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[*From the* Quarterly Journal *of the* Geological Society *for February* 1879.]

On a new Species of Loftusia from British Columbia. By George M. Dawson, D.S., Assoc.R.S.M., F.G.S., of the Geological Survey of Canada.

[Plate VI.]

In 1869, Dr. W. B. Carpenter and Mr. H. B. Brady described, in the 'Transactions' of the Royal Society, two remarkable types of gigantic arenaceous Foraminifera, under the generic names of *Parkeria* and *Loftusia*. For the description of the latter form Mr. Brady is more particularly responsible, and to the genus then created by him I have now to add another species, for which the name of *Loftusia columbiana* is proposed.

The original specimens of *Loftusia* were obtained many years ago by Mr. W. K. Loftus in Persia. They were referred to in his paper on the geology of the Turco-Persian frontier and districts adjoining, published in the Quarterly Journal of the Geological Society in 1855, but remained undescribed till they came into Mr. Brady's hands. From the geological descriptions by Mr. Loftus, and other forms of Foraminifera found in the same stones, Mr. Brady believes the geological position of *Loftusia persica* to be in the oldest Tertiary rocks.

The specimens now to be described are from the interior of British Columbia, and their age is, I believe, Carboniferous. Examples of the form were first collected by Mr. J. Richardson, of the Geological Survey of Canada, in 1871, and are mentioned in the Report of Progress for 1871–72. About a year ago, I examined Mr. Richardson's specimens with some care; but during the past summer, having opportunity to visit the locality from which they were procured, the occasion was taken to collect a large number of additional specimens, representing all varieties of appearance and preservation. Mr. Thomas C. Weston has prepared from these and Mr. Richardson's specimens a number of transparent sections, from which the accompanying descriptions and drawings have been made.

Most of the specimens are from Marble Cañon, a remarkable valley which runs through from the banks of the Fraser River to the bend of Hat Creek, with a direction nearly transverse to that of the main features of the country. For a distance over ten miles, the sides of the valley are formed almost continuously of mountains of limestone or marble. The first impression is that an immense thickness of limestone is represented in the exposures; but, although the dips are too obscure to allow the attitude of the beds to be worked out throughout the length of the Cañon, some small sections show that part at least of the beds have been sharply folded and the whole series of folds overturned. This being the case, it may be that a comparatively thin limestone or series of limestones forming a succession of folds superimposed on a broad anticlinal flexure account for the appearance presented. That the limestones have a very considerable thickness, however, would appear from the fact that about seventeen miles to the north-west they are seen forming a range of mountains, which rise to altitudes of over 1500 feet above the level of the neighbouring valleys, and run from near Kelly's Lake to Canoe Creek. The physical relations of the beds will, however, be described at greater length in the next Report of the Geological Survey.

Though inclined to correlate these limestone beds, on stratigraphical and lithological evidence, with others from which Carboniferous forms have been obtained, no fossils more characteristic than the joints of Crinoidal columns were for some time found in association with the Foraminifer now described. After some search, however, specimens of *Fusulina* were discovered, thus bringing these into relation with the *Fusulina*-bearing limestones found elsewhere in the province, and also very widely over the western part of the North-American continent.

Many loose fragments and boulders of *Loftusia*-limestone were also found at "The Fountain," on the surface of a high terrace, there overlooking the Fraser. This place is about nine miles south-westward from the nearest of the Marble-Cañon exposures; and the specimens here may have been derived from a distinct outcrop not yet discovered.

In certain beds of the limestones of Marble Cañon, the *Loftusia* occurs almost to the exclusion of other forms, characterizing the rock, and having been the agent in its production, just as *Fusulinæ* occur in the best examples of *Fusulina*-limestone or *Globigerinæ* in the Atlantic ooze. Other beds of a nearly white colour and almost porcellanous aspect on fracture—though purely calcareous—are found on microscopic examination to consist of the comminuted remains of smaller Foraminifera, the mass resembling a thoroughly hardened chalk. Through these a few more or less perfect *Loftusiæ* may be scattered. *Fusulinæ* appear to be very scarce in the Marble-Cañon limestones; they are much more abundant in those of other parts of the country, composed principally of Crinoidal fragments. They seem to have preferred a bottom composed of the débris of the larger calcareous organisms to the fine oozy bed most congenial to the *Loftusia*.

The typical and most abundant form of *Loftusia*-limestone is a pale or dark grey cryptocrystalline rock, in which the more perfect specimens of *Loftusia* appear thickly crowded together as paler spots, generally pretty sharply defined. The limestone breaks freely in any direction, the fracture passing equally through the matrix and included organisms, which it is impossible to separate from the stone. The matrix generally seems to be composed in great part of granular calcareous matter similar to that employed in building up the test of the *Loftusia*, but more irregular in size of grain, and with an occasional fragment of a Crinoid or example of some smaller Foraminifer. When a *Fusulina* is found, even on the same thin section with a *Loftusia*, it differs totally from the latter in appearance. The fine tubulation of the walls has not been preserved; but the calcite is homogeneous and almost milky in appearance, while the fragmental character of the test of *Loftusia* is apparent even under a low power, and it has a peculiar sparkling aspect.

In form, the species bears a close resemblance to *L. persica*, especially to the stouter variety represented in plate lxxvii. fig. 3 of Messrs. Carpenter and Brady's memoir. I have not observed any specimens to assume a form quite so much elongated in proportion to the breadth as that given in figure 3 of the same plate. It is a regular oval, with circular cross section, the ends varying from obtusely rounded to bluntly spindle-shaped. The Marble-Cañon form, however, is very much smaller than *L. persica*, both in its external dimensions and proportionally in all its structures. By measurement of a number of specimens, the average length of the shorter axis appears to be from 19 to 20 hundredths of an inch, that of the longer axis about 30 hundredths; one specimen measuring as much as $\frac{27}{100}$ in its lesser diameter has been found. Some may attain a length of $\frac{35}{100}$ or even $\frac{40}{100}$ of an inch; a remarkably long and narrow example measured $\frac{16}{100}$ of an inch by $\frac{33}{100}$ of an inch. I have not been able to observe any regular furrowing of the outer surface of the test, though from the appearance in cross sections, it is probable that a tendency to such marking exists in some specimens. Others must have become more or less rough and irregular in form, from the acervuline mode of growth frequently assumed in the larger examples. Many specimens are, like those of the Persian form, more or less oval or elliptical in the outline of the cross section. As, however, in some specimens many examples may be found in different stages of degradation towards absolute shapelessness, I believe, as Mr. Brady does of the Persian form*, that this is abnormal, and the result of changes after the death of the animal. In some cases, specimens of irregular form are scattered among others of normal appearance, and seem to have decayed or collapsed more or less completely, before the consolidation of the sediment. In other layers, the whole rock has very evidently been compressed during metamorphism, all the Foraminifera being flattened parallel to one plane.

The structure of this form is in most respects strikingly similar to that of *Loftusia persica*, and, like it, extremely complicated. Without Mr. Brady's elaborate and lucid description of the former, it would have been a matter of no small difficulty to make out the plan of growth of this smaller species, which it is possible to examine in thin sections only.

In describing the structure, the same terms made use of in the memoir already several times referred to will be employed. I would also call attention to the diagrammatic representation of the plan of the test of *Loftusia* on page 743 of the memoir.

No central primordial chamber, or series of chambers, like that of *Parkeria* has been found. The nucleus of the test appears to be, as in *L. persica*, a loose-textured granulated mass, nearly circular in cross section. It has not been observed, however, to become so distinctly cancellated as appears to be the case in *L. persica*.

In theory, this test may be said to consist, like that of the original

* *Op. cit.* p. 742.

species, "primarily of a continuous lamina coiled upon itself, like a scroll constricted at the ends. The space enclosed by this 'primary lamina' is divided into chambers by longitudinal septa. The septa are of 'secondary' growth; that is to say, they are not continuous with the principal wall or 'spiral lamina,' but are rather offshoots from it"*. As seen in a transverse section of the test, these septa are not perpendicular to the spiral lamina, but very oblique to it; and on further examination they are found to lie nearly parallel to the surfaces of a supposed second scroll, concentric with the first, but not, like it, constricted at the ends. The lines of intersection of the "secondary" septa and "primary" lamina make, therefore, curved or oblique outlines on the surfaces of the latter. The septa show, however, as straight or nearly straight lines in longitudinal and tangential sections.

A series of "tertiary" ingrowths further pass between the opposed surfaces of the "primary" lamina and these and the "secondary" septa. These processes are in the form of pillars, and are arranged in rows, longitudinally and transversely, appearing most regular in a longitudinal section. They are at right angles, or nearly so, to the "primary" lamina. The structure is further complicated by the fact that the "tertiary" columns, where they attach themselves to the spiral laminæ at their distal extremities, expand into a more or less regular cross-shaped form, the arms of which, uniting with those from the neighbouring pillars, form a reticulated framework. This, owing to the regularity of position of the columns, may almost be considered as forming a system of crossed rafters supporting the "roof" of the space contained between each two consecutive folds of the "primary" lamina, while the columns do not show any such expansion on the "floor." The spaces between the expansions or rafters, constituting a series of imperfect chambers, are further filled with a loose cancellated growth, which sometimes depends more than halfway to the "floor." This represents the system of "irregular anastomosing tubes" and "parallel columnar or tubular processes" occupying a like position in *L. persica*; but in the form now under consideration, probably owing to the greater size of the calcareous particles in proportion to that of the test, and its consequent rougher construction, no distinct tubulation is recognizable.

The greatest number of convolutions of the "primary" lamina actually observed is seventeen. Ten is a very common number in average-sized specimens. The average breadth of the space enclosed between two successive convolutions of the lamina is one hundredth of an inch; and this is maintained with considerable regularity, though in young specimens the first two or three whorls are much less. The "tertiary" processes or pillars, and the bars of the reticulated framework connected with them, are generally in diameter from one four-hundredth to one three-hundredth of an inch, very rarely as much as one hundredth.

The "primary" lamina, as in *L. persica*, is a thin and definite wall, generally appearing in microscopic sections as a well-defined,

* *Op. cit.* p. 743.

though often somewhat flexuous dark line. The "tertiary" ingrowths, or pillars, are composed of comparatively large particles, though these scarcely ever attain a size of one thousandth of an inch. Though rough in outline when examined under a high power, they are well defined and compact-looking at their proximal extremities; where they are involved in the spongy growth from the roof, they become less definite and occasionally appear almost to vanish before uniting with the lamina.

The expansions of the pillars against the roof, or rafters as they have been called, are much deeper than wide, and though definite and clearly seen in tangential sections of the lamina, are generally not distinguishable from the spongy ingrowth in transverse or longitudinal sections. Both the rafters and cancellated ingrowth appear to differ much in texture from, and to be much more transparent than, the columns. The secondary ingrowths, or septa, are of similar material, and in many cases are scarcely to be distinguished but for the expansion of the pillars upon them.

The separation of the primary lamina from the subsidiary cancellated growth, said to be common in *L. persica*, and represented in plate lxxix. fig. 2 (*op. cit.*), has not been observed in any of these specimens, a circumstance probably in connexion with their smaller size and less complex structure. Many specimens show externally a layer of variable thickness of acervuline or irregular growth. This appears to occur chiefly in those examples which may be supposed to have attained maturity, and to have formed a stronger protecting crust round the delicate fabric of the test. Fig. 2 (Pl. VI.) represents this feature, which does not appear to be found in *L. persica*. A layer of chambers without any definite external lamina appears to be formed, and these chambers communicate outward, with still less regular openings, and degenerate eventually into a cancellated or spongy mass of calcareous particles, which is generally limited by a firmer and darker outer layer. Smaller Foraminifera are occasionally included in the substance of the test of the *Loftusia*, though much larger than any of the granular fragments usually composing it.

In the matrix of some of the specimens are a few examples of a form which, though seen only in transparent section, from its precise resemblance in size and shape to that figured by Mr. Brady as *Climacammeria antiqua** in his memoir on Carboniferous and Permian Foraminifera, I have no hesitation in referring to this species.

Mr. Brady says of the genus *Loftusia* that it would "seem to find a natural place at the head of the Arenaceous series of Foraminifera, a position corresponding to *Alveolina* in the Porcellanous group, and *Fusulina* among the Vitreous forms." It is indeed remarkable to find the Palæozoic forerunner of the more gigantic Tertiary *Loftusia* agreeing with it so precisely, even in many of the more minute points of structure. The case is analogous to that of the discovery by Mr. Brady in Carboniferous rocks of *Nummulina pristina*, which in the

* Monogr. Palæontographical Society, vol. xxx. p. 68, plate ii. fig. 8.

same way corresponds very closely with the Tertiary and modern Nummulites.

In the arrangement of the pillars uniting the folds of the lamina, the spongy ingrowth filling the chambers, and in other points, this *Loftusia* bears a striking resemblance to some forms of *Stromatopora*. It differs, however, in its regularly spiral character, and in the fact that no pores have been observed to traverse the "primary" lamina. It is scarcely probable, however, that the organic connexion between the different parts of the *Loftusia* was maintained only in directions parallel to the circuitous course of the lamina.

## Genus Loftusia, Brady.

Loftusia columbiana, sp. nov.

Test oval; circular in transverse section; the ends rounded or very obtusely spindle-shaped; chambers many, narrow; septa very oblique, more nearly parallel to the sides of a cylinder than is the primary lamina; primary lamina and septa, or "secondary" ingrowths, supported by pillars or "tertiary" ingrowths; pillars numerous, arranged in parallel lines transversely and longitudinally, expanding laterally at their distal extremities to form imperfect chambers, which are filled with a loose, granular, cancellated growth. Exterior of test frequently becoming irregular and acervuline. Length of test about $\frac{30}{100}$ of an inch, width of test about $\frac{19}{100}$ of an inch; intervals between successive folds of the adult primary lamina about $\frac{1}{100}$ of an inch.

Carboniferous Limestone, Marble Cañon, British Columbia.

## DESCRIPTION OF PLATE VI.

Fig. 1 represents portion of a transparent section, nearly at right angles to the longer axis of the Foraminifer. The test is represented by the darker shading, while more transparent calcite fills the chambers. The primary lamina is designated by *a*, and is seen to be thickened by the spongy ingrowth. *b* designates one of the more perfect secondary growths or septa. Many of the tertiary ingrowths end proximally before reaching the inner lamina; this may arise in some cases from the slight obliquity of the plane of section to the direction of their axes. That the section is not truly through the centre of the form is seen at *d*, where it becomes tangential to the inner layer, and exhibits a portion of the primary lamina in plan. (× 25.)

Fig. 2 is a portion of a longitudinal section of the outer part of the test. *a* designates the primary lamina; *c* the tertiary processes or pillars. *e*, *f*, & *g* refer to the acervuline or irregular exterior portion, well developed in this specimen. At *e* an irregular tier of chambers has been formed, which pass outwards in some places almost imperceptibly into *d*, a spongy or cancellated mass, which is generally limited externally by a more or less definite wall, *g*. The secondary growths, or septa, are not seen in this section, and this is very frequently the case in longitudinal sections. It arises partly from the greater transparency of these as compared with the thickened floors and the pillars, and apparently partly also from the circumstance that they are in reality more fragile. (× 25.)

Fig. 3 represents a portion of a longitudinal tangential section, which is very instructive, as showing nearly all parts of the test. This may profitably be compared with that given on plate lxxix. fig. 1 of Messrs. Carpenter and Brady's memoir. *a* indicates a part of the primary lamina, which is thickened, as before described, and may consequently be seen as a series of rather broad dark zones, indefinite on their inner edges, and running parallel to each other. *b* points out one of the secondary growths or septa; these may be seen running parallel to the longitudinal axis of the form. They appear wide, from being cut obliquely, but also, in many cases, from the identification with them of the longitudinal rods or rafters formed by the expansion of the pillars. At right angles to these, at *i*, are seen rods formed by the union, transverse to the axis, of the distal ends of the pillars. At *c* the section becomes nearly radial, and the pillars are seen as in figure 2. At *d* part of the thickened primary lamina is shown in plan. (× 25.)

Fig. 4 is nearly longitudinal and radial, representing part of three folds of the primary lamina (*a*) and the pillars uniting them (*c*). The irregularities of these are shown, and the cancellated growth from the inner side of the lamina is indicated by *h*. (× 75.)

Fig. 5. Portion of the thickened primary lamina shown in plan. At *d* the greater part of the spongy thickening has been removed in grinding down the section. The rafter-like thickenings from the intersections of which the columns spring are here clearly seen. The darker zone surrounding this part represents the primary lamina and its thickening (*h*) obliquely cut. Where, at the edges, the section becomes more nearly at right angles to the curved lamina, the pillars may be seen running out. (× 75.)

Fig. 6. Transverse section through the nucleus of a very young specimen, showing the first convolutions. (× 45.)

Fig. 7 represents the external form of the organism of actual size. The figure on the right is of an unusually long variety.


A. S. Foord lith.

Mintern Bros. imp.

LOFTUSIA COLUMBIANA.