XVI.—*Notes on some Minerals of the Mawddach Valley.*

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THE late eminent palæontologist, Mr. Salter, F.G.S., characterized the portion of the lovely valley of the Mawddach, at, and near the Falls of the Cain and Mawddach Rivers, "a perfect geological puzzle."

Certain it is, that touching Tyddyngwladus, the survey maps are greatly at fault; and, that the rocks, thereabouts, most of them, are of *pre-cambrian* age.

Dr. Hicks, F.G.S., has hit upon the truth, approximately, I think, in what he calls *Dimetian* at St. David's, (as applied to the lowest beds of this district.)

After more than a year's unceasing investigation of these puzzling rocks and their associated minerals (chiefly with reference to the modes of occurrence of the "precious metals"). I must frankly acknowledge that the locality geologically, to my comprehension, remains pretty much as Salter left it, a "puzzle."

I am quite content to leave the exact order of superposition of these rocks in the hands of the geologists; and, will briefly state that the hand-specimens I have collected show:—

Black micaceous and talcose schists; black and green shales; hard, dark-grey, felspathic, ashy, and cindery-looking uncleavable (for the most part,) slates; (*lower silurian* of the survey). Black slates, (*upper cambrian* or *lingula-flags* of the survey). Felspathic and "Trappean" grits; hard coarse sandstone; rough schists, shales and slates (*lower cambrian* of the survey.)

Portions of felspathic-lava beds; striped cinder-beds, both chloritic and mixed with grit and sandstone; spotted, blotched, felspathic, sedimentary and interbedded "trap-rocks."

Bits of ashy-beds, yellow clay, "Elvan," "Flookan," and quartzite.

The usual "intrusive greenstones" of the survey, which are green, grey, and reddish in colour, fine, medium, and coarse-grained, often very coarse-grained, prominently quartzose, and, prominently hornblendic; also, diabase, and diorite, and the "magnificent uralite porphyry."

The minerals include compact and crystallized baryte, calcite (sparsely), orthoclase, chlorite, black hornblende, white scaly mica, white, yellow,

ferruginous, calciferous, auriferous, plumbiferous, zinciferous, cupriferous and pyritous quartz, with the cherty or hornstone variety abounding, which is often powdered (so to speak) with extremely fine gold, all of which is so light that it will float on water. Talc also, occasionally, and uralite. Native gold, native silver, native antimony, native copper, galena, copper pyrites, iron pyrites, mispickel, marcasite, rhodochrosite, tetrahedrite, polytelite (of D. Forbes,) pyromorphite, blende, stibnite, senarmontite, berthierite (?), aphthonite (of Glocker ?), earthy malachite, platinum (?), titanoferrite (of Forbes), &c.; some interesting particulars of which I reserve for other occasions.

Gold is found *in situ* in the metallic state, of a very pale yellow color. As yet, it has not been found in anything approaching geometric forms of crystallization. Generally, the gold is disseminated in whitish crystalline quartz, or in hornstone, in a state of division so minute as to be scarcely discernible by the aid of a powerful lens. Occasionally, this precious metal is found something like what Sir R. Murchison characterised as "crystallised twigs." This gold as found answers to *Pliny's* "electrum," containing from 10 to 15 or more per cent of combined silver.

Much has been said about 'derivative forms' of gold; but from a long series of observations, I cannot be persuaded to believe in derivative forms, touching systematic crystallization. I believe, rather, that gold, hereabouts, is frequently contained in quartz in a *non-metallic* state; and that, in process of time, be it short or long, particles of gold in ever-varying shapes (not definite forms) increase palpably in size and weight, even in and upon quartz apparently wholly destitute of the ordinarily associated metallic sulphides.

I have treated this subject at great length in a former number of the Mineralogical Magazine.*

Some of the specimens described in that paper, have since given me ample proof that I am altogether in the right about it. And recent repeated analyses convince me too, that gold exists here in a state of sulphide, and *probably* in some other state, or states, not yet generally known.

The electrum here, is frequently in quartz more or less surrounded with galena, blende, iron pyrites, copper pyrites (chalcopyrite of *Dana*), mispickel, (arsenopyrite of *Dana*) marcasite! But chiefly with galena and blende, and a proustite-looking mineral, an exceptional condition of blende.

I have treated many specimens of galena in quartz with hot acids, got rid of the sulphide, and obtained the electrum theretofore enclosed within

* No. 5, p. 158.

it, growing, as it were, out of the quartz, which could then, sometimes, become easily detached.

I have some reason for believing that the galena in such cases is the more recent mineral-aggregate.

I find, also, electrum in argentiferous galena, altogether unassociated with quartz, or other metalloid.

I find bits of gold of several grains weight in the sand and silt of the River Mawddach.

This stream-gold is worth 5s. an ounce more than the electrum which is found disseminated throughout the lode-stuff generally.

I gave my friend the late D. Forbes, F.R.S., a goodly sample of this stream-gold, and the following is what he wrote of it.

"The portion received contains the native gold in the form of small flattened, elongated spangles, in size from about a pinshead, down to almost dust, and of a rich yellow colour; it was accompanied by abundance of fine black sand, supposed to be magnetic oxide of iron, from its being strongly attracted by the magnet, but which, on analysis turned out to be titanoferrite. It also contained small particles of quartz, slate-rock, mica, and some small cubes of iron pyrites and galena.

The specific gravity of the gold, carefully separated from any other admixture, was found to be 15·79 at 60°F.; quantity employed 22·75 grs.

20·16 grs. afforded 17·71 grs. metallic gold; 3·89 grs. chloride of silver; 0·09 gr. insoluble quartz; and, 0·10 gr. sesquioxide of iron.

The results when calculated give:—

Gold..	17·71	=	84·99
Silver	2·92	=	13·99
Iron	0·07	=	0·34
Quartz	0·09	=	0·43
Cu & Loss	0·07	=	0·35
	20·86	=	100·00

Several of the largest spangles of gold appeared of a peculiar rich color, owing to their being coated with, as it were, a varnish or thin film of sesquioxide of iron, which persistently adhered to their surface; and, probably, was the source of a part, if not of all the iron found by analysis. This coating was no doubt the cause of the gold appearing to the eye considerably richer than it actually turned out to be, on assay."*

I have very recently washed out about half an ounce of similar gold (only chiefly in larger pieces) from the same locality.

* *Philosophical Magazine, Nov.* 1867.

It is associated with bits of galena, blende, titanoferrite (of Forbes), quartz, marcasite, and fragments of rock-debris.

The iron is removable by a magnet, but particles of gold will also adhere.

Some of this spangle-gold is tarnished as Forbes describes, but it is generally tarnished by titanic acid; and the tarnish is instantly removed by sodium or potassium amalgam, and will then yield to the ordinary processes of amalgamation. Without taking into account the greater pureness of this stream-gold, compared with the electrum of the lode-stuff, I think it more than probable that it did not originate at Tyddyngwladus at all. It was more likely brought down by the Mawddach floods from the Gwynfynydd or Cwmheisian mountains, or from still nearer the sources of the Cain and Mawddach rivers.

In my paper on 'Mineral Growth at ordinary temperatures,' already referred to, I have shown, that at times, under apparently ordinary conditions, gold, silver, copper and iron suddenly exude from the surface of the minerals (especially gold from quartz, and silver from calcite and argentite); and this extrusion for convenience of expression I termed 'Mineral Growth.'

The expression does not happen to be generally acceptable to the mineralogical mind; but the metals 'grow' (in the sense I mean it) for all that.

In that paper I referred to a lump of white quartz weighing half a hundred weight, which once occupied a place in a 'rockery' in a fern-corner of my garden.

This stone in December, 1877, shot out a 'crystallized twig' of electrum-gold more than $\frac{1}{16}$ of an inch long in the course of ten days, probably it grew in less time than that.

This, and other 'growths,' fell (or grew) off sometime between the beginning and ending of the observed ten days. In May, 1878, another sprig shot up from the very same spot, and remains thereon, probably to this time. [I loaned the stone to the Liverpool Museum, and have not seen it since]. Similar detachments may account for most of the stream-gold at this place, and, probably elsewhere.

Why the stream-gold of this district contains less silver than the electrum *in situ*, I cannot as yet determine; but the fact is so. Sections of some of the water-worn gold show that *cavities* in them are very prevalent. These, as Forbes suggests, are air-cavities, nearly all of them, and will account primarily for the comparatively low specific gravity of stream-gold, as a rule.

The electrum *in situ* hereabout is most unequally distributed.

It is generally thought that native or free gold never occurs uncombined

with silver, probably this is so. However, free gold frequently contains Fe, Cu, Hg, Pd, Pt, or Ir, or several of them in combination.

The Mawddach stream-gold contains traces of Pt, Ir, and Cu, as well as about 14 per cent of silver.

In some of the pyritous minerals found here, I am certain that the gold does not exist, always, in a metallic state; but that it is frequently combined with Sulphur or Arsenic; or, more or less with both; and occasionally with antimony.

At present, I have detected no tellurides (such as Tetradymite), found so commonly in the Clogau mountain about 5 miles from Tyddyngwladus.

I have several times found spangles of gold at the roots of ferns, growing near the western side of the Mawddach river; and, for more than two miles along the eastern side, a series of shallow pits gave me similar gold at every sinking.

In one place I got several ounces of stream-gold from the margin-dirt.

In the ordinary operation of washing this dirt with the 'batea,' the most 'experienced hand' fails to concentrate the whole of the gold contained in it. There are always mineral admixtures of high specific gravity, such as galena, magnetite, &c.; and, the lighter gold (alluded to above) is always more or less persistent in floating off. So that gold-washing, *per se*, is necessarily attended with great loss of gold (in two ways at least).

Gold-washing in the Mawddach can never be profitable except to 'old hands at it,' on their own account solely, who can conscientiously keep all they may happen to get.

My own trials at it invariably cost me 9d. to 1s. a grain! although the Rhine sand is considered worth washing when containing only 0·00000012 per cent of gold!

The results of two analyses of the Clogau gold, by D. Forbes, are as follows:

Gold	30·69 =	90·16	..	4·86 =	89·83
Silver	3·15 =	9·26	..	0·50 =	9·24
Copper and Iron..	trace =	trace	Fe	trace =	trace
Quartz	0·11 =	0·32	..	0·04 =	0·74
Loss	0·09 =	0·26	..	0·01 =	0·19
	34·04 =	100·00		5·41 =	100·00

Forbes further writes:—

"The metals Au. and Ag. are known to alloy with one another in all proportions, when fused: and, being both monometric in crystallization, are doubtless isometric in their replacements."

"It is interesting, however, to observe that the above analyses closely agree with the formula $Au^6 Ag$, which, supposing the equivalent of Au. and Ag. to be respectively 196 and 108, would, on calculation, require a per-centage composition of

Gold	90·88
Silver	9·12
	100·00 "*

The most interesting occurrence (from a crystallographical point of view), is what appears to have been a rhomb of chalybite, changed to limonite, &c., around which quartz has commenced to aggregate in a crystalline form.

* The Clogau gold is of a darker color than the Mawddach gold generally, owing to silver and tellurium being replaced by copper. Forbes noticed this himself in a communication to me, and I have often found it so.