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THE UPPER PART OF THE EDMONTON FORMATION OF RED DEER VALLEY, ALBERTA

(REPORT)

BY

C. M. STERNBERG

OTTAWA

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INTRODUCTION

The Edmonton formation on Red Deer River is a significant succession of beds, not only because of its important coal deposits and its abundant content of dinosaurian remains, by means of which its age can be closely determined, but also because of the splendid section of about 1,000 feet (1, p. 61)[1] of beds from the marine Bearpaw to the close of the Cretaceous period.

[1] References, in brackets, are to publications listed at the end of this report.

Tyrrell referred to these beds as the Edmonton series, which he regarded as uppermost Cretaceous (13, p. 138), and drew the upper contact at the top of the Big (Ardley) coal seam (13, p. 61). Brown also regarded the top of the Ardley seam as the top of the Edmonton (3, p. 362).

Sanderson divided the Edmonton series into Lower, Middle, and Upper members, and included in the Upper member the beds above the Ardley seam to an erosional unconformity at the base of the Paskapoo formation (1, pp. 61, 62). He placed the contact between the Lower and Middle members at the top of a thin marine bed, named the Drumheller marine tongue (1, p. 63), and the base of the Upper member was drawn at the top of a dark, possibly marine, shale that includes a layer of volcanic ash that he named the Kneehills tuff. Sanderson has correlated this tuff bed with a similar bed in the Cypress Hills area near the top of the Whitemud formation (1, p. 94). He says, "The discovery at the top of the Edmonton of a marked disconformity that appears to have been developed during the deposition of the Lance and some later beds, leads to the conclusion that the Upper Edmonton is older than the Lance of Montana and Wyoming" (1, p. 93). Russell follows Sanderson in correlating the Whitemud of Saskatchewan with the upper part of the middle Edmonton member (9, p. 127).

Vertebrate palaeontologists, who have collected from the Edmonton formation in the past, considered it as a continuous series of beds (3, p. 373), and reference to lower or upper parts of the formation had no connection with Sanderson's division. Very little collecting was done from above the volcanic tuff bed except for 2 or 3 miles upstream from the old Tolman ferry, where good exposures are to be found especially on the east side of the river. Brown regarded the Edmonton as intermediate in age between the Belly River and Lance, but closer to the former (3, p. 374). Some 12 years after Brown's paper appeared, the writer published a few notes on the Edmonton formation, in which he concluded that it was nearer Lance than Belly River age (10, p. 104).

Part of the 1946 field season was spent by the writer in collecting from Upper Edmonton beds for the purpose of correlation. Collecting and observations were confined largely to tps. 33 and 34, rges. 21 and 22, W. 4th mer.

AGE OF UPPER EDMONTON BEDS

The discovery, during the 1946 field season, of Triceratops in the Upper Edmonton member throws new light on the age of these beds, and shows that Sanderson's division between Middle and Upper Edmonton members represents a distinct faunal break. The Ornithischia, especially the Ceratopsia, evolved very rapidly and, therefore, are splendid horizon markers. Triceratops is a well recognized Lance genus, and its presence in the Upper Edmonton beds shows that this member must be considered as of Lance age. Parts of three skulls of Triceratops were collected between the tuff bed and the Ardley coal seam. One, consisting of a brow horncore, part of a dentary, and many pieces of the crest, was in a slumped block in NW. $\frac{1}{4}$ sec. 29, tp. 34, rge. 21, now 90 feet below the Ardley? seam but probably dropped as much as 20 feet from its original position. The other two specimens[1]

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[1] The term "specimen" as used here, refers to all parts of one individual.

were obtained in NW. $\frac{1}{4}$ sec. 2, tp. 34, rge. 22. One was in slumped beds and scattered over the hillside, but the other was in place in a bed of clay 55 feet above the tuff bed on the west side of Red Deer River. This last specimen consisted of the left half of the skull with complete left squamosal, but lacking the jaws, nasal horncore, and beak. There were also a few disarticulated dorsal vertebrae and massive ribs. This specimen will be studied and described later. Also fragments of crests, an occipital condyle, and caudal vertebrae of Triceratops, teeth of Leptoceratops, vertebrae and limb bones of Thescelosaurus, phalanges of Ornithomimus, and a skeleton of Tyranosaurus? were collected or observed. The skeleton of Tyranosaurus had partly fallen out of the bank, and was in such hard sandstone and ironstone that it was not worth collecting. It lay 45 feet below the Ardley seam, on the east side of a large coulée in NE. $\frac{1}{4}$ sec. 10, tp. 34, rge. 22. (Sandstone sample No. 2 was collected from just above this skeleton.) The writer hesitates to identify the large carnivorous dinosaurs from poorly preserved material, but this specimen shows very open cancelous structure, much more so than in Gorgosaurus or any specimen observed in the lower parts of the Edmonton formation, and a cervical centrum checks closely with those described by Osborn as Tyranosaurus (8, p. 387). Hadrosaurs appear to be very scarce, and although Brown reports one from the upper beds, no remains were seen by the writer in the Upper Edmonton member, whereas in all lower beds hadrosaurs are by far the most common forms.

The writer revisited the quarry from which he collected the type of Thescelosaurus edmontonensis in 1925 (11), and determined that it is in the Upper Edmonton member near the base of the thick sandstone bed just above the tuff. No bones of

Thescelosaurus were ever collected or observed by the writer below this tuff bed.

Brown reported a skull and part of skeleton of the Lance genus Ankylosaurus and a fragmentary skeleton of a ceratopsian (3, p.360) from the upper part of the Edmonton. The ceratopsian was later described as Leptoceratops gracilis (4). It has not been possible to establish positively that these specimens came from above the tuff bed, but Mrs. R. H. Nichols, scientific assistant at the American Museum of Natural History, wrote, at Dr. Brown's suggestion, that the stratigraphic locations of the Ankylosaurus and Leptoceratops specimens could best be seen from photographs published by Brown in a popular article (2, pp. 276-277). These illustrations undoubtedly show the thick sandstone bed near the base of the Upper Edmonton member. For the illustration on page 277 the caption states that the pick points to the skull of Ankylosaurus at a point 300 feet above the river. The illustration on page 276 shows clearly that the sandstone bed is above a rather extensive bench that seems to be the same as the one in this area at about the level of the tuff bed. Elevations by aneroid barometer indicate that the level of the tuff is about 250 feet above the river.. Mrs. Nichols stated that both specimens came from the same horizon. It seems almost certain that both of these specimens were collected from above the tuff bed. Also the shark described by Lambe as Palaeospenax ejuncidus and the mammal tooth ?Eodelphis sp. reported by the writer (10, p. 104) are now known to have come from above the tuff horizon.

With this revised information as to the horizons from which certain specimens were collected, it is evident that only one known Middle Edmonton, ornithischian genus, that is Anatosaurus, continued to Lance time. There is no positive evidence that any parts of Arrhinoceratops, Anchiceratops, Saurolophus, or any member of the Lambeosaurinae[1] came from the upper 50 feet of the

[1] There do not appear to be good grounds for removing Cheneosaurus and Tetragonosaurus to a new subfamily, the Cheneosaurinae, as was done by Lull and Wright (6, p. 178).

Middle Edmonton. The faunal evidence seems to justify Sanderson's and Russell's correlation of the upper part of the Middle Edmonton with the Whitemud formation of southern Alberta and Saskatchewan, but the erosional unconformity between the Whitemud and Frenchman formations is considerably older than that below the Paskapoo. The Upper Edmonton member is here correlated with the Frenchman formation of Saskatchewan (5, p. 94). No unconformity has been noted at the base of the Upper Edmonton member, but it was noted that the change in the type of sediments is abrupt, and that in some places small clay balls are mingled with dinosaur bones in the coarse sandstone overlying the dark clay bed containing the Knoehills tuff.

Though there is a definite faunal break between the Middle and Upper Edmonton members there does not seem to be any faunal break between the Lower and Middle Edmonton beds. Anchiceratops, Hypacrosaurus, Cheneosaurus, Saurolophus, Edmontosaurus, and Anatosaurus are all known from both below and above the Drumheller marine tongue. Arrhinoceratops came from just below this bed. The Belly River (Oldman) genus Stegoceras, mistakenly called Troödon (12), has been reported from the Middle Edmonton, but the material is fragmentary. Parksosaurus (11, p. 492) from the Lower Edmonton may or may not be ancestral to Thescelosaurus. Of the Lower Edmonton armored dinosaurs Anodontosaurus and Edmontonia, the latter has been reported from the Oldman formation also. The ornithomimids from the Edmonton have been referred to the Lance genus Ornithomimus and the Oldman genus Struthiomimus. The genotype of Ornithomimus is incomplete, and better material is needed before it can be determined if all ornithomimids belong to one genus. So far as is known all the big carnivores in the Lower and Middle Edmonton belong to the genus Albertosaurus. Teeth of the Judith

River Troödon were collected from the Middle Edmonton (12), and may also be represented in the Lance fauna. Fishes, crocodiles, turtles, and champsosaurs are scarce and of little stratigraphic value.

LITHOLOGY OF UPPER EDMONTON BEDS

It would appear, as stated by Sanderson, that during Lower and Middle Edmonton time the area was a sinking plain, very little above sea-level, and that at the time the Drumheller marine tongue was being deposited marine or brackish conditions were general. If Sanderson is correct in assuming that the dark clay containing the Kneehills tuff is of marine origin, it would suggest that at this stage the shallow sea again covered the whole area. This period of quiescence may have been of sufficient duration to bring about physical changes, for the sediments above are more sombre in colour, contain very much less bentonite, and quartz replaces feldspar as the predominant mineral. Sandstones are more abundant, and more resemble the overlying Paskapoo than the sandstone of the underlying Edmonton. Increased uplift at the beginning of Lance time appears to have brought about the final retreat of the inland Cretaceous sea from this area, and the beds above are continental deposits.

The strata above the tuff are variable, but contain less bentonite and more quartz than in the beds below, and in most sections at least the basal 40 or 50 feet is a coarse sandstone only moderately consolidated. This bed is an excellent aquifer, and springs of sweet water emerge from it at the foot of the cliffs. Apparently the water penetrates the sandstone until it reaches the impervious bed of dark clay at the top of the Middle Edmonton member, where it is forced to seek an outlet. No springs have been observed in the Middle or Lower Edmonton, where the fine sediments and bentonitic clay prevent free percolation of underground water. Probably partly as a result of this seepage at the base

Of the thick, loosely consolidated sandstone bed, there is a noticeable tendency for it and overlying beds to slump. A great area of such slumped material can be seen northwest of the mouth of Big Valley Creek, and in some places rather large blocks have been carried far from their original positions. On the west side of Red Deer River, upstream from the old Tolman ferry, in sec. 15, tp. 33, rge. 22, most of the upper beds are badly mixed because of slumping. On the other hand, Middle and Lower Edmonton beds are slumped only where they have been undercut.

Time did not permit careful examination of the Upper Edmonton beds far above the mouth of Big Valley Creek, but viewed from a distance it is apparent that much slumping has taken place. No examination was made of the Paskapoo beds or of the disconformity mentioned by Sanderson.

On the east side of Red Deer River, in the north half of township 33, the sombre sandstone overlying the tuff is fairly thick, and contains several hard beds that give it more stability and prevent slumping. Here good exposures are to be found. In a few other places more clay occurs in the lower layers and, therefore, no springs and little slumping.

In sec. 30, tp. 34, rge. 21, near the top of the bank, is the base of a coal seam that may represent what is left of the Ardley seam. What appears to be the same seam was identified in sec. 24, tp. 34, rge. 22, by Allan and Sanderson as the Ardley seam (1, map 8). Between this seam and the Kneehills tuff are about 200 feet of light grey sandstone and clay. Sandstone sample No. 3 was taken from the first-mentioned locality a few feet above the tuff, and Triceratops was collected from about 90 feet below the coal seam. On the east side of a large coulée, in sec. 10, tp. 34, rge. 22, near the highest point, a coal seam has burned out. No doubt this represents the Ardley seam, and its base is 220 feet above the Kneehills tuff. These measurements check fairly well with those given by Allan and Sanderson in their chart (1, p. 57), which shows 290 feet of Upper Edmonton beds including quite a thickness above the Ardley seam. They also state that east of Ardley the tuff bed occurs about 220 to 240 feet below the Ardley seam (1, p. 29).

Sanderson made a mechanical analyses of eighteen samples of sandstone from various localities, but it is noted that not one of these is from the Upper Edmonton member. In discussing the sandstone, Sanderson says, "The clastics of the Edmonton possess remarkable uniformity in one respect; no grains over 1 mm. diameter have been observed in the many samples which the writer has analyzed. The whole formation is composed of remarkably fine-grained clastics (1, p. 64). -- Rosiwal measurements on several thin sections show that from 40 to 65 percent of the larger clastics are plagioclase; as high as 80 percent has been recorded (1, p. 65). -- The analyses shown in table 5 indicate that the processes of sorting were not effective in separating the finer grades of sediments. No arenaceous sediments of greater than 1 mm. diameter reached this area in Edmonton time. Most of the clastic matter is less than 0.5 mm. in diameter" (1, p. 74). These remarks are applicable to the Lower and Middle Edmonton, but not to the beds above the Kneehills tuff.

A large proportion of the Upper Edmonton is composed of fairly well sorted, moderately coarse sandstone. Moreover, the three samples taken from different localities and horizons show that much of the material is quartz, whereas in Sanderson's samples feldspar predominates. On the other hand, samples of Paskapoo sandstone collected and analysed by Sanderson (1, p. 97) show a close similarity to those collected by the writer, as to sorting, grain size, and the predominance of quartz. It would appear that the country was elevated earlier than Sanderson believed, and that the upper part of the Edmonton and the Paskapoo formation were laid down under somewhat similar conditions.

Mechanical Analyses of Sandstone Samples

Sample No. 1 was collected from opposite the mouth of Big Valley Creek, in sec. 32, tp. 34, rge. 21, a few feet above the tuff bed. Sample No. 2 came from just above the Tyranosaurus skeleton 42 feet below the Ardley seam, in NE. ¼ sec. 10, tp. 34, rge. 22, and No. 3 is from the Thescelosaurus quarry about 15 feet above the base of the Upper Edmonton in SE. ¼ sec. 35, tp. 33, rge. 22. These three samples have been analysed by the Ceramic Section of the Division of Metallic Minerals, Bureau of Mines, Ottawa, and the following is Mr. J. G. Phillips' report:

"The samples were broken down by gentle rubbing in a mortar blunged with water (with added dispersant) after which washing tests were carried out in the usual manner.

Results

Sample No.	Sand Fraction Per cent	Clay Fraction Per cent
2250 - 1	89.9	10.1
" - 2	92.0	8.0
" - 3	88.8	11.2

Screen Analyses on Sand Fractions

Sample No.	2250-1	2250-2	2250-3
+ 14 mesh	0.1%	1.0%	0.1%
-14 + 20	0.1	4.2	1.0
-20 + 28	0.5	9.5	4.2
-28 + 35	22.9	14.5	14.0
-35 + 48	48.2	23.5	27.1
-48 + 65	14.8	24.4	31.5
-65 + 100	4.7	11.0	12.0
-100 + 150	2.6	4.5	3.6
-150 + 200	1.8	2.3	2.0
-200	4.2	5.0	4.4

Examination for Mineral Content

"The sand fractions obtained from the washing tests were examined under the petrographic microscope.

"The predominant mineral is quartz, some of which was present in the form of individual grains, other portions being present as aggregates of very fine-grained quartz cemented together. Sericite aggregate grains were present in considerable amounts, and other minerals found in smaller amounts included biotite mica, hornblende, tourmaline, feldspar, and a black opaque unknown.

"The three samples have apparently about the same mineral content."

The method of measuring grain size was different than that used by Sanderson, but when the mesh is translated into millimetres we see that 25 mesh is slightly larger than 1 mm. and 200 mesh, the smallest screen used, is larger than 0.1 mm. In sample No. 1 almost 0.7 per cent of the grains are 1 mm. in diameter and more than 71 per cent are larger than 0.5 mm. In sample No. 2, about 14 per cent of the grains are 1 mm. or more, and about 50 per cent are more than 0.5 mm. In sample 3 about 5 per cent of the grains reach 1 mm. in diameter. The percentage of large grains in these samples would be slightly reduced because the clay, about 10 per cent, was first removed. Only one of Sanderson's samples from Red Deer River region, that from between seams 5 and 6 at Rosedale, approaches these samples for 1.0-0.1 mm. size (1, p. 65). The average of grains above 0.1 mm., 250 mesh, for Sanderson's eleven samples from Red Deer River area is less than 58 per cent, whereas the average of the above three samples is about 90 per cent.

CONCLUSIONS

The presence of Triceratops, Tyranosaurus, Thescelosaurus, and Ankylosaurus in the Upper Edmonton member shows conclusively that these beds are of Lance age. They are correlated with the Frenchman formation of Saskatchewan. There is no faunal break between the Lower and Middle Edmonton members. The sandstones of the Edmonton formation lying above the Kneehills tuff are coarser, better sorted, and contain more quartz grains than those of the Lower and Middle Edmonton beds, and the upper beds include relatively much more sandstone.

Allan and Sanderson have shown that the pre-glacial channel of Red Deer River was approximately in its present position, but that it was greatly deepened in post-glacial time. In the neighbourhood of Big Valley Creek, and for several miles down stream, is a bench, first on one side of the river and then on the other, at approximately the level of the Kneehills tuff. It would appear that the pre-glacial channel meandered about in the softer sandstone and shale, and in this area did not cut much below the level of the tuff bed. The pre-glacial valley of the creeks and large coulées coming in from the west seldom reach the tuff bed, but the post-glacial, narrow, steep parts have cut down through the Middle Edmonton beds. In one large coulée, in tp. 34, rge. 22, the valley floor drops 350 feet to the river in about 3 miles.

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