

XIII.—*Notes on the Sutherland Goldfield.* By EDWARD GREENLY, F.G.S., H.M. Geological Survey. (*Communicated by permission of the Director-General of the Geological Survey.*)

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1. INTRODUCTION.

ALTHOUGH a good deal has been written concerning the gold of Sutherland, it may be useful, as there seems to be a renewal of interest in the subject, to recapitulate the information actually obtained up to the present time, including a few additional points which came to light during the progress of the Geological Survey in the auriferous area. Verbal information of any value was difficult to obtain in the district itself.

To Dr Joass, of Golspie, I must express the greatest obligation. He has aided me in every way, including the loan of important specimens, and furnished the greater part of the subjoined Bibliography.

2. BIBLIOGRAPHY.

The following papers have been published on the subject, in chronological order as nearly as possible:—

1. Notes on the Sutherland Goldfield.  
By J. M. Joass, M.D. (with introduction by Sir R. I. Murchison). Quart. Journ. Geol. Socy. 1869.
2. Researches in British Mineralogy,  
By David Forbes, F.R.S., &c. Phil. Mag. 1869. (One of a series, 1867-9, on allied subjects.)
3. Something from the Gold Diggings in Sutherland.  
By the Author of "Frost and Fire." Odds and Ends Series, No. 22. 1869.

4. The Sutherland Goldfields.  
By Wm. Cameron. Glasgow Geol. Socy. 1870.
5. On the Matrix of the Gold in the Scottish Goldfields.  
By James Bryce, M.D., F.G.S. Brit. Assn. Report. 1870.
6. The Geognosy and Mineralogy of Scotland. Sutherland.  
Part VI., p. 504.  
By M. Forster Heddle, F.R.S.E.
7. The Geology of Sutherland.  
By H. M. Cadell, B.Sc., F.G.S. 1886 and 1896.

I would draw especial attention to the paper by Dr Joass for general description, and to those by D. Forbes and Dr Heddle for chemical analysis.

These are all the papers to which I have been able to obtain references. If anyone can tell me of any others, I shall be much obliged, in order to make the Bibliography of this subject as complete as possible.

### 3. FACTS ASCERTAINED UP TO 1893.

The foregoing papers contain good descriptions of the physical characters and general geology of the district, particularly the Old Red Sandstone and the Jurassic series, the crystalline schists being the rocks of which least was known at the time.

The localities also are recorded at length, and (except perhaps in the Berriedale area) it is clear that the ground has been well searched for a long distance.

Further, I would draw attention to the following points:—

*a.* Analyses of the gold are given by D. Forbes and Dr Heddle, from which it appears that it contains usually from 18 to 20 per cent. of silver. A button obtained from vein-quartz contained no less than 71.43 per cent. of silver, an interesting point in connection with facts which will be given below. Its physical characters, including the peculiar "hackly" surface, have been noted and described.

*β.* The other heavy minerals most abundant in the gravels, and which make up the principal part of the dark residues always obtained in washing, are described by D. Forbes. They are almandine garnets and dark oxides of Iron. The latter consist of titaniferous magnetite (with 8 per cent. of  $\text{TiO}_2$ ), and Black Iron Glance with Ilmenite.

The vein-quartz analysed by Dr Heddle likewise yielded Ilmenite, Magnetite, and apparently also metallic Iron.

*γ.* The gold occurs in alluvia bordering the rivers. It is richest, of course, in pot-holes and rock-pockets, and between

the foliation planes and in the joints of rocks exposed in the stream-beds; but occurs also in the terraces themselves, and in coarse as well as fine material, from fine silt to rough tumultuous gravel.

The lower portions of these beds are said to be richer than the upper.

It is reported also to have been found in the unstratified drift of the moors.

δ. It has *not* been found along streams running wholly or chiefly over Jurassic Rocks, Old Red Sandstone, or the Granite of the Ord.

It has been found along streams running over *all* types of the crystalline schists; but most richly where they are full of granite veins and sills.

ε. With regard to its having been found *in situ*—

- i. Dr James Bryce states that gold was washed by workmen from the powder of granites, the specimens being selected by himself at Suisgill.
- ii. The vein quartz sent to Dr Heddle for analysis contained an "electrum-like" alloy (Au. 28·57, Ag. 71·43) in the proportion of 39·2 grains per ton.
- iii. Gold was found in three pebbles, two of which are paste granites (or pegmatites?) of the type occurring at Kildonan, and the third a quartz schist or quartzite, apparently of clastic origin.
- iv. Dr Joass appears to have found gold in a quartz vein examined by Dr Heddle and himself in Kildonan Burn, for details of which see Dr Heddle's paper, p. 509.

#### 4. FACTS ASCERTAINED DURING THE PROGRESS OF THE GEOLOGICAL SURVEY.

The Geological Survey of the Kildonan area was made chiefly during the years 1893 and 1894, and all the ground in which gold was found in any quantity is now surveyed. The main valley and its tributaries from Helmsdale to Torrish Burn were mapped by Mr Hugh Miller, and from Duibh near Kildonan to Kinbrace by myself, there being a narrow strip still unsurveyed between Duibh and Torrish. Mr Miller has also surveyed the Blackwater area, and the country draining to the coast, as well as a tract about Ousedale in Caithness.

In all probability the most useful result with regard to future investigations into the occurrence of the gold will be the actual map itself.

The alluvia have been laid down upon it, the granite veins



and sills picked out, and certain subdivisions established among the crystalline schists.

These subdivisions are as follows :—

Quartz-schist.

Granulitic biotite schist.

Flaky or flaser mica-schist.

The quartz-schist is a hard, flaggy, granulitic schist, containing a good deal of felspar and white mica. Though probably a highly altered sedimentary rock, clastic texture cannot now be detected with certainty in any but a few places. Thin seams of black minerals, chiefly magnetite (idiomorphic) and ilmenite, with probably some chromite, are not uncommon.

A good exposure is seen at Kildonan Bridge.

The pure white quartz-schist of Eireannaich differs from this Kildonan rock in several ways (not only in being a much purer and cleaner rock, but also in containing peculiar accessory minerals, particularly idiomorphic olive Tourmaline) and it is possible that they are *not* merely varieties of the same mass.

The Granulitic Biotite schist resembles the quartz-schist structurally, but contains biotite instead of muscovite, and more felspar. It is often difficult to distinguish between these two types. Good sections are to be seen in Suisgill Burn above Allt na Briste.

The flaky mica schist (as I have called it for lack of a better name) contains quartz, felspar, and both micas. Garnets are abundant in some bands, and the aluminous silicate sillimanite is very generally present. The texture differs from that of the other two, being much less regular, the micas are wavy and in large flakes, and felspar augen not uncommon. Good sections are seen at Suisgill Lodge.

These types pass into each other, but are fairly well marked out on the large scale.

With regard to the granites, nothing need, for the purposes of this paper, be added to the description given of them by Dr Joass.

Basic igneous rocks are very rare, and so also is true vein-quartz. I have only mapped three or four quartz-veins as much as two feet thick. Perhaps it may be as well to remark here that the quartz-rock of Eireannaich is not a vein-quartz, but a schist, resembling other large masses throughout the Highlands, which are of sedimentary origin.

With regard to the alluvia and drifts there is not very much to say. The sand and gravel terraces along the tributary streams are narrow, being seldom as much as 150 ft. in width, though the deposits are often pretty thick. Those along the main river reach  $\frac{1}{2}$  of a mile, in the reaches which I sur-

veyed. As a rule they are of finer material than those in the tributaries.

Almost the whole surface of the country is covered with Glacial Drift, rock being seen only in the stream courses and on the brows and tops of the hills. This drift is not a true "Boulder Clay," but is loose and sandy. In certain portions it is stratified, or at any rate beds of sand and tumultuous gravel occur, which, although they are more overlain by unstratified drift, are not separated from it by any defined surface feature. These are 150 ft. thick in the upper waters of the Suisgill. They should be clearly distinguished from the terrace-gravels. Blocks of Foliated Granite and of Diorite are pretty frequent in the drift, which must have come from the west, but the bulk of the material is of local origin. The white quartz-schist of Eireannaich is of rare occurrence, even close under the watershed. Besides these general results, which have but an indirect bearing on the question, one of more direct interest was obtained.

While mapping the upper waters of the Kildonan Burn, I found that the rocks, instead of being hard and fresh close to the surface, were decomposed to the depth of 20 or 30 ft. to such an extent that, while retaining all such structures as foliation, veining, and the like, they crumbled into sand between the fingers, and could be dug with a trowel, like some of the granites of Cornwall: and it occurred to me that by digging out and washing this material it would be possible to deal with much larger quantities of rock than by examining fresh specimens, however carefully. And therefore, if the gold were disseminated in very small quantities, there would be a far better chance of detecting it. However decomposed the rock might be, gold, if present uncombined, would not suffer, and would no more be carried away in solution than quartz: and even if combined, the instability of the compound would, it seemed, bring about a reduction to the metallic state sooner or later. So I dug and washed seventeen basins full of this, carefully avoiding all merely superficial sand that was clinging to the face of the cliff.

The rock was a fine granulitic quartz-schist, containing a fair amount of felspar, and some biotite, and so approaching the granulitic biotite-schist in type. It contained a few pegmatitic veins, but these were avoided; and a fine, sharp, even sand was obtained, composed of quartz, with 8 to 10 per cent. of felspar, and some muscovite and biotite.

Unfortunately, I omitted to measure the cubical capacity of the basin, and so cannot give more than an approximate estimate of the amount washed: but from measuring lately with a very similar basin and very similar sand, I think that it must have been about 350 lbs. From this were obtained 610 grains of

With regard to the actual parent rock, the facts given in 3  $\delta$  make it clear that we must look to the crystalline schists complex. Among these, vein-quartz and basic rocks appear to me to be too rare for us to look to them wholly, in spite of the facts quoted under 3  $\epsilon$ , ii. iv. Admitting that gold has been found in quartz-veins in Kildonan, it does not follow that it is confined



to them. The tendency of gold to segregate along with quartz seems sufficient to explain its presence in such few little quartz veins as there are in the district. And, although of course we must remember how much ground is concealed by drift, I am still inclined to think that the vein quartz of the area is insufficient to account for the gold in the gravels.

Personally I incline, with Dr Joass, to look to the granites. Without laying too much stress upon the results obtained by Dr Bryce (for details are not given in his paper by which we can feel certain that all risk of error was excluded), the two auriferous granite pebbles appear to me to be genuine, from their close resemblance to local rocks. Now of granites there is abundance in the district, and, though the matter cannot be considered as settled, perhaps the following consideration may help us.

The assay shows that, though disseminated in exceedingly minute quantities, gold does exist in the heavy minerals of the schists. And the high proportion of silver agrees with the analyses of the alluvial gold, and even more with that from the vein-quartz analysed by Dr Heddle.

But as the gold in the schists has not been found in visible particles, it is probable that the visible particles in the gravels must be aggregations from finely disseminated matter.

That there has been a great deal of migration of material in the schists during the process of metamorphism is certain, from the garnets and sillimanites they contain. That there must have been also migration of material in connection with the formation of the granites seems to me also certain: and I would call attention to the views of Mr Miller concerning the granites in his area, a very brief account of which can be found in the Annual Report of the Geological Survey for 1893.

Now, as gold certainly has a tendency to travel along with highly acid material, it seems to me quite reasonable to suppose that rocks containing gold, when permeated by a magma as acid as a granite, and by the superheated waters accompanying this, should readily yield up its gold, and that that gold should find a final lodgment in the veins and sills in which the granite eventually consolidates.

This is of course mere speculation; and our experimental knowledge of the salts of gold can tell us very little indeed concerning their behaviour under such conditions as these.

How the gold was introduced into the schists, it is, of course, quite impossible to say. The origin of the schists themselves is involved in sufficient mystery at present.

If, however, they are metamorphosed sediments, as seems probable, I would call attention to the occurrence of gold in the

matrix of the somewhat altered conglomerate at Johannesburg (a slice of which, by the kindness of a friend, I am able to exhibit), and also to the fact that iron sulphides abound in this conglomerate, and that it was from iron oxides in the schists of Kildonan that gold was obtained.

#### 6. SUGGESTIONS FOR FUTURE INVESTIGATION.

With regard to future investigation, I would point out that the method of digging and washing decomposed rock has been tried in one instance only; and that it may yet conclusively solve the question of origin, and at the same time decide whether the gold can ever be profitably worked in the rocks as well as the alluvia.

These alluvia are not very extensive; they must sooner or later be exhausted; and I agree with Mr Cadell and Mr Miller in thinking that the unstratified drift is unlikely to be profitable.

I should suggest that decomposed portions of the flaky schist, of the granulitic biotite schist, and especially of the granites, all of which are well exposed in Suisgill Burn, should be examined in this way.

The residue should not be rejected even if gold is not visible, but I quite expect the granites will yield visible particles. It does not follow, however, that any of them are likely to be very rich, for the alluvial deposits have been concentrated from a wide area.

Finally, I would remark that in these matters residents, who can go over the ground at leisure, are much more likely (particularly if they have the survey map in their hands) to be successful than the Geological Surveyors, who have plenty to occupy their time and thoughts in the construction of the map and the general geology.

To residents, then, I would commend the further investigation of this question.

And in the event of disappointment from an economic point of view, I would point out that an unexpected scientific reward may await success: For there can be little doubt but that the history of the gold is bound up with the general history of the crystalline rocks of the district.

And while, for lack of precise knowledge of the chemistry of the compounds of silicon, we lose our way among a chaos of changing and complicated silicates, it might prove possible to track such a mineral as gold, retaining its individuality through stage after stage in the career of mineral change, and so supply a clue to some of the processes of metamorphism, intrusion, segregation, and foliation, which have combined to build up a gneissose complex such as that of eastern Sutherland.