open at all seasons; and a science whose problems are graven on every feature of the landscape—hill and valley, lake and river, crag and gorge, beetling sea-cliff, and sandy shore.

Nor do its intellectual attractions as a main branch of natural science constitute its sole attractions. Its bearings on other departments of knowledge, its startling speculations, and bold generalisations, can never fail to secure the interest of the cultivated intellect. Nor least the bearings of these generalisations on modern thought in all that appertains to new notions of time, immutability of law, continuity, and progress, and other themes that are gradually widening the restricted boundaries of olden belief, and giving a more catholic impulse to human aims and to human aspirations. And if all this, or even less than this, can be ascribed to geology during its brief cultivation of little more than half a century, what, we may presume to ask, will be the influence of its teachings during the remaining portion of the century that lies before us?

Tuesday, 21st November 1867.

Dr PAGE, President, in the Chair.

The following Communication was read:—

The Gold and Gold-Fields of Scotland. By W. LAUDER LINDSAY, M.D., F.R.S.E.

While visiting, in 1861, the auriferous districts of the province of Otago, New Zealand, I was much struck with the similarity, as respects physical geography and geology, between that country and many parts of Scotland. It immediately occurred to me that, in so far as the physical conformation obtained, and the same geological structure existed in many parts of Scotland, there should be a co-equal diffusion of gold as respects at least its area; and I proposed to myself to determine how far this suggestion or belief would be borne out by actual investigation. Since that period I have given all the attention that opportunity permitted to the subject of the diffusion of gold in Scotland, both as regards its area and quantity. I have traversed Scotland in its length and breadth, and visited its principal outlying islands—the Hebrides, Orkney, and Shetland. In 1863 I paid a special visit to the Leadhills district, which, some centuries ago, yielded to systematic working upwards of half a million's worth of gold, and which, regarded by the test of its then productiveness, is fairly entitled to the appellation of a "gold-field." In order to compare the Scottish gold and gold rocks with those

of other auriferous countries, I made a special examination of the International Exhibition of 1862, and of all the museums accessible to me in Britain, Australia, and New Zealand. I have also studied, so far as appeared to be necessary, the somewhat voluminous literature of gold and gold rocks in the mineralogy and geology of gold in Scotland, and other auriferous countries. In doing so, I very soon found I had been forestalled, to a certain extent, both in my anticipations or beliefs, and investigations, by an Australian mineral surveyor, Mr Calvert, who had been struck in a similar way with the apparent resemblance between the gold rocks of Australia and those of Britain, and who subsequently traversed and examined the suspected or ascertained auriferous districts of Britain, and gave a summary of his results and of his literary investigations in a work entitled "The Gold Rocks of Great Britain and Ireland," published in 1853. This work does not appear to me to have attracted that attention in Scotland which it deserved, and this may have arisen from the speculative views which pervade it; but it contains much important information, compiled from a great variety of resources, historical and archæological, regarding former gold workings, and the ascertained or supposed distribution of gold in Scotland. I shall, however, avoid, in the present communication, recapitulating information which is so easily accessible to those interested, and propose confining myself more particularly to my own inquiries, when results are confirmed by those of Mr Calvert, so far as the latter go.

The remarks I have now to offer are thus based on—

1. A personal survey of the gold-fields of New Zealand.
2. A personal superficial survey of Scotland and its principal outlying islands.
3. Inspection of the specimens of gold and gold rocks in the principal museums of Britain, Australia, and New Zealand; and
4. A study of the literature of gold in Scotland and other auriferous countries.

My special conclusions regarding the Scottish gold-fields are based mainly on—

1. The similarity of the rocks of Scotland to those of all, or most other, auriferous countries; and
2. The actual discovery of gold in former and recent times, as illustrated by prehistoric remains and historic records.

My general results or conclusions are—

1. That gold is much more extensively or generally diffused in Scotland than has been hitherto supposed.
2. That the area of diffusion, and the extent to which it occurs, can only be determined by systematic investigation, equivalent at least to the "prospecting" of gold-diggers.
3. That hitherto, and with certain limited and local excep-

tions, there has been no such systematic prospecting in Scotland; and

4. That there are indications, if they do not always amount to proofs, of the existence in Scotland both of auriferous quartzites —that is, of gold *in situ*—and of auriferous "drifts," using the term "drift" in its most comprehensive sense.

Let me at once disabuse the minds of my audience of any sanguine expectation that I am prepared to announce the discovery of a "payable gold-field" in Scotland, or to recommend as a profitable speculation the establishment of a company to operate on either the auriferous quartzites or drift. I will have occasion to show, in the course of my remarks, that in certain senses, *but only in these senses*, gold-washing or working in Scotland actually *is*, and might still further become, remunerative, and that it does, and might further, take a place as one of the local industries of our country. But my object is at present the much humbler one of simply endeavouring to draw attention to a subject which requires pre-eminently local investigation over a wide area, investigation of a kind, however, so simple that it may appropriately be undertaken by the parochial clergy, or medical practitioners, as well as by resident proprietors, or their representatives. More especially do I deem the subject one befitting the attention of our national surveys, geological and topographical. The former has just been revivified in Scotland by the appointment of a most competent and active director, and by a considerable increase of its working staff. The Geological Survey, however, has scarcely yet entered on an examination of the Silurian district, which may be expected to be more or less auriferous throughout Scotland. Hence, I think that "prospecting" for gold, which does not involve the necessity for costly instruments, or much expenditure of time, might be made a legitimate and proper department of the duties of the working staff of the survey in question. I have no doubt that investigations so conducted would add largely to our knowledge of the area over which, and the extent to which, gold is distributed in Scotland, while they would rectify many errors that at present exist.

Before making general observations on the Scottish gold-fields, or comparing them, as regards their richness or extent, with those of other auriferous countries, which are better known, I propose giving briefly the principal results of my observations and inquiries at and concerning what I may safely denominate the Crawford or *Leadhills gold-field*, the whole of that moorland and hill region of the southern highlands—Upper Clydesdale—the southern extremity of Lanarkshire, variously known as Crawford, or Crawford Moor, or Crawford-Lindsay, which includes the district now known as the Leadhills, and forms the water-shed of the four great southern rivers (the Clyde, Nith, Tweed, and

Annan), has repeatedly, and in various ways, proved to be more or less auriferous. Calvert "prospected" the whole Leadhills district, and found gold in every gully and valley. Griffin also "prospected" the whole district with the similar result, that he found gold in dust or grains, "everywhere." But long prior to their modern system of "prospecting," some of the Leadhills valleys are the scene of the far-famed alluvial washings under Sir Bevis Bulmer in 1578–92, and it was from the produce of such washings that the Scottish Regalia were fashioned in 1542, and Kings James IV. and V.'s celebrated bonnet pieces coined. Bulmer's chief washings are said to have been in the Valley of the Elvan, and he is also represented as having washed the whole bed of the Glengonner water. But vestiges of ancient "diggins," precisely similar to those of Otago, are to be met with in many parts of the Leadhills district. For instance, I found the haugh or "flat" on the banks of the Glengonner water above Abington and immediately below Glencaple Burn, covered with a series of quartz-like mounds, exactly resembling those with which I was familiar in the famous Gabriel's gully at Tuafoka in Otago, and which are said really to mark the site, or one of the sites, of Bulmer's celebrated workings. It was the gold prospecting in this district, it is said, that led to the discovery of the lead, which has proved so much more permanent a source of prosperity to the district, to which it has, moreover, given its distinctive modern name of late years; and at present gold is systematically collected by the Leadhills miners chiefly in certain localities, viz., in the Windgate or Windygate Burn, in Langcleuch Burn, in Bellgall Burn, in the whole course of the Elvan and Glengonner from the Clyde to their source. The gold occurs chiefly in the gravelly clay, locally known as "Till," as this coats the flanks of all the Leadhills valleys; but it is also to be found in the shingle, gravels, or clays of the stream-beds. Several of the miners have considerable reputation as skilful and successful gold-finders, and their practised eyes are constantly finding gold in both localities, the hill sides, and the stream beds. This gold is invariably what is known as "drift" or "alluvial" gold. There is no present local evidence of the existence of auriferous quartzites. But in 1803 the late Professor Traill of Edinburgh found gold in a vein of quartz *in situ* at Wanlockhead. All the gold belonging to this district which I have seen is of a granular or nuggety character, and quite comparable with the usual produce of Otago, or other auriferous countries. Some of the "nuggets" found in former times, and preserved in the cabinets of local proprietors, are of very considerable size and value. The cabinet of the late Lord Hopetoun contains two—one of them weighing 2 lbs. 3 oz.=27 oz. or 12·960 grs., which at the current price of gold in Australia, L.4 per oz., is worth

L.108; collected, it is said, about 1502, prior to the systematic workings of Bulmer. The other, weighing 1 oz. 10 dwts., or 720 grains. The first would appear to be by far the largest mass of native gold ever found in Scotland. Since, however, systematic gold workings on a large scale were discontinued, the size of the Leadhills nuggets has been greatly smaller, the largest seldom now exceeding 2 or 3 grains, though they are frequently found of that size. Just previous to my visit in the autumn of 1863, a nugget of 30 grains had been found, and another single nugget, whose weight I failed to ascertain, sold for 25s. at Abington. More generally the gold occurs here as rough granules, coarser and larger than those constituting what could properly be called "dust," and of this considerable quantities are frequently collected in limited periods for special purposes, such as marriage gifts, or jewellery to, or for the local proprietors. Thus, in a fortnight in 1862, 975 grains were collected for the Countess of Hopetoun, and on another occasion 600 grains in six weeks by thirty men at spare hours, fifteen working in the forenoon, and the other half in the afternoon. About Abington, in 1858, similar quantities were collected under similar circumstances to furnish marriage jewellery for Lady Colebrooke. Between May and October 1863, three miners, in the intervals of leisure from their usual work, collected for me 33 grains which they found in the "till," about forty yards above the bed of the stream, half way down the Langcleuch Burn, between Leadhills and Elvanfoot: their charge was 20s., that is, at the rate of about L.15 per ounce, or 7½d. per grain. During the last five years the price of crude gold in Australia and New Zealand has averaged from L.3, 17s. 6d. to L.4 per ounce, so that the Scottish diggers obtained for their produce nearly four times as much as the New Zealand or Australian diggers got for theirs. The price appears at first sight to be extremely and disproportionally high; but the cases are by no means parallel; for in the case of the Leadhills gold, the collection is made to meet demands for cabinet specimens, or for jewellery materials under circumstances quite exceptional. The Leadhills miners collect their gold mostly to order; it is thus at once disposed of, and hence gold is seldom to be found there for sale, or only in very small quantity. On one occasion I was offered a sample of 140 to 160 grains for L.5; that is, at the rate at which I purchased my smaller sample, but the miners rarely have so much in their possession unsold. In the summer of 1862, by way of holiday work, the miners frequently collected quantities of 14 to 54 grains. The able-bodied Leadhills miner never, however, gives up his usual labour, at which he earns 15s. per week, for the more precarious gains to be derived from gold-finding. To gold seeking he devotes only his spare hours, his holiday time, or his periods of sickness or debility.

The price he generally more or less readily obtains for his gold varies necessarily with the demand and supply. Sometimes it rises to 7½d. per grain or L.15 per ounce, sometimes it falls to 5d., but the more common or average price is 6d. per grain, or L.12 per ounce, while the average market price may be quoted at present at L.4 per ounce, or 2d. per grain. The director of the mines at Leadhills estimates gold-washing at these prices as only capable of yielding, at present wages, 3d. per day, while lead-mining gives upwards of 2s., or more than eight times as much, with the great additional advantage of a certain or regular occupation. He, however, has such an opinion of the abundance of the gold, the facility with which it may be collected, and the probable remunerativeness of the gold working, that with a favourable lease of the ground he and many others would at once combine to commence systematic operations. Other local authorities are, however, much less sanguine of profitable results from working the gold on a larger scale or by whatever means, though there is an unanimity of opinion as to the *general prevalence of gold, and its easy accessibility, throughout the district.*

The method of collecting gold by washing at Leadhills is essentially that employed in the early history of gold diggings in all auriferous countries; but there can be no doubt that collection would be facilitated, the produce increased, and the remunerativeness of the operation improved, by the application of the most modern machinery now used in countries where gold-mining has long become a settled industry. Even the present apparatus for working lead might be applied, with modification, to the working of gold, a circumstance worthy of attention in connection with the fact that gold is found in the refuse of the lead workings.

The Scottish gold-fields may be divided geographically or topographically into three—the Northern, Central, and Southern.

1. The *Northern* comprises the greater part of the counties of Sutherland, Ross, Inverness, and Argyle, north of the Caledonian Canal. It occupies the longitudinal axis of the northern peninsula of Scotland, is second in size only to the central area, and has yet almost entirely to be explored.

2. The *Central* lies between the Caledonian Canal and the valley of the Tay; includes a great part of the shires of Inverness (southern half), Aberdeen, Banff, Kincardine, Perth, Forfar, Argyle, Stirling, and Dumbarton. It is by far the largest of the three areas. Like the Southern gold-field it forms a transverse belt across Scotland, and much of it remains to be explored.

3. The *Southern* comprises great part of Dumfries, Kirkcudbright, Wigtown, Ayr, Selkirk, Peebles, and Lanarkshire, and includes, more particularly, parts of the districts of Nithsdale, Annandale, Eskdale, Ettrickdale, Tweeddale, and Clydesdale, and

the Lammermuirs (in Haddington and Berwick). It is the smallest of the three areas, but is the best known, and, so far as ascertained, the richest.

Geologically the area of these three great gold-fields is that occupied in Scotland by the *Lower Silurian* strata and their drifts. These strata are divisible, however, only into two great groups, viz., the Southern, corresponding to the *Southern* gold-field as above delineated, characterised by the Greywackés of the Southern, and the *Northern*, comprising what I have above described as the Northern and Central gold-fields, characterised by the micaceous schists of the Grampians. But though the Lower Silurian strata are the rocks, in, or in connection with which gold is most frequently found in other auriferous countries, it is most likely to be found throughout Scotland. Experience shows that gold may be contained in a great variety of other rocks and their drifts of other ages, both older and more recent. It is, indeed, much easier to catalogue the rocks or deposits in which gold does not occur, than to enumerate those in which it has been found in different parts of the world. For instance, the recently discovered gold-fields in Upper and Lower Canada, as well as in Nova Scotia, and, according to Dr Sterry Hunt of the Canadian Geological Survey, in the Laurentian area, while gold occurs also in Laurentian gneiss in Sweden. In Scotland the area occupied by *Laurentian* gneiss comprises the Hebrides and the modern seaboard of Sutherland and Ross-shire. There is thus good ground for a careful examination of this area, though I have met with no evidence that even a trace of gold has hitherto been found within it. Again, it has been stated that in certain other parts of Canada the gold rocks are *Upper Silurian*, so that there is no reason, *a priori*, why, *e.g.*, our Pentlands should not prove to be an auriferous area. According to Professor Whitney, certain at least of the gold-bearing rocks of California are yet more recent, while the experience of New Zealand, Australia, and other auriferous countries, has demonstrated the frequent occurrence of gold in granites, syenites, sandstones, and limestones, and their debris, apparently of very different ages. Under these circumstances, it would hardly be safe to predicate that gold will *not* be found in any given district or rock in Scotland, and there is apparent evidence to show that gold-fields have actually been made, where, geologically, gold certainly was not to be expected, and would not have been predicated. All records of gold-fields, however, in areas occupied by rocks not generally auriferous, require to be carefully examined. In some of these cases, it is possible that the auriferous rocks did not belong to the district, but were erratics originally from Silurian regions; in other cases, it has been proved that the substance supposed to be gold, was in reality

iron pyrites, or mica. A local newspaper of 1865 states that, in Elginshire (a Devonian district), a gentleman picked up a piece of auriferous quartz near Woodside. Calvert states that David I. made a grant of a gold mine in Fifeshire, a district which is wholly Old Red Sandstone or Carboniferous; and gold is also recorded to have been found in other unlikely counties or localities, such as Linlithgow, which is wholly Carboniferous; and Orkney, which is mainly Old Red Sandstone. Within my own recollection, about the period, I think, of the discovery of the wonderful auriferous riches of Australia, the neighbouring county of Fife was the scene of a regular "rush" to the West Lomond in search of gold. This hill consists of carboniferous shales, with intrusive beds of Greenstone, overlying the Upper Old Red Sandstone, separating the Old Red Sandstone of Perthshire to the north from the Carboniferous system of Fifeshire to the south. Under these circumstances, it need scarcely perhaps be added, that the fruit of the diggings of the peasantry of Abernethy and Newburgh was *iron pyrites*. The inhabitants of the ancient "kingdom" do not seem, *then*, to have realised or appreciated the truthfulness of that very trite saying, "All is *not gold* that glitters."

At many localities throughout the area which I have assigned to the Scottish gold-fields, actual finds of gold have been made in recent or former times, and this is one of the strongest arguments for their thorough exploration. Of such gold-finds, the following will suffice as illustrations:—

I. *Northern Gold-Field.*

1. *Sutherlandshire.*—Helmsdale water. A nugget found here in former times weighed 10 dwts., or 240 grains.

II. *Central Gold-Field.*

1. *Perthshire.*—(A.) *Breadalbane*, area of Loch Tay, and headwaters of the Tay. A nugget found in former times weighed 2 oz., or 960 grains. Sir James Simpson tells me that he was shown a specimen of gold, with its matrix (quartz), by the late Marquis of Breadalbane, from Tyndrum. In 1861 Professor Tennent of London found gold in quartz, associated with iron pyrites at Taymouth.

(B.) *Upper Strathearn*, area of Loch Earn, and the headwaters of the Earn. Glen Lednoch (Ritchie); streams falling from the north into Loch Earn (Ritchie); Ardvoirlich, south side of Loch Earn.

(C.) *Glenalmond* (Mercer); Glenquoich and other valleys of the Grampians.

2. *Forfarshire.*—Clova district, areas of Angus, Edzell, and Glenesk.

3. *Aberdeenshire,* area of the Dee, Braemar, Invercauld, coast about Aberdeen, and in the sea-sand.

In New Zealand, and other auriferous countries, gold is very commonly associated with *magnetic iron sand,* containing or not titanium, and other minerals, or with iron sulphides. It is of interest to know that the sands of the Dee, which consist, mainly, of the *debris* of granite and gneiss, contain considerable quantities of magnetic iron sand and iserine, with which are associated smaller amounts of titanium, uranium, and arsenic. The gneiss of Braemar often contains *much* magnetite in place of mica (Nicol), while iron, or oxides, or sulphides, are common in all the schists and granite of Aberdeenshire (Nicol).

4. *Argyleshire,* Dunoon.

III. *Southern Gold-Field.*

1. Headwaters of the *Clyde,* including the Ech, Crawford Moor, or Leadhills district; Elvan water, Glengonnar, Glencaple, Winloch, Short Cleuch, Lammington Burn.

2. Headwaters of the *Tweed;* Manor water, which flows north to the Tweed; Meggat water, which flows south to St Mary's Loch; other feeders of the Yarrow and Glengaber.

There are traces of prospecting and digging in former days in Meggat water valley, similar to those which occur in Leadhills. In the British Museum I saw two specimens of Tweeddale gold —the one nuggety, and in quartz, a very rich sample—the other granular rather than nuggety. Griffin prospected St Mary's Loch district, and found gold in dust or granules everywhere.

3. Headwaters of the *Annan,* Moffatdale; streams falling into Moffat water; Hartfell range, about Dobbs Linn; several small finds of gold were made in the summer of 1863, and one small nugget, weighing about 6 grains, was exhibited in Moffat (*Scotsman,* August 10, 1863).

It ought to stimulate to the search for gold in *Scotland* that Gold Mining Companies are in actual operation in *Ireland* (Wicklow) and *Wales* (Merionethshire). In the former the works appear to be what are generally known as "alluvial," or "washings;" while, in the latter, the operations are more properly those of quartz-reefing or mining. Hitherto there have been few well-authenticated discoveries of gold quartzites of any extent *in situ* in Scotland, but this is simply, I believe, because they have not been systematically looked for. That they occur, is rendered at least probable by the fact of the frequent discovery of nuggets, with the matrix adherent; while, in all old historical references to the working of gold in Scotland, gold *mines* are

spoken of—a phrase which, though an ambiguous and comprehensive one, leaves open the question whether quartz-reefs and reef-crushing were not known about Bulmer's time. The quartz-reefs of the mountains near Dolgelly, in Merionethshire, penetrate strata of Lower Silurian age, resting on the Cambrian series, and disturbed here and there by eruptive greenstone. The gold is there associated with metallic sulphides (iron, copper, lead, and zinc), metallic oxides (iron and copper), telluric bismuth, graphic tellurium, ores of silver, and other minerals. In Wales, moreover, gold occurs, as it does in New Zealand and other auriferous countries, in the clay or loam which covers the *tops* as well as flanks of hills. Irish geologists have recognised a close resemblance between the features of the Tuafoka gold-field of Otago, New Zealand, and those of Croghan, Kinsella, in the county of Wicklow. In a most interesting discussion on a paper, descriptive of the Otago gold-field, which I laid before the Royal Geological Society of Ireland in January 1865, a mass of gold worth L.120 was exhibited fresh from the Carysfort Mining Company's operations in Wicklow, while its exhibitor remarked, "He might adopt the geological description, contained in the paper just read, as applicable to the gold-fields of the county of Wicklow. The parallel between the two districts was so complete, that he could almost fancy the gentleman who described the New Zealand gold-fields had never stirred beyond the valley of Croghan, Kinsella."

It were premature, perhaps, to discuss the *remunerativeness* of gold-working as a national industry, or even the question whether it is destined ever to become again, as it once was, at all events, a local industry, until we are in possession of data showing approximately the extent and richness of the Scottish gold-fields. Our present data are of the most imperfect and unsatisfactory kind, and yet they are sufficient, I think, to demonstrate the fact, that gold is widely distributed over Scotland, and to render it of, at least, scientific importance, to make the exact area and richness of its distribution a subject of systematic research. Meanwhile the evidence collected goes to show that gold-working is not remunerative in Scotland to skilled and able-bodied labour at the current high rates of wages, while it may be most remunerative, as a field of extra labour, to paupers and others, the value of whose labour is small. The Gipsies of Hungary, who are of roving life and idle habits, wash gold in the Transylvania rivers, when it is too hot in summer for other avocations. They thus gain a livelihood, which, precarious and speculative though it be, is yet suited to their tastes and habits. They wash the finer sands on a wooden tray, covered with woollen cloth, and the coarser gravels on a ribbed board (Ansted),—a procedure which, *mutatis mutandis*, is what is adopted by gold-diggers in alluvial

washings in New Zealand, Australia, California, and all other auriferous countries.

I had intended instituting comparisons between the Scottish gold-fields and those of Otago, New Zealand, and also of making certain observations on the auriferous drift of Scotland, but my present remarks have so far exceeded the limits I originally proposed to myself, that it is desirable to treat each of these remaining subjects in a separate paper on some future occasion.

Thursday, 5th December 1867.

Dr PAGE, President, in the Chair.

The following Communication was read :—

On the Glacial Phenomena of the Pyrenees. By P. W. STUART MENTEATH, Esq.

Thursday, 19th December 1867.

Dr PAGE, President, in the Chair.

The following Communication was read :—

On the Valley of the Tay at Perth, with reference to the Surface Formation. Part I. By CHARLES P. NICOLSON, Esq., M.A., B.Sc.

Thursday, 16th January 1868.

Dr PAGE, President, in the Chair.

The following Communication was read :—

On the Connection of the Lower, Middle, and Upper Old Red Sandstones of Scotland. By JAMES POWRIE, Esq., F.G.S., F.R.S.E., Vice-President.

The views of many of those justly ranking amongst the highest geological authorities of the day being by no means at one as to the proper mode of dividing and correlating some portions of the Palæozoic formations, especially that known as the Old Red Sandstone or Devonian formation, I shall endeavour to put together very shortly a few of the principal facts which seem to me to bear on this subject, chiefly as these are exhibited in the development of that formation in Scotland, it being not only very