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ORIGINAL ARTICLES.

I.—On some Samples of Rock from Borings at Sangregrande, Trinidad.—Part I.

By R. J. Lechmere Guppy.

(FOLDING PLATE VII.)

I HAVE been favoured by P. N. H. Jones, Esq., engineer of the Waterworks, with specimens from a boring at Sangregrande undertaken by the Government of Trinidad with a view to ascertain the extent and position of the Tertiary coal-seams of that district and other facts. The specimens consist of a dark-coloured (blackish) sand-rock, finely (but slightly irregularly) laminated, the lamination being at an angle of about 50° from the horizontal. The samples came from 150, 250, 400, 500, and 600 feet deep below the surface. I examined each one separately, but as the differences between them, whether as regards mineral constitution or organic contents, are only slight, and in fact two portions from the same depth show often as much difference as samples from different depths, I shall describe the whole together. These specimens are from boring No. 3, Plate VII.

The rock is of a blackish or dark-grey colour, and is principally composed of very fine sand with particles of mica. When washed and passed through fine muslin only about $\frac{1}{100}$ part remains. Calcareous matter is under 10 per cent. in quantity, and exists almost entirely as shells of Foraminifera and Mollusca. Crustacea and echinoderm remains also occur, and there are numerous Polyzoa, a few Ostracoda, and scales, teeth, and ear-bones of fishes. I could not detect coccoliths or calcaroma, but the nature of the material is unfavourable for their detection. The material of this rock is not of any economic value, but it is interesting as throwing light upon geological questions and upon the conditions which prevailed at the time of its deposition. The neighbourhood of land is indicated by the quantity of clastic material, but the fineness of the grains and the tenuity of the laminæ of deposition show that it was at some distance off. Data exist for an approximate estimate of the position of such land, and the elementary facts are indicated in my papers in

the Proceedings of the Victoria Institute, Trinidad, 1902, and the Journal of the Geological Society of London, 1892.

With one exception the rock appears to be of the same quality and consistence throughout. At 500 feet occurs a harder bed composed of similar material to the other beds, but indurated and not liable, as the other beds are, to disintegration by water. This harder bed contains only traces of calcareous matter, and much fewer organic remains than the others.

I have no particulars of the material found at intermediate depths, but presuming that it is uniform or nearly uniform throughout it would appear that we have here a thickness of more than 500 feet in depth of very fine sedimentary material, probably deposited in a sea somewhere about 20 to 50 fathoms deep. It might even have been more, but to ascertain this other circumstances not at present known would have to be taken into account. The deposition of so extensive a stratum of such material implies a long period of time during which the conditions of the area on which deposition was taking place remained generally the same.

The molluscan and other organic remains exist entire within the matrix, but being for the most part in the state of powder they cannot be extracted. The Foraminifera and a very few Mollusca and Ostracoda alone are of a sufficiently compact consistency to stand extraction by washing, which is the only mode of operation practicable, as any attempt by more forcible means results in the complete disintegration of the fossils.

Doubtless also here, as in the Naparima and Pointapier beds, many Foraminifera appear as fragments only, such as *Rhabdammina*, *Haliphysema*, *Dendrophya*, etc. But leaving apart such organisms as these, there will be, if occasion serves in the future, an enormous extension of this list of fossils.

MOLLUSCA.

Balantium.	*Pleurotoma.*
Bulla.	*Nucula.*
Dolium.	,,
Fusus.	*Pecten.*

The only specimens extracted were a *Pecten* and a *Nucula* (single valves). One valve of a *Pecten* is ornamented with radiating elongate-elliptical blotches of purplish-brown colour, showing how persistent the original colouring must have been to have been preserved in such decolorizing material as that of which these beds are composed.

POLYZOA.

The only generically identifiable one is *Cupularia*, but others seem to be *Membranipora*, etc.

OSTRACODA.

Bairdia woodwardiana, Brady; *Cytherella polita*, Brady. There is also a prawn-like crustacean over an inch long.

FORAMINIFERA.[1]

I deal in greater detail with the fossils of this group, as they present determinable specimens belonging to known forms.

Clavulina (Haplostiche) Soldanii, Parker & Jones. (Pl. IX, Fig. 1.)

This species is numerous at all depths, but especially at 150 and 250 feet. It does not occur in the Naparima (oceanic) beds, but I have examples from the *Ditrupa*-bed of Pointapier, which I originally identified as *Clavulina cylindrica*. The length of the longest example from the Sangregrande boring is 3 mm., its breadth being 1 mm.; the stoutest example is 2·5 mm. long by 1·5 mm. in diameter. There are many smaller examples of varying forms.

Reophax scorpiurus, Montf. (Pl. IX, Fig. 2.)

This is not quite as common as *H. (Cl.) Soldanii*, but is nevertheless fairly abundant in some samples. It has not hitherto been met with by me in any of the other Microzoic rocks of Trinidad. It is usually about 2 mm. in length.

Amodiscus incertus, Orb.

A single specimen somewhat like that figured in Ann. Nat. Hist., vol. iv (1869), pl. xiii, figs. 3*a*, *b*.

Cyclamina cancellata, Brady, var. deformis, nov. (Pl. IX, Fig. 3.)

Most specimens of this form are distorted by a sudden change in the axis of growth of the last whorl, whereby the shell acquires a sort of humpbacked appearance. It is often very thin, seldom indeed as thick as the forms found abundantly in some of the Naparima oceanic beds. It is one of the largest Foraminifera in the Sangregrande boring, being mostly 3 mm. in diameter, and occurs at all depths in the boring.

Miliolina macilenta, Brady. (Pl. IX, Fig. 4.)

Diameter 1·0 mm.

Miliolina seminulum, Linné.

Diameter 2·0 mm.

Spiroloculina tenuiseptata, Brady. (Pl. IX, Fig. 5.)

Longest diameter 1·0 mm. It is questionable if this is distinct from *Sp. limbata*, Orb.

Bolivina punctata, Orb.

Minute *Bolivinæ* are as abundant in this rock as in most of the Microzoic formations of the island.

[1] Plates VIII and IX, illustrating the Foraminifera, will appear in the concluding part of Mr. Guppy's paper.

BULIMINA INFLATA, Seguenza.

TEXTULARIA SAGITTULA, Defrance. (Pl. IX, Fig. 6.)

Length 1·0 mm. Fairly abundant in some samples.

TEXTULARIA GRAMEN, Orb. (Pl. IX, Fig. 18.)

Length 1·0 mm.

TEXTULARIA CARINATA, Hantk. (Pl. IX, Fig. 7.)

Length 1·5 mm.

TEXTULARIA TROCHUS, Orb. (Pl. IX, Fig. 8.)

Diameter 1·0 mm., height 1·5 mm. I take *T. turris* and *T. Bareti* to be merely varietal forms of this species.

TEXTULARIA ASPERA, Brady. (Pl. IX, Fig. 17.)

Only three examples were found, of which one (much the largest) measured 3 mm. in length.

NODOSARIA RAPHANISTRUM, Linn. (Pl. IX, Fig. 9.)

The form found here is identical with *N. bacillum*, Defr., as found in the Vienna Basin and elsewhere. The synonymy of the species includes *raphanus*, *Zippei*, *badenensis*, *acuta*, and many others. It is probably not distinct from *N. obliqua*, the larger and more strongly ribbed forms being found in shallow water, while the smaller, more delicately costate forms come from deeper water. *N. raphanistrum* is not found in the oceanic beds. The longest specimen from the Sangregrande boring is 5·5 mm. in length; it is broken. Some smaller examples are perfect.

NODOSARIA OBLIQUA, Linn. (Pl. IX, Fig. 10.)

The form found in the Sangregrande boring is *N. vertebralis*, Batsch, which is only one of the many names conferred upon more or less distinct varieties of this species. The length of our longest specimen is 3·5 mm.

NODOSARIA SOLUTA, Reuss. (Pl. IX, Fig. 11.)

Our specimens are generally of the curved variety, with little or no constriction between the segments except perhaps one or two of the later ones. It is exactly the same as *N. elegans* of the Vienna Basin. The examples are usually about 2·3 mm. long.

CRISTELLARIA ROTULATA, Lam. (Pl. IX, Fig. 12.)

Under this I include *C. calcar* and *C. cultrata*, as the forms found here are somewhat intermediate. It is mostly small, the largest being 2 mm. in diameter.

CRISTELLARIA ACULEATA, Orb. (Pl. IX, Fig. 13.)

Similar to the Pointapier specimens, except that the last whorl is seldom so much produced. Longest diameter 2 mm.

UVIGERINA (SAGRINA) RAPHANUS, Parker & Jones. (Pl. IX, Fig. 14.)

The specimens are about 1·3 mm. in length. The species is very abundant at all depths in the Sangregrande boring. It is the short

form resembling fig. 23 of pl. lxxv of the "Challenger" Report. Brady says it is essentially a coral-reef foraminifer, but the conditions of the Sangregrande deposit would not admit of coral-reefs. Our form may be said to be indicative of shallow water, and a depth of 10 to 50 fathoms would probably suit it best. A very few specimens of the long form have occurred to me in the Naparima oceanic beds, and I think that this long form belongs to deep water.

Brady ("Challenger" Report, p. 580) admits that the term *Sagrina* is not required.

UVIGERINA CANARIENSIS, Orb.

Length about 0·6 mm. Specimens sometimes slightly costate.

POLYMORPHINA LANCEOLATA, Reuss.

A few very minute examples for which the above name may stand until fuller information is obtained.

GLOBIGERINA BULLOIDES, Orb.

The forms found at Sangregrande resemble most the Vienna Basin specimens, and do not attain the great development in number, size, or variety that we find in the Naparima oceanic beds.

SPHÆROIDINA BULLOIDES, Orb.

Not very common.

PLANORBULINA (DISCORBINA) ELEGANS, Orb. (Pl. IX, Fig. 15.)

Diameter about 0·5 mm. This agrees fairly well with the figure of D'Orbigny's Modèle No. 42 given by Parker & Jones, but not quite as well with the figure given by Goës (Carib. Rhiz., pl. viii, figs. 269–71), which is *R. complanata*, Orb. It suggested itself to me as a small and delicate modification of *Planorbulina Wullerstorfi*, a common and well-developed foraminifer in the oceanic beds of Naparima.

It has been proposed to dispense with the genus *Anomalina*, and to include the species classed under that name, together with those comprised under *Truncatulina*, in the genus *Planorbulina*. In my lists no species from the oceanic beds appears under the name of *Planorbulina*, but some five species are recorded under that of *Anomalina*. *Pl. larvata*, a remarkable form, is recorded from the shallow-water beds, and I have since found it in the *Ditrupa*-bed of Pointapier.

PLANORBULINA UNGERIANA, Orb.

One or two small specimens of this species occur.

PULVINULINA ELEGANS, Orb. (Pl. IX, Fig. 16.)

Specimens few and small; the largest was 1 mm. in diameter. This species as a fossil can always be distinguished by its coloration, its white septal bands, marginal rings, and umbilical boss, contrasting with the chocolate-brown interspaces. The Sangregrande specimens are perhaps referable to the var. *partschiana*.

The Sangregrande Borings.—Part II.

Since writing Part I of this paper I have been favoured by the Hon. Walsh Wrightson, C.M.G., Director of Public Works, with reduced diagrams of the three borings made at Cunapo, near Sangregrande, for the purpose of ascertaining particulars relative to the coal-seams in that neighbourhood, and with access to the samples of the cores brought up. These extend our knowledge of the geological conditions very considerably. In Part I of this paper I gave a description of the rocks and fossils of boring No. 3. The diagram of this boring (Plate VII) shows that from 200 feet to the bottom of the boring at 600 feet the composition of the strata is nearly uniform, being the foraminiferal sandstone I have described. This deposit probably recurs in boring No. 2 (82 to 132 feet) and boring No. 1 (90 to 486 feet). At 12 to 18 feet in boring No. 3 there is an ancient river-bed with very hard compact cherty stones, similar to those found in some of the existing river-beds. I do not think that the material of these stones exists anywhere in the form of a continuous layer or stratum, or, if they do, such layer is not of any great extent. It probably exists as lenticular or nodular masses varying in size, and when the containing softer material is carried off these hard stones remain in the river-beds. So with the Naparima rocks near Sanfernando, the harder masses remain heaped upon the beach, while the softer material in which they were imbedded is carried away.

With the exception of two small seams, one of 6 inches at 29 feet, and one of 2 inches at 89 feet, no coal was encountered in any of the borings. Nevertheless, the composition of the strata at the top of each of these borings indicates perhaps littoral conditions or at least shallower water than the material deeper down in the borings. The bed underlying the coal-seam at 89 feet in boring No. 1 is a soft black argillaceous rock with very fine sand, impressions of plant remains, and small bits of coal. This stratum, less than 3 feet thick, is confusedly bedded, and represents, I think, the bottom bed and very beginning of the coal series.

The problem of the relation of the strata pierced by these borings to the coal-bearing series is now before us. These strata are, with a slight exception, of marine formation: are they above or below the coal series?

So far as we can judge from the information now at hand, it would seem that they are below. If they were above it would follow that there had been a depression of land since the deposition of the coal in order to admit of the deposit of a marine formation above it. But taking all the known circumstances into account, I think this unlikely. There was probably a movement of upheaval continued throughout the Miocene period which raised the Cretaceo-Tertiary series of Montserrat (including the Manzanilla Eocene formations) above the level of the sea, leaving an arm of the sea between the Montserrat Range and the Parian Range. Into this channel the river Guarapiche (taking its rise and upper course in Venezuela) emptied itself, and

CUNAPO COALFIELD.

Diagram of Bore No. 1.

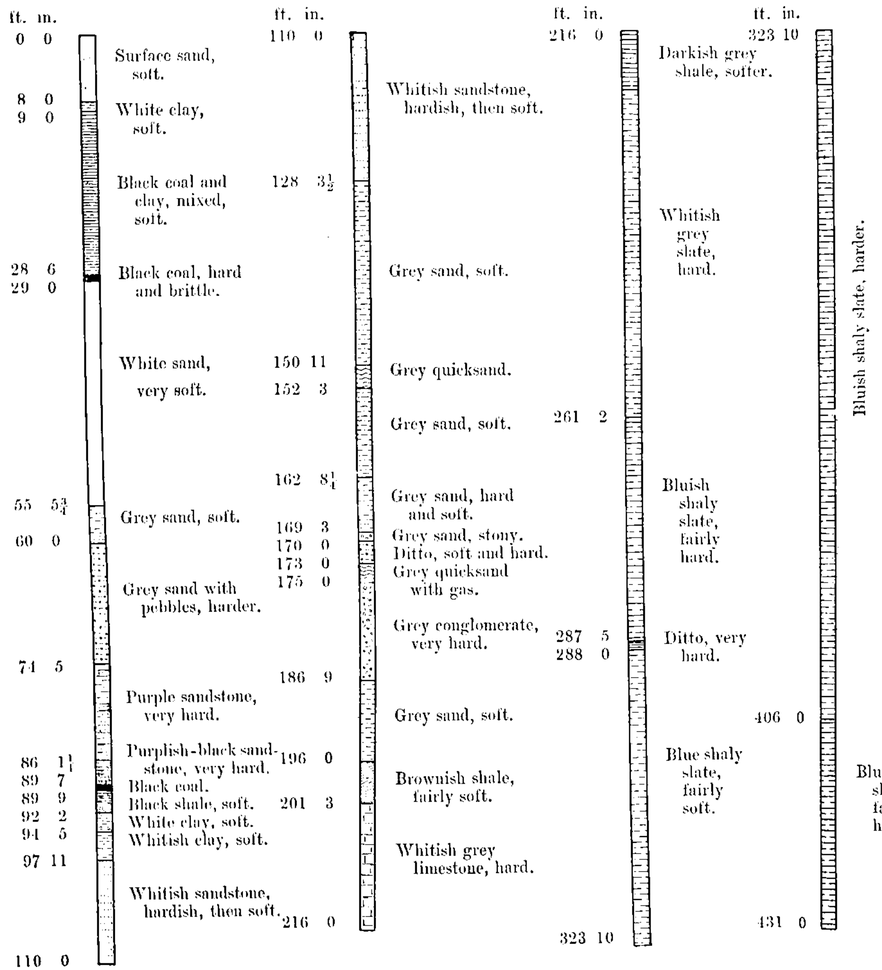

Diagram of Bore No. 2.

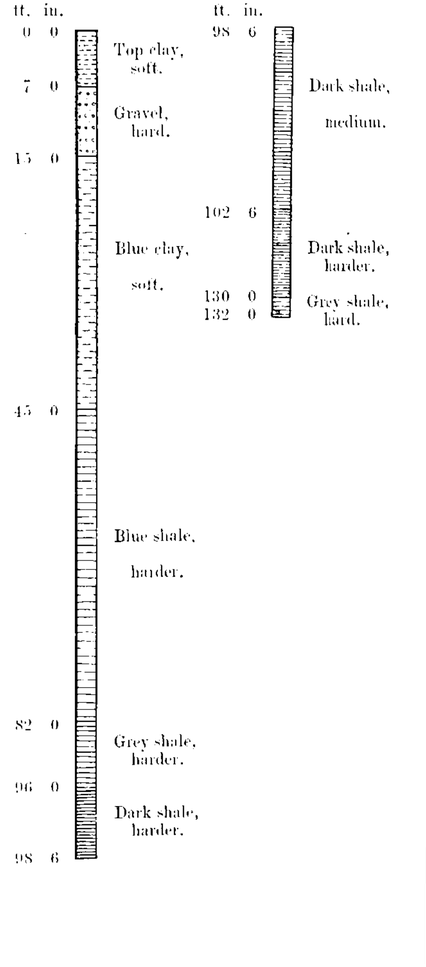

Diagram of Bore No. 3.

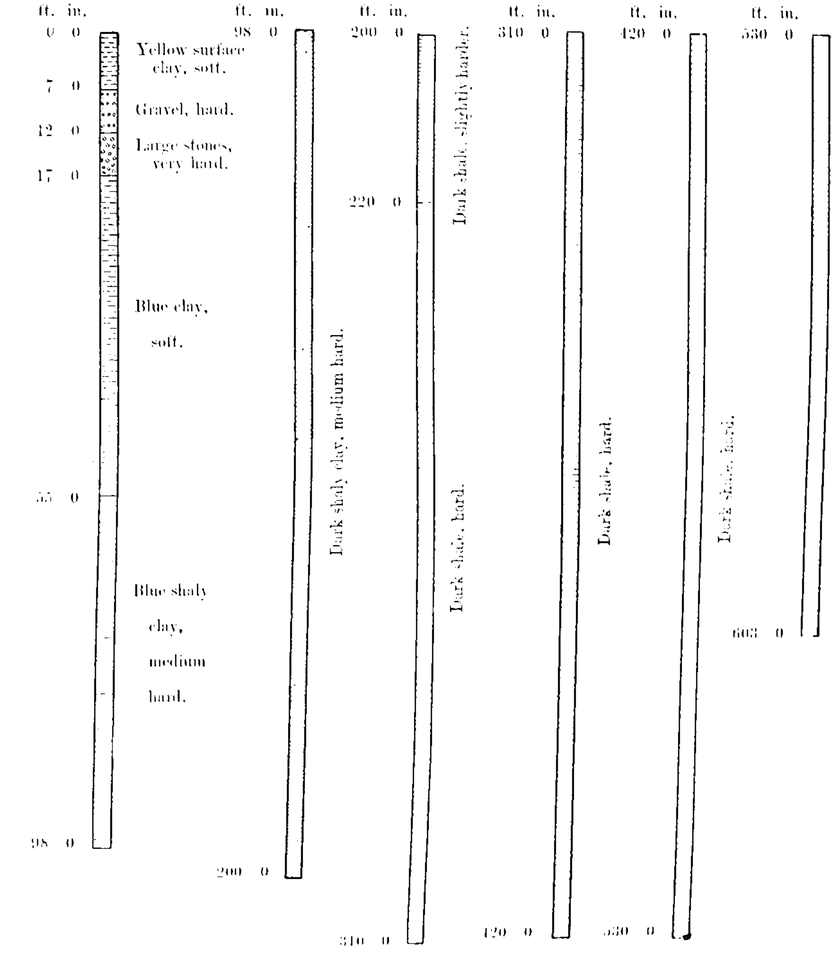

DIAGRAM OF THE BORINGS MADE AT CUNAPO, NEAR SANGREGRANDE, TRINIDAD:

TO ILLUSTRATE MR. R. J. LECHMERE GUPPY'S ARTICLE.

as this channel was filled up by the fossiliferous sands and other deposits the coal-bearing series followed under estuarine and fluviatile conditions. Therefore I think that these borings pierce strata inferior to the coal series.

In some parts of the Caroni and Oropuch country occurs a large estuarine formation which, in my opinion, succeeded the Miocene formation, and was deposited by the Miocene and Pliocene extension just mentioned of the river Guarapiche (see my papers in Geological Society's Journal, 1892; GEOLOGICAL MAGAZINE, 1900; and Proceedings Victoria Institute, Trinidad, 1902). It is a very fine-grained argillaceous formation, frequently capped by fresh-water gravels, and this may very probably overlie the coal series in places.

Note.—I am informed that at the site of the borings near the Cunapo river, about seven miles from Sangregrande, the surface is about 150 feet above sea-level.

Second Note.—In reference to the conclusions arrived at from this imperfect study of the geology of the Sangregrande district, I may quote a remark by S. A. Miller in his "North American Geology," etc., that "a general knowledge of geology is probably of greater importance to the people of the United States than a like amount of information in any other department of natural science," a remark which might be extended to a larger area than the United States.

EXPLANATION OF FOLDING PLATE VII.

Diagrams showing the strata passed through in the Sangregrande Borings Nos. 1, 2, 3.

(*To be continued.*)

II.—SOME GRAPTOLITE ZONES IN THE ARENIG ROCKS OF WALES.

By GERTRUDE L. ELLES, Newnham College, Cambridge.

THE Arenig Series, as originally defined by Sedgwick, has undergone much subsequent modification by its founder and other authors. There have been separated off from it the Tremadoc Series at the base, and the Llandeilo Series above, and a certain amount of ambiguity has arisen as to what constitutes the Arenig thus restricted; possibly, therefore, the recognition of three well-defined graptolite sub-faunas within the series in certain districts may help in some degree towards the solution of the problem.

In both North and South Wales there appears to be a well-defined belt of rocks characterised by graptolites of the 'tuning-fork' type (dependent series). In South Wales this constitutes Hicks' Llanvirn Group; it comprises two zones—

1. Zone of *Didymograptus Murchisoni*.
2. Zone of *Didymograptus bifidus*.

The upper zone of *D. Murchisoni* is the equivalent of the beds forming the lower part of the Llandeilo Series, including the Llandeilo Limestone, in part at any rate; the lower zone of *D. bifidus* is the uppermost limit of the Arenig Series.

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