

THE BASE OF THE ORDOVICIAN IN THE CANADIAN ROCKIES.*

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For several years the writer has been interested in the problem of locating the contact between the Ordovician and Cambrian in the Canadian Rockies, but until the past season (1929) has had little opportunity to see the Ordovician formations in the field. Dr. Walcott applied the term Ozarkian to certain strata found in the western part of the Rockies which are between beds definitely Upper Cambrian and those which are definitely Canadian in age. The formation so situated he named the Mons, and stated: "The lower Mons (Briscoia) faunule is strongly related to that of the Upper Cambrian, and the upper faunule has a large proportion of genera of an Ordovician facies" (1, p. 36).¹

The typical locality for the Mons is on the southeast side of Mons Glacier, about 48 miles northwest of Lake Louise station, but has, until very recently, been best known from its great development in the vicinity of Sinclair canyon, northeast of Lake Windermere. According to Walcott (1, p. 16), the Mons is 3,826 feet thick in this canyon, and contains four characteristic faunules, which he named, in descending order, the Ozarkispira, Hungaia (now Kainella), Symphysurina, and Briscoia faunules.

The Briscoia fauna was found 200 and 400 feet from the base, and that of Symphysurina, 610 feet, 1,855 feet, and 2,587 feet from the base. The Kainella and Ozarkispira faunules were not found actually in this section, but on Stoddart Creek, five miles south. The Kainella faunule was 2,587 feet above the base, and the Ozarkispira faunule at 3,326 feet.

Walker, in his report on the geology of the Windermere map-area (2, p. 22) considered the Mons formations of Walcott to be the same as the Goodsir of Allan, hence used the former name, as having priority. He recognized that the oldest of the Mons faunules, that with Briscoia, was the one characteristic of a formation which Schofield had named Sabine, from its presence on Sabine mountain about 34 miles southeast of Sinclair canyon. He therefore considered the Sabine as equivalent to the lower part of the Goodsir.

*Shaler Memorial Series.

¹ See bibliography at end of paper.

Walcott had identified fossils collected by Schofield from the Sabine as of Upper Cambrian age, but after studying the section in 1924 (1, p. 27), he concluded that the Sabine was a southern representative of the Mons. This decision he reversed in 1928 (3, p. 227), thus arriving at what I consider a satisfactory solution of the problem of the Cambrian-Ordovician boundary. Incidentally it eliminates any necessity for the use of the term Ozarkian in this region.

FAUNA OF THE SABINE FORMATION.

Walcott states (3, p. 228) "the Sabine formation contains a typical Upper Greensand fauna of the Franconia formation as developed in Wisconsin. It contains *Ptychaspis*, and particularly a close ally of *Ellipsocephalus curtus*."

At the typical locality the formation is 742 feet thick. Walcott has listed the following fossils (1, p. 27):

From the upper 297 feet.

Billingsella origen Walcott, *Huenella juba* Walcott, *Eoorthis iophon* Walcott, *Agnostus* cf. *josepha* Hall, *Ptychaspis* 2 sp., *Conaspis* cf. *anatina* Hall and cf. *Saratogia wisconsinensis* Owen.

Just below these strata fragments of a *Briscoia* similar to *B. sinclairensis* were found, and nearer the base, *Ptychaspis* and *Ellipsocephalus*.

It now appears that at least 400 and perhaps 600 feet of the lower part of the Mons at Sinclair Canyon belongs to the Sabine formation. Here, among others, Walcott listed (1, p. 19): *Saukia*, 3 sp., *Briscoia dalyi* Walcott, *B. sinclairensis* Walcott, *Platycolpus* sp., *Kingstonia* sp.; *Plethopeltis* sp., *Ptychaspis* sp., *Ptychostegium* sp., and *Taenicephalus* sp.

In his latest paper (3, p. 242), Walcott recognized the Sabine formation in the lower 505 feet of the typical Mons in the Glacier lake area. Among others he listed: *Briscoia sinclairensis* Walcott, *Ptychaspis eurydice* Walcott, and *Saratogia* sp.

In the Tilted mountain section, Walcott states that the Sabine is 415 feet thick. This is southeast of Glacier lake and about 10 miles east of Lake Louise station. He lists (3, p. 292): *Eureka* sp., *Dikelocephalus* sp., *Illaenurus* sp., *Saukia* sp., *Ptychaspis* sp., *Irvingella* sp., *Conaspis* sp., *Ellipsocephalus curtus* Whitfield and others.

Still further southeast in the Ranger canyon section in the

Sawbacks, about 7 miles west of Banff, Walcott cites an "unnamed formation" which is evidently the Sabine. It contains (3, p. 266): *Eoorthis*, *Agnostus*, *Briscoia*, *Saukia*, and *Hardyia*.

These are the principal known localities for the Sabine. I think one can hardly question the Upper Cambrian age of the fauna. There is no admixture of any element which suggests the Ordovician.

FAUNA OF THE MONS FORMATION.

The Mons formation as restricted by Walcott in 1928 contains only three instead of four faunules. So far as at present described these are not very distinct. *Symphysurina* for instance, seems to extend all through the formation. Only a very small part of the fauna is, however, described.

The Glacier lake section is the type for the Mons, there 975 feet thick. From the upper 60 feet, Walcott listed, among others (3, p. 341): *Ozarkispira leo* Walcott, *Walcottoceras monsenis* (Walcott), *Endoceras robsonensis* Walcott, *Plethopeltis* sp., *Hystricurus* sp., *Leiostegium* sp., and *Xenostegium eucerus* Walcott. The other faunules are not mentioned.

The Clearwater canyon section is about 40 miles southeast of Glacier lake. The Mons has there a thickness of 1,338 feet according to Walcott (3, p. 327).

The *Ozarkispira* faunule is found in the upper 230 feet. From a horizon about 970 feet below the top Walcott lists: *Protorthis ionos* Walcott, *Agnostus* sp., *Hystricurus* sp., *Kainella* sp., *Symphysurina* sp., *Xenostegium shepardi* Raymond, and *Bellefontia nonium* Walcott. In the basal 18 feet, *Syntrophia* cf. *calcifera* (Billings) and *Symphysurina eugenia* Walcott were found.

At Fossil Mountain and further southeast in the Sawbacks similar but less extensive faunas were obtained.

Returning to the Sinclair canyon and Stoddart creek sections in the Stanford range, we find that with the Sabine formation removed, the Mons is still about 3,300 feet in thickness. Near the top, with *Ozarkispira*, Walcott found (1, pp. 17-23): *Xenostegium* 2 sp., *Agnostus* sp., *Hystricurus* sp., and *Bellefontia*. Lower in the section, with *Kainella*, were *Symphysurina* sp., *Apatokephalus* ? sp., and *Hystricurus* sp.

The middle, or true *Symphysurina* faunule had, besides that genus, *Hystricurus* 4 sp., *Lingulepis nabis* Walcott, *Lingulella*

ibicus Walcott, *Syntrophia perilla* Walcott, *Billingsella coloradoensis* (Shumard), and others. Nearer the base, fragments of *Xenostegium* were found.

CHUSHINA FORMATION.

The equivalent of the Mons in the Robson district was called the Chushina formation by Walcott. It rests on the Upper Cambrian Lynx formation, which is apparently the equivalent of the Sabine, since it has yielded *Dikelocephalus* to Burling (3, p. 367).

The fossils known from the Chushina have been derived from the Extinguisher. Walcott lists, among others (3, p. 359): *Lingulella ninus* Walcott, *L. ibicus* Walcott, *Billingsella archæas* Walcott, *Endoceras robsonensis* Walcott, *Walcottoceras monsenis* (Walcott), *Hystericurus*, several species, *Apatokephalus* sp., *Kainella billingsi* Walcott, *Kainella*, 7 sp., *Symphysurina*, 7 sp., *Xenostegium taurus* Walcott, and *Leiostegium*, various species.

Collecting at this locality recently, the writer was greatly impressed by the abundance of asaphoids. The general aspect of the fauna is Ordovician. *Bellefontia*, *Hemigyraspis*, *Symphysurina* and other asaphoids were the most common fossils.

A discovery of the greatest interest and importance was made by Mr. A. Lombard last summer in the medial moraine below the Extinguisher. He found a small slab containing four specimens of graptolites which Dr. Ruedemann has identified as *Dictyonema flabelliforme anglica* Bulman. Dr. Ruedemann has very kindly prepared descriptions and figures, which are included in a note which follows this article. The presence of this graptolite indicates, as Dr. Ruedemann points out, the lowest zone of the Ordovician, and greatly strengthens the evidence derived from the other fossils.

AGE OF THE FAUNAS OF THE MONS AND THE CHUSHINA.

Dr. Walcott considered that the faunas of these formations were of "Ozarkian" age, that is, that they were younger than the Cambrian and older than the Ordovician. In an earlier paper (4), written when much less was known about them, I tried to show that they were of earliest Ordovician age, comparable to the Ceratopyge faunas of Europe. It is now

obvious that I tried to prove too much, for I managed to bring *Briscoia dalyi* into the discussion. The article was, however, written before Walcott's work was published—in fact, before most of it relevant to the present subject was even done.

I find that my present opinion, after several years of experience, is not very different from what it was in 1922. I have not been in the Stanford range or in the Glacier lake district, but have seen something of the faunas at Donald, B. C., in the Robson district, in Jasper Park, and in the Sawbacks. I have also had the advantage of a critical study of the trilobites of similar faunas in northern Vermont (5). Perhaps because of this latter experience, I am particularly impressed by the similarity of conditions at the end of the Cambrian in the western Canadian Rockies and in Vermont. In neither region is there evidence of any emergence of long duration at this time; in both, thinly bedded limestone was being deposited both during and after the Upper Cambrian; in both places intraformational "edgewise" conglomerates were formed, indicating recurrent periods of shallow water and brief emergence. The same types of fossils, and some of the same genera are found in both regions. In both, the occurrence of fossils is remarkably sporadic.

Although there is no Ordovician element in the fauna of the Sabine formation, the brachiopods of the Mons and Chushina have a decidedly Upper Cambrian aspect. Such genera as *Lingulella*, *Lingulepis*, *Billingsella* and *Eoorthis* are well represented. These form, however, the chief residuals from the older days. *Syntrophia* is a genus as characteristic of the Beekmantown as of the Cambrian. The few gastropods and cephalopods so far found suggest Ordovician rather than Cambrian, but it is in the trilobites that one sees the new order of things.

The most striking and abundant of the trilobites of the Mons are the asaphoids and asaphoid-like trilobites. *Isoteloides* is common in the typical Beekmantown, *Bellefontia* according to Walcott is chiefly "Ozarkian" but passes into the Beekmantown (the type-species is Canadian), and the trilobites which I have been calling *Hemigyraspis* are Canadian. The fossils which I confused with *Symphysurus* in my previous article, now named *Symphysurina* by Walcott, appear to be closely allied to *Platypeltis*, which has commonly been considered as synonymous with *Symphysurus*. I agree that the three genera can be dis-

tinguished, but they are apparently closely related and of about the same age. Changing the name has not yet been shown to have altered the significance. *Xenostegium* may not be a true *Megalaspis*, but it is a type of trilobite that one would associate with an Ordovician rather than a Cambrian fauna. In addition to these abundant asaphoid-like trilobites, there are several species of *Hystericurus* and *Leiostegium*, both Beekmantown genera in Vermont and eastern Canada.

The "hold-overs" among the trilobites are *Kainella* and *Plethopeltis*. *Kainella* appears to be a dikelocephalid closely allied to *Richardsonella*, which is found in the Upper Cambrian of Vermont. *Plethopeltis* is well represented in the Upper Cambrian of New York, Vermont, Quebec, and the upper Mississippi Valley.

The presence of *Dictyonema* goes far toward upholding my contention that the fauna of the Mons is oldest Ordovician.

FAUNA OF THE FORMATIONS SUCCEEDING THE MONS.

In the Windermere region, the Mons is, in most places, overlain by the Glenogle shale. It is of variable thickness, but where best developed, it has faunules of three zones of the Levis, the upper with *Diplograptus dentatus*, the middle with *Tetragraptus*, and near the base, a poor representation of the *Clonograptus* fauna. In other words, the Glenogle appears to be of Upper Beekmantown age.

At Glacier lake, and southeastward to the Sawbacks, the limestone of the Sarbach formation is above the Mons. Very little has yet been published about the fauna of the Sarbach. At Glacier Lake, above the typical Mons, it is reported to contain *Isoteloides* and fragments of other Canadian fossils (Walcott, 3, p. 340). The longest list yet published is that of Walcott from the northeastern shoulder of Fossil mountain, about 10 miles northeast of Lake Louise station. These are (3, p. 389) *Phyllograptus ilicifolius major* Ruedemann, *Didymograptus pacificus* Ruedemann, *Ophileta* sp., *Eopteria* sp., *Megalaspis* sp., and *Goniurus* sp. Ruedemann considered the graptolites to indicate zones 2 or 3 of the Deep Kill section. These fossils were from the upper half of the Sarbach, suggesting that the formation is the calcareous equivalent of the Glenogle.

The lower part of the Sarbach at Clearwater canyon is said to contain a *Megalaspis-Bellefontia* fauna (3, p. 330).

In Sinclair canyon and elsewhere in the Stanford range, the lower part of the Glenogle is calcareous, and contains a small fauna which suggests the Sarbach; Walcott (3, p. 221) reports the finding by Walker of a *Megalaspis* similar to *M. limbata* and a *Shumardia* in limestone above the Mons and beneath the shale of the Glenogle. *Shumardia* is a very common fossil in the Levis.

The Mons is, therefore, followed by formations of Upper Beekmantown age.

SUMMARY.

The lower portion of the "Ozarkian" of the Canadian Rockies has been segregated as the Sabine formation, which Walcott has shown to have a typical Upper Cambrian fauna. The remainder of the Mons is characterized by a fauna with striking Beekmantown affinities. As in the east, certain elements of the Cambrian fauna linger, but the Ordovician types predominate. Some of the genera in the Mons persist into the Sarbach, which is of Upper Beekmantown age.

There is no difficulty in distinguishing the fauna of the Sabine from that of the Mons, hence the contact between the two formations is a practical as well as a logical place to draw the line between the Upper Cambrian and Ordovician.

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