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XIV.—*Descriptions of some of the larger Forms of Fossilized Foraminifera in Scinde; with Observations on their Internal Structure.* By H. J. CARTER, Esq., Assistant Surgeon, Bombay Establishment.

[With a Plate.]

THROUGH the kindness of several officers of the Bombay Army, access to the Museum of the Bombay Branch of the Royal Asiatic Society, and my own experience in Scinde, I have become acquainted with many, if not most, of the larger forms of fossilized Foraminifera of that country; and as descriptions of them may prove acceptable to those engaged in the study of geology in Scinde and elsewhere, I have much pleasure in offering them to the public through the medium of this valuable Journal.

I wish it had been in my power to point out the particular parts of the Nummulitic Series in which they are found, but as we are perfectly ignorant of all detail of this kind respecting Scinde, it must be left for future opportunity to develop.

In the description of these Foraminifera, I shall not confine myself to their external characters alone, for generally speaking this would be useless, but having studied them by sections, shall also allude to their internal structure, which, though already given most faithfully by Dr. Carpenter (Quart. Journ. Geol. Soc. vol. vi. p. 21), yet there are some parts still incomplete which I shall endeavour to supply, and some observations which can only be made intelligible when the forms of *Operculina*, *Assilina*, *Nummulina*, *Alveolina*, *Orbitoides*, and *Orbitolites* are considered together and described successively.

The distinguishing characters of these genera, familiar, at least in name, to all who are acquainted with the classification of Foraminifera in D'Orbigny's '*Foraminifères fossiles du Bassin Tertiaire de Vienne*,' and in his '*Cours élémentaire de Paléon-*

tologie et de Géologie Stratigraphiques,' I shall here premise ; that the reader, if inclined to study them, may have no trouble in immediately referring to the same sources from which I have derived my guide.

Order III. HELICOSTEGUES.

Fam. 1. NAUTILOIDÆ.

Genus NUMMULINA, D'Orbigny.

" *Shell* free, equilateral, orbicular or discoidal, thick, encrusted, without appendices at the border, formed of a *spire* embracing, with whorls very near together and numerous ; the last always marked in the young animal, but often impossible to be found in the adult. *Chambers* small, short, near together, very numerous, the last projecting in the young animal, but indistinct in old individuals ; pierced by an opening, transverse, linear, against the turn of the spire, often concealed in the adult."

ASSILINA, D'Orbigny.

" *Shell* free, equilateral, orbicular or discoidal, very compressed, formed of a *spire* embracing only in the young animal. Afterwards whorls apparent and without appendices at the border. *Chambers* small, short, very numerous, the last projecting in the young animal, but not so in the adult, each pierced by an *opening* against the turn of the spire."

" *Relations and differences.*—The *Assilina* like the Nummulines have a projecting mouth when young ; but they are distinguished by all the turns of the spire being apparent in the adults instead of being embracing."

OPERCULINA, D'Orbigny.

" *Shell* free, equilateral, oval or discoidal, very compressed, formed of a *spire* not embracing, regular, equally apparent on both sides, turns contiguous and increasing very rapidly. *Chambers* numerous, narrow, the largest projecting beyond all the rest, pierced at all ages by an opening which is visible, triangular, against the turn of the spire."

" *Relations and differences.*—It is evident, that by the situation of its opening, this genus comes near to the Assilines ; but it is distinguished from them by its opening being triangular instead of a transverse slit, and by its chambers increasing regularly without becoming narrow towards the opening."

ALVEOLINA, D'Orbigny.

" *Shell* free, regular, equilateral, round, oblong or elongated in the direction of its axis, not variable in its enlargement, com-

posed of a very regular *spire*, embracing at all ages ; whorls often very near together, not formed of many chambers, elongated transversely, divided into a great number of capillary cavities by partitions longitudinal to the whorl, the openings round, numerous, and in lines transverse to the whorl*.”

CYCLOSTEGUES, D'Orbigny.

“ Animal composed of numerous segments placed in circular lines. Shell discoidal, composed of concentric chambers, simple or multiple ; no spire.”

“ *Cyclolina*, D'Orb. 1839. Shell discoidal, each chamber pierced by a number of pores making an entire circle round the rest.”

“ *Orbitolites*, Lamarck, 1801. (*Orbulites*, 1816, non *Orbulites cephalopodes*.) *Marginopora*, Quoy et Gaimard, 1836. Shell discoidal, plane, equal, and encrusted on both sides, presenting concentric lines. Chambers numerous in irregular transverse lines only visible at the border.”

“ *Orbitolina*, D'Orb. These are *Orbitolites* with unequal sides ; the one convex, encrusted, presenting concentric lines ; the other concave, not encrusted ; presenting numerous chambers, in oblique lines upon the side at the circumference.”

“ *Orbitoides*, D'Orb. Shell discoidal, convex on both sides, formed of a single range of chambers, round the disk, very thickly encrusted about the middle, and presenting either radiating lines or granulations†.”

To these characters I shall add the following observations before proceeding further :—

First as regards the distinction between the genera *Assilina* and *Nummulina*. This is said to consist chiefly in the spire not being embracing in the former, and which appears to be the case to the naked eye. But if we make a vertical section of *Operculina*, which, from its extreme thinness, is still further removed from *Nummulina* than *Assilina*, it will be seen, under a magnifying power, to be formed of several layers, which may be traced from the centre to the circumference, showing, that as the turn of the spire is progressing, the deposition of new material not only takes place at the margin but on both sides of the shell generally, in a line from the last chamber in process of development up to the central or first-formed one. If then this can be seen in a shell so thin as that of *Operculina*, how much more evident must it be under the same circumstances in *Assilina* !

* Foram. Foss. du Bassin Tert. de Vienne, par M. Alcide d'Orbigny.

† Cours élément. de Paléontologie et de Géologie Stratigraphique, par M. Alcide d'Orbigny.

which is the case. D'Orbigny's grand distinction, therefore, of the spire not being embracing in *Assilina*, would seem to be more apparent than real, and although sufficient for common purposes, yet, if we add to it the *absence* of chambers above and below the central plane, we shall not only have a real, but a more evident distinguishing sign for *Assilina* than the one just mentioned.

Second, as regards the division of *Nummulina* into subgenera. It appears to me that this may be advantageously done by separating those in which the septa extend from the circumference to the centre in more or less continued sinuous lines (Plate VII. figs. 11 & 15), from those in which these lines are so branched and inosculate as to present a densely reticulated structure (fig. 21).

These differences have already been alluded to by Dr. Carpenter (*loc. cit.*).

In the latter subgenus would then come *Nummularia acuta*?, Sowerby, which borders close upon *Orbitoides*, from possessing this reticulated structure on the surface, a comparatively less development of the spire and chambers, a tendency to an abrupt prominence in the centre, and an expanded thin margin.

From *N. acuta* we should then pass on to *Lycophris dispansus*, Sowerby, where the spire is still more incomplete, and then to *Orbitoides Mantelli*, or *Orbitolites Mantelli* (for we shall see hereafter that we must make this an Orbitolite), where the spire is entirely lost.

In the last two genera I have been at much pains to ascertain if the rows of chambers in the central plane are arranged spirally or concentrically, and I think that I have been as successful, as, under the circumstances, we can expect to be.

For some time I was unwillingly obliged to yield to the opinion of D'Orbigny, that the rows of chambers commenced concentrically, for having taken adult specimens of *Lycophris dispansus* and *Orbitoides Mantelli* for sections, I found the centre in each species invariably filled with calc-spar, which apparently was surrounded by circles of chambers at its circumference, that is, where the latter began to appear. Hence I had given up almost all hope of being able to determine this satisfactorily, when I conceived that the origin of this structureless centre might be owing to a decay of the central chambers only in the adult animals and its subsequent filling with calc-spar during fossilization; and, that if I took very young individuals, I might obtain what I wanted. Accordingly I made sections of specimens not larger than the 24th part of an inch in diameter, and found just what I had expected, viz. the centre in its natural state, that is, filled with chambers to the central point.

I will now shortly describe the central planes in both these species, reserving a more particular description of them until we come to the descriptions of the species themselves.

In *Lycophris dispansus* the central plane is extremely, though uniformly, thin throughout, and only one chamber deep. The chambers commence in an imperfect spire, round a central spheroidal or oval cell, not much larger than the chambers themselves generally. Around this cell are a few chambers which have—one a semilunar, and two or three the pear-shaped forms of the chambers commencing the spire in the nautiloid forms of Foraminifera (compare fig. 26. Pl. VII. with fig. 7. Pl. IV. vol. x.); the rest are more or less polygonal. From these chambers (about seven in number), as many rows of others fly off from the centre in whorls similar to the sparks of a rotatory fire-work, but these rows soon diminish in breadth, and end more or less abruptly upon the back of each other; when another set rises from their circumference, which takes a larger latitude; and so on successively, a series of whorls or wreaths follow upon the back of each other, until the rows appear to form concentric circles, still every here and there dipping inwards, or suddenly terminating on the preceding ones, even to the circumference. This is the appearance presented by the central plane; but the real spire must be traced across the rows in the position that it would be in Foraminifera wherein it is more perfectly developed, if it be traceable at all.

In *Orbitoides Mantelli**, however, the central plane is very different; here it is not uniformly thin throughout, but thin in the centre and thick at the circumference, from the cells being only half the size in the former than they are in the latter; they are also all spheroidal, or elongated vertically, and not quadrangular. When they are elongated vertically, this seems to depend on two or more running into each other in this direction; hence the central plane, instead of being composed of only one layer of quadrangular chambers as in *O. Mantelli*, is composed of a plurality of layers of spheroidal ones; this, together with the smallness of the central cells, their great similarity, and the whole plane which they compose being more or less wavy, renders it almost impossible in the section to detect the central cell itself, or to determine whether the others are arranged around it in concentric circles; while it seems almost equally impossible to trace them in circles towards the circumference, to determine this, where their arrangement even is most distinct.

Hence it would appear, that D'Orbigny is not warranted in giving the distinguishing character of concentricity to the rows of chambers in his order *Cyclostègues*, for in his three first genera, which are all alike in this respect, we have seen that it is almost impossible to determine this; and in the last genus, viz.

* Quart. Journ. Geol. Soc. vol. vi. p. 30.

Orbitoides, of which *Lycophris dispansus* is a type, it is evident that it is not the case, but that the chambers are arranged subspirally.

That *Orbitoides Mantelli* should be included among the *Orbitolites* and not among the *Orbitoides*, must also now be evident, from the striking differences that exist between it and *Lycophris dispansus*, and its identity in structure with *Orbitolites* generally; while the intervening link between it and *Nummulina* is naturally supplied by *Orbitoides* bearing the characters above mentioned. It may be observed, that the cells of the central plane in *O. Mantelli* are elongated and not spheroidal, but the one seems to be as constant as the other, and the elongation vertically only to depend, as before stated, on the thinness above and below of the walls of the cells forming the central plane, which renders those parts imperfect or imperceptible in the vertical section, and makes the cells appear to run into one another; while the opaque material or intercellular substance showing out at their sides, gives them that septal and at the same time quadrangular form, which approximates the whole central plane in appearance to that seen in the vertical section of *Orbitoides* and *Nummulina*.

There are several other observations which I have to make on the structure of these two genera, but they will be better understood in connection with their species when respectively described.

As the list of synonyms of the discoidal Foraminifera already described is very great, for the short time they have become interesting*, at the same time that their descriptions are very few and not within my reach, I shall avoid as much as possible introducing new names here, in hope that others who are more favourably situated may be able to do this from my descriptions and figures, if required, or that I may be able to do it myself at some future period, when I have better means of comparing the specimens of different localities than I at present possess. Meanwhile, as so little has been done in the subject, I am not without hope that that which I have now to offer may be found useful.

In order of description I shall not exactly follow D'Orbigny's arrangement, that I may be the better able to show the transition from the simple to the more complicated forms of discoidal Foraminifera. Thus, I shall place *Operculina* before *Nummulina*, &c.; *Alveolina* after *N. obtusa*, Sowerby, and before *N. acuta*, id.; and then pass on to *Orbitoides* and *Orbitolites*.

The figures in the Plate are intended to represent the largest

* See Murchison on the Structure of the Alps (Quart. Journ. Geol. Soc. vol. v. p. 309).

specimens of the species I have met with respectively, and where the characteristic structure externally has been too minute to be seen by the naked eye, a small portion has been magnified in the centre. Indeed in almost all, the lines and markings are larger than they are naturally, and are therefore represented as seen under a magnifying glass of low power, for in no other way could these characters be given.

As a typical description of *Operculina* and the structure of foraminiferous shells generally, I must refer the reader to my observations on *O. Arabica*, published in vol. x. No. 57 of this Magazine, by a perusal of which an understanding of what follows will be much facilitated.

OPERCULINA, D'Orbigny.

1. *Operculina inæquilateralis* (H. J. C.). Inequilateral, oval or discoidal, thin, horizontal or wavy; centre prominent, margin thickened, rounded, cord-like. Spire more or less irregular, more apparent on one side than the other, consisting of three whorls concave on one side, flat on the other, increasing rapidly from a central cell. Chambers numerous, narrow, slightly reflected. Septa reflected, more apparent on one side than the other. Diameter of largest specimens 5–24ths of an inch (Plate VII. figs. 1, 2).

Loc. Muskat in Arabia.

Obs. This species differs a little from D'Orbigny's characters in being inequilateral, but the difference between the two sides is so slight, that it cannot be referred to any other genus. The intercameral communication I have not been able to make out, and although D'Orbigny almost invariably gives its shape and position in the nautiloid Foraminifera as a distinguishing character, yet I have hardly ever been able to see it satisfactorily in any of the species that I have examined.

O. inæquilateralis is a characteristic fossil of a thick, pink-coloured, silico-calcareous, sandy stratum at Ras Ghissa, the first little cape south of Muskat, which is a port on the north-eastern coast of Arabia opposite Scinde. I have inserted its description here chiefly for the purpose of commencing with the simplest form of nautiloid Foraminifera, and also from its proximity in locality to Scinde.

2. *O.* —? Equilateral, discoidal, plane or slightly wavy, thin. Centre prominent and presenting granulations or small tubercles, projecting more in the young than in the adult state; tubercles situated over the septa, one to each; margin slightly thickened, rounded, cord-like. Spire more or less regular, equally evident on both sides; consisting of six whorls, gradually increa-

sing to the last, which is 1-24th inch broad; each whorl overlapping or embracing, with its internal border, the external margin of the preceding one, which is rounded and cord-like. Chambers numerous, reflected; septa reflected, apparent on both sides. Diameter of largest specimens 5-12ths of an inch; thickest part, which is the margin, 1-36th of an inch (figs. 3, 4).

Loc. Scinde; in company with *Alveolina*, near the town of Tatta.

Obs. In this species, which is twice the diameter of the last and generally more horizontal, the whorls are more numerous and the spire increases more gradually. I could not discover the intercameral communication.

ASSILINA, D'Orbigny.

1. *A. irregularis* (H. J. C.). Equilateral, discoidal, more or less wavy, compressed, thin. Centre depressed, margin thickened, rounded, cord-like. Spire more or less irregular, projecting on both sides, excepting in the centre, where it is nearly obscured; consisting of nine whorls increasing gradually towards the penultimate, which is 1-12th inch wide; each whorl overlapping or embracing, with its internal border, the external margin of the preceding one, which is thickened, rounded, and cord-like throughout the spire. Chambers subquadrangular, oblong, irregular in size, presenting a number of minute granulations over their surface externally. Septa straight, radiating, and a little reflected, evident on both sides except in the centre. Diameter of largest specimens 11-12ths of an inch; thickest part, which is the margin, 1-24th of an inch (figs. 5, 6).

Loc. Scinde.

Obs. This, although somewhat resembling the last-described species of *Operculina*, differs from it in being much larger and coarser in form, in the extreme irregularity of its spire and development generally, the depression in the centre, the obscurity of the three first whorls, and in the penultimate whorl being the broadest. I could not discover the intercameral communication.

2. *A.* — ? Equilateral, discoidal, slightly wavy, thick, smooth, depressed in the centre, angular at the margin, presenting broken curvilinear lines on the surface with minute granulations between them, arranged in a spiral form, radiating from the centre, indicating the position of the spire and septa. Internally whorls more or less wavy, more or less irregular in breadth, the largest between the centre and the circumference (2-48ths of an inch broad); about nineteen whorls may be counted within half an inch of the centre. No chambers above or below the central plane. Diameter of largest specimens $1\frac{1}{2}$ inch; thickest

part, which is between the centre and the margin, 3–12ths of an inch (figs. 7, 8).

Loc. Scinde.

Obs. This closely approaches *Nummulina* from its size and thickness; the spire and septa however are still more or less visible externally, but the increased thickness of the shell obscures their prominence, and gives the surface more smoothness and uniformity. The edge is thick and angular instead of being round and cord-like as in the foregoing species, and the whole now closely approaches a Nummulite.

NUMMULINA, D'Orbigny.

1. *N.* — ? Equilateral, discoidal, more or less wavy, thin, gradually diminishing in thickness from the centre towards the margin, presenting on the surface numerous small papillæ or granulations, between sinuous lines running more or less irregularly from the centre to the circumference, the latter being the most evident of the two in the young shell. Internally whorls more or less wavy, more or less irregular in breadth; the widest between the centre and the circumference (2–48ths inch broad); about twenty whorls may be counted within half an inch of the centre. Compressed chambers above and below the central plane. Diameter of the largest specimens $2\frac{4}{12}$ inch; thickness in the centre 2–12ths of an inch (figs. 9, 10).

Loc. Scinde.

Obs. The great point of difference between this and the last-described species of *Assilina* is the presence of the compressed chambers above and below the central plane in the former. The whorls here therefore are evidently what are termed embracing, and the centre is prominent on both sides instead of being depressed. This Nummulite attains the largest size of any species that has come under my observation.

2. *N. millecaput* ? Equilateral, discoidal, more or less wavy, thick, angular at the margin, presenting sinuous lines on the surface in close approximation, which extend from the circumference to the central prominence on each side, presenting a series of superficial whorls in the adult animal. Internally turns of the spire very numerous, more or less wavy and irregular in breadth, the widest between the centre and the circumference 1–48th of an inch broad; about forty-eight whorls may be counted within half an inch of the centre; compressed chambers above and below the central plane. Diameter of the largest specimens $1\frac{6}{12}$ inch; thickness in the centre 3–12ths of an inch (figs. 11, 12).

Loc. Egypt.

Obs. This differs from the foregoing species in its general thickness; the number and approximation of its sinuous lines; the absence of the small granulations or papillæ between them, and the greater number and narrowness of its whorls. The sinuous lines, although confused and in whorls all over the surface in the adult animal, are nevertheless distinctly sigmoid in the young one, running from the circumference to the central prominence of the shell on both sides.

This specimen was brought from Egypt. It appears to be *N. millecaput*. That figured by MM. Joly and Leymerie is $1\frac{1}{2}$ inch in diameter. Generally the *Nummulites* of this kind from Egypt which I have seen (those of the Pyramids to wit) have been about an inch in diameter and about 2–12ths inch thick. I have inserted its description here and figure in the Plate for the sake of comparison, not having met with one of the same kind in Scinde.

3. *N. obtusa*, Sowerby. Equilateral, more or less globular, compressed in the centre, obtuse at the margin. Surface presenting sinuous lines in close approximation, and in confused whorls in the adult animal, but simple and sigmoid in the young shell; extending from the septa at the circumference to the central prominence on each side. Internally whorls numerous, the broadest between the centre and the circumference; lines of the spire nearly as widely separated above and below the central plane as they are in the central plane itself. Chambers numerous, reflected; septa reflected. Diameter of the largest specimens 11–12ths of an inch; thickness 2–10ths; number of whorls thirty-three (figs. 13, 14).

ALVEOLINA, D'Orbigny.

1. *Alveolina melo*, D'Orb. (*Melonites spherica*, Lamarck.) Spherical, equilateral, presenting longitudinal lines which extend in a sigmoid form from apex to apex; and minute transverse parallel ridges between them, marking corresponding internal divisions of the chambers. Internally chambers fusiform, sigmoid, divided into hair-like spaces by transverse septa which are the continuations of the ridges mentioned; the whole arranged in a spiral form. Diameter 5–24ths of an inch (fig. 15).

Loc. Scinde, Arabia.

2. *Melonites spheroides*, Lamarck (fig. 16).

Loc. Scinde, Arabia.

Obs. This has the same characters as the last, with the exception of being larger and a little elongated. Longest diameter 7–24ths of an inch; transverse diameter 6–24ths. Abounds about Yolta in Scinde, where it is well known by the name of “tomra,” and

is made into strings of beads for Hindu pilgrims and others of the Hindu faith. They are said to be prepared for this purpose by being repeatedly struck with a hammer, until the external layers peeling off leave a smooth surface.

3. *Fascicolites elliptica*, Parkinson (fig. 17).

Loc. Scinde.

Obs. This also has the same characters as the foregoing species, but is much elongated, almost cylindrical. Length 7-24ths of an inch; breadth 3-24ths. It abounds about Hyderabad, and near the Buran river, in company with a discal Orbitolite to be hereafter described.

There is nothing to distinguish these species one from another but their spherical, spheroidal and elliptical forms respectively. The two latter appear to have their peculiar localities in Scinde, and to be sparingly mixed together. On the south-east coast of Arabia, where they are also found in company with discal *Orbitolites*, the spheroidal form is most common. D'Orbigny has made this the last genus of his second section of nautiloid Foraminifera, but I have inserted their description here, to show the transition from the flat to the elongated forms of his *Helicostegues*.

Let us now return to the descriptions of the other *Nummulites*; which will be found to differ from the foregoing in the absence of the sinuous lines on the surface and in the presence of the reticulated structure mentioned.

4. *Nummularia acuta*?, Sowerby. Equilateral, discoidal, wavy; centre rather abruptly prominent, margin thin, acute; surface presenting a subgranular, reticulated structure, the interstices of which tend to a spiral arrangement towards the circumference. Internally consisting of a thin central plane of chambers arranged in a spiral form, with layers of compressed ones above and below it. Whorls numerous. Chambers three times as long as the whorl is broad. Septa straight or but slightly reflected; each chamber divided into three or more reticulate divisions by sub-septa, which structure, extending from the circumference to the central prominence, gives the surface the reticulated appearance mentioned; each interstice corresponding to a compressed cell, which is the external extremity of a columnar pile extending down, more or less regularly, to the central plane. Diameter of largest specimens 7-12ths of an inch; thickness in the centre 3-10ths (figs. 21, 22).

Loc. Scinde.

Obs. This appears to be *N. acuta*, Sowerby (Grant's Geol. Cutch, *loc. cit.*), from its subgranular surface, size and shape. I do not know any other species like it in Scinde, if this be not the

one. There is another species (figs. 19, 20) of this character which abounds in the nummulitic rocks at the island of Masira, on the south-east coast of Arabia, but this appears to be *N. Garausiana* (Joly et Leymerie, Mém. sur les Nummulites, pl. 1. figs. 9–12). It is also subgranular on the surface and presents the reticulated structure of the species just described, but with a tendency to radiation in its lines, which approximates it to the *Nummulites* of the first subgenus, and therefore its place in this should precede *N. acuta*. Its diameter is 9–24ths of an inch, and its thickness 3–24ths of an inch.

The reticulated structure on the surface, while it characterizes this subgenus of *Nummulina*, also allies it strongly to *Orbitoides*. Another character which distinguishes *N. acuta* from the foregoing species, is the greater length of the chamber being in the direction of the spire instead of across it, and its subdivision into reticulate ones, which, with the thinness of the central plane, implies a commencing disappearance, or imperfect state, of the latter generally; it is also more abruptly prominent in the centre and thinner and more expanded in the margin. All this, while it separates *N. acuta* from the *Nummulites* of the first subgenus, tends towards the structure of *Orbitoides*, in which the chambers of the central plane are arranged subspirally. The lines too, which are seen descending in this as well as in other discoidal Foraminifera, to the central plane, are but the opaque matter filling up the interstices between the reticulate chambers; and in the midst of which are situated the interseptal vessels, which pass down to the central plane and ramify throughout the shell.

CYCLOSTEGUES, D'Orbigny.

ORBITOIDES, D'Orb.

1. *Lycophris dispansus*, Sowerby (Grant's Geol. Cutch, *loc. cit.*). Discoidal, wavy, more or less equilateral, centre abruptly prominent, margin expanded and excessively thin and fragile at the edge; surface subgranular or tuberculated, especially over the central prominences; tubercles round, irregular in size and shape, united together by stellate lines. Internally presenting an extremely thin plane of quadrangular chambers, compressed vertically; oblong, and arranged subspirally, with their long axis in the direction of the horizontal diameter of the shell. Compressed chambers above and below the central plane, arranged in successive layers, like those of *Nummulites*, and more or less over each other, so as to form columns, which radiate more or less regularly from the central plane to the periphery, and end in the tubercles before mentioned. Diameter of largest specimens half an inch (figs. 23–29).

Loc. Scinde, Cutch, and Arabia.

Obs. I have already stated that the chambers of the central plane (fig. 24) of this genus commence from a central cell. This cell is spheroidal or elliptical, and perhaps a little larger than the generality of those which succeed it; the next formed is semilunar, and then comes a pear-shaped chamber or two; after which, the rest, that are in contact with the central cell, are more or less polygonal. From each of these chambers comes off a line of others in a spiral form, which, diminishing abruptly in breadth, terminates upon the back of the preceding one, the first being the shortest; to this succeeds another series of lines or rows terminating in like manner, but of wider extension; and so on successively, until the plane, as before stated, appears to be formed of concentric circles. Sowerby's account and figures of the external and internal structure of this fossil (*loc. cit.*) accord with my own observations; but Dr. Carpenter (*Quart. Journ. Geol. Soc. loc. cit.*) I think has been misled in considering the pillars of Sowerby "nothing more than the opaque matter filling the perforations;" since by a proper section, these columns are seen, as before stated, to be the piles of compressed cells (fig. 29), as they ascend from the central plane, surrounded by the "opaque matter" to the periphery. It is in this "opaque matter" that Dr. Carpenter's "perforations" are situated, that is, in the interseptal or intercellular spaces, which it partially fills; his perforations being the orifices of the interseptal vessels described in the structure of the shell of *Operculina Arabica* (*loc. cit.*).

In this species of *Orbitoides* we have the "stellate lines" uniting or as it were supporting the columns of the cells. They consist of bars or vertical septa of opaque matter extending from one column to another, in straight lines, but diminishing in thickness towards the central plane, where they become faint and at last disappear altogether. They form the only distinguishing character between this species and *Orbitoides Prattii* (see illustrations to Dr. Carpenter's paper, *loc. cit.*); yet I am pretty sure that I have seen them in a section of the latter, near the central plane (where of course they were not present on the surface), just as they are represented in fig. 14 *b* of Dr. Carpenter's illustrations, which this author regards as a feature of an undescribed species. Hence I am inclined to the opinion that *Lycophris dispansus* and *Orbitoides Prattii* are but varieties of the same fossil.

I should also here mention, that when the central plane of *Lycophris dispansus* is ground down to an extreme thinness, an interseptal space appears between the septa and an opaque line in the centre of it indicative of the former existence of an interseptal vessel there, as in *Operculina* and *Nummularia*: this is also seen in Dr. Carpenter's illustrations (fig. 34).

2. *Lycophris ephippium*, Sowerby (*loc. cit.*).*Loc.* Cutch.

Obs. Of this fossil Mr. Sowerby states: "These two fossils [*Lycophris dispansus* and *L. ephippium*] may possibly be different stages of growth of the same species," which seems to me very probable.

3. *Orbitoides Prattii*.*Loc.* Scinde, Cutch, Arabia.

Obs. I have just stated the reasons which induce me to think that this is merely a variety of *Lycophris dispansus*.

ORBITOLITES, D'Orbigny.

1. *Orbitolites Mantelli* (H. J. C.). *Nummulites Mantelli*, Morton (Quart. Journ. Geol. Soc. vol. iv. p. 12). *Orbitoides Mantelli*, D'Orbigny (*ib.*). Discoidal, wavy, equilateral or inequilateral; centre abruptly prominent on one or both sides, margin more or less expanded, very thin, plane or wavy, more or less obtuse at the edge; surface smooth, subgranular or tuberculated, especially over the prominent portions of the centre; tubercles minute, round, irregular in size and shape. Internally presenting a central plane, thin at the centre, thick at the circumference, composed of spheroidal or elongated cells, small in the centre, large at the circumference, placed in rows which appear to have a concentric arrangement, but this is indeterminate; cells alternate in adjoining rows. Compressed chambers above and below the central plane, arranged in successive layers like those of *Orbitoides* and *Nummulites*; more or less over each other, so as to form columns which radiate from the central plane to the periphery, where they end in the granulations or tubercles mentioned. Diameter of largest specimens half an inch (figs. 30–31).

Figs. 32, 33, 34, appear to be merely varieties in form of the same species.

Loc. Scinde, Arabia.

Obs. This fossil, though at first sight almost identical with *Orbitoides*, is nevertheless on minute examination strikingly different. 1st. It is for the most part inequilateral, which at least is the opposite with *Lycophris dispansus*; its surface also is smoother from the granulations being more minute. 2nd. The central plane is thin in the centre and thick at the circumference; in *Orbitoides* it is extremely and uniformly thin throughout. 3rd. It is composed of a plurality of layers of spheroidal or elongated cells (figs. 36, 37); in *Orbitoides* it consists of a single layer of quadrangular cells (fig. 27). 4th. The cells are very

minute and confusedly arranged in the centre ; in *Orbitoides* they are as large in the centre as at any other part and distinctly arranged. All this, while it tends to separate *Orbitoides Mantelli*, D'Orb., from *Lycophris dispansus*, which is a type of the genus *Orbitoides*, approximates it just as much more to *Orbitolites* ; hence my reasons for changing its name.

The subgranular or tuberculated form which this species, as well as *Lycophris dispansus*, presents externally, arises from the extremities of the columns of compressed cells projecting above the surface, increased sometimes, probably, by the intercellular substance having been worn or dissolved away ; but this is not the case towards the circumference, on account of the columns being shorter, more vertical, and therefore nearer together, which of course renders the intercellular space smaller.

The septa seen in a vertical section of the central plane consist of opaque matter which surrounds the columns, and as the latter end more or less in pointed extremities upon an imaginary central plane, we often see those of the opposite side interknitting with them, and the chambers of the centre of the plane assuming a triangular shape (fig. 39) ; sometimes they are quadrangular, and the septa continuous across the plane (fig. 38) ; at others they are oblong vertically and curved a little outwards, like the septa seen in a vertical section of the central plane of *Nummulites*, which is their common form towards the circumference (fig. 37) ; while, just as often, the central plane is composed of two or three layers of spheroidal cells entire (fig. 36) ; from which I am inclined to infer, that where the other forms appear, it is merely from the cells running into each other vertically, and their parietes in this direction disappearing partially or altogether. In examining a vertical section of this plane, we frequently observe that every other space is a septum and not a cell ; this is owing to the cells being arranged alternately in adjoining rows.

2. *Orbitolites* — ? Equilateral or inequilateral, discoidal, patulous, more or less wavy, gradually diminishing in thickness from the centre, which projects a little above the general surface, to the margin, which is thin, though more or less obtuse at the edge. In other respects the structure of this is the same as that of the last species described. Diameter of largest specimens 2 inches ; thickness 3–24ths of an inch (figs. 40, 41).

Loc. Scinde.

Obs. The great points of difference between this and the last species are, that it is not abruptly prominent in the centre, and diminishes gradually to the margin. It also attains a far larger size ; and, as Dr. Carpenter has remarked, *loc. cit.*, sometimes “seems, instead of being a circumscribed disk,” to have spread

itself irregularly in every direction. The latter character is not more peculiar to it, however, than to the foregoing species.

From its frequent deep, patulous and wavy form too, the sections of this Orbitolite often indicate a stellate or other complex figure, which however is not the case when freed from the matrix in which it may be imbedded; for with the exception of the foliaceous extension mentioned, it seems almost always to be discoidal. It is sometimes thicker on one side than the other, like the last species, but tends more to a horizontal than a vertical development, and therefore more nearly approaches the species about to be described, which is altogether discal, and without any incrustation on either side, being representative only of the central plane of this and the last species.

D'Orbigny's genus *Orbitolina*, in which there is an incrustation on one side only, I have not yet seen, unless that be considered it, where one side is plane and the other convex, as in fig. 33, which I think may be a variety in form of either of the foregoing species, and which, after all, has an incrustation of compressed cells on the plane side, although not prominent. That species I consider to have no incrustation where the central plane comes to the surface.

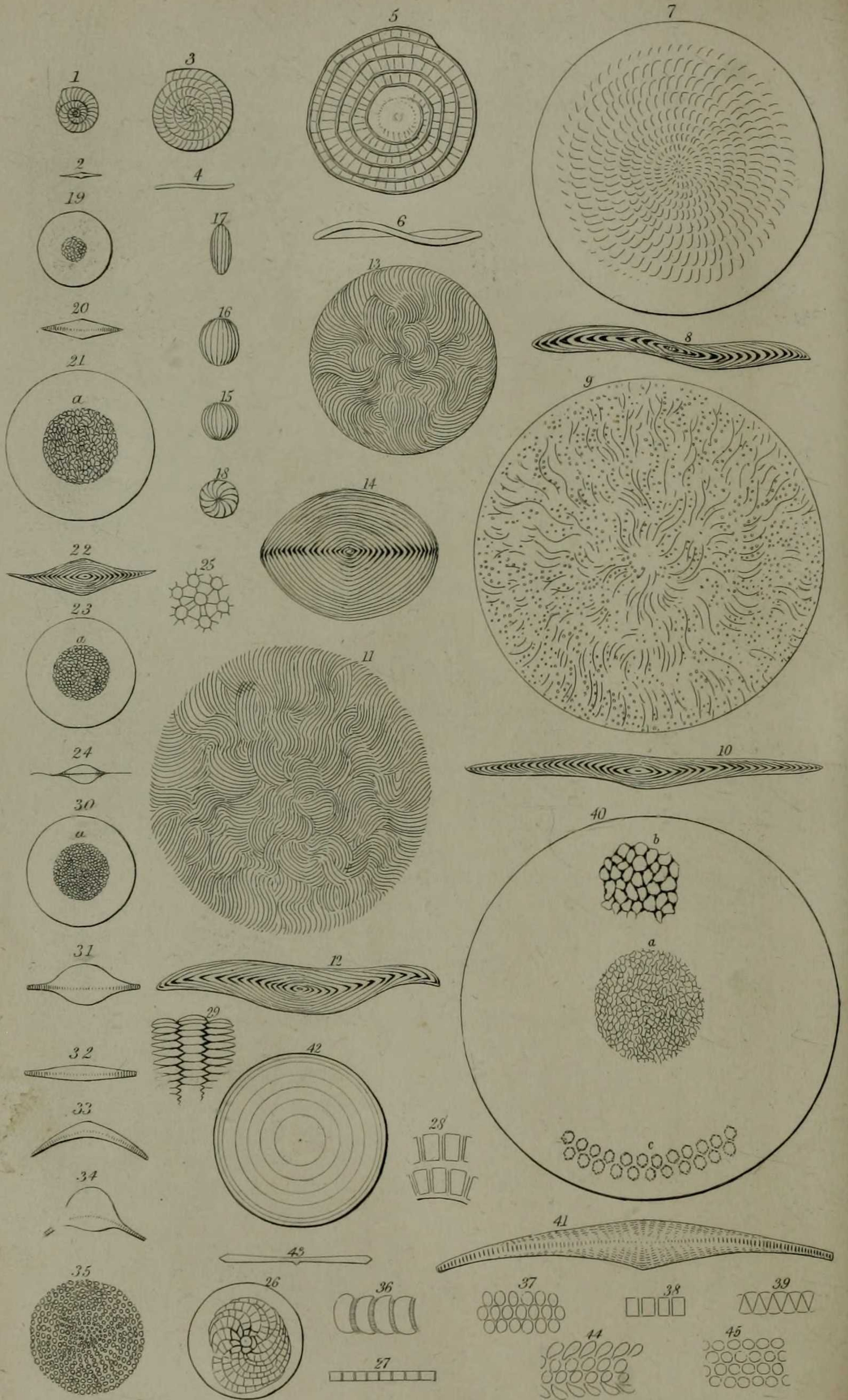
CYCLOLINA, D'Orbigny.

1. *Cyclolina pedunculata* (H. J. C.). Inequilateral, discoidal, smooth, thin in the centre, with a small papillary eminence on one side; thick at the margin; presenting concentric circles on the surface, alternately raised and depressed, with cells arranged circularly, which are hardly visible to the naked eye (fig. 25). Cells small in the centre, enlarging towards the circumference, spheroidal interiorly, elongated at the surface (fig. 44), arranged in circular rows, alternate in each row. Diameter of largest specimens 10–12ths of an inch; thickness at the margin 1–48th of an inch (Pl. VII. figs. 42, 43).

Loc. Scinde.

Obs. This is, as it were, nothing but the central plane of the foregoing species; that is, its development rests here, there being no incrustation on either side, and no compressed cells above or below the disc. I have called it *pedunculata* from the little papillary eminence in the centre on one side, this being constant in the few specimens I possess. By a typographical mistake, this species has been called "Indian" instead of Scindian, vol. x. No. 57, p. 175, of this Magazine.

Thus we have passed, in description, from the simple nautiloid form of *Operculina*, in which the spire and septa are all visible exteriorly, to *Assilina*, where they are more or less obscured in



the centre; thence to *Nummulina*, where there is an addition of compressed chambers on each side the central plane, expanding above and below into the globular form of *N. obtusa*; and elongating in *Alveolina*. Returning to the subgenus of *Nummulina*, which presents the "reticulated structure" externally, we have passed on to *Orbitoides*, where the characteristic spiro-central plane of the nautiloid forms of Foraminifera is beginning to disappear, and then to *Orbitolites*, where it is entirely lost; ending with *Cyclolina*, which bears the same relation, in the simplicity of its structure, to *Orbitolites*, that *Operculina* bears to *Nummulina*.

EXPLANATION OF PLATE VII.

- Fig. 1.* *Operculina inæquilateralis* (No. 1). 2. Vertical section of ditto.
Fig. 3. *O. —?* (No. 2). 4. Vertical section of ditto.
Fig. 5. *Assilina irregularis* (No. 1). 6. Vertical section of ditto.
Fig. 7. *A. —?* (No. 2). 8. Vertical section of ditto.
Fig. 9. *Nummulina —?* (No. 1). 10. Vertical section of ditto.
Fig. 11. *N. millecaput?* (No. 2). 12. Vertical section of ditto.
Fig. 13. *N. obtusa*, Sowerby (No. 3). 14. Vertical section of ditto.
Fig. 15. *Melonites spherica*, Lamarck (No. 1). 16. *M. spheroides*, id. (No. 2).
 17. *Fascicolites elliptica*, Parkinson (No. 3). 18. Arrangement of the septal lines at the apex in the last three species.
Fig. 19. *Nummulites Garausiana?* 20. Vertical section of ditto.
Fig. 21. *Nummularia acuta*, Sowerby (No. 4): *a*, magnified view of reticulated structure on the surface. 22. Vertical section of ditto.
Fig. 23. *Lycophris dispansus*, Sowerby (No. 1): *a*, magnified view of reticulated structure on the surface. 24. Vertical section of ditto.
 25. Stellate arrangement of tubercles, magnified. 26. Central part of central plane of chambers, magnified. 27. Portion of vertical section of ditto ditto. 28. Magnified view of septa, showing interseptal spaces and remains of interseptal vessel? 29. Vertical columns of cells ending in tubercles, magnified.
Fig. 30. *Orbitolites Mantelli* (No. 1): *a*, magnified view of reticulated structure of the surface. 31. Vertical section of ditto. 32, 33, 34. Vertical sections of varieties.
Fig. 35. Central plane of *Orbitolites Mantelli*, magnified. 36. Vertical section of elongated cells of ditto. 37. Vertical section where the cells are entire and have not run into each other. 38. Vertical section of central part of central plane where the chambers are quadrangular. 39. Ditto where the internal ends of the columns interlace with each other.
Fig. 40. *Orbitolites —?* (No. 2): *a*, magnified view of surface, showing reticulated structure; *b*, the same still more magnified; *c*, arrangement of the cells of the central plane towards the circumference. 41. Vertical section of ditto.
Fig. 42. *Orbitolites pedunculata* (No. 3). 43. Vertical section of ditto. 44. Arrangement and form of cells in vertical section of ditto. 45. Ditto on the surface.