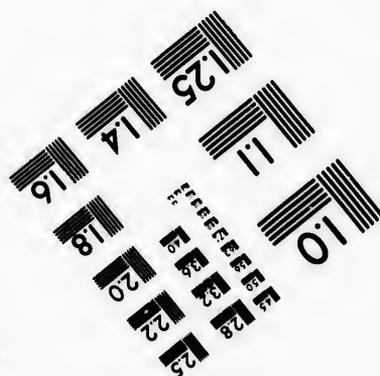
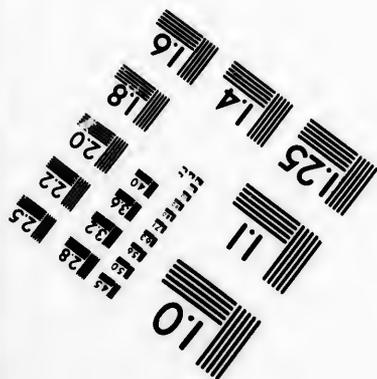
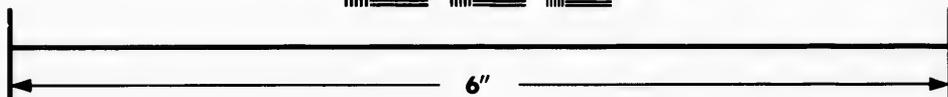
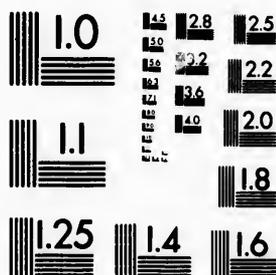


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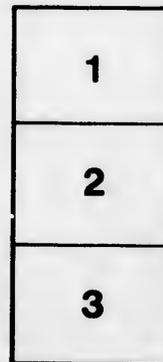
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companion of Lord Milton in his journey across North America, had kindly undertaken to read the present paper, or rather extracts from it, accompanied with some observations of his own, which appeared necessary in order to render the subject more intelligible to the meeting.

The following paper was then read by Dr. Cheadle:—

- 1.—*On the "Benches," or Valley Terraces, of British Columbia.* By  
MATT. B. BEGBIE, Chief Justice of British Columbia.

The paper was described by Dr. Cheadle as being a report compiled by Mr. Chief Justice Begbie, at the request of the Governor of British Columbia, in answer to questions put by the Rev. W. Robinson, of Cambridge, and transmitted through the Colonial Minister. The extracts from the report read by Dr. Cheadle were as follow:—

I have received and perused the despatch from the Secretary of State to yourself, dated the 21st June, ult., enclosing a letter from the Reverend William Robinson, dated 13th June, 1870, to which you wish me to reply.

I regret very much that I am ignorant of all save the first principles of geology, in fact of all except some quasi-technical expressions which everybody knows by rote, and which probably every unscientific person must use inaccurately. But at your request I will state as well as I can what I have seen.

The benches in question are so curious that they must immediately attract the attention of the most unobservant. Accordingly I took occasion to remark upon them in a report of my first circuit in British Columbia (in March and April, 1859), addressed to Governor Douglas. It will be seen there that I attributed the "benches" to the same origin as the "mountain roads" of Glen Roy, to which Mr. Robinson refers. But the plateaux on Fraser River being often much interrupted, they in many places far more nearly resemble in appearance the plateaux which were the scene of the battle of Rivoli, mountains, river, and all; the Fraser River is, however, a much stronger river than the Adige.

In 1859 I had only seen the "benches" on Fraser River or its immediate vicinity up to a distance of fourteen or fifteen miles above Lilloett. Subsequent observations, and a further acquaintance with the country, do not induce me to change the opinions expressed in the above mentioned report, though some of the details are very inaccurate.

It was perhaps scarcely possible for any person who has never seen Fraser River, or obtained an accurate description of it, if any verbal description can be accurate, to form an idea of its banks.

Being informed that this bench formation uniformly, *i.e.* everywhere, extended from a point below Lytton to some point above Lilloett, Mr. Robinson might naturally conceive that the formation extended uniformly, that is, regularly, and so might ask his third question, *viz.* whether the bench at Lytton rises or falls as you travel up the stream, and whether it finally dies out at Lilloett.

The distance from Lytton to Lilloett is 43 to 45 miles, and this may seem a considerable extent of bench formation when compared with Glen Roy, which extends but 20 miles. But the bench formation in British Columbia extends the whole distance of Fraser River so soon as the delta is left, as far as I have travelled up it, *i.e.* full 400 miles, and then the benches are seen running on, miles ahead. Wherever the formation has a chance of showing itself from Hope upwards, *i.e.* wherever it is not interrupted by precipices, or chasms, or denudations, there are benches more or less clear and regular. Up the Quesnelle River, and on Cottonwood, an affluent of Fraser River next above Quesnelle, and Lightning, affluent of Cottonwood, up to within 25 miles of the Bald Mountain, the backbone of the Cariboo range, I still found exactly similar benches. The formation extends all up Thomson River, far above Kamloops, along both forks, as far as I could see. There are several well defined terraces on the Okanagan; in particular on the "Rivière du Sable," halfway down the lake, mounds like truncated pyramids, or rather a pile of four or five truncated sections of pyramids. On the only portion of the Columbia River which I have travelled, *viz.* Fort Shepherd to Fort Colville, the formation is just as distinct and striking as on Fraser River, and I am informed and fully believe that it is quite uninterrupted down to Snake River, in lat.  $46^{\circ}$ . The largest benches, both in length and breadth, that I have seen are in the valley of the Upper Kootenay River, about long.  $115^{\circ} 30' w.$  (Lilloett being  $122^{\circ} w.$ ). At Rock Creek, and all along Kettle River, the trails run for miles and miles along just such benches, and so too all along the Similkameen River and the Nicola River, not only at its influx into the Thomson, where there are six or eight heaped one upon top of another, but all along its course to the Nicola Lake. In fact, it may be said that everywhere in the Colony on the *east* side of Fraser River, wherever there is a river of any size, and the hills or mountains are near, but not too near, you find yourself on one of these benches, more or less regularly formed, but even when externally irregular, bearing traces of original regularity.

Just the same appearances are presented on the only parts west of Fraser River over which I have travelled, *viz.*, along what was

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called the Douglas road, now abandoned, starting from the head of Harrison Lake along the Lilloett River, and reaching Lilloett Flat (town site) on Fraser by a beautiful pass upwards of 100 miles in length, separated from Fraser by peaked mountains of considerable height, 4000 to 7000 or 8000 feet. But it is reported to me that similar level benches compared to those at Lilloett exist on the upper waters of the Skeena and other rivers at the northern extremity of the colony.

In Vancouver Island, the only instance of bench formation, of which I am aware is at the gold-diggings, near Sooke, about 20 miles from Victoria, where there are a few miles of benches, in, I think, two or three terraces. So far as I know, these are, however, quite isolated. The bed-rock in this part of Vancouver Island is generally trappeous, often granite, generally full of quartz veins, slightly auriferous, much rounded, and in many places, where exposed, smoothed and grooved in the manner which, I believe, is usually attributed to the action of heavy ice, or glaciers. There is, so far as I can see, very little or no difference in the materials or derivation in any of these benches, scattered as they are over this enormous territory, and at all sorts of heights above the sea-level up to 2500 or 3000 feet, which must be the least height of the benches on Lightning Creek.

But though the whole extent of the formation be vastly greater than at Glen Roy, the Scotch parallel terraces are far longer than any pair of corresponding benches which I recollect here. Until the tamer part of the river is reached, near Alexandria, it is rare to meet with a bench on Fraser River which extends a mile along the stream; while the intricacy of their outline is such that it is very difficult, without actual inspection; or a very good model, which would be both difficult and expensive, to form anything like a correct idea of the formation. A good photograph would be useful, but I cannot find one that has been taken with the slightest reference to these benches, so as to show their number, height, and correspondence on opposite sides of the valley. The formation of all these benches, and the materials of which they are composed are, as above stated, nearly everywhere very similar. It is like what I understand by the term "northern drift;" fine loam at the top, sometimes with an undue proportion of sand, coarser gravel beneath, mixed with water-worn pebbles, some of which (on Fraser and Thomson chiefly) attain almost to the dignity of boulders. Stones from 100 lbs. to 1 ton weight I should say are not uncommon on these two rivers. These are generally of granite, or of a metamorphic slate, sometimes volcanic, a few quartz; all very much

waterworn. The benches present every variety of elevation, one above another, from 3 feet to 300 feet. Ample, and too painful, opportunity is afforded the traveller for examining their materials, stratification, and thickness in sections of these benches, as the trail continually ascends and descends the too frequent gullies and chasms, formed some by the rush of the melted snows in early summer; scooped out, however, probably in many cases by much more abnormal and potent cataclysms, the bursting of some lake in recent times. The stratification appears to have been in some cases horizontal, in others in great whirls, always as if taking place in water, at rest or in motion.

On the other hand, if at Glen Roy there are but two or three benches 20 miles long—and the benches here are but a mile or two in length in general—there are in British Columbia not two or three, but an infinite multitude of such benches scattered over a tract certainly more than 100,000 square miles in extent. Almost in every case where benches occur, there are one or more—occasionally ten or a dozen—between the rivers and the base of the nearest hill; and similar benches, similarly irregular in number, on the opposite side of the river, one, or more, of which is almost certain to correspond in level with one, or more, on the spectator's side. But the changes on the river-banks are so frequent from the violence, and often the very sudden changes of violence, of the streams, from the frequent land-slips, and, in my opinion, from the gentle but continued upheaval or depression of the surface, that the corresponding bench on the opposite side of the river is often found to be wanting: sometimes many benches seem to have been swept away at once.

I have everywhere noticed that the highest benches are near the highest mountains and the most violent streams, in positions where the effect of some subsequent flood would be most likely to obliterate all traces of its predecessor, or else where volcanic agency is not disguised. But, generally speaking, on the Upper Fraser, where the stream runs less violently, and where there are only hills, no mountains—and those generally at some little distance from the river—the benches are more regular, and vary only by a few feet in level.

Wherever two benches meet, with rare exceptions, they are sharply defined by a bank or cliff at an angle of  $45^\circ$ , exactly similar to that by which the lowest bench falls on the river or lake which bounds it, and apparently formed in the same way, *i.e.* by the action of water alongside.

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the direction of the neighbouring stream. But I suspect that they follow its general inclination—it might be said, incline "conformably" with the stream, as a general rule. For instance, it is very common for ditches—which, of course, always have some fall, though their fall varies extremely from an inch in a mile to an inch or more in a yard—to be carried along a bench in the direction of the principal stream, very rarely against that direction, and only when the supply is taken from a side creek, when, of course, the ditch may be taken in any direction. This question could not be determined without levelling a good many benches carefully. I should not be disposed to place much reliance on a barometer for such minute differences of level, and any hypsometer I have seen would be useless. But as to the transverse inclination (*i.e.* in the direction at right angles to that inquired of by Mr. Robinson), a great many benches, especially as they recede from the river, have a very decided inclination, *i.e.* they slope from the mountain towards the stream, and sometimes very rapidly, as if an upheaving force had burst through a slightly flexible stratum of drift, and raised it to the highest point just before it finally emerged. Nevertheless, the benches sometimes slope the reverse way; so that I know two or three instances of benches where lakes are formed next to the mountain base, the bench presenting an appearance similar to the "lip" on rivers running through alluvial flats, but which appearance is, I think, due to quite a different cause from the "lip," *viz.*, to a local depression having taken place after the formation of the bench.

Having made these very imperfect preliminary remarks, I shall now consider the questions put by Mr. Robinson. I fear I cannot give a categorical answer to them, chiefly owing to my own ignorance, from not having paid sufficient attention to the points inquired into; but partly, perhaps, because Mr. Robinson appears not to have conceived these benches as they really are.

Taking, then, the first and third questions in connection with each other, *viz.*—First, "How many terraces or benches are there at Lytton? On which of them does Lytton stand, and what are their heights above each other?" Third, "Does the terrace on which Lytton stands come nearer the river as you ascend the river, and so die out about Lilloett?"

These questions seem to indicate the idea of one continuous terrace, if not several, running all the way from Lytton to Lilloett, about 43 miles. But there is one large river—the Thomson—immediately above Lytton; so that the flat is perhaps not more than half a mile long. There are many creeks and points of bed-rock,

and innumerable gullies, before you reach Lilloett; and it would appear to the traveller almost as if every river, creek, and point of rock and gully completely changed the system of benches. For 40 miles above Lytton the terraces are, at least on the east bank, more broken up and disorderly than in any part of the course of the river.

My impression is that all these three flats slope, but very slightly, in the general direction of the Thomson and Fraser. I am sure that the upper plateau does. The slope is considerable enough to be noticed in riding to or from the town. Within a quarter of a mile to the south of the town a deep and steep gully occurs; and there is no flat apparently corresponding to the three thus isolated, either on the south of the gully, or on the west bank of the Fraser, or north bank of the Thomson River. The Lytton group, like fifty other groups within 50 miles, seems to stand alone.

Just before reaching Lilloett, however, the benches become exceedingly striking. Speaking from memory, I should say there were at least five or six different benches, apparently as level, green, and well defined as billiard tables, on the east bank, and a still greater number on the west bank, or Lilloett side, where they are intersected in a most picturesque way by the brilliant N'Koomptch, running through the magnificent gorge leading from Seton Lake, about 3 miles from the Fraser, the northern extremity of the Douglas trail already referred to.

Here I may as well state and answer Mr. Robinson's second question: "How many terraces are there at Lilloett? On which of them does Lilloett stand? and what are their heights above one another?"

There are, I should say, speaking from memory, at and in sight of Lilloett, at least 15 or 16 benches on both sides at various levels, some three or four on each side of Fraser River exactly corresponding in level: but many on either side of the river having no apparently exact counterpart on the other bank. Lilloett stands on a plateau, which I judge to be about 160 feet above high-water mark of Fraser River, varying between March and June 30 to 40 feet vertical. This plateau at one place goes right down to the river by the usual steep bank or cliff (angle of  $45^\circ$ ), but in other places it connects with other plateaux; so that you may, if you please, make one abrupt descent, or two, or three, or even four, to reach the Fraser. I have never been on the highest bench in this neighbourhood, which I should say is on the east side, and which I should judge to be 500 or 600 feet above the Fraser. The benches next the Fraser are apparently very nearly or perfectly

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level. Next the mountains—from base to base of mountain, 1 mile to 3 miles—the benches slope very much, as if upheaved by and shouldered off from the mountain in its gradual elevation.

The different benches at and about Lilloett vary very much in their elevations above each other, from two or three feet to 60 or 80 feet or more. They are generally from a quarter of a mile to a mile or two in length—one perhaps may be two miles and a half (next Fraser River), east bank, below and opposite to Lilloett.

Mr. Robinson's fourth question is—"I believe there are at least three benches at Alexandria, and that the fort stands on the lowest, 50 feet above the stream and 1470 feet above sea-level. How many terraces are there at Alexandria, and how far are they above each other? I am particularly desirous of ascertaining the height of the topmost."

There are, I should think, on the fort side (west bank of the river) at least twelve or fifteen terraces immediately at Alexandria; and from their regularity and contiguity—being generally narrow, and only a few feet differing in height—present a very singular and striking appearance: like a gigantic flight of steps ascending the hillside gradually.

The present fort stands on the west bank (where the benches are more numerous than on the east bank), on the lowest bench, not, I should say, above ten feet above high-water mark. The Fraser here rises perhaps 25 feet vertical. The fort of ten years ago, to which Mr. Robinson probably refers, now nearly pulled down, stood on a higher bench, I think the third, about 40 or 50 feet above high-water mark perhaps, but I should guess from memory not above 30 feet. As to the 1470 feet above sea-level, that is probably within a few hundred feet of the truth. I mean I should place the level at from 1400 to 1900 feet. The terraces opposite to Fort Alexandria, though less numerous, are perhaps more extensive both in length and breadth, apparently perfectly level, though out of the upper bench, about half a mile below and opposite to the fort, there rises a very beautiful instance of basaltic columns, about the dimensions of those at Staffa; no cave, however, but a bold front facing to the south-west, and about 200 yards from north to south—40 or 50 feet high, speaking from memory. At their foot, that is, on the south-west front, there is a mass of débris, and the plain seems slightly upheaved for 100 yards or so. The top of the columns is crowned with a similar sort of mould and vegetation to that at their foot.

It may not be out of place to state one or two instances which have induced me to think that changes of level are now going on in a gradual way in, at all events, some parts of the colony. At a

point near Fraser River, about thirteen miles south of Quesnelle, and again in a more conspicuous, and, indeed, a wonderful, instance on Hat Creek, an affluent of Buonaparte River close to the entrance of the Marble Cañon, I have noticed beaver-dams on a slant, abandoned dams, of course. A beaver-dam, I need not say, is a beautiful piece of engineering, constructed entirely of branches and earth, never known to give way, never built on a stream that runs dry in summer and, of course, as level as the surface of the water it is built to retain. On Hat Creek, at the point in question, there must have been a large colony, for the dams extend in various directions for an aggregate length of very many hundreds of yards.

I should think that any violent commotion would have greatly disturbed such dams; but these were all quite perfect, though on a slant probably of one in ten, there was no longer any water running, or any retained on the surface; though there were indications of water at no great depth. The old watercourse was quite visible. Many of the animals' favourite cotton-wood trees were growing there, perhaps thirty years old, but no sign of any living beaver. There were many old cotton-wood stumps, but they were very old, and a fire had been over the ground, so I could not decide whether these trees had been felled by beaver or otherwise.

From the similarity of soil, formation, &c., the theory might well be ventilated that all the country east of the Fraser, and a large tract on the west bank, has been at some distant geological period the bed of a vast lake or series of lakes considerably larger than that existing from Lake Superior to Lake Ontario; and that various ridges of hills and mountains have been, either together or separately, but at many distant periods of elevation, gradually protruded under and through this bed, laying it at last completely dry, and indeed at a very considerable elevation above the sea-level: upheaving a large mass of the continent, viz. at least from Fort George, near the 54th parallel to Snake River,  $46^{\circ}$  N., and from near Bentinck Arm, in  $127^{\circ}$  W., to Wild Horse Creek, in  $115^{\circ} 30'$  W.; and laying bare vast valleys of denudation, such as are to be seen not only in the Fraser, Thomson, Columbia River, &c., valleys, but in the valleys of much smaller streams. Hat Creek, Alkali Creek, Canoe Creek, &c., now run at the bottom of very deep basins, vastly larger than can be apparently referred to the erosive power of the present insignificant streamlets, none of which are larger than the water of Leith, near Edinburgh; and many run in valleys, with walls of solid rock half filled with débris similar in material to the benches, and apparently water-worn on the surface universally. These

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valleys are from one to five miles in width, and 700 or 800, sometimes, as Canoe Creek, 1200 feet deep by my measurement. The surface is scored and grooved in every direction by the action of great whirls and torrents, but mainly as if vast quantities of ooze mud and débris had been pushed down into the valley from the side hills. In many places I have noticed very curious little conical hillocks, just like the peaks of volcanoes, but formed of the same aquatic gravel and loam. In two or three I have found a sort of core of bed rock, and it seemed as if their formation was due to this latter arresting the lacustrine deposit, and these may thus have been formed into a cone by the whirl of eddies or by the effect of gravity, as may be seen any day by tilting over a cart of gravel on a small boulder.

There is yet one other phenomenon to which I have alluded, which occurs frequently in British Columbia, as might be expected from the steepness of its mountain sides, the nature of the bench formation which adheres to them, and the vast quantity of snow and rain which falls in so mountainous a country—viz., landslips.

Three, at least, of these have within the memory of man fallen into the Fraser, and nearly dammed up, however temporarily, that enormous river, viz., one about 12 miles above Lytton, the ruins of which still remain, one about 10 miles above Lilloett, and one two or three miles below the present Fort Alexandria, which caused a flood sweeping away the old fort with all its contents, and causing the loss of many of the Hudson Bay Company's employés there. The fort was thereupon established on the bench referred to by Mr. Robinson. There are several "dry" landslips, if I may so term them; of these two or three examples may be seen near Soda Creek, one of which is about one mile long and half a mile wide. Other beautiful examples may be seen in the Pavillon Creek, nearly 21 miles from Lilloett, on Thomson River, 15 miles from Lytton, on Bridge River, &c. Some of these are several miles in length, and must include thousands of acres. In most of them trees growing at the time of the slip are still growing on the displaced mass, leaning at every angle with the horizon.

In some the bench seems to have gone down sheer, bearing with it, unharmed, all that was growing on it, and leaving a perpendicular cliff. In some, the displaced surface seems to have moved painfully and grindingly over the subjacent bed-rock, and the surface is broken into a thousand irregularities; at Pavillon, and on Thomson, the mass looks not unlike an earthen "glacier du Rhin."

Dr. CHEADLE made the following observations on the paper:—The benches, or terraces of British Columbia are levels or ledges found on the side of the valleys

of the Thomson and Fraser, two of the principal rivers in the country, and also in the valley of the Columbia River. They are found all along the valleys, from the mouth to very nearly the sources of the rivers, and at different levels, —the terrace on one side corresponding with that on the other. This is not, however, always the case, for here and there one of the pair of terraces has been washed away. As you may well imagine, where the stream has risen unusually high, or a landslip has occurred, a terrace may have been carried away on one side or the other. These terraces give a most peculiar character to the scenery. It is said that Nature abhors a straight line, but here you have nothing but straight lines. Instead of the ordinary undulations met with at the bottom of a valley, or simply an alluvial flat, you have a succession of terraces rising one above the other. In travelling up the river you go along one of these terraces for a certain distance, then suddenly you are brought up by a sloping bank like the face of a railway embankment; you ascend it, and find yourself upon another level plain; you go on for a certain distance, and you come to a similar embankment, and so it is throughout. These terraces have been observed on other rivers; and they are, perhaps, more numerous and extensive on the Columbia River than on the Fraser and Thomson. Similar terraces are not unknown also in other parts of the world. They have been noticed, I believe, in some of the valleys of the Himalayas, and have been described by Dr. Hooker. The parallel roads of Glen Roy in Scotland are well known; and similar benches have, I believe, been seen on some of the rivers of Patagonia. Nowhere, however, are they so numerous, so striking, or prolonged over so extensive a district, as in British Columbia and Washington Territory. They are found over the whole watershed of the Fraser, Thomson, and Columbia,—an extent of country amounting to about 200,000 or 300,000 square miles. The others are merely isolated cases in comparison. The character of the country where these terraces occur is very striking. After traversing the central plains of the North American continent from east to west, and surmounting the steep ridges of the Rocky Mountains, you find, instead of a corresponding plain on the western side, that you are still amongst mountains. The view from the western slope of the main chain over British Columbia is one of the most magnificent, perhaps, in the world. In every direction, as far as the eye can reach, extending apparently to the ocean, nothing but a closely packed mass of mountains is visible; many of them the loftiest snow-clad peaks, and separated only by the narrowest valleys. Washington Territory, which is drained by the Columbia, is less mountainous, but is still intersected here and there by great mountain-ranges.

The nature of the material of which these benches are made, their uniform level, and the straight lines, all prove satisfactorily that they are water formations; and their being found only on the river valleys, and disappearing as soon as you pass through the estuaries, proves that they were formed by the action of *fresh* water. It is a matter of extreme interest, and there has been much speculation, as to how these terraces have been formed. They have been formed by water, but in what way? Do they bear any relation to one another? Are the terraces in Scotland and India and British Columbia all parts of a system resulting from a common cause, or do they depend on local causes?

Mr. Gibbs, geologist to the United States exploring expedition 1853-4, observed these terraces on the Columbia River, and gave an accurate and careful description of them, arriving at the same conclusion as Mr. Begbie, that they are water formations, the relics of extinct lakes. But it seems to me that Mr. Begbie's explanation of this drainage having been effected by the gradual upheaval of the mountains through the river-beds is hardly sufficient; for I think, if that were so, we should have one level flat representing the original bed of the lake, and no terraces of successive elevation. The suc-

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cession of terraces, one above the other, seems rather to prove there was a succession of drainings,—that the lake was drained off to a certain level, at which the water remained for a time; after that to a still lower level, at which the water again remained for a time, and then there was a further letting off of the water, and in this way each successive pair of terraces was formed. How this occurred will be better understood, perhaps, if I just sketch to you the formation of the country in which these terraces are found. They are met with, as I said, in the basins of three rivers: the Fraser, the Thomson, which is an affluent of the Fraser, and the Columbia and its tributaries. Now these rivers, the Fraser and Thomson, are surrounded, you may say, on all sides by lofty mountains, or by extremely high land—they form, in fact, central basins; and not only are they walled in on every side landward, but their exit to the sea is barred across by a great range of mountains, called the Cascade Range, so that they have to burst through that barrier to escape into the ocean. Exactly the same thing is the case with the Columbia River, which is surrounded on all sides by mountains of great elevation, which dam the water in every direction; and, like that of the Fraser, it would be prevented by the Cascade Range from reaching the sea, but for a rent through which it passes. Thus in all these cases you have a central basin surrounded by lofty mountain walls. The passage by which these rivers escape to the sea is exceedingly narrow; so that the Fraser, which some 200 miles from its mouth is as broad as the Thames at Richmond, is only a stone's throw across where it passes through the narrow chasm near its mouth. It is obvious that a slight geological change would completely dam up this river. An obstruction at any part along the chasm would flood the country over an immense district above. Exactly the same holds with regard to the Columbia. A very slight amount of obstruction there—a landslide—would completely dam up the river, and stop its exit into the sea. And this is the case not only near the mouth, but also at numerous places up the river where it passes through similar narrow gorges, so that at many points for several hundred miles above the mouth of the Columbia, I imagine, and all the way up the Fraser, a succession of lakes might easily be formed by any accident occurring to obstruct the stream lower down. Now, if we suppose that the converse of this were the case,—that these lakes existed, the waters being held back by dams at certain points,—it is clear that on the giving way of these barriers, the water would be drained off, and the bed of the lake be laid dry. I have shown how very easily an accident such as the damming up of the stream might occur, and it is curious that Mr. Begbie mentions three instances in which this has partially taken place by landslips. Dr. Hector also, who visited that country, relates another instance in which the same thing apparently occurred on the Columbia. He mentions that the Columbia River for 30 or 40 miles flows almost without current, and that an Indian tradition stated that at that part it was formerly extremely rapid and of uniform swiftness, and that it ran under a gigantic arch of rock; but an earthquake took place, the arch fell in, damming up the stream, and the country was flooded. It does not require any great stretch of the imagination to see how the converse might occur, and instances of this are also recorded. Mr. Gibbs, of the United States survey, points out two or three places along the Columbia River where, in his opinion, such barriers had undoubtedly existed; and he mentions, in particular, one instance in which huge masses of rock had been displaced by the force of the stream, and carried a short distance down. These masses of rock had evidently not come from far, for the strata just above had been disrupted, and the rocks were not in any degree water-worn. It is possible that these barriers may have been broken through, not necessarily by any general convulsion, but by the erosion of rivers weakening them; or it might be that the continual upheaval of the continent has gradually weakened them so much, or displaced them so much,

that at last they have given way, and the water has escaped. I think we must suppose that a number of such accidents have taken place, because there are so many successive terraces. The terraces on the Lightning were nearly 3000 feet above the level of the sea, on the Kootenay 2600 feet; the top bench at Lytton only 800 feet; while the top bench at Lilloett is from 1300 feet to 1400 feet. The lowest bench at Alexandria, higher up the stream, is from 1400 feet to 1900 feet: so that it appears not only must there have been several accidents by which the water was drained off at different periods, but there must have been several different barriers.

The Rev. W. ROBINSON said that the well known terraces in and about Glen Roy were horizontal, and of the same altitude on the two sides of the streams. There had evidently been no elevation or depression of the region since their formation. We were, therefore, driven to the conclusion, that they were formed by water standing at their height. The water might possibly have been higher than the topmost terrace, but at least it has been as high; that is, between 1100 and 1200 feet above the present sea-level. By some means, the barrier that held in the water at that height gave way, so far as to let it down to the level of the second terrace; and, again, after an interval, to the level of the third terrace. The one point, however, on which he aimed to fix attention, was the existence of that great body of deep water where now is dry land. It was that fact that awakened curiosity to know whether the British Columbian terraces were similar to the Scotch. He wished distinctly to recal one sentence of Mr. Begbie's communication,—“From the similarity of soil, formation, &c., the theory might well be ventilated that all the country east of the Fraser, and a large tract on the west bank, has been at some distant geological period the bed of a vast lake.” This intelligent gentleman then traversed that extensive region, with its valleys from 1 to 5 miles in breadth, and from 700 to 1200 feet deep; and the phenomena he witnessed suggested to him the presence there, at some past time, of a deep lake or sea,—a collection of water like that which certainly existed formerly in Scotland, but on a far larger scale. No one had given such laborious attention to terraces as Mr. Robert Chambers. The fruits of his investigations were before us in his work on ancient sea-margins,—a work containing descriptions of terraces in Scotland, Ireland, England, France, Switzerland, Scandinavia, and North America. Naturally his attention was much directed to Great Britain; with what result? He did not suggest as a theory which may deserve to be ventilated, but as a conclusion about which he had no doubt, that the sea formerly stood at least from 1200 to 1500 feet above its present level. Of course, under such conditions, what is now called Great Britain would be an archipelago. Again, Sir, then, we find terraces yielding to a very sagacious observer the inference of a high-water level. The same distinguished man investigated the terraces of North America, and drew the same inferences from them; viz., that they originated in a sea-level much higher than that now existing. Connected, then, with terraces, four points are before us. (1.) The certain existence at a recent geological period of a large body of deep water in and about Glen Roy; large, because the terrace system there runs about 20 miles from east to west, and 12 from north to south. (2.) The terraces of British Columbia induce Mr. Begbie to throw out the hypothesis of a vastly larger body of deep water there. (3.) The same conclusion reached respecting England, by our most practised investigator. (4.) The same conclusion reached by him respecting North America. Now, if these terraces had been rightly read, we could scarcely avoid a wider hypothesis, which should connect and comprise the four already named, and which might be best given in the words of Robert Chambers,—“There is enough to justify a question regarding uniformity of level, not only throughout North America, but (bold as the idea may in the present state of knowledge and of hypothesis appear)

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between the old and new continents;" so that he was led by his study of the terraces to conceive of a sea-level common to Europe and North America, and at least between 1000 and 2000 feet above the present level.

Mr. Robinson proceeded to suggest that the water of the world has been more than once rolled from one hemisphere into the other, and that in the post-tertiary times it was all north of the equator. As showing how that might be, he referred to a paper in the 'Journal of the Royal Geological Society of Ireland,' vol. i. part 3, p. 288, and to a letter in the 'Athenaeum' of October 19, 1867; and argued that nothing but such a high water-level would account for the terraces of the world, the former state of the Arctic regions, the prodigious amount of drift distributed in one general direction from the extreme north far towards the south pole, and other geological phenomena.

Mr. DALLAS said he had travelled over a great deal of the country described by Dr. Cheadle, and had come to the conclusion that the terraces could have been formed only in one of two ways,—either by the hand of man, or by natural causes. Of course they were not made by man, and therefore the only hypothesis left was that they were caused by water. He agreed with Dr. Cheadle in thinking that they must have been formed by the draining off of the water at various epochs, though it was difficult to say what was the precise cause of the sudden drainage. It might have been by subsidence of the earth, by overflow, or by the water gradually percolating through, and at last forming a channel for itself. He did not think that the formation of the terraces in British Columbia and Washington Territory had any necessary connection at all with that of the terraces in Scotland and other parts of the world, because there were very simple explanations why they should exist in some parts of the world and not in others. The chain of the Rocky Mountains runs from north-west to south-east, and forms a barrier across the country. Between that and the Cascade Range, which runs nearly parallel to it, there must have always existed, as there does now, a large basin; and it was easy to imagine that that basin had been filled with water, though not necessarily at one level—the intervening country between the two main ranges being, in fact, a net-work of mountains. The accumulated waters of the various basins, in forcing a passage by the channels of the Columbia, the Fraser, and other minor streams, might have formed the successive terraces at various periods in each district of country; and he maintained that no real ground existed for attributing the fresh-water terraces of the old and new continents to one simultaneous cause. So far as his observation extended, the terraces were a true level, and had no slope with the rivers.

Mr. Woods asked whether the surface of the terraces and their bases were formed of the same material, or whether there was any marked difference.

Dr. RAE said when he visited British Columbia he was on a telegraph survey, and could not wait to take any measurements of the terraces; but it struck him very forcibly that, instead of being horizontal, they sloped with the river-bed. If such were the fact, it would upset the theory of a large inland lake.

Dr. CHEADLE said it was clear that the terraces were not formed by sea water, but by fresh water, for they are found only in the river valleys, and not on the coast; they entirely cease after the rivers pass the Cascade ranges. He agreed with Mr. Dallas in thinking that the whole of the interior basin of British Columbia had been pretty well filled with water, by a number of lakes at different levels very like the present lakes of Canada. The barriers damming up those lakes had been broken through, and the waters drained off. The upper stratum of the benches is of the same material as the lower stratum, with this exception, that the coarser and heavier material has sunk to the bottom, so that there is tolerably fine sand at the top. Nothing but careful observation could settle the question as to whether the terraces were perfectly horizontal or sloped with the river.

