglomerate.

Top of the shale is at K 10290, a limestone with angular components, such as a block of red quartzitic sandstone with calcite veins. This conglomeratic limestone dips with about 35 degrees toward WSW, and forms the base of the Upper Patos Conglomerate.

b) Thickness

The thickness is about 25 m.

c) Lithology

The shale is calcareous black phyllitic, weathering silvergrey and reddish, alternating with silty and sandy shale. Three limestone layers (S 72 a–c) are 5 to 20 cm thick, and were sampled by Alfred Senn in the lower part of the shale. These limestones are grey to black, dense micrites with fossil remains. On the weathered surface, and polished surface, these limestones show oolitic texture.

d) Paleontology

In thin sections of samples S 72 a–c one recognizes not only abundant fecal pellets but also foraminifers, as well as algal and molluscan remains. Dr. J.P. Beckmann (private information) made the following observations on samples from S72: Fairly common fragments of calcareous algae (Dasycladaceae): *Actinoporella*, ? *Clypeina*, ? *Pseudoactinoporella*, ? *Neomeris*, ? *Pseudoepimastopora*, *Salpingoporella*, *Acicularia*, ? *Neogyroporella*. Foraminifera: *Trocholina*, ? *Neotrocholina* sp. (possibly including *Trocholina infragranulata*), *Lenticulina*, Textulariidae. Also gastropods, pelecypods and echinoderms.

e) Age

Dr. Beckmann considers the age of the Puerto Brion Shale to be most likely Early Cretaceous (Neocomian to Aptian).

Upper Patos Conglomerate Member

Type locality: At the west side of the Bahia de los Patos, where at K 10290 the conglomeratic limestone is resting on the Puerto Brion Shale.

a) Stratigraphic relationship

Bottom of the Upper Patos Conglomerate is the top of the Puerto Brion Shale, which below the conglomeratic limestone of K 10290 is a black phyllite, weathering silvery white and red mottled.

Top of the conglomeratic limestone is not known, being covered by the sea.

b) Thickness

The Thickness of the Upper Patos Conglomerate Member is about 65 m as far as can be judged from the exposures.

c) Lithology

Compared with the Lower Patos Conglomerate there appears to be no difference in the lithology of the matrix of the conglomeratic limestone, nor in the nature of the components. JS1231 is a typical sample of this Upper Conglomerate (Pl. I, Fig, 4) but at K 10280 one observes again block components of several cubic meters. Among the components at Puerto Brion there is a block (K 10305) measuring 60 × 60 × 30 cm of a dark bluish limestone full of small gastropods and a few pelecypods. No similar limestone is known from Trinidad up to now. The dark, silty conglomeratic limestone carries white calcite veins and is alternating with phyllitic shale, as well as with silty and sandy shale. The beds are strongly jointed and are covered with red residual soil. At K 10283 there exists a large sink-hole of about 30 m diameter and about 15 m depth. It is situated in grey conglomeratic limestone with angular pieces of pink fine grained quartzitic sandstone, of dense blue limestone with fossil remains, of white vein quartz, and normal thin intercalations of ooidal limestone with small fossil remains.

d) Paleontology

Dr. Beckmann (private information) observed in sample K 10305 of Puerto Brion small pelecypods and some gastropods, as well as scattered calcareous algae (? *Cylindroporella* and others).

e) Age

Dr. Beckmann considers the age of the Upper Patos Conglomerate to be most likely Early Cretaceous (Neocomian to Aptian).

Conclusions

1. The Laventille Formation contains a few macro-fossils. These are totally different from those of the Toco Formation at Toco, as well as from those of the Cuche Formation of the Central Range and Pointe-à-Pierre, or of the rich Güinimita Formation of the Paria Peninsula.

2. The Laventille Limestone is no coral or algal reef, and the Patos Conglomerate Member is no talus development of a reef. The latter is a poorly sorted polygenetic near-shore breccia and conglomerate.

3. The Laventille Shale below the Laventille Limestone at Port-of-Spain contains lenses of gypsum that can be equated with the Patao Member of the Cariaquito Formation, which lies below the Güinimita Formation.

4. The Laventille Formation in Trinidad may possibly be of Earliest Cretaceous, or even of Late Jurassic age (Portlandian ? to Valanginian ?).

5. The Patos Conglomerate Member of the Laventille Formation is probably of Early Cretaceous, possibly of Neocomian to Aptian age.

6. The Laventille Limestone could form a glide-mass deriving from the north and being dumped onto Early Cretaceous phyllitic shales of which the Laventille Shale forms a part.

Acknowledgments

The author is indebted to Dr. Erle G. Kauffman and Dr. John W. Wells for identification of fossils. Dr. J.P. Beckmann provided the list of micro-fossils, and Mr. J.B. Saunders samples and observations. Dr. J. Arnoth checked the mineralogy of a rock-sample. Mr. W. Suter prepared the photographs. Mr. R. Panchaud and Mr. M. Schneider helped with the drawings.

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Plate I

Fig. 1 View of cliffs of north and east side of Patos Island with marine erosion terrace at the foot of the cliffs.

Fig. 2 *Inoceramus* sp. aff. *I. trapezoidales* THOMPSON & WILLEY, ×2 (USNM 163 539).

Fig. 3 New species of ramose coral *Astrocoenia*, superficially resembling *Stylina harrisoni* (GREGORY 1929) of Early Cretaceous age, ×1 (Nat. Hist. Museum Basel, D 5405).

Fig. 4 JS 1231 a sample of the Upper Patos Conglomerate with calcite veins, black, rounded pebbles of silicified limestone, white angular pieces of vein-quartz, and with grey, angular and edge-worn components of light brown sandstone, ×1.

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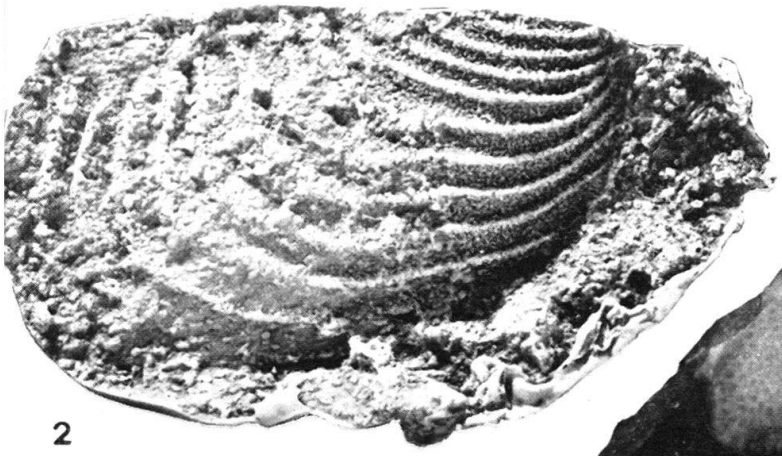

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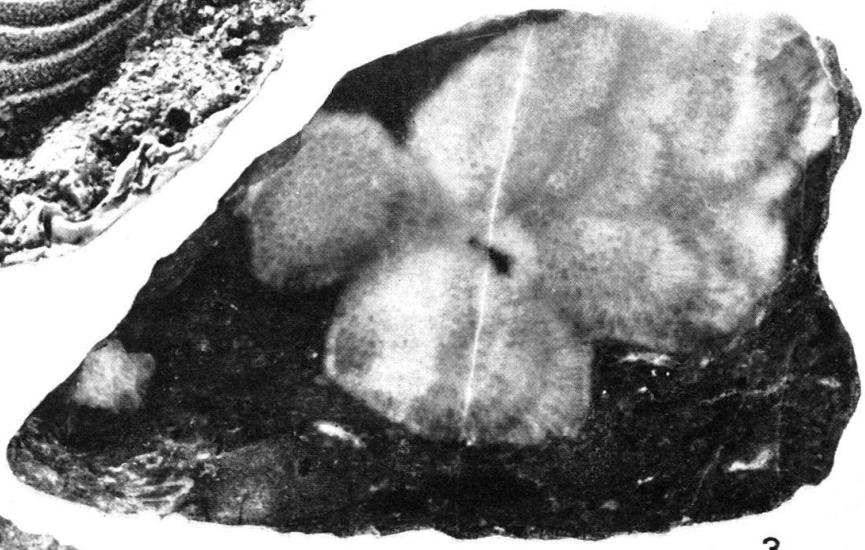

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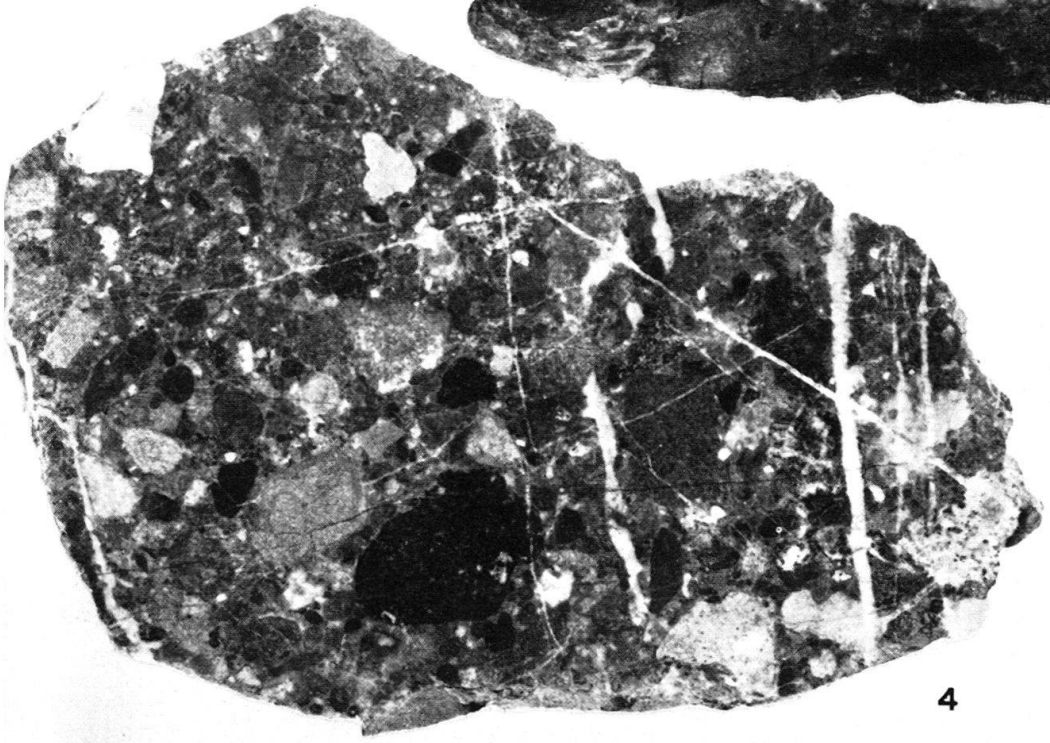
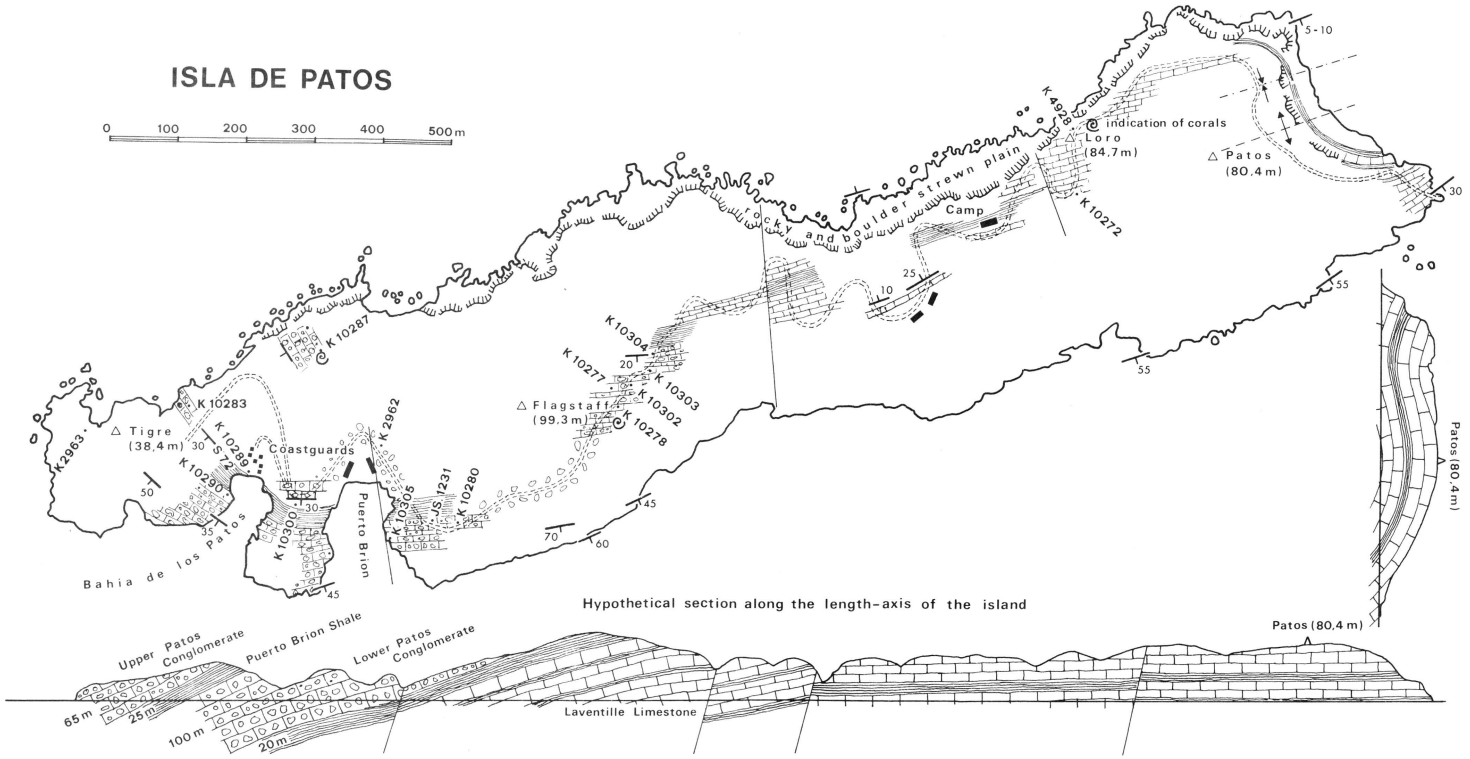


4

ISLA DE PATOS



Hypothetical section along the length-axis of the island

Tentative columnar section through Laventille Formation of Patos