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ORIGINAL ARTICLES.

I.—NOTES ON THE INVERTEBRATE FAUNA OF THE UITENHAGE SERIES
IN CAPE COLONY.

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of Cape Colony.)

THE rich invertebrate fauna of the Uitenhage Series has long attracted attention, owing to the conspicuous nature of some of its components and the divergence of opinion which has arisen in the various attempts to bring it into correlation with Secondary faunas in the European area. A recent examination of the fossils collected from the Uitenhage Beds by the Geological Survey of Cape Colony has afforded an opportunity of reconsidering, in the light of extended knowledge, the conclusions of those who have previously studied this question of correlation. A comparative study of the fauna, with an account of some new species, based principally upon the materials collected by the members of the Survey, will shortly be contributed to the fourth volume of the "Annals of the South African Museum"; but in the meantime, the following brief notes, in which are embodied some of the principal results, may be of interest to a wider circle of readers.

The most comprehensive published accounts of the Uitenhage Beds, including the results of the recent surveys, are those written by Mr. A. W. Rogers and Professor E. H. L. Schwarz.¹ As regards the affinities of the marine fossils, the view that these indicate a Lower Cretaceous age has been most convincingly upheld in the palæontological studies of Krauss and Neumayr,² whose opinion is the one which is now most widely accepted. Sharpe and Tate,³ on the other hand,

¹ Rogers & Schwarz, "Report on the Survey of parts of the Uitenhage and Port Elizabeth Divisions": Ann. Rep. Geol. Comm., 1900, p. 3; Cape Town, 1901. Rogers: "An Introduction to the Geology of Cape Colony," pp. 281-318, 1905. Rogers, "Geological Survey of parts of the Divisions of Uitenhage and Alexandria": Ann. Rep. Geol. Comm., 1905, pp. 15-33, 45; Cape Town, 1906.

² F. Krauss, "Ueber einige Petrefacten aus der untern Kreide des Kaplandes": Nova Acta Acad. Cæs. Leop.-Carol. Nat. Cur., vol. xxii, pt. 2, p. 439; Bonn, 1850. M. Neumayr, in E. Holub & M. Neumayr, "Ueber einige Fossilien aus der Uitenhage-Formation in Süd-Afrika": Denkschr. d. k. Akad. Wiss., Math.-Nat. Classe, Band xlv, p. 267; Vienna, 1882.

³ D. Sharpe, "Description of Fossils from the Secondary Rocks of Sunday River and Zwartkop River": Trans. Geol. Soc. Lond., ser. II, vol. vii (1856), p. 193. R. Tate, "On some Secondary Fossils from South Africa": Quart. Journ. Geol. Soc., vol. xxiii (1867), p. 139.

believed the fauna to be of Jurassic age, and their view has until recently continued to find adherents. A few authors have suggested that the series may be in part Upper Jurassic and in part Lower Cretaceous.

The great majority of the invertebrate fossils collected from the Uitenhage Beds consist of Mollusca, and have been obtained from localities in the valleys of the Sunday's, Zwartkop's, and Coega Rivers. A more detailed examination of the fauna than that undertaken by previous writers fully corroborates Neumayr's conclusion that a large percentage of the Mollusca show affinity to Cretaceous rather than to Jurassic forms. There is, moreover, abundant evidence in support of the opinion of those who have ascribed to the Uitenhage Series a Lower Cretaceous age, although, as might be expected, there are a few bivalve forms which bear a somewhat close resemblance to familiar Jurassic types. It will suffice, however, to mention the presence of *Holcostephanus* (sensu stricto), the restricted group to which V. Uhlig and F. Suess have applied Pavlow's name *Astieria*, typified by *H. astierianus* (d'Orb.); *Hamites*; *Crioceras*; *Bochianites*; *Hoplites* (sensu lato), here represented only by *Acanthodiscus*, Uhlig, and perhaps also *Solgeria*, Uhlig; *Trigonia* of the divisions Scabræ and Pseudo-quadratæ; *Ptychomya*; *Thetis*, and *Solecirtus*. All these, so far as we know, are confined elsewhere to the Cretaceous rocks, and taken together, they give most decisive evidence of a Lower Cretaceous age. In Europe, *Holcostephanus* (sensu stricto) is almost wholly, if not entirely, confined to strata of Upper Valanginian and Lower Hauterivian age, and this genus is so richly represented in the Uitenhage Beds as to suggest strongly the soundness of a correlation with this part of the Neocomian stage. It has been frequently stated that *Holcostephanus atherstoni* (Sharpe), a Uitenhage species, actually occurs in the Lower Hauterivian of Europe; and although a careful examination of the evidence fails to bear this out, there can be no doubt that several *Holcostephani* in Cape Colony are intimately related to certain European forms. The remains of plants found in the Uitenhage Beds do not give such definite indications of geological age as the Mollusca, but it will be remembered that Professor A. C. Seward has expressed the belief that the balance of evidence furnished by the plants is in favour of a Wealden age.

It becomes a matter for some astonishment that Tate should have expressed so positively the opinion that the Uitenhage fauna is of Jurassic character, and should have arrived at the curious conclusion that these supposed 'Oolites' of South Africa represent the whole of the Jurassic rocks of Europe with the exception of the Upper Oolites, and illustrate an intermingling of palæontological types which are analogous to, or identical with, those distributed in successive zones in Europe. A study of the actual specimens upon which Tate based these conclusions shows clearly that he failed to see the true significance of the Cephalopoda, and that while making use of some bivalve types little adapted to serve the purposes of a critical correlation, he was further misled by several quite erroneous identifications.

Restricting our attention to the marine development of the Uitenhage Beds, it may be stated confidently that there is no palæontological

evidence to show that even a part of the series is of earlier age than Neocomian. Those very forms which, if taken alone, might with some justification have been thought to indicate a Jurassic age, occur relatively high up in the series in association with shells of undoubted Neocomian type. On the other hand, some of the more characteristic marine forms have been shown by Mr. Rogers to occur near the base of the great Sunday's River sections as well as at higher horizons, and to have a much more extensive vertical range in the series than was formerly suspected. The closely similar nature of the marine fauna found at various horizons, together with other evidence, points to conditions of relatively rapid deposition. This unity of character, as shown by a study of the whole fauna, and also the fact that the Surveyors failed to find evidence for zonal differentiation which might be utilised in establishing any scheme of palæontological subdivisions in the series, seems to indicate without doubt that a very restricted time-period is represented by the whole of the marine beds. In considering the relations of the fresh-water beds to the strata of marine origin, Messrs. Rogers and Schwarz have sufficiently emphasised the part played by rapid contemporaneous variation of facies, and have shown how this factor precludes even a broad, generally-applicable classification, based upon a consistent succession of fresh-water and marine beds.

Representatives of the Lamellibranchiata largely preponderate among the Uitenhage Mollusca, and many of them provide data which usefully supplement the more desirable evidence afforded by the cephalopod-types, in the question of a correlation with European standards. When, however, we seek to trace relationships between the Uitenhage molluscs and those of Lower Cretaceous deposits situated in extra-European regions, it becomes necessary to rely almost entirely upon the evidence of the lamellibranchs, leaving out of account the fact, recognised by Pavlow and Uhlig, that some of the *Holocostephani* of the Uitenhage Series show near affinity to *H. schenki* (Oppel), from the Spiti Shales. Certain lamellibranchs, some of which are well-characterised forms, point to the relationship which existed between this development of the Neocomian in Cape Colony and the Oomia *Trigonia*-beds in Cutch, the strata yielding *T. ventricosa* (Krauss) in the Godavari district and in Hazara, the Neocomian deposits in German East Africa, and the Lower Cretaceous strata of presumably like age in Chili, Bolivia, and the Argentine Republic. In making these comparisons, important significance must be attached to the evidence of some of the *Trigonia*, notably of the divisions *Pseudo-quadrata* and *Scabræ*.

F. Stoliczka, W. Waagen, O. Feistmantel, W. T. Blanford, and R. D. Oldham, all drew attention to the apparently close relationships existing between some of the bivalves in the Oomia Beds of Cutch and certain species in the Uitenhage Series, and the recent study of these faunas has shown that the evidence for such relationship is, in truth, of a very striking character. It is well known that a species of *Trigonia* which occurs very abundantly in the Oomia Beds was referred by the Indian geologists to *T. ventricosa*, first described by F. Krauss from the Zwartkop's River, Cape Colony. Although many of the

Indian specimens show a rather less degree of inflation than individuals representing the average characters of the species in South Africa, I do not consider that the points of distinction are such as to warrant specific separation, or even to permit the certain recognition of two well-defined local races. Should, however, the correctness of this opinion be called in question, the very close resemblance between the shells ascribed to *T. ventricosa*, from these widely separated habitats, must retain the strongest significance, when viewed in connection with the evidence for relationship between some of the associated forms in the one area and certain of those in the other. Several bivalves of the Uitenhage Beds, including such specialised forms as *Cucullæa kraussi*, Tate, and *Seebachia bronni* (Krauss), have very closely comparable, and perhaps identical, representatives in the Oomia group, and a new *Trigonia* from the Sunday's River Beds, belonging to the specialised and short-lived group Pseudo-quadratae, bears a close resemblance to *T. mamillata*, Kitchin, a member of the same division of the *Trigoniae*, from Cutch. The association of these Indian forms with a large *Gervillia* which closely resembles *G. dentata*, Krauss, has already been made known. The striking similarity between the *Trigoniae* of the group of *T. v-scripta*, Kitchin, in the Oomia Beds, and the group of *T. vau*, Sharpe, in the Uitenhage Series, has been discussed elsewhere,¹ and while the adult stages in the members of the two groups probably illustrate homœomorphy, the presence of these analogous forms only serves to emphasise the remarkable aspect of similarity shown when we place side by side the identical and proximate types in the faunas of these widely separated areas. A review of the evidence so far available must certainly lead to the inference that these faunas in South Africa and India are approximately contemporaneous, and that the lines of intercourse between the two areas at that time were probably much more direct than was believed by Neumayr, W. T. Blanford, and others, to be the case. The evidence for the age of the Uitenhage fauna is so decisive that it becomes necessary, by means of this indirect correlation, to refer the *Trigonia*-bearing beds of the Oomia group to the Neocomian.

In the case of the Neocomian fauna in German East Africa which G. Müller believes to be related to that of the Uitenhage Series,² the evidence is of a somewhat less satisfactory character, but I am of opinion that the indications are sufficiently clear to show the correctness of Müller's view. Here, again, peculiarly characterised *Trigoniae* are a special feature in the fauna, and some of these recall Indian and South African forms. For example, *T. kühni*, G. Müller, possesses characters which appear to indicate relationship to *Trigoniae* of the group of *T. vau*, Sharpe, or the group of *T. v-scripta*, Kitchin, while *T. beyschlagi*, G. Müller, very closely resembles *T. crassa*, Kitchin, a degenerate costate form which occurs abundantly in Cutch. Another *Trigonia* has been referred by Müller to *T. ventricosa* (Krauss), and a large *Gervillia* is very closely comparable with *G. dentata*, Krauss, if it is not actually identical with it.

¹ F. L. Kitchin, "The Jurassic Fauna of Cutch," vol. iii, pt. 2, No. 1, Genus *Trigonia*, p. 66: Palæontologia Indica, ser. ix (1903).

² G. Müller, "Versteinerungen des Jura und der Kreide": Deutsch-Ost-Afrika, Band vii, pp. 514–571; Berlin, 1900. F. L. Kitchin: op. cit., p. 121.

A search for traces of the characterising features of the Uitenhage fauna among the Lower Cretaceous fossils described from South America also reveals evidences of a suggestive kind, as recognised by several authors. From the Belgrano Beds in Patagonia, T. W. Stanton¹ has described two *Trigonia* which at once recall South African forms. *T. subventricosa*, Stanton, appears to be nearly allied to *T. ventricosa* (Krauss), and *T. heterosculpta*, Stanton, not only exhibits a peculiar type of adult ornamentation comparable with that exemplified by *T. vau*, Sharpe, and another related South African form, but its adolescent characters show that there is in all probability true relationship with this group of *T. vau*. Here, again, in the Belgrano Beds is found an associated *Gervillia* of large dimensions which does not seem to be widely removed from *G. dentata*, Krauss, of Cape Colony. From Chili, R. A. Philippi has described *Trigonia* which share the characters of peculiar sculpture and siphonal prolongation exhibited by the group of *T. vau*, Sharpe, and are probably related forms. The *Trigonia* of the group Pseudo-quadrata described by G. Steinmann, R. A. Philippi, and C. Burckhardt from Lower Cretaceous beds in Bolivia, Chili, and the Argentine Republic, form an important connecting link with the Uitenhage fauna. *T. transitoria*, Steinmann, a member of this well-marked group, occurs with significant associates in the *Trigonia*-beds of Neocomian age exposed on the left bank of the Rio Agrio opposite Las Lajas, Argentine Republic.² These beds yield another member of this group of *Trigonia*, and also a species which very closely resembles *T. conocardiformis* (Krauss), one of the most characteristic forms in the Uitenhage fauna. *T. eximia*, R. A. Philippi, from the Tinguirica valley in Chili, appears to be very closely related to these. The Chilian shells ascribed by Bayle and Coquand to *Ostrea couloni* bear a considerable resemblance to *Exogyra imbricata*, Krauss, of South Africa, with which Coquand himself later ventured to identify them. Accompanying this oyster in Chili is *T. delafosseii*, Bayle & Coquand, the resemblance of which to *T. ventricosa* (Krauss) has been remarked upon by J. Lycett, W. Paulcke, and myself.

From this brief sketch it may be seen that certain groups of bivalves which form characterising elements as yet unknown to occur in Europe, have a remarkably wide distribution in a Neocomian development of southern type. Thus, *Trigonia* of the group Pseudo-quadrata occur in India, Cape Colony, and South America; *Trigonia* of degenerate costate type, unknown elsewhere, are found in Cutch and in German East Africa; *Trigonia* of the groups of *T. v-scripta* or *T. vau* occur in Cutch, German East Africa, Cape Colony, and South America; *Trigonia* of the type of *T. ventricosa* are also met with in India, East Africa, Cape Colony, and South America; the remarkable form *T. conocardiformis* has a close counterpart in South America; the genus *Seebachia* is known from Cutch and Cape Colony, while a species of *Cucullæa* which exhibits some striking distinguishing features has

¹ T. W. Stanton: Rep. Princeton Univ. Exped. to Patagonia, 1896-1899, vol. iv, pt. 1, Marine Cretaceous Invertebrates, pp. 18, 20, 1901.

² C. Burckhardt, "Beiträge zur Kenntniss der Jura- und Kreideformation der Cordillere": Palaeontographica, Band I (1903), pp. 72-75.

a similar distribution, and, like *Seebachia*, is without any near representative in the European area. The distribution of *Gervillia* of the type of *G. dentata* and large *Exogyra* resembling *E. imbricata* may perhaps also be allowed to have some significance when considered in relation to the occurrence of the forms with which they are associated.

These, in brief, are some of the more significant facts which must be borne in mind when we consider the broad questions of distribution which arise from a comparative study of the Uitenhage Mollusca. Having regard to the manner in which a number of the ammonoids from the Sunday's River Beds permit of close comparison with related European types, it is surprising that these South African forms or even closely allied species are as yet unknown to occur in Cutch, and their apparent absence from the Neocomian deposits of German East Africa and of South America is also noteworthy. Nevertheless, a study of the Uitenhage fauna, undertaken in the light of fuller knowledge, dispels the idea, put forward and emphasised by M. Neumayr, that this fauna proclaims its isolated position by the sharp contrast it shows to the comparable faunas of other regions, and that it may hence be considered to support the theory of an Indo-African land-barrier in early Cretaceous times.¹ Neumayr laid great stress upon the contrast between the fauna of the Neocomian belemnite-beds in the north-west of Madagascar and that of the Uitenhage Series. Even allowing that these faunas are strictly contemporaneous, which has not yet been demonstrated, it is probable that the difference of facies, as recognised by P. Lemoine, would alone suffice to account for the contrast. These belemnite-beds in Madagascar probably represent comparatively deep-water conditions, while the Uitenhage fauna exhibits a shallow-water, littoral character. Since the time when Neumayr wrote, great advances in our knowledge of the occurrence of Cretaceous deposits in Madagascar and on the neighbouring African coast have been made by French geologists, and many facts have now been brought to light which cast doubt upon the existence of an effective barrier to migration between the equatorial and southern waters to the east of the African continent in Cretaceous times. It may reasonably be asserted that the evidence derived from a study of the Neocomian fossils of Cape Colony gives no support to Neumayr's view.

It is well known that Neumayr attached great importance to the occurrence of *Belemnites africanus*, Tate, in the Uitenhage Series in support of his theory of the distribution of cephalopods according to climatic zones.² He found this form to belong to a group which, though occurring in the colder waters of the northern hemisphere, is without representative in the warmer equatorial regions. The known distribution of *Holcostephanus* (sensu stricto) might be thought to contribute in like manner and with no less force of suggestion to the

¹ M. Neumayr, "Die geographische Verbreitung der Juraformation": Denkschr. d. k. Akad. Wiss. Wien, Math.-Nat. Classe, Band I (1885), p. 57. "Erdgeschichte," Band II, 2nd ed., pp. 259, 261, 295, 296, 529; Leipzig and Vienna, 1895.

² M. Neumayr, "Ueber neuere Versteinerungsfunde auf Madagascar": Neues Jahrb. für Min., 1890, Band I, p. 1.

evidence in support of the broad principle laid down by Neumayr, but we must hesitate before attaching any such significance to the facts. Our knowledge is as yet very incomplete, and, moreover, a body of evidence relating to the distribution of fossil Cephalopoda has now been accumulated which casts the strongest possible doubts upon the soundness of Neumayr's theory.¹ Facts set forth in the writings of S. Nikitin, F. Kossmat, C. Burckhardt, G. Boehm, and other authors show clearly the necessity of exercising the greatest caution in estimating the significance of the Uitenhage cephalopods in any general question of distribution. The apparent absence of identical or closely related forms from the Neocomian rocks of German East Africa and of Cutch is very probably owing to our imperfect knowledge of the fossil faunas in these districts; but if this be not the case, the real absence of these cephalopods may possibly have been determined by conditions of a local nature, in manner not unknown among the cephalopod-faunas of various geological horizons within restricted areas in Europe. The same remarks apply to the Neocomian faunas of South America, which have not yet been shown to include any of the South African *Holcostephani* or related forms; but it need scarcely be mentioned that the absence of these Cephalopoda in South America, even though real and not merely apparent, could not be utilized as negative evidence in support of Neumayr's theory. It may be remarked, finally, that the indications for relationship between the bivalve faunas of the Uitenhage Series and the Lower Cretaceous deposits in South America rather tend to strengthen the view, supported by other evidence, that an ancient land surface at that time connected the African and South American continents.

II.—THE LOWER ORDOVICIAN ROCKS OF SCANDINAVIA, WITH A COMPARISON OF BRITISH AND SCANDINAVIAN TREMADOC AND ARENIG ROCKS.

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(WITH A MAP, PLATE X.)

(Concluded from the June Number, p. 267.)

CONSIDERING now the details of the various districts, we notice that in South Öland the basal beds are shaly and conglomeratic; the higher part is calcareous, and by increase in the proportion of matrix passes into a creamy-white limestone which is wonderfully fossiliferous (O 1 and C). The highest beds are again glauconitic, soft, and shaly. Northward the proportion of calcareous material diminishes, and a band of shale with *Shumardia*, whose lithology and fossil content agree with that of the Ottenby *Ceratopyge* shales below the unconformity, is interstratified with the limestone. This bed is quite inconstant, but in Central Öland another shale band containing *Euloma* occurs low down in the limestone. Beyond Borgholm (O 5 and O 6) all limestone disappears, and only glauconitic shale separates the

¹ M. Neumayr, "Ueber klimatische Zonen während der Jura- und Kreidezeit": Denkschr. d. k. Akad. Wiss. Wien, Math.-Nat. Classe, Band xlvi (1883), p. 277.