ART. XIII.—*Further observations on the age of the Red sandrock formation (Potsdam group) of Canada and Vermont;* by E. BILLINGS, F.G.S., Palæontologist of the Geological Survey of Canada.

1. QUESTIONS OF PRIORITY.

AT the time of writing the note on the Red sandrock formation of Vermont in this Journal, last September ([2], xxxii, 232), I was not aware that Prof. C. B. Adams had previously recognized the resemblance of the Highgate trilobites to *Conocephalites.* Shortly afterwards while searching for some of the earlier published documents on the older rocks of North America I met with his paper and published it in full in the Canadian Naturalist and Geologist in an article on the Rocks and Fossils of Phillipsburgh (Can. Nat. and Geol., vol. vi, p. 324). Mr. Hitchcock's note in this Journal, ([2] xxxii, 454) shews that Prof. Z. Thompson was the original discoverer of the trilobites in question. He also states that these fossils were sent to Prof. Hall in 1847, who then gave them the name of *Conocephalus* and further that he (Mr. Hitchcock) again shewed them to Prof. Hall in 1858, and that he was not then able to give more definite information respecting them. I have never seen the Third Annual Rept. Geol. Vt. to which Mr. Hitchcock refers. I did not assume to have discovered the fossils, but so far as is known at present, I was the first to decide the age of the Red sandrock series on palæontological evidence alone. Dr. Emmons has long held that these rocks belong in part to the Calciferous and in part to the Potsdam formations. My observations only go to show that he is right.

I must also state that Barrande first determined the age of the slates in Georgia in Vermont holding *P. Thompsoni* and *P. Vermontana.* At the time I wrote the note on the Highgate trilobites it was not known that these slates were conformably interstratified with the Red sandrock. This discovery was made afterwards by the Rev. J. B. Perry and Dr. G. M. Hall, of Swanton. As to the Taconic rocks, it should always be borne in mind that since Emmons first published his Taconic System both Sir Roderick Murchison and Barrande have extended the Lower Silurian downwards so as include the Primordial zone. The Taconic rocks are thus made the base of the Lower Silurian, not by Prof. Hall but by Sir R. I. Murchison and Barrande. Emmons correctly determined their age in a general way by placing them below the Lower Silurian as it was defined in 1839, or in the base of the Lower Silurian as the formation is now limited. The age of the limestones at Point Levi opposite Quebec was determined by me in 1860.

2. Additional evidence on the age of the Red sandrock.

During the last summer Mr. J. Richardson, of our Survey, was engaged under the direction of Sir W. E. Logan in making an examination of the rocks on both shores of the Straits of Belle Isle, the object being to find if possible a section in which the sequence of the lower formations might be seen to better advantage than they can be in the disturbed region of Canada East. He returned in October, having been completely successful. On the North shore of the Straits he found at the base of the series 141 feet of sandstone holding *Scolithus linearis* resting upon the Laurentian formation; and lying upon the sandstone 231 feet of limestone with *P. Thompsoni*, *P. Vermontana*, and a number of other species of which I shall give a list farther on. On the south shore of the Straits he found a great series of limestones, the lower part of which undoubtedly belongs to the Calciferous sandrock formation. The upper portion may belong in part to the Chazy and Black River, but the fossils appear to be all new species and have not yet been studied sufficiently to decide with certainty from their aspect alone. The sandstones and limestones on the north shore of the Straits appear to be of the age of the Potsdam of Pennsylvania and Tennessee. The form of the *Scolithus* is identical with that which occurs in these two States, and some portions of the rock is a coarse red sandstone exactly like specimens sent to me about a year ago from Tennessee, by Prof. Safford.

Since the date of my former note published in this Journal in September last (before quoted), the Red sandrock of Vermont where it extends into Canada near Phillipsburgh, has been examined more in detail by Sir W. E. Logan and myself. At Herrick's Mills in the Township of St. Armand where the formation is cut through by the valley of the Rock River it is overlaid on the east side by a series of black slates and thin-bedded limestones holding *Bathyurus Saffordi*, the most abundant trilobite of the upper part of the Calciferous sandrock. The same rocks in the same relation extend into Vermont. *B. Saffordi* was found in several places in the limestone interstratified with the slate near the junction of the two formations in the first mile south of the boundary line, beyond which the rocks were not examined. Dr. P. J. Farnsworth of Phillipsburgh also collected fragments of trilobites one mile east of the sandrock and about a mile south of the boundary in Vermont. These appear to belong to a species of *Asaphus*. On the west side of this exposure of the Red sandrock, three-fourths of a mile south of the line, I found another locality of *Conocephalites*, but the species is different from that noticed in my former communication. I have described it under the name of *C. arenosus*.

But the most important and interesting locality is 1½ miles east of Swanton, discovered by the Rev. J. B. Perry and Dr. G. M. Hall. The black slates holding *Palæophycus incipiens*, *Obolella cingulata*, *Orthisina festinata*, *Camerella antiquata*, *Paradoxides Thompsoni*, *P. Vermontana* and *Conocephalites Teucer*, are here seen conformably interstratified with the Red sandrock. Four of these species occur in the limestone which immediately overlies the sandstone with *S. linearis* on the north shore of the Straits of Belle Isle, and it therefore seems quite clear that the rocks of these two localities (860 miles distant from each other) are of the same age.

Taking all these facts together scarcely anything more is necessary to show that the Red sandrock of Vermont is of the age assigned to it by me from the examiuation of the *Conocephalites* at Highgate in July last. The independent discoveries of Mr. Richardson at Belle Isle and of Dr. G. M. Hall and Mr. Perry at Swanton are quite conclusive as to the geological position of *P. Thompsoni* and *P. Vermontana*. Barrande's opinion founded altogether upon the aspect of these trilobites is thus completely verified.

My object in making these researches was to ascertain with as much certainty as possible the age of the sandstone at Phillipsburgh, and, in prosecution of that design, I examined the rocks at St. Albans, Burlington, and Snake and Buck mountains, (the last two localities in Addison county, Vermont). At the promontory called Sharpshins, on the lake shore near Burlington, the cliff consists of black slate at the base, overlaid by what appears to be a whitish magnesian limestone. This place has been several times described, but what struck me as particularly worthy of notice, is that the under side of the limestone, where it is in contact with the slate is smoothed, presenting very much the appearance of slickensides. I infer from this that either there is a fault here, or, that the limestone has moved on the surface of the slate. The limestone appears to be either Potsdam or Calciferous.

Snake and Buck mountains have often been appealed to by the advocates and opponents of the Taconic System. The first mentioned of these two hills is capped by sandstone and magnesian limestone beneath which there is to be seen a great formation of black slate. Emmons calls the latter Taconic slate, and the upper rocks Calciferous sandrock. He also holds that there is a fault running along the face of the mountain by which the sandrock is thrown up, so that its base is 700 feet above the Trenton limestone. In this I think he is right, but the rock which constitutes the top and eastern slope is not Calciferous; it is the Potsdam. I crossed the mountain from west to east about three-fourths of a mile from its northern extremity, and found the sandstone

with the interstratified magnesian limestone to be of great thickness. In the last exposure in the fields at the eastern side, I found the same form of *Scolithus* in abundance which characterizes the upper beds of the Potsdam in Canada. I could not find the exact position of the fault in this mountain, but at Buck mountain, which is of exactly the same structure, I think its existence can be positively determined. This mountain is cut in two by a narrow valley crossing it obliquely near the southern extremity. The road through this valley runs to Vergennes. Following this road from the south, after passing through the gorge in the mountain we cross a level meadow several hundred yards in width. Where the road leaves the meadow there is a small ascent caused by an exposure of the Chazy or Black River limestone. On reaching this point the observer should turn to the right and go straight to the base of the mountain. Here the exact position of the fault can be seen. The sandstone rises in a nearly vertical wall to the height of about 80 feet. At the base the blue fossiliferous limestone dips towards the cliff, but is separated from it by an interval of about 15 or 20 feet—covered with broken stones. Here there is positive evidence of a dislocation, because in following along the base of the cliff, lower beds of the sandstone continually rise from below above the limestone. This occurs in consequence of the strata of the two formations, not being tilted up in the same plane, the sandstone on the east side of the fault dipping more to the south than the limestone on the west side. While upon the spot I thought I could see the edge of the fissure on the west side. I have pointed out this locality thus particularly with the hope that some other geologist may be directed to the spot who may have more time to study the details than I had.

The fault at Snake Mountain must have an upthrow on the east side of about 3000 feet, for it is equal to the whole thickness of the 700 feet of black slates, the whole of the Potsdam Calciferous, Chazy, Black River, and part of the Trenton. The mountain itself is at present only about 1000 feet higher than the surrounding plain, having, no doubt, been reduced by denudation. It appears to me quite certain that there must be a great deposit of slate beneath the Potsdam in this region, otherwise, this enormous fault would have brought up the Laurentian gneiss. But no trace of it is seen anywhere about the mountain except in the the usual forms of loose boulders.

I shall conclude with a list of the fossils discovered at the localities above mentioned. I place the sandstone and limestone of Belle Isle and the red sandrock of Phillipsburgh and Vermont in the Potsdam group provisionally, leaving it for those who are more interested in the nomenclature of the formations than I am to decide upon any other name that may be found to be just and more generally satisfactory.

Table showing the geographical and geological distribution of the species mentioned in this paper in Vermont and Belle Isle, so far as is known at present.

	Geographical distribution.			Geological distribution.	
	Belle Isle.	Vermont.		Potsdam group.	Calciferous Sandrock.
1	*		Scolithus linearis (Hall),	*	
2	*	*	Palæophycus incipiens (Billings),	*	
3	*		" congregatus "	*	
4	*		Archeocyathus Atlanticus "	*	
5	*		" Minganensis, "	*	*
6	*		Obolus Labradoricus "	*	
7	*		Obolella chromatica "	*	
8	*	*	" cingulata "	*	
9	*		Orthis (undescribed) "	*	
10	*		" " "	*	
11		*	" " "	*	
12		*	Orthisinia festinata "	*	
13		*	" (undescribed) "	*	
14	*		" " "	*	
15		*	Camerella antiquata "	*	
16	*	*	Paradoxides Thompsoni (Hall),	*	
17	*	*	" Vermontana "	*	
18	*		Conocephalites miser (Billings),	*	
19		*	" Adamsii "	*	
20		*	" Teucer "	*	
21		*	" Vulcanus "	*	
22		*	" arenosus "	*	
23	*		Bathyurus senectus "	*	
24	*		" parvulus "	*	
25	*		Salterella rugosa "	*	
26	*		" obtusa "	*	
27	*		" pulchella "	*	

Upon the above table I beg to make the following remarks:

The two genera of trilobites *Paradoxides* and *Conocepholites* are undoubtedly Primordial types. Bathyurus makes its first appearance in the Potsdam group, is most abundant in the Calciferous sandrock, and becomes extinct in the lower part of the Trenton, where it is represented by one rare species, *B. spiniger*, the *Acidaspis spiniger* of (Hall) Pal. N. Y., vol. i, p. 241, pl. 64, fig. 5.

OBOLELLA is a new genus closely allied to *Obolus*. There are four species known to me, one in the Potsdam of Wisconsin, another in the limestone near Troy in New York, (apparently either Calciferous or Potsdam) and the two mentioned in the above list. One of these, *O. cingulata*, may constitute a distinct genus. I have proposed to call it *Koturgina* but retain it for the present in *Obolella*.

ORTHISINA FESTINATA is about the size of the well known *O. Verneuli.* Externally it has more the aspect of a Trenton limestone fossil than that of a Primordial form. The casts of the interior however show that the dental plates of the ventral valve are totally absent, while in the species of the upper part of the Lower Silurian they are largely developed. This difference is so great that some naturalists would make a new genus for the reception of this species.

CAMERELLA ANTIQUATA is very like the Chazy *C. varians.*

The species of *Orthis* are of the fine ribbed type like *O. perveta* (Conrad) Chazy, Black River and Trenton.

ARCHEOCYATHUS, is a remarkable new genus with a radiated poriferous structure and I am not yet quite certain whether it should be referred to the Sponges or to the true Corals. One of the species, *A. Minganensis,* resembles a huge *Cyathophyllum* two feet in length and four inches in diameter, but with the cup so deep that only about half an inch at the base is solid, the whole resembling a curved hollow cylinder narrowed to a point and closed at one end. This species occurs in the limestone of Belle Isle and also in rocks which seem to be the bottom of the Calciferous sandrock at the Mingan Islands.

SALTERELLA. I have proposed this genus for the reception of some species of small conical fossils composed of several hollow sheaths inserted one within the other. They resemble *Tentaculites. Serpulites Maccullochi* (Salter) in SILURIA, and also in the Jour. Geo. Soc., vol. xv., pl. 13, fig. 31, of the Lower Quartz Rock of Scotland, is a species of the same genus.

The new species are all described in a brochure recently published by the Geological Survey. (NEW SPECIES OF LOWER SILURIAN FOSSILS. By E. Billings. Montreal, Nov. 21st, 1861.)

Montreal, Canada E., Nov. 25, 1861.