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The Rev. T. H. Browne, High Wycombe, Berks; Thomas Grange Hurst, Esq., Mining Engineer, Backworth, Northumberland; and W. R. Williams, Esq., Mining Engineer, Dolgelly, North Wales, were elected Fellows.

Professor Nilsson, of Stockholm, was elected a Foreign Correspondent.

The following communications were read:—

1. A DESCRIPTION *of the ECHINODERMATA from the STRATA on the SOUTH-EASTERN COAST OF ARABIA, and at BAGH on the NERBUDDA, in the COLLECTION of the GEOLOGICAL SOCIETY.* By P. MARTIN DUNCAN, M.B. (Lond.), Sec.G.S.

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1. *Introduction.*—There is a small collection of Echinoderms, Brachiopods, Pectens, and Zoantharia in the Foreign Museum of the
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Society, which came from Bagh on the Nerbudda. It forms a portion of that assemblage of fossils which enabled Capt. Keatinge to determine the existence of Cretaceous strata in the north-west of the Indian peninsula, and it was presented to the Society by Dr. H. J. Carter, F.R.S. The specimens from the cliffs at Ras Fartak and Ras Sharwén, in South-eastern Arabia, were collected by Dr. Carter, and include Echinoderms, Zoantharia, Foraminifera, and Pectens; they were given to the Society by their distinguished collector in the hope that they would, at some time or another, be examined and named, special reference being made to the Bagh series.

Hearing that I was studying the Bagh fossils, Dr. Carter wrote to me to direct my attention to those from S.E. Arabia; for he considers that both the localities are of Neocomian age*, and that they are along the same line of the great fault which, running parallel with the coast-line of S.E. Arabia, reaches the Vindya range on the Nerbudda.

2. *Position of the Strata.*—The town of Bagh is situated about 22 miles from the Nerbudda, 145 miles from the sea, and about 850 feet above its level. A Bryozoan limestone had long been known to exist in its neighbourhood, and the stones of Mandoo, crowded as they are with fossils, had excited the attention of Drs. Carter and Oldham†. Capt. Keatinge and Mr. Blackwell visited the caves whence the stones were quarried, and made as careful observations as could be expected under very unfavourable circumstances. Their collection of fossils was examined; and, as far as can be judged, these observers have fairly proved their Cretaceous age. Before

* H. J. Carter, 'Geological Papers on Western India, &c.,' 1857, p. 623.

† T. Oldham, 'On some Additions to the Knowledge of the Cretaceous Rocks of India,' p. 6.

‡ Kindly furnished by Dr. H. J. Carter, F.R.S.

this, both an Oolitic and a Nummulitic age had been given to this red Bryozoan limestone; but Capt. Keatinge, on the strength of the Pectens, contented himself with asserting it to be Cretaceous*. Unfortunately no stratigraphical data were obtained by Capt. Keatinge and Mr. Blackwell which were of any direct value in estimating the geological age of the Bagh limestone; but Dr. Carter recognized a similarity of arrangement between the limestone and a subordinate sandstone of Bagh and the strata on the coast of S.E. Arabia. He, moreover, recognized the identity of the Pectens at Ras Fartak and those from Bagh†.

The Arabian fossils were derived from argillaceous strata of a red colour, which are superimposed conformably on a deep, coarse micaceous sandstone, and which are succeeded by beds of White Limestone. The sandstone is unfossiliferous; but Dr. Carter asserts that the White Limestone belongs to the Upper Cretaceous series‡, and that it is succeeded by Nummulitic beds in many places.

The white sandstone of Bagh and the micaceous sandstone of South-eastern Arabia correspond, according to Dr. Carter; and the limestone and argillaceous strata which cover these respectively are also considered by him to be geologically equivalent. The parallelism as asserted is seen in the following Table:—

<i>South-eastern coast of Arabia.</i>		<i>Bagh.</i>	
White limestone§	2000? feet.	} = {	Red argillaceous limestone and clays ... 15-20 feet. Sandstone 100 feet.
Red argillaceous shales and coloured limestones	1000? feet		
Sandstone	1700? feet		

In concluding his remarks on these strata, Dr. Carter writes||, "On comparing, therefore, the fossils and the strata in which they are found at Bagh and its neighbourhood with those on the south-eastern coast of Arabia, we can come to no other conclusion, that I see, than that part, at least, of the coloured strata in both localities belong to the Neocomian division of the Cretaceous period. I would also add here, that there is a remarkable similarity between Mr. Blackwell's specimens of limestone from Bagh and those from Tendu-dkdera, about 60 miles below Jubbulpore, where this gentleman has also found a rich development of argillaceous iron-ore mixed with limestone. The coloured strata on the south-east of Arabia are also characterized by their ferruginous nature; so that at all three places we get similar limestones and similar developments of iron-ore, with the same kind of fossils in two, viz. at Bagh and on the south-eastern coast of Arabia."

My observations on the fossils have led me to agree with Capt. Keatinge and Mr. Blackwell concerning their Cretaceous age, and to admit that Dr. Carter's remarks are consistent with fact, with one exception. If that able geologist had had the advantages now offered

* Oldham, *op. cit.* p. 11.

† Carter, *op. cit.* p. 623.

‡ *Ut supra.*

§ The only fossils I have seen from these limestones are some *Echinocyami*, which cannot be distinguished from *E. Altavillensis*, Agass. (Eocene of France).

|| *Op. cit.* p. 624.

to palæontologists, he would doubtless have placed the strata he has described in the Upper rather than the Lower Greensand horizon, and would have considered them *Cénomanian* rather than *Neocomian*.

3. *The Rarity of described Prenummulitic Echinoderms in Asia*.—The Echinodermata are so numerous in both collections that they at once attract attention; this communication therefore refers especially to them.

There have been but few Echinoderms described from any strata in Asia below the Nummulitic, and only nine species have been carefully determined. Of these, two are from the Cretaceous rocks of Sinai, and the others were described by Professor Edward Forbes in his essay on the fossils of Southern India*. Generic names of the specimens from Bagh and South-eastern Arabia have been suggested by Drs. Oldham† and Carter‡ respectively; but their necessarily superficial examination did not produce satisfactory results.

The Ras Fartak and the Ras Sharwén Echinoderms add seven species to the Asiatic list; and their study is the key to the determination of the Bagh collection, which affords four species, one of which is in the Arabian collection. The united collections have a well-marked facies, and present the same general likeness to European forms from a well-studied locality, which was also noticed to occur by Professor Forbes with regard to certain Cephalopoda in Southern India. Dr. Carter having personally collected the South-eastern Arabian specimens prevents any doubt being thrown on their *bonâ fide* nature; and the same remark may be made with regard to the Bagh series, Capt. Keatinge being responsible for their having been found in the strata he termed Cretaceous. The marked nature of the facies, and the identity of most of the species with well-known forms from Western Europe, render it necessary that there should be no doubt on the subject of the localities whence the specimens were derived. The collections, as a whole, may be ascribed to an horizon comprehended between the Gault and the “chalk-with-flints” in Europe; and they refer very faintly to the Echinoderms from Southern India, and in like manner to the forms from the North American Cretaceous rocks.

4. *List of the Species of Echinoderms in the Collections*.—The following is a list of the species, with their synonyms and localities:—

Ras Fartak and Ras Sharwén, South-eastern Arabia.

1. <i>Cidaris Cénomanensis, Cotteau</i>	Yvre-L'Évêque		1 specimen.
2. <i>Pseudodiadema Roemeri, Desor</i>	Plâner Inférieur of		
<i>Tetragramma depressum, Roemer</i> ...	Hildesheim		2 specimens.
3. <i>Salenia scutigera, Gray</i>	Le Mans, Martigues,		
<i>Cidaris scutigera, Münster</i>	Minorca, War-		
<i>Salenia personata, Defr.</i>	minster		2 specimens.
— <i>scripta, Agassiz</i>			
— <i>petalifera, Bronn</i>			

* “Fossil Invertebrata from Southern India,” Trans. Geol. Soc. 2nd ser. vol. vii. p. 97.

† *Op. cit.* p. 11.

‡ *Op. cit.* p. 604.

4. <i>Holctypus Cénomanensis</i> , <i>Guéranger</i> }
— <i>planatus</i> , <i>Roemer</i>	Le Mans, Texas	4 specimens.
5. <i>Pygaster truncatus</i> , <i>Agassiz</i>	Condécieux, Ile d'Aix	1 specimen.
6. <i>Epiaster distinctus</i> , <i>Agass.</i>	Villiers-sur-mer, N. }
of Ireland	1 specimen.
*7. <i>Hemiaster similis</i> , <i>D'Orb.</i>	Le Mans	1 specimen.
8. <i>Cottaldia Carteri</i> , sp. nov.	Ras Sharwèn.....	2 specimens.

Bagh, on the Nerbudda.

1. <i>Hemiaster Cénomanensis</i> , <i>Cotteau</i>	Le Mans	6 specimens.
*2. <i>Hemiaster similis</i> , <i>D'Orb.</i>	Le Mans	2 specimens.
3. <i>Nucleolites similis</i> , <i>Desor.</i>	Yvre-L'Evêque.....	1 specimen.
<i>Echinobrissus similis</i> , <i>D'Orb.</i>		
4. — <i>subquadratus</i> , <i>D'Orb.</i> , sp.	Chaux de Fonds?.....	3 specimens.

It is not only convenient but necessary to refer foreign forms to those of well-known European strata, both to avoid the unnecessary multiplication of species and to obtain a definite idea of the affinities and the palæontological value of the new fossils. Collections like those under consideration will, after such a reference, be noticed to contain, usually, forms which must be arranged as follows:—

1. Species identical with those of distant localities.
2. Varieties of these species.
3. Varieties of species known in distant localities, but absent in the collections.
4. Species closely allied to those found in distant localities (representative species).
5. Varieties of these species.
6. New species without any decided affinities with those of distant localities.
7. Species and their varieties which refer to older or newer strata.

The forms from Arabia and Bagh can be arranged in the following manner under the sections:—

1. *Pseudodiadema Roemeri*, *Salenia scutigera*, *Holctypus Cénomanensis*, *Epiaster distinctus*, and *Pygaster truncatus*, from South-eastern Arabia; *Nucleolites similis* and *Hemiaster Cénomanensis*, from Bagh.
2. Two varieties of *Holctypus Cénomanensis*, from South-eastern Arabia.
3. *Cidaris Cénomanensis* and *Hemiaster similis*, from South-eastern Arabia.
4. *Cottaldia Carteri* from South-eastern Arabia.
- 5 and 6 are not represented.
7. *Echinobrissus subquadratus*, a variety, from Bagh.

5. *Other Fossils in the Collections.*—The following fossils were derived from the same localities as the Echinodermata:—

* Common to Bagh and South-eastern Arabia

I. *South-eastern Arabia.*

Pecten quadricostatus, Sow.
— *æquicostatus*, Lam.
Neithea Alpina, D'Orb., sp.
Actinospongia, sp.
Patellina concava, Carter, sp.* }
Orbitolina concava, Lamk. }

II. *Bagh.*

Neithea Alpina, D'Orb.
Pecten quadricostatus, Sow.
Rhynchonella depressa, Sow.†
Thamnastræa decipiens, Michelin, sp. }
Centrastræa Cénomanensis, D'Orb. }
Escharina, sp. *Vincularia*, sp.
Eschara, sp. *Serpula plexus*, Sow.

The *Pecten quadricostatus*, Sow., has an immense range, and it is figured by F. Roemer from the Chalk of Texas (Kreideb. von Texas, 1852, p. 64). The coral appears to belong to the species which, under these names and that of *Thamnastræa pediculata*, De Fromentel, ranged from the Neocomian to the Hippuritic chalk of Gosau inclusive. The Upper Greensand horizon of all these forms is sufficiently distinct, and is very confirmatory of the geologic position of the Echinodermata.

6. *Description of the Varieties and of a new Species.*—I. *HOLECTYPUS CÉNOMANENSIS*, Guéranger. As a specimen which cannot be distinguished from the type is amongst those from Ras Sharwèn, the varieties are easily distinguishable. Dr. Carter considered the species to belong to the genus *Discoidea*; but the specimens have not the internal arrangement of that marked genus. He selected the form which is considered by me to be the type of *H. Cénomanensis* as his "1st species," and ranged the others under other species recognizable by numerals‡. This *Holctypus* has been ably studied by Cotteau and Triger; and its abnormal fifth oviductal plate has, after the examination of numerous specimens, been decided to be perforated. All the Arabian specimens show the fifth generative pore. It is interesting to observe that the tendency which this species has to vary slightly is seen in the Arabian as well as in the European specimens.

Variety 1. The specimen is nearly twice as large as the type, has larger tubercles and less prominent ambulacral spaces.

Variety 2. The specimen is slightly larger than the type, and has a pyramidal instead of a rounded upper surface.

The essential structural details remain the same in both varieties, which are very closely allied. The resemblance of the species to *H. macropygus*, Agass., sp., of the Neocomian is very great; but zoologically the fifth pore necessarily places it in a subgenus; it does not, however, interfere much with the idea that *H. Cénomanensis* is a descendant by variation (probably in consequence of obeying some law of "correlation of growth") of the older type *H. macropygus*.

There is a species (*H. planatus*, Roemer) described by F. Roemer§, from Fredericksburg, which is barely specifically different from that under consideration; and MM. Cotteau and Triger||, in their admirable analysis of the species which have come before them, have detected other *Holctypi* with five generative pores. They decide that *H. Turonensis*, Defr., sp., of the Chalk of Touraine, extends into the Upper

* Prof. T. Rupert Jones has kindly determined this species for me.

† Mr. Davidson informs me that this *Rhynchonella* resembles the variety found in the Irish Upper Greensand.

‡ Carter, *op. cit.* p. 605.

§ Kreideb. Texas, p. 84.

|| Echinides de la Sarthe, 1861.

Chalk in the form of a variety which is subconical and not so much depressed as the type, and that both have five generative pores.

The small tubercles, which are crenulated and perforated, the position of the anus, and the general form of the test are repeated sufficiently to admit the following under one species. The series will then stand thus:—*Holactypus Cénomaneensis*, Guéranger. Varieties: 1. some French unnamed forms, which vary very slightly from the type; 2. var. 1, from South-eastern Arabia; 3. var. 2, from South-eastern Arabia; 4. var. *Turonensis*, from the Lower and Upper Chalk; 5. var. *planatus*, from Texas. The species follows the law, that those widely dispersed vary greatly; and its great diffusion, both in area and in depth, is very remarkable.

II. *CIDARIS CÉNOMANENSIS*, Cotteau. The variety of this species differs from the type in having the second or internal two rows of granules in the ambulacral spaces barely developed. The primary or external rows are like those of the type, and extend to the summit, occupying the interporiferous zone for some distance. This difference is insufficient to be specific; but its recognition as pertaining to a variety throws some doubt on the propriety of separating *C. Cénomaneensis* from *C. vesiculosa*, these species differing only in the granulation of their ambulacral spaces.

III. *HEMIASTER SIMILIS*, D'Orb. There is a variety of this species in South-eastern Arabia, and a second at Bagh. Both have wider spaces between the rows of pores in the ambulacra than the type, and the test is generally more globular than in the European specimens; moreover the posterior ambulacral areas are a little longer than in the type, but still they are very short. The Bagh variety is broader and more globular than the South-eastern Arabian.

Figs. 2-4.—*Illustrating the structure of Cottaldia Carteri.*

Fig. 2. *Cottaldia Carteri*: side view, natural size.

3. The same: diagram of the apical disk.

4. The same: diagram of an ambulacral space, poriferous zones, &c.

IV. *COTTALDIA CARTERI*, spec. nov. The test is circular in outline, much compressed above and below, and tumid at the sides. The tubercles are of the same size, both on the ambulacral spaces and interambulacral areas. There are two rows of tubercles in the ambulacral spaces, and from six to eight in the interambulacral areas; the tubercles are arranged moderately horizontally, are surrounded by a scrobicular circle, which is ridged and faintly granular. The generative pores are five in number. The pores of the poriferous zones are in single pairs throughout. The peristome is at the bottom of a rather deep cavity. Breadth of test $1\frac{1}{2}$ inch; height $\frac{1}{2}$ inch. The size, compressed shape, and the disposition of the tubercles distinguish this species from that nearest to it, the *C. Benettia*, Koenig, sp., which is so characteristic of the British and French Upper Greensand. *C. Carteri* is clearly the representative of its close ally.

V. *ECHINOBRISUS SUBQUADRATUS*, D'Orb., sp. This Neocomian type is represented by a variety at Bagh, of which there are several specimens in various grades of growth. The variety has all the minute details of the specific form, but the posterior margin is not incurved or emarginate; it is faintly out of the curve in the convex direction, but not more. This variety is so like the type in its other essentials, that it clearly led to the error of giving a Neocomian age to the beds at Bagh. The specimens are mineralized, like the rest of the collection; and although there is of course a suspicion of their being "derived," still there is quite as much to be said to the contrary.

7. *On the Affinity and Identity of the Species with those of other and remote Cretaceous Strata, and on the Correlation of the Arabian and Bagh Beds with the typical European Series.*—It is hardly necessary to observe that the close affinity of the Bagh and South-eastern Arabian fossils, the position of the strata with regard to the great south-west fault, and their conformability to an unfossiliferous sandstone render the parallelism of the two deposits tolerably evident. They present a remarkable assemblage of Echinodermata and some other fossils very characteristic of the European Upper Greensand and Lower Chalk. Most of the species have a wide range, both vertically and horizontally; some are restricted in their bathymetrical diffusion in certain European strata, but are not so in others; and it is one of the singularities of the collections that they should comprise many of the European Echinodermata* which have this wide range and a tendency to vary also. Mr. Darwin's generalization, that largely diffused species vary greatly, obtains much confirmation from the study of collections like these.

All the species are fairly Cretaceous, and there is no admixture of

* Much credit is due to the philosophic investigations of Messrs. Cotteau and Triger (*Echinides de la Sarthe*, 1861), who have so faithfully recorded the numerous varieties of many species which were considered very typical and stable in the French Cénomanién. The determination of the varieties of some of the species which occur in the Asiatic strata has been greatly facilitated by their researches, and by considering and acting upon the latitude which can be fairly given to variation in Europe.

those types which, foreshadowing the fauna that attained its maximum of development in early Tertiary times, complicate the palæontology both of the South-Indian and North-American Chalk.

The nearest Cretaceous strata to the south of Bagh are those which were noticed by Messrs. Kaye and Cunliffe, and whose fossils were described by Edward Forbes and Sir Philip Egerton*. The collection from Pondicherry has no species in common with those at Bagh and South-eastern Arabia, and its fossils, according to Forbes, belong to a lower horizon; but the Trichinopoly beds yielded fossils which have a slight community of facies with the northern; there are, however, no identical species. If those species which Edward Forbes considered to be unusual in the Cretaceous fauna be removed from the collections from Trichinopoly and Verdachellum, this community of facies becomes stronger, and it is evident that it is produced by the forms which are common to the European and South-Indian Cretaceous faunæ.

The varieties of *Hemiaster similis* at Ras Sharwên and Bagh are remotely allied to Forbes's *Brissus rana*†; and *Hemiaster Cénomane* from Bagh is allied to *Brissus expansus*, Forbes, both the *Brissi* being really *Hemiasters*.

Here the similarity ends; and the northern beds, being on an horizon inferior to those at Trichinopoly and Verdachellum, are probably the equivalents of the Ootatoor beds‡.

The other Cretaceous rocks of India, as yet described§, belong to the Upper Chalk, and their organic remains point clearly to a higher horizon than those of Bagh and S. E. Arabia. The great Cretaceous deposits of Sinai, Egypt, Syria, Palestine, Asia Minor, and the Caucasus, whose fossils are comparatively unknown, do not ally the strata under consideration with the Crimean, Russian, and Eastern European Chalk, except in a general sense. The few Echinodermata from Sinai and Egypt|| have no affinity with those just described; but the ubiquitous *Pecten quadricostatus* is common in the Chalk in Northern Asia Minor at the Kara-dagh¶. Von Buch and Abich** determined a Neocomian and an Upper Greensand, with a doubtful Gault, in the Caucasus: although there are many species common to

* Trans. Geol. Soc. 2nd ser. vol. vii. p. 97.

† The student of some of the great French works on the Echinodermata may perhaps be astonished at my referring this fossil to Edward Forbes. It is referred to Desor by D'Orbigny without any notice being taken of the original describer. The manner in which these little mistakes (which, however, are never made to the detriment of French observers) are brought about is instructive. Forbes described the species as *Brissus rana*; long afterwards Desor (Catal. Rais. p. 125) altered the generic name to *Hemiaster*, and subsequently D'Orbigny, dropping Forbes's name, calls the fossil *Hemiaster rana*, Desor. The same thing occurred with regard to Forbes's *Brissus expansus* and *B. inæqualis*. In fact, the reader of D'Orbigny's 'Paléontologie Française' naturally refers all these species to M. Desor, who honourably gives the synonyms in his 'Synopsis des Echinides,' 1858.

‡ For information about these beds, see H. F. Blanford, Memoirs of the Geol. Survey of India, vol. iv.; also *infra*, p. 407.

§ Oldham, Quart. Journ. Geol. Soc. vol. xix. p. 526.

|| Desor, Synopsis des Echinides Fossiles.

¶ Bull. de la Soc. Géol. de Fr. 2nd ser. vol. xvi. p. 398, 1850 (Tchibatcheff).

** Zeitschrift der deutsch. geol. Gesell. vol. iii. p. 15, 1850-51.

these last strata and those of the basin of the Loire and at Warminster, still none of them are found in the collections presented by Dr. Carter. The geology of Abyssinia is so little known that the existence of Cretaceous rocks has been both asserted and doubted. An *Holectypus* very closely allied to the common species at Ras Sharwèn is found in the Constantine Cretaceous beds* in North Africa; and the Chalk in the Balearic Isles has yielded the *Salenia personata*. The German Pläner (doubtless, from its having been so well examined) presents the first indications of a close affinity with the Arabian and Bagh series; and this affinity becomes nearly complete in the districts of the French Cénomaniën, at Le Mans, l'Île d'Aix, and Villiers sur Mer, &c., which contains no less than thirteen out of the eighteen Asiatic species, either as identical species or as varieties. The Irish Upper Greensand contains *Epiaster distinctus* and the same variety of *Rhynchonella depressa*, Sow., which is found at Bagh; and the *Salenia personata* with *Pecten æquicostatus* are common to the English Upper Greensand and the strata in South-eastern Arabia and at Bagh.

The North-American Chalk has but a small palæontological affinity with the distant Asiatic series: a portion of it by no means well-defined has a certain similarity of facies, and in Texas there is a community of species. Roemer's *Holectypus planatus* is clearly the species previously described as *H. Cénomaniensis* by Guéranger from Condécieux, and which is also a characteristic form in the South-eastern Arabian Chalk. *Pecten quadricostatus* is also a Texan species. Here the affinity between the two series ends, as far as America is concerned; for the Arabian and Bagh series is on a higher horizon than the Neocomian of the Andes and of Trinidad†. It must be conceded that the affinity of the Asiatic species with those of the neighbouring Cretaceous deposits will most probably appear greater as new forms are collected, and that the remarkable association of so many familiar species will then become less striking, but not the less true.

8. *The Impossibility of establishing a close Synchronism between the Asiatic and other Cretaceous Strata.*—It has been noticed that the red strata of Bagh and South-eastern Arabia, whence the fossils collected by Capt. Keatinge and Dr. Carter were derived, rest on unfossiliferous sandstones. The white limestone which rests conformably on the Arabian red strata has yielded no satisfactory series of fossils; and it may be of Nummulitic age, for the only Echinoderm from it is an *Echinocyamus* allied to Eocene rather than to the Upper Cretaceous species.

The red strata thus stand alone as regards stratigraphy; but their palæontology clearly determines them to possess the homotaxis of the typical Upper Greensand strata of Western Europe.

To determine their contemporaneity is impossible, even relatively; for the vertical range of so many of the species is so great, and the parallelism of the allied European Cretaceous beds is not exact.

* Desor, *op. cit.*

† Duncan and Wall, "On the Geology of Jamaica," *Quart. Journ. Geol. Soc.* vol. xxi. p. 1.

The numerous natural-history provinces in Europe between the upper member of the Neocomian and the Chalk with flints, and the existence of littoral, deep-sea, and coral zones of life, prevent the possibility of a close correlation of the British, Irish, French, German, and Spanish Middle Cretaceous strata. This statement may be carried further, and it will appear that the remoter the strata are from those considered the types, the greater is the difficulty of establishing a parallelism, so that at last such distant deposits as the North American and South Indian present anomalies. The succession and parallelism of the strata do not tally in Ireland, England, and Western and Southern France; moreover there is the difficulty about the relative position of the Hippurite-Chalk of Provence, Germany, and North Africa. The restricted range of some so-called characteristic species in the French Cénomanien, and their greater range in the British Upper Greensand and Lower and Upper Chalk, have moreover tended to complicate the parallelism of the German beds containing them. It is this varying range which offers some data for reflection upon the great duration of the fauna which is considered characteristic of the Upper Greensand and its more or less definitely parallel strata. The Hippurite-limestone of Provence rests on the Cénomanien with *Exogyra columba*, *Ammonites varians*, and *Ammonites peramplus*; and these fossils are restricted bathymetrically to this Upper Greensand in France. In Saxony and in Bohemia* these *Ammonites* are found in the Pläner above the Hippurite-Chalk, but the *Exogyra* is wanting; and thus these species, which have a range in England in the Upper Greensand to well up in the Chalk-with-flints, outlived a great fauna of Hippurites and Corals, and witnessed great geographical changes of which the study of the English series gives but little trace. The same *Ammonites* are found above, but not below, the Hippurite-Chalk of Constantine†; and the great development of this zone of *Rudistes* must be remembered in estimating the time which elapsed during the changes in physical geography inferred by the existence of coral and Hippurite reefs preceded and followed by the conditions favourable for Ammonite-life. There were, in the first instance, the conditions favourable to the existence of a fauna characterized by Ammonites, Bivalves, and numerous Echinodermata. In the second these conditions were greatly altered, and an age of subsidence produced a deep sea with the essential physical geography of a coral-sea, whose Madreporaria are represented in the recent period by reef and atoll species, but which were accompanied by a great fauna of *Rudistes*. In the third instance such changes occurred as reproduced the same conditions which characterized the Prehippurite sea, and Ammonites, Echinoderms, and Bivalves migrated from the positions into which they had been driven by the alteration of the sea-depth. The duration of the second era may be estimated by the fact that a number of species of *Rudistes* arose, attained their greatest development, and probably

* Coquand, Bull. Soc. Géol. de Fr. 2d ser. vol. ix. p. 340, 1853.

† Ewald, quoted by D'Archiac, Hist. Prog. Géol. vol. v. p. 313, 1853.

died out in it, and that the coral-fauna of the period nearly equals that of the Midtertiary age. Yet during this vast lapse of time many species of Cephalopoda, Mollusca, and Echinodermata were living out of their former zone, were competing with the dwellers of the sea into which they emigrated, and finally returned to their original position. There was abundance of time for any amount of diffusion; and doubtless the strong species varied, as is their wont, and left their remains over vast areas. Now the Echinodermata and some of the other fossil remains from Bagh and South-eastern Arabia are represented in the faunæ of all the divisions of the European Chalk between the Gault and the Chalk-with-flints. They may have originated in the Asiatic Chalk, and may have emigrated to the districts referred to in Europe; the reverse may have happened; or, as is more probable, the species arose in various districts by variation from species competing strongly, perhaps under changes of physical conditions, and the Bagh and South-eastern Arabian beds may represent only one or all the European series between the Gault and Upper Chalk.

9. *Remarks on the Identity, Persistence, and Variability of the Species.*—It has been mentioned that the European Upper Greensand and its associated strata are represented in the equivalent deposits at Bagh and in South-eastern Arabia by identical species, varieties of species, and by a representative species. The common Cretaceous facies of the faunæ is thus retained, although there are forms in them which refer both to earlier and later ages. Thus the variety of *Echinobrissus subquadratus*, which is a Neocomian species, is a common fossil at Bagh, and its specimens are numerous in the small collection.

Differing from the type in having a very slight instead of a decided incurvation posteriorly, the variety presents all the other specific attributes, and it occupies the same relative position in the Bagh fauna which varieties of certain Midtertiary species do in the existing distribution of living beings. The Hemiasters, on the contrary, connect the Middle with the Upper Cretaceous, and with the Tertiary Echinodermata. The new *Cottaldia* is representative of the *Cottaldia Benettii*, Koenig, sp., so characteristic of the Tourtia; and it is reasonable to infer, from the great similarity of their structure, an adaptation to the same mode of life. The new species clearly fills up the vacancy produced by the absence of the well-known form, which would cause a sensible gap in any series of Upper Greensand Echinoderms.

There appears to be an indisposition on the part of some distinguished geologists and naturalists to admit the occurrence of the same species in distant strata or in remote areas. The slow progression of species, and their constant competition with others during their diffusion, have suggested that greater or less variation must occur, and that the original type is never found in very remote localities, but varieties of it, some of which are sufficiently permanent to be considered closely allied species. Some naturalists assert that even if the distant forms be identical to the eye they must be specifically

distinct; so deeply has the hypothesis of the restriction of species to definite areas influenced the judgment. It is evident, however, that direct observations must supersede hypotheses in the study of nature; and that carefully recorded facts are not to be overruled by theoretical considerations. Nearly every palæontologist who has studied foreign as well as European fossils, and the majority of those naturalists who have had a great scope of observation, determine that the whole truth is not conveyed in the opinions just mentioned, and that although the forms of distant localities are to be referred to the same families, genera, and sections of genera, and that varieties of species replace the species at a distance, still species identically the same are found separated by great distances or diffused over great areas. It is quite true that some species are restricted in their vertical and horizontal range; but others, as Mr. Darwin remarks (*Origin of Species*, p. 381), "have migrated over vast spaces and have not become greatly or at all modified." There are numerous examples in many families in all formations, from the Silurian to the Recent, of these wide-wandering and unchanging species, and many more of those which are more or less modified or varied. It is difficult to restrict the notion, of the influence of external physical conditions (in a state of change or not) upon specific variation, within its correct bounds. It is clearly the opinion of those who have decided against the possibility of the great range of species, that these external conditions, such as climate, position in latitude and altitude, moisture, heat, sea-depth, &c., greatly influence and enhance variation, or prevent it entirely. But the great biologist just quoted places the matter in its true light; and his following remarks* apply in the strongest manner to the assemblage of species from Bagh and South-eastern Arabia:—"As the variability of each species is an independent property, and will be taken advantage of by natural selection only so far as it profits the individual in its complex struggle for life, so the degree of modification in different species will be no uniform quantity. If, for instance, a number of species which stand in direct competition with each other migrate in a body into a new and afterwards isolated country, they will be little liable to modification; for neither migration nor isolation in themselves can do anything. These principles come into play only by bringing organisms into new relations with each other, and in a less degree with the surrounding physical conditions."

The inherent power of variation which exists more or less in all animated beings irrespectively of the influence of external physical conditions, and which is shown, in the simplest form, by the so-called individual differences, is doubtless governed, restricted, and increased by definite laws. Natural selection even acts with varying intensity as the great excitant. So some species are very persistent, others vary more or less, and many are so variable as to be termed polymorphic. The simultaneous occurrence of persistent and variable species over great areas is a fact, and there is nothing abnormal in it. As the different longevities of species, and also of the individuals

* Darwin, *op. cit.* p. 381.

of species are both regulated by determinate laws, so are, doubtless, the apparently inexplicable associations of persistent, variable, nascent, and moribund species.

It would appear that every instance of wide dispersion of species in former ages is equalled, both as regards the longitude and the latitude, at the present day. From the Lower Silurian to Tertiary times, identical species have existed over vast areas of every formal formation—formal; for although the succession of forms has never ceased, still the science of geology requires some starting-points for its nomenclature, and they are either determined by apparent breaks* or more artificially by the culmination of the abundance of certain living forms. The diffusion of Arctic and Alpine species during the glacial period is considered in one of the most philosophical chapters of Darwin's work; and it testifies to the identity of species over vast areas of latitude and longitude with or without gaps. And modern investigation, the careful collection and examination of specimens, has determined that whilst some species are restricted in their areas, others have an enormous range; and these belong to many families. By considering the enormous range, with or without intermediate gaps, of many freshwater forms of Arctic and Alpine species of plants; of temperate ferns; of corals—from the Red Sea to the remotest islands of Oceania, or from the Levant to Zealand; of Bryozoa and Algæ—species being common to the European and Australian seas; and, lastly, of Echinodermata—some having a habitat of 50° of latitude†, of 30° of latitude, and 80° of longitude‡, and others being found on the eastern coast of Africa and the Gallapagos§, at Guadaloupe and Port Essington§, at Labrador and Kamtschatka|| respectively,—by these considerations it may be decided reasonably that there is no restriction to the area of the diffusion of persistent or identical species. The idea of time can only be brought to bear by noticing the rapid diffusion of species artificially introduced into oceanic islands or remote continents; but it is certain that some widely ranging species have had the opportunity for diffusion and variation from the Midtertiary age to the present day.

Amongst the identical species from South-eastern Arabia there is one, the *Pygaster truncatus*, Agass., which is a very persistent and non-varying form. It is interesting that this species should be the last known of the important Oolitic genus *Pygaster*, that it should depart somewhat from the generic attributes¶, and that, being a rare fossil in the French Cénomanién, it should not have appeared to vary in the distant Arabian Chalk. Another species, the *Holætypus Céno-*

* See Prof. Ramsay's Pres. Add. Geol. Soc. 1863-64.

† *Echinodiscus inaurita*, Van Phelsam, sp., Red Sea, Zanzibar, Mauritius; *Echinodiscus bifora*, Lamk., sp., Madagascar, Red Sea, Indian Ocean; *Dendraster eccentricus*, Eschscholtz, sp., Kamtschatka, California.

‡ *Encope tetrapora*.

§ *Echinoneus cyclostomus*, Leske.

|| *Echinarachnius parma*, Gray. For these localities, see Synopsis of Echin. Irreg. Brit. Mus.

¶ MM. Cotteau et Triger (*op. cit.*) have some excellent remarks on this species, p. 117.

manensis, has a somewhat analogous relation to the other species of its genus. The *Holotypi* flourished in Oolitic times, and have not been found in strata higher than the Lower Chalk. *Holotypus Céno-manensis* is therefore a late species, and it departs somewhat from the generic characteristics by having a fifth generative pore; but, unlike the *Pygaster*, it is a very variable species. The *Salenia* and the *Epiaster* belong to species which vary in Europe: this is proved, in the first instance, by the difference in the published types of the species, and by comparing foreign with British specimens, and in the second instance by M. Desor's determination that the variation in the subanal projection of *E. crassissimus* is sufficiently great to render *E. distinctus* a doubtful species, and that it is identical with *E. Varusensis*. The species *E. crassissimus* and *E. acutus* have been decided to be the same. In fact all these Epiasters are varieties of a single type: but which this may be, cannot be determined. They are all found in the same strata in Europe.

10. *Conclusion*.—The ferruginous nature of the strata containing these fossils has been noticed. The iron is for the most part in the form of a dull-red sesquioxide; but here and there are traces of the sulphuret. Some specimens of the rocks are light in colour, and consist of clayey limestone, very hard and with a fine texture. This clay is the original matrix, the salts of iron and the fossils being accidental deposits having mutual relations and forming the great bulk of the strata. The fossils are usually well preserved, have been but slightly rolled, were deposited in a soft clay, and, from the comparative absence of the sulphuret of iron and of the evidences of its destructive mineralization, their details are generally very perfect.

These observations on the nature of the deposits confirm the impression produced by the study of the habits of the existing representatives of the fossil forms in estimating the bathymetrical horizon of the strata. The fossiliferous clays with *Cidaris*, with flat Echinoderms, Pectens, rugged *Ostrea*, Brachiopods, Bryozoa, and Foraminifera, could not have been deposited at a less depth than that included in the Nullipore (No. VII.) zone of Forbes. Strictly speaking they are not littoral deposits; but when considered in relation to a neighbouring very deep-sea or oceanic deposit, they may be so termed, and thus accord with the well-known theory of Messrs. Godwin-Austen and Daniel Sharp, that the Upper Greensands are littoral deposits in relation to the Lower White Chalk. Finally, it is consistent with the harmony of nature that there should be a close connexion between widely diffused species, their occasional persistency, their more frequent tendency to variation, their range in depth and in space, their belonging to a zone of sea-depth where there are great facilities for emigration and diffusion, their entombment in the fine calcareous clay of a sea-bottom removed from the regions where conglomerates and rocks can be formed, and their mineralization by a pure oxide of iron.