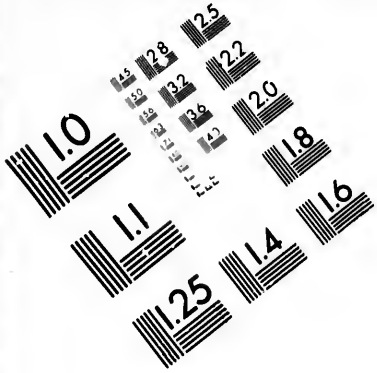

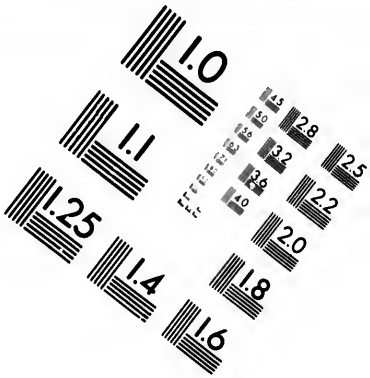

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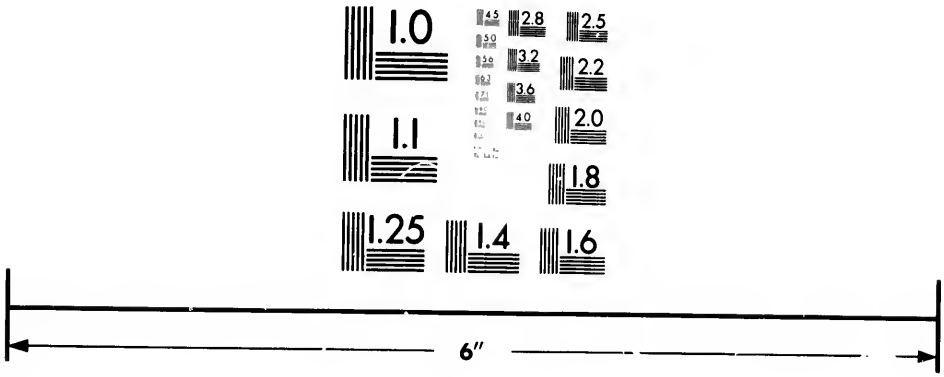

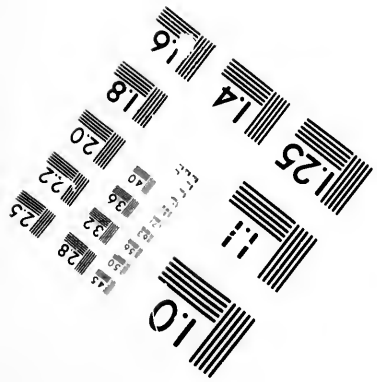

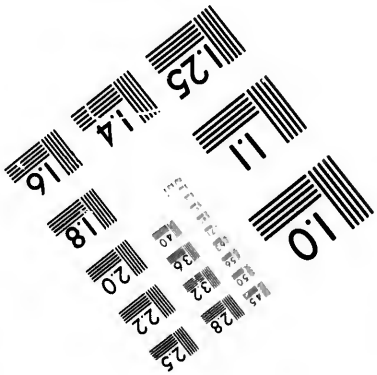

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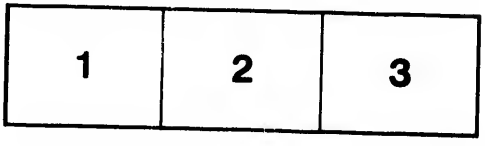
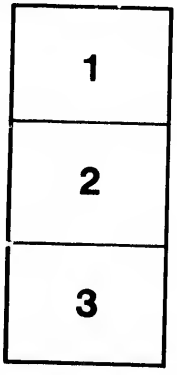
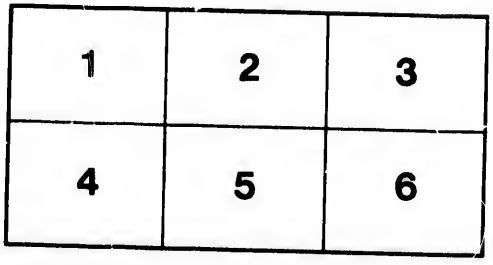




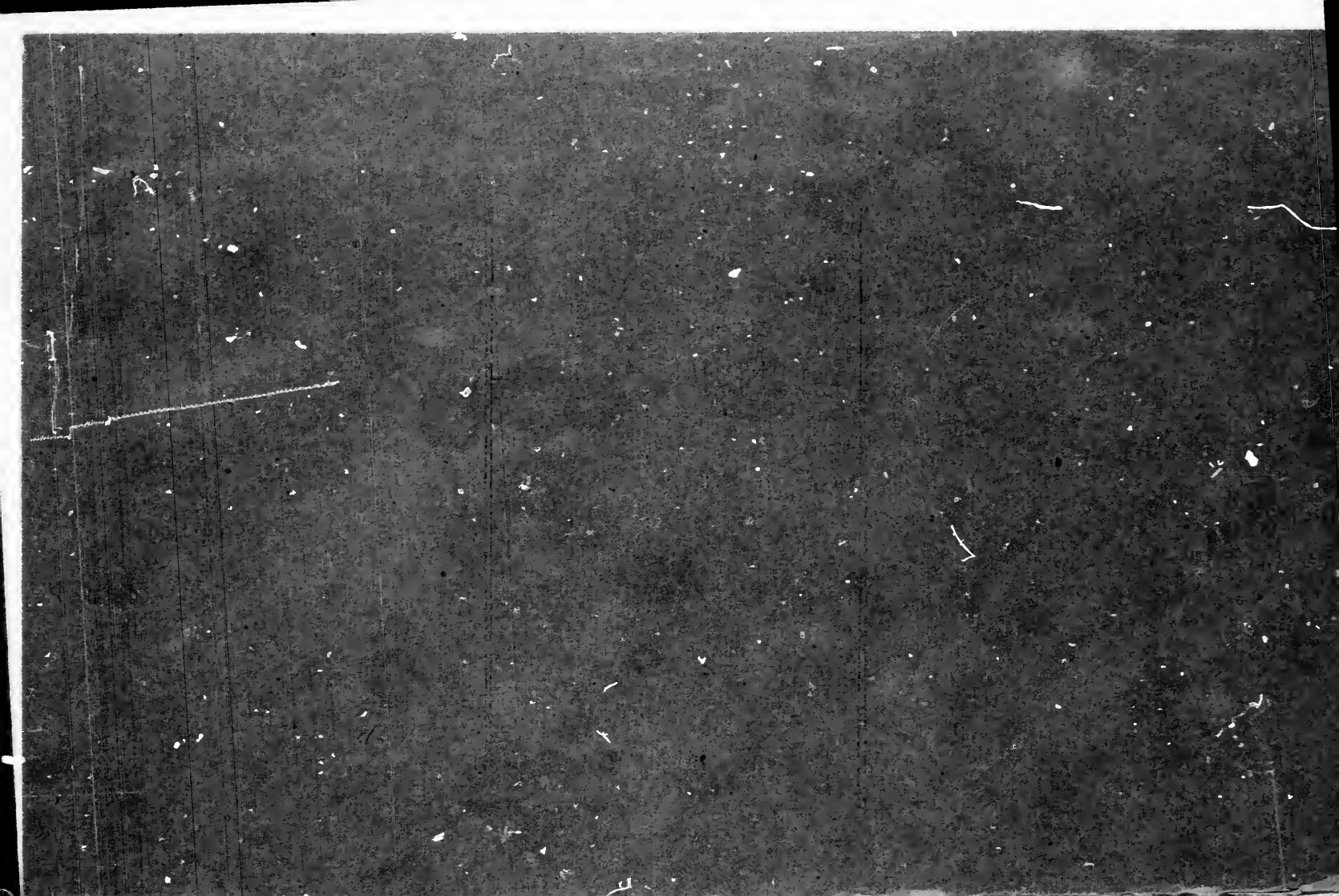


15.

ON THE

SUPERFICIAL DEPOSITS AND GLACIATION OF THE DISTRICT IN THE VICINITY OF THE BOW AND BELLY RIVERS.

By GEORGE M. DAWSON, D.S., F.G.S., F.R.S.C.



ON THE

SUPERFICIAL DEPOSITS AND GLACIATION OF THE DISTRICT IN THE VICINITY OF THE BOW AND BELLY RIVERS.

By GEORGE M. DAWSON, D.S., F.G.S., F.R.S.C.

(*Reprinted from the Report of Progress, Geological Survey of Canada*, 1882-84.)

The superficial deposits, those materials which, resting indifferently on the worn beds of the Cretaceous and Laramie, form the actual surface of the district now under description, are so largely those of the glacial age that to describe them is practically to outline the history of that very interesting period. In general the older rocks are deeply mantled with these deposits, and it is seldom, except in the neighbourhood of the mountains, that these appear, save in the deep river-valleys. The superficial deposits have, in fact, not only greatly modified the appearance of the county as a whole, but have given character to, and impressed a general uniformity on, the nature of its soil.

Influence of drift deposits.

The general characters of the several deposits of the glacial period are, however, so similar, that it will not be necessary to enter in great detail into the description of localities. One of the most striking features, indeed, of the glacial deposits of the North-west is their extraordinary persistence and similarity of character over immense areas. Compared to their vast extent their thickness is almost infinitisimal, yet they everywhere characterize the surface in uninterrupted continuity for hundreds of miles.

As a part of the discussion of the superficial deposits of the plains as a whole, in connection with the Boundary Commission exploration, I

Previous notes on glaciation.

(*Page in original report*, 139 c)

have already given such facts as came under observation in the immediate vicinity of the 49th parallel, and while the greater knowledge of the district now obtained enables much to be added to these descriptions, it does not alter them in their main features.*

Pre-glacial condition of the country.

The pre-glacial aspect of the county has been much rougher and more diversified than that which it at present presents. It must have been for a very long time in the later Tertiary periods subjected to denudation, and deeply marked by rain and rivers. The glaciating agents have doubtless planed off many of these irregularities, and the surface has besides been deeply buried in its deposits, to which the general name of drift has been applied in the preceding parts of this report. These have been laid down in greatest thickness in the pre-existing hollows and low tracts, and the general effect has been a filling up of the asperities, and the production of wide areas of almost perfectly level prairie. That this has been the case is evidenced by the fact that while some of the higher plateaus and ridges are but scantily covered with drift, the thickness shown in many of the river sections is over two hundred feet.

Old and new river channels.

Whatever the courses of the pre-glacial rivers (and there is no evidence that they departed widely from the present west-to-east system of drainage) the new streams which began to form channels for themselves when the glacial conditions had passed away, certainly did not follow the old beds. This is shown by the fact that while in some cases almost the entire height of the scarped banks along the streams is formed of Cretaceous and Laramie rocks, in others these banks are altogether composed of drift deposits, the base of which lies even lower than the present river-bed.

General thickness of drift.

As a rough estimate of the importance of the drift deposits in the district, it may be stated that in the region east of the Porcupine Hills, they probably average at least one hundred feet in thickness.

The following is a list, in descending order, of the superficial deposits developed in the region under discussion :—

Table of deposits.

Stratified sands, gravels and silts.
Upper boulder-clay.
Interglacial deposit with peat.
Lower boulder-clay.
Quartzite shingle and associated beds.

Quartzite shingle below boulder-clay.

Resting immediately on the surface of the Cretaceous and Laramie, in a number of widely separated localities, is a deposit of well rolled pebbles or shingle, consisting for the most part of hard quartzites, and

* See Quart. Journ. Geol. Soc., Nov., 1875, and Geology and Resources of the 49th Parallel. 1875.

derived entirely from the Palæozoic rocks of the Rocky Mountains.* Limestone is occasionally found in this bed near the mountains, but the shingle as a whole has evidently been subjected to such prolonged wear while on its eastward course, that this and other soft materials have been altogether ground down before attaining any very great distance from the place of origin. The pebbles are seldom more than a few inches in diameter, and are often very uniform in size, forming a closely packed bed, in which the stones are arranged with their longer axes parallel to the plane of deposit.

Distribution of quartzite shingle.

This quartzite shingle bed has been observed on the Old Man River below Fort MacLeod, in several places. It is entirely wanting on the upper part of the St. Mary River, appearing for the first time at a point six miles from its mouth. It may be seen on the Belly, on the right side of the valley near the trail-crossing at Coal Banks, and in several other places on its lower course, as at Big Island bend, the north-west angle of Drift-wood bend, and in the north bank opposite Wolf Island. At the last-mentioned locality it is associated with stratified sand and clay beds, a circumstance not elsewhere observed.

The section here is as follows, in descending order:—

Section at Wolf Island.

	FEET.
1. Pale yellowish-grey, more or less perfectly stratified boulder-clay, about	100
2. Purplish, finely-bedded sandy clay, with thin layers of ironstone and a lignite bed eighteen inches thick. A few Laurentian pebbles near the base	8
3. Unstratified boulder-clay, holding stones up to 2′ 6″ diameter	15
4. Stratified yellowish and brownish-yellow sands, with a few stones, some of which are Laurentian	15
5. Fine pale purplish-grey clay	4
6. Stratified yellowish sands	6
7. Quartzite shingle deposit, without Laurentian fragments, becoming clayey and full of derivod fragments from underlying rocks at base (about)	15
8. Cretaceous shales and sandstones with eroded surface (to water)	10
	173

Quartzite shingle on Bow and Red Deer Rivers.

On the section formed by the Bow River, the quartzite shingle is seen in a number of places. It was first recognised at a point a few miles above Highwood River, where it has a thickness of fifteen feet,

* There is no admixture of Laurentian or Huronian material, to which an eastern or north-eastern origin would have to be assigned. It is possible that a portion of the quartzites and associated rocks may have been originally derived from portions of the Rocky Mountains range far to the north, but in the absence of any evidence to that effect, and in view of the fact that the lithological characters—even some of a peculiar and expectional kind—found in the pebbles of the shingle, are precisely those of the rocks of the mountains to the west, it is most probable that they have been thence derived.

and is near the water-level. Below the Highwood it was seen at one place near the lower end of Pine Cañon at an elevation of sixty feet above the river. At a point, a few miles above the Arrow-wood Creeks, it has a thickness of fifteen to twenty feet, the base being about twenty feet above the water, and the summit capped by ten to fifteen feet of hard boulder-clay. About three miles above the Blackfoot Crossing it is again well shown. Its existence was also suspected at several points below the Blackfoot Crossing, but could not be proved owing to the extensive slides which have occurred in the banks. It was also recognized by Mr. McConnell at several places on the Red Deer River within the limits of the map.

Origin of shingle.

The origin of the quartzite shingle is a question of great interest, but at the same time a very difficult one. It at first appeared to be certain that it must have been brought eastward from the mountains by rapid streams, of a date immediately preceding the glacial period, and that it must either still occupy the channels of these, or have been spread abroad in some wide body of waters into which they flowed.

Miocene conglomerates.

The discovery in the Cypress Hills, in 1883, by Mr. McConnell, of an extensive Miocene formation, the greater part of which is composed of precisely similar shingle more or less cemented together by calcareous matter, must now, however, be taken into account. It is possible that this formation which now caps the high plateau known as the Cypress Hills, at one time spread much more widely, and that its gravels have been re-arranged and spread over the neighbouring plains by pre-glacial streams as denudation proceeded, and further, that these Miocene beds may have supplied much of the quartzite material which enters largely into the composition of the boulder-clay and its derived deposits. The fact, however, that exactly similar quartzite gravels can be traced up into the foot-hills, in the valleys of some of the streams, forming a thin layer beneath the boulder-clay, where there is no evidence whatever of the existence of any Miocene beds, tends to prove that a portion, at least, of the quartzite gravels here referred to, have been derived immediately from the mountains, in times just preceding, or marking the initiation of, the glacial period. The question is one admitting of much additional investigation.

Two sources of supply.

Irregularity in distribution of shingle.

The level of these pre-glacial gravels, often differs very considerably in the river sections, as compared with the water-level of the modern rivers. The gravels, however, tend generally to characterize the lower parts of the district, and are, for example, quite wanting along almost the entire course of the St. Mary. They are by no means universally spread even in the parts of the district which they characterize, a fact which may be due either to an original irregularity in distribution, or to their subsequent partial removal and mingling with

the general substance of the drift of the glacial period. No glaciated stones were anywhere found in these gravels, and the line between them and the boulder-clay is usually a perfectly distinct one. The only section which shows a blending with the base of the boulder-clay is that already quoted at Wolf Island, apart from which the shingle might be regarded as a deposit referable to the last stage of the Tertiary.*

The boulder-clay. The boulder-clay, which constitutes by far the most important member of the drift deposits, is very variable in thickness, having in some places a volume of nearly two hundred feet, while in others it is quite thin. It presents the usual characters of this deposit, being, as a rule, a hard sandy clay, containing a variable and often very considerable proportion of Laurentian and Huronian erratics, mingled with fragments of quartzites from the Rocky Mountains, and sandstone blocks from the Cretaceous or Laramie. The mass of its finer components, however, usually appears to have been derived from the beds underlying it at no great distance, and has been formed of these materials ploughed up and kneaded together. In consequence of this circumstance its colour varies considerably, ranging from dark blackish- or bluish-grey to lighter tints of the same, and often becoming yellowish-grey or fawn-coloured, especially where weathered. On the St. Mary, it was observed to have in some places a distinctly reddish tint, due to the colours of the neighbouring reddish clays of the Willow Creek subdivision of the Laramie. Where shown in good sections, it is generally divisible into an upper and lower part, the latter being more compact, and though not without stratification planes, showing them in a less marked manner, while the former is, as a rule, not only more distinctly stratified but also less compact. This feature is specially well shown on the BellyRiver below Coal Banks, and between the upper and lower boulder-clays the remarkable sedimentary deposits, described in a succeeding paragraph, here occur.

Colour.

Upper and lower parts.

Distribution. The boulder-clay, from its massive character, frequently weathers in

* Since the above was written, Mr. J. B. Tyrrell, in the course of the geological examination of the country north of the Red Deer River, has found gravels or incoherent conglomerates capping the Hand Hills, precisely like those of the Cypress Hills. These have yielded no fossils but there can be little doubt that they are like those of the Cypress Hills, of Miocene age. This discovery appears to show that the Miocene shingle-beds may have been much more widespread and important than previously supposed, though but occasional remnants of them, capping the higher plateaus, are now found. It may even be, that in the distribution of the quartzite gravels above described as underlying the boulder-clay, we have a general definition of the area of the Miocene formation, the immediately pre-glacial gravels having resulted from its waste, and accumulated in the valleys of streams which ran through the old Miocene area. It must still, however, be admitted that similar gravels underlie the boulder-clay near the mountains, and that these have probably no connection with the denudation of Miocene beds, but have been derived directly from the mountains. The question of the mode of transport of so great a quantity of coarse gravel to such a great distance from its source in the mountains, and its deposition on the soft beds of the plains in Miocene times, without any evidence of ice action, is a very difficult one.

river-cliffs into prismatic and columnar forms, and it is this deposit which is concerned in most of the heavy land-slides which occur along the valleys of the streams. It may be regarded as entirely covering by far the larger part of the surface of the district, but on approaching the base of the mountains is replaced by morainic accumulations due to local glaciers. Certain tracts characterized by the presence of a great thickness of boulder-clay have already been alluded to in the general description of the river sections. It rests often directly on the Cretaceous and Laramie rocks, even in the immediate neighborhood of localities where the intervening shingle deposit was observed well developed, and its base is often below the level of the water, even in the deeper river-valleys.

Interglacial beds.

The intercalated finer beds, above alluded to, are well shown in the section at Wolf Island (p. 141 c). They are seen also in a number of places on the Belly between Wolf Island and Coal Banks, and the body of water in which they were laid down must have been a very extensive one. On the east side of Drift-wood bend, seven miles west of Wolf Island, the following section occurs:—

Section at Drift-wood Bend.

	FEET.
1. Boulder-clay, with traces of stratification, to top of bank	40
2. Finely stratified, pale-grey sand, with irregular lenticular masses of soft ironstone, a few inches thick	15
3. Brownish-grey, earthy, sandy clay, distinctly stratified, with carbonaceous layers, which in places become impure lignite; small selenite crystals and concretions. 3′ or more (variable.)	3
4. Grey, fine sand with ironstone concretions, (like No. 2)	15
5. Massive boulder-clay with large stones and boulders, sometimes distinctly glaciated. Laurentian and quartzite fragments (to foot of bank)	80
	153

Interglacial peat.

Four miles further up the Belly, at the north-west angle of Drift-wood bend, the same beds are again shown, but the carbonaceous layers have here coalesced to form a distinct bed, about a foot thick, of imperfect lignite or indurated peat. A specimen collected here has been examined by Mr. C. Hoffmann. It is very strongly acted on by caustic potash, affording a dark-brown liquid. On analysis by the method adopted for the Cretaceous and Laramie fuels it yielded the following results:—

Hygroscopic water	7·74
Volatile combustible matter	23·13
Fixed Carbon	22·05
Ash	47·08
	100·00

In the approximate equality of volatile combustible matter and fixed carbon, and its percentage of water (when allowance is made for the large proportion of ash) this material resembles a poor lignite or good quality of peat.

Deposits overlying boulder-clay.

Overlying the boulder-clay are wide-spread stratified deposits, the distribution of which assists materially in giving uniformity to the tracts of level plain. It is, indeed, quite exceptional to find the surface soil consisting of boulder-clay disintegrated in place, as occurs only on the slopes of plateaus, or in hollows formed by denudation. That the beds overlying the boulder-clay have not been merely formed by its re-arrangement in water without the addition of new material, is indicated by the fact that in many places erratics much larger than those chararterizing the boulder-clay of the locality are found strewn over the surface of the country. The beds observed in river sections and elsewhere to overlie the boulder-clay are generally gravels or sands below and sandy or clayey loams above. The latter form the subsoil over most of the region, and are generally rather pale brownish- or yellowish-grey in colour.

Moraines distinguished from boulder-clay.

Along the base of the Rocky Mountains, moraines, in a more or less degraded condition, are abundant, and evidently due to considerable local glaciers which debouched from the present valleys of the range. The material of these moraines, when seen in section, differs considerably from the boulder-clay proper, not only in the fact that the included fragments are entirely of Rocky Mountain, or local origin, but in its greater degree of hardness, the greater roughness and angularity of the stones, and so far as observed the complete absence of bedding.

Moraines near the mountains.

On the Waterton River, moraine material of this kind was first seen about ten miles from the base of the mountains. West of the river, for some miles below the lake, a ridge which has evidently been a lateral moraine of the Waterton Lake glacier, occurs; and several hills of the same character, with large blocks derived from the mountains protruding from and scattered over them, are found about the lower end of the lake and opposite the valley of the South Kootanie Pass. For about thirty miles northward along the base of the range, moraines are of constant occurrence, and can easily be recognized owing to the sparsely wooded character of the foot-hill belt in this region. Each little valley now giving issue to a brook, has formerly contained a glacier, and the old lateral moraines, sometimes still very well preserved, run off from the base of the mountains like spurs.

Bow valley glaciers.

The Bow River valley, in correspondence with the large area of mountains tributary to it, appears to have held a glacier of larger size than any elsewhere originating in the mountains in this district. In several places some miles up the pass the rocks bear traces of heavy

glaciation, and at "the Gap" the limestone is deeply grooved and fluted by the passage of ice. Near and above Morley, portions of lateral moraines of this glacier project through terraces of later date as ridges, parallel to the direction of the valley.

Between Morley and Calgary on the Bow, a deposit more closely resembling boulder-clay than true morainic matter was observed in several places, but the stones in it are entirely those of the mountains or sandstone blocks from the underlying beds.

Terraces and planes of denudation.

Terraces are prominent features in some parts of the river-valleys in this district, but are generally clearly due to the action of the river itself at a former period. The extensive tracts of almost perfectly level prairie which occur, afford evidence of water action of some duration, and may be regarded as wide terraces. The eastern face of the Porcupine Hills appears from a distance to be very distinctly terraced, but this aspect was found to be due to the outcrop of the nearly horizontal sandstone beds. On approaching the mountains, however, true terraces of a more significant character present themselves in many places.

Highest terraces.

Terraces in the entrance to the South Kootanie Pass at a height of about 4,400 feet have already been described in my Boundary Commission report. In the valleys of Mill and Pincher Creeks, and those of the Forks of the Old Man, east of the actual base of the mountains, wide terraces and terrace-flats are found, stretching out from the ridges of the foot-hills, and running up the valleys of the various streams. Actual gravelly beaches occasionally mark the junction of the terraces with the bounding slopes, and they have no connection with the present streams, which cut through them. The level varies in different localities, but the highest observed as well characterized attains an elevation of about 4,200 feet.

Terraces in Bow Valley.

In the Bow Valley near Morley, and thence to the foot of the mountains, similar terraces are found which are quite independent of the modern river; and in the wide mouth of the valley of the Kananaskis Pass a series of terraces were seen from a distance, which must rise to an elevation of at least 4,500 feet.

Terraces in the mountains.

In the Bow and Crow Nest Passes, within the first range of the mountains, terraces are in many places well developed, but as local conditions, such as the stoppage of these valleys by transverse glaciers, may account for the existence of water at the elevations they mark, they do not possess so much interest as those above described.

Laurentian and Huronian boulders.

The occurrence of Laurentian and Huronian fragments in vast numbers as erratics over the district now described, at such a great distance from the nearest points of outcrop of the parent rock, and at elevations

Western limit.

so considerable, is a matter of much interest. The western limit of the Laurentian and Huronian drift may be said to reach the base of the

Rocky Mountains, in the vicinity of the 49th parallel, for fragments of these rocks were found on the Waterton River two miles below the lake, within three miles of the actual edge of the Palæozoic rocks, and at an elevation of 4,200 feet. Northward, on the head waters of the Old Man, Laurentian drift is found, though sparingly, as far west as the mill on Mill Creek, at a height of 3,800 feet, and a single Laurentian boulder was seen about half a mile west of Garnett's, near the trail leading to the Crow Nest Pass, at a height of about 4,200 feet. I did not, however, observe any Laurentian drift on the North Fork of the Old Man, and it is probable that it is absent or nearly so in the district sheltered by the higher parts of the Porcupine Hills. On the Bow River no Laurentian or Huronian erratics were seen west of Calgary, and even after their first appearance they are very scarce for some distance. As the height of the Bow River at this point is only about 3,300 feet, the western limit of the Laurentian drift cannot conform strictly to any contour-line of the present surface of the country.

Drift deposits in northern Montana.

South of the 49th parallel, the country travelled over from Fort Benton, on the Missouri, by the MacLeod trail, is all more or less thickly strewn with Laurentian erratics. South of the Marias River, the stones were observed to be chiefly quartzites of varying colours and doubtless of Rocky Mountain origin, but with these are mingled in larger or smaller proportion, granitic, gneissic and schistose Laurentian rocks, and these occur equally in the river-valleys and on the highest portions of the plains crossed by the trail. There is also, however, particularly in the vicinity of the Missouri, a proportion of granite boulders with flesh-purple felspar and bluish, rather opalescent quartz, which I did not recognise as Laurentian, and which may be derived from some not far remote mountain region. North of the Marias the conditions continue similar, and are, in fact, practically identical with those of the region more especially treated in this report.

No crystalline rocks in the mountains.

In this entire district there is no possibility of confounding the Laurentian and Huronian erratics with those from the Rocky Mountains, which do not afford any granitic or gneissic rocks or crystalline schists.

Great elevation of Laurentian and Huronian erratics.

The actual heights at which Laurentian and Huronian erratics are found are in some instances very great. A few of the more striking cases may be noted. The heights given are probably trustworthy to within fifty feet, having been worked out by comparison with the regular barometric observations at Fort Benton, which have been kindly supplied by General Hazen.—At the summit of the high ridge forming the southern continuation of the Porcupine Hills, which is crossed by the road between Fort MacLeod and Pincher Creek at an

elevation of 4,390 feet, Laurentian stones were found, though not abundant. In 1883 several indubitable Laurentian boulders, representing three varieties of granitic and gneissic rocks, were found about twenty miles north of the 49th parallel, at an elevation of 5,280 feet. They occur on the summit of a high ridge, which is evidently of morainic origin, within a few miles of the Palæozoic rocks of the mountains, but for the reasons elsewhere given they can not have been derived from these mountains, and their origin must be sought with that of those so numerous at lower levels, to the east or north-east. This is the highest point at which Laurentian boulders have been found in the district. Numerous similar erratics are found on the high country near the Milk River, and between that stream and the St. Mary River, about the intersection of the 49th parallel and 113th meridian, at an elevation of about 4,200 feet.

No drift on summit of Rocky Spring Plateau.

A few miles south of the 49th parallel, on the MacLeod-Benton trail, the Rocky Spring plateau is crossed. The south-eastward front is a steep escarpment facing a comparatively low plain, and is very thickly strewn with Laurentian and Huronian erratics as though it had at one period constituted a shore-line. Northward, the plateau slopes gradually down from its greatest elevation of 4,176 feet. The highest point of the plateau, crossed by the trail, is, for a mile or more, quite without drift deposits or erratics, but before any considerable descent is made to the north, erratics become abundant, though not large, and much resemble the remains of an old beach deposit. The height of the Laurentian drift here is about 4,100 feet. From other observations it is certain that this elevation does not constitute the limit in height of the Laurentian material, and it seems possible that the summit of this plateau was occupied by a snow-field during glacial times which prevented the accumulation of the deposits elsewhere found.

Erratics on flanks of Sweet Grass Hills.

The Three Buttes, forming isolated high summits in the centre of a wide plain, offer peculiar facilities for the determination of the highest points attained by the glaciating agent and Laurentian erratics. Much more time might profitably be employed in the investigation of the facts here than I was able to spare. In 1881 an examination of the western flanks of the West Butte, however, proved that Laurentian boulders of small size, with cream-coloured limestone resembling that of the Winnipeg basin, are abundant at an elevation of 4,600 feet, while the highest observed Laurentian fragments attained a height sixty feet greater.

Occasional great size of boulders.

Very large boulders were noted in a few places in the district. A remarkable group of these, composed of Huronian quartzites, occurs near the lower part of the Waterton River, and it is notable generally that some of the heaviest boulders are found not far from the western

limit of the Laurentian and Huronian drift. One of these erratics is 42×40×20 feet, a second 40×30×22, and both are partly buried in the soil. The height of this point was not exactly determined, but must be between 3,200 and 3,300 feet. In common with all the larger boulders of the district these are surrounded by a shallow saucer-like depression, caused by the pawing of the buffalo, and their angles are worn quite smooth and glossy by the rubbing of these animals upon them.

Post-glacial denudation.

While the main river-valleys whether on the area of the plains or in the foot-hills and Porcupine Hills, evidence very considerable post-glacial erosion, the general surface of the plain country east of the Porcupines seems to have suffered very little in this respect since the waters, (which under any hypothesis must have covered it at least at the close of the glacial period), left its surface. In the numerous lakes and pools occupying shallow depressions and without defined outlet, in the entire absence over considerable areas of drainage channels, and their general infrequency, evidence appears to be given that the rainfall of the eastern portion of the district has been continuously very small since the glacial period. Wherever the surface has locally been considerably lowered by denudation, great numbers of boulders appear, and their comparative rarity over great portions of the plains can be due only to the persistence of the finer surface covering since glacial times.

Mode of glaciation of the Great Plains.

Theoretical conclusions as to the mode of glaciation of this district have, as far as possible, been excluded from the foregoing summary of the facts. Apart from the local glaciers of the Rocky Mountains, it is evident that it has been accomplished by some agent moving westward or south-westward from the Laurentian axis which bounds the region of the Great Plains to the east. This agent has carried with it great quantities of Laurentian and Huronian material, which in the vicinity of the 49th parallel reaches at its extreme limit a point over 700 miles distant from the nearest exposures of the parent rock, and to an elevation more than twice as great as that attained by any part of the Laurentian area. To explain this latter fact it seems now almost certain that we must assume that the western region was, in glacial times, relatively to the Laurentian area more depressed than at present. As I have elsewhere, in the publications before referred to, discussed at some length the question whether a glacier or floating ice best accounts for the facts, it is not here proposed to recapitulate the arguments. Two theories only, however, seem tenable. Either a great confluent glacier, occupying the Laurentian highlands or passing over them from the Hudson's Bay region, stretched continuously to the slopes of the Rocky Mountains, or such a glacier, extending but a limited distance

from these highlands, supplied numerous and massive icebergs which floated in a great inland sea occupying the present position of the plains.

Significance of old drainage channels.

I still believe that the latter supposition best accounts for the facts of the glaciation and glacial deposits of the plains. I would, however, point out one circumstance which seems to give some colour to the former hypothesis. This is the existence of a number of wide, old, abandoned water-channels, which may be supposed by this theory to have carried the drainage of the county, and water produced by the melting of a great glacier of the kind implied, round its front at different periods in its retreat. The existence of these I am unable otherwise satisfactorily to explain, except on the supposition of considerable relative changes of level of different parts of the district in post-glacial times. Mr. Warren Upham has lately traced a number of such channels in Dakota (hypothetically extending his reasoning also to western Manitoba), for which he accounts by the first-mentioned or great-glacier theory.

Great coulées.

In the southern part of the district of the present report, and particularly in the country south of the Belly River, great old channels of the kind above referred to are displayed in a very striking manner in Verdigris, Etzi-kom, Pā-kow-kī, and Chin Coulées and their tributaries. These resemble old river-valleys long disused and now carrying little or no water. I am inclined to regard them as a portion of the earliest drainage system of the plains, outlined at the time at which the waters which distributed the stratified materials overlying the boulder-clays first subsided, and when the rainfall of the region was considerably greater than at present. That these first channels have not, in the particular part of the region now referred to, continued to be the drainage-channels of the country, is perhaps in part due to the much greater depth and importance rapidly attained by the valleys carrying copious and perennial streams derived from the mountains. In the entire obliteration of the original south-eastward slope of the valleys of Verdigris and Pā-kow-kī Coulées, and other peculiar circumstances referred to, in a previous part of this report (p. 14 c) in connection with their present aspect of Milk River, as well as in several local details respecting the relations of the present drainage and the old channels, we appear to find evidence of a greater amount of elevation of the southern as compared with the northern part of the district.* So far as it has affected these old drainage-channels this must have occurred in immediately post-glacial times, and may have been a continuation of the same process which has resulted in the present much greater elevation of erratics in the southern as compared with the northern part of the region.

Their probable origin.

Greater post-glacial elevation to the south.

* See also Geology and Resources of the 49th Parallel, p. 264.

Unless explained by relative differences in level during the glacial period, such as those above suggested, between the Bow River country and that near the 49th parallel, the absence of Laurentian erratics, over the region west of Calgary can only be accounted for by the existence of Rocky Mountain glaciers of sufficient size in this region to fend off the eastern glaciating agent. It is not improbable that such glaciers obtained, and if they can be proved to have existed, it would also prove, in the most convincing way, the approximate contemporaniety of action of the glaciating agents of the Rocky Mountains and Laurentian region. It is certain, however, that the glaciers of the mountains had somewhat decreased before at least the final period of dispersion of Laurentian erratics, for these have been found overlying distinct morainic material of Rocky Mountain origin.

Proof of great uplift of western region.

That the elevation of the western as compared with the eastern part of the plains, was relatively much less in glacial times than at present, seems a reasonable supposition, but must be regarded no longer as merely an hypothesis, for the position of the interglacial materials in the boulder-clay offers a strong positive argument in its favour. It must be supposed that these beds, from their finely stratified character and evidences of tranquil deposit, were laid down, not along the gradually retreating edge of a lake, but in the bottom, and at depths not very considerable. This being the case, the deposits give us the means of recognizing a surface—that of the lake bottom—which was at least proximately horizontal during the interglacial period at which they were formed. From Wolf Island to Coal Banks, the two points furthest apart at which the deposits were observed, is a distance of forty-five miles in a direct line, on a bearing of about S. 70° W. The height above the river of the deposits at the former locality is seventy feet, at the latter, one hundred and five feet, giving a slope eastward of 0·77 feet per mile in addition to that of the present river bed. The latter may be assumed as indicating that of the present surface of the country, as a whole.

Plane of interglacial deposits.

The elevation of the beds in the intermediate Drift-wood bend section is about ninety-six feet, but the locality is only about six miles westward on the same line, and the resulting slope per mile is 4·3 feet, in addition to that of the river, in the same easterly direction, a rate of fall locally much greater than that above determined for the whole distance.

The rate of fall of the Belly River, by its course, between Coal Banks and its mouth, is 6·8 feet to the mile, but on the line above defined (which is that of its general direction) between Wolf Island and Coal Bank, 12 feet to the mile. Adding the general slope previously ascertained for the intercalated beds, we find their eastward inclination to be 12·77 feet to the mile.

General eastward slope of plains produced in post-glacial times.

The general eastward slope of the plains from the base of the mountains to that of the Laurentian region at Lake Winnipeg is about 5 feet to the mile, but the elevation increases more rapidly westward and in the region now considered; and if the intercalated beds referred to were again brought back to horizontality, the plains between the mouth of the Belly River and Coal Banks would become nearly horizontal also.*

Distribution of placer gold.

Besides the effect of the glaciation of the country on its soils and general features, a further result of economic importance in connection with this period is the distribution of gold. Dr. Selwyn in 1874† expressed the belief, based on an examination of the country near Edmonton, that the gold found in the rivers of the Great Plains has been derived from the Laurentian and Huronian region to the east, and not from the Rocky Mountains. The facts met with in the district now reported on conclusively prove the correctness of the above statement. In favourable spots on all the streams of which the banks and beds show abundance of Laurentian and Huronian drift, fine gold may be obtained, while beyond the edge of this drift in the immediate vicinity of the mountains, I have never been able to detect a "colour."

It would be premature to state positively that none of the streams in the mountains yield gold. It is possible that local auriferous deposits may occur, though from the nature of the rocks so far observed in the eastern ranges, not very probable. The general auriferous character of the rivers of the plains depends, however, on the distribution of gold, usually in a very fine state, which has been derived from the old crystalline rocks of the Laurentian and Huronian. In the Bow and Belly district no systematic attempt has yet been made to work the placer deposits on the rivers.

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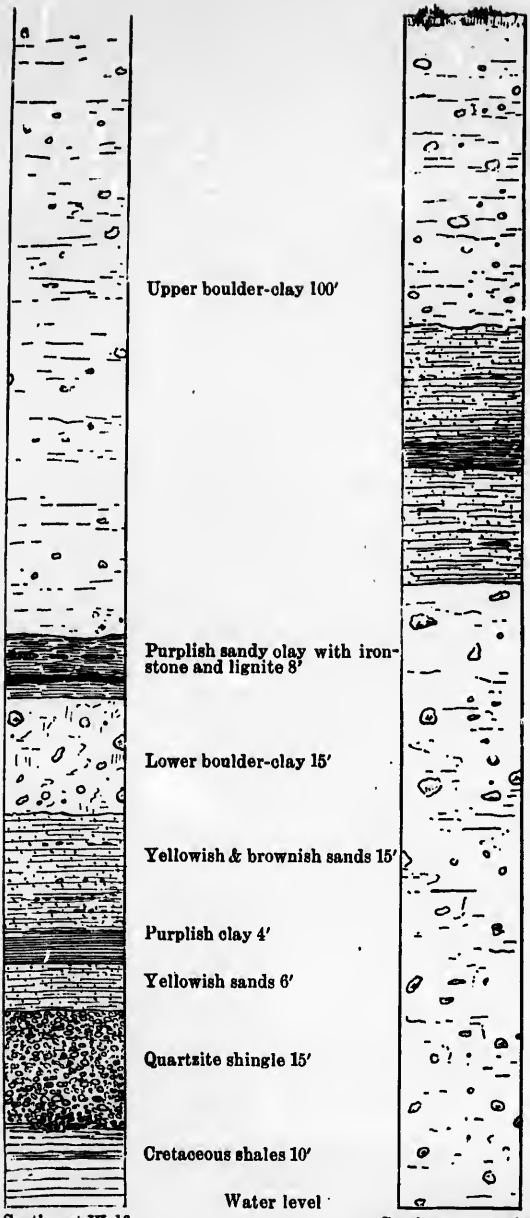
* In the region west of the Missouri, the present inclined position of the Pliocene beds shows that since the time of their disposition that part of the region in the vicinity of the Rocky Mountains has been greatly elevated. It may well be that the eastward slope of the portion of the plains here treated of may have been produced as a result of the same great movement, and if so the facts above recorded would assign it a date subsequent to that of the glacial period.

† Report of Progress, 1773-74, p. 58.



Section at Wolf Island (p. 141 c.)

Section on east side Drift-wood Bend (p. 144 c.)

SECTIONS ON THE BELLY RIVER ILLUSTRATING RELATIONS OF UPPER AND LOWER BOULDER-CLAYS, INTERGLACIAL DEPOSITS AND QUARTZITE SHINGLE.