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Note on the Geology of Wuntho *in* Upper Burma, *by* Fritz Noetling, Ph.D., F. G. S., *Palæontologist, Geological Survey of India, with a map.*

Geographical features.—The area described in the following pages comprises part of the Wuntho sub-division of the Katha district in Upper Burma. It extends, roughly speaking, between Htygaing on the Irrawaddi, and the Mu valley; in its eastern part only low hills rise from the surrounding plains, but in its western part the large massive of the Maingthong hills form a tract of approximately 75 miles in length.

The Maingthong hills, which I partly examined begin near Lat. 23° 45′ and Long. 90° 20′ near the junction of the Daungyu Choung with the Mu river. From this point the hills extend in a nearly northerly direction, the tract widening out gradually till it reaches its greatest breadth of 30 to 35 miles near Lat. 24° 5′.

It may be said to be limited by the broad valleys of the Mu and its tributary the Nam-Maw in the west, but its eastern boundary is less sharply defined. In the southern part the broad Wuntho valley forms the boundary, but further towards north the low hills to east come quite close up to the central massive forming for some distance a low watershed between the Meza and Mu river. North of these low hills the eastern boundary is again well defined being formed by the broad valley of the Meza river.

The highest point in this hilly tract is Maingthong hill (5,510 feet), the south-western spurs of which have been geologically examined.

The Toung-thon-lon (5,565 feet) at Lat. 24° 56′ and Long. 95° 52′ may possibly form the northern continuation of the Maingthong tract, but it was not visited.

Geological features.—I can only give a rough outline of the geological features of this area, owing to the almost unsurmountable difficulties, which the dense, nearly impenetrable jungle places in to the way of geological researches. Here and there a rock protrudes from under the thick vegetable mould which everywhere covers the ground. But nothing can be seen of the dip and strike of the strata. The trained eye, however, learns very soon to judge from the difference of the surface soil, whether a change in the nature of the underlying rocks has taken place. For instance, it is always easy to distinguish whether there are tertiary strata or diorite *in situ* below the surface soil, but the exact boundary lines must be guessed at. Even the valleys afford little opportunities for the geologist, owing to the impenetrable jungle.

As far as I could ascertain only eruptive rocks take part in the formation of the Maingthon hill tract whilst the surrounding low hills to the east, south and west of the eruptive mass consist of miocene beds, both of the lower or Chindwin and the upper or Irrawaddi group. Older formations occur only close to the Irrawaddi river, where the low ridge which runs almost due north, near Htygaing, is formed by mica schists, with an easterly dip; some traces of metamorphized carboniferous limestone may be seen on the eastern side of the ridge which forms the watershed between the Meza and Mu river, the crest of which is formed by an extensive serpentine dyke.

A.—Eruptive Rocks.

1. *Quartz Diorite.*—The rock which is chiefly developed in the Maingthong hill tract is a crystalline rock which from its outward appearance must be placed between granitites and quartz diorites.

So far as it is known the quartz diorite occupies chiefly the central part of the tract; it is well seen on the road from Wuntho to Pinlebu, between the villages of Myelin and Hethat, that this is so may be seen on the footpath which leads from Wuntho to Myelin, but the locality where I found it best developed is the Tayawchoung, a feeder of the Yu river; here enormous masses may be seen in rounded forms covering the slopes.

There is sufficient reason to believe that the quartz diorite is not only developed in the shape of a central mass, but that numerous dykes radiate from the centre, which show a considerable difference from the central mass; such a vein may be seen in the Nam-Maw ravine east of Mawteik where it undoubtedly penetrates the black rock (aphanite). Occasionally veins of white quartz may be seen in the diorite, but so far as I know they are not metalliferous.

2. In close connection with the diorite occurs a hard black rock which is developed either in homogenous masses or is well stratified. This mode of occurrence may be seen in the Nam-Maw ravine, east of Mawteik; after having passed Mawteik where a truly intrusive rock of the trap type can be seen, an exceedingly hard dark rock forms the bed of the river; for about half an hour this rock may be traced without any apparent change being noticed, excepting occasional fissures; then the rock disappears beneath the jungle, and when it crops out again, it is apparently of the same type, but now well stratified. The strike is 45° N. E.-S.W. and the dip 45° W. It is crossed by a system of jointing, running 340° N. N.-W.-S S. E. and dipping 62° E.

Mr. Holland describes this rock as follows:—A compact bluish-green rock breaking with a semi-conchoidal fracture, studded with minute grains of magnetite pyrites and pyrrhotite, the last-named minerals occurring also in irregular patches. Specific gravity 2·86. Under the microscope the rock presents the characters of a volcanic agglomerate rather than an ordinary lava or a dyke rock. Fragments of plagioclase felspars, hornblende and augite in all stages of decomposition are mixed with opaque grains of magnetite and pyrites in a microlithic groundmass. It contains a trace of gold but not enough for estimation.

Mr. Holland further remarks that only the occurrence in the field can decide exactly the origin of the rock, but from the microscope alone it seems to be a consolidated volcanic ash.

Mr. Holland's supposition is perfectly correct; when I first discovered this rock it struck me at once as not being of truly sedimentary origin, although being perfectly stratified. In fact the bedding goes so far that the grains and patches of magnetite pyrites run parallel to it. My first idea was that this must be a consolidated volcanic ash, very probably deposited in water. At all events under this circumstance the hard bluish rock mentioned above is also a cemented and hardened volcanic ash on the top of the stratified beds.

This hardened volcanic ash may be seen all along the outskirts of the Maingthong hill tract forming particularly the surrounding region; I first noticed it near Padeingon, about 15 miles in a straight line north of Wuntho, and from there I traced it all along the lower hills which form the outskirts *viâ* Pinlon, Kyaungon, as far as Wuntho; on the road from Wuntho to Pinlebu between the 7th and 8th mile where there are extensive old gold-diggings, this hardened volcanic ash shows, according to Mr. Holland, exactly the same composition as that from Mawteik which is not less than 28 miles in a straight line distant from that place. Here the simultaneous occurrence of the stratified and the non-stratified beds can also be seen, and the first are apparently the lower; a sample of the non-stratified rock exhibits the following characters:—A coarser grained rock than that from Mawteik, presenting the characters of a compact and altered agglomerate. There is a considerable development of epidote at the expense of the decomposing felspathic material which is in large quantities. Fragments of amygdaloidal andesite are occasionally found included and undergoing the general decomposition. Specific gravity 2·884. I need hardly add that it also contains numerous specks of magnetite pyrites.

To me it seems most probable that the diorite and the volcanic ash are in generic connection, although this has not been actually proved yet; the probably sub-marine diorite eruptions were accompanied by large showers of ash which form now these pseudo-sedimentary rocks. Undoubtedly, subsequent eruptions produced dykes, which intruded into the surrounding ash masses and these dykes chiefly attract our attention. They were of two types—one, closely allied in composition to the diorite; the second, chiefly consisting of felspathic quartz which contains a more or less considerable quantity of auriferous pyrites.

(*a*) *Pyritic veins* (*auriferous.*)

The known pyritic veins are only found on the eastern side of the Maingthong hill tract, but I have not the slightest doubt, that subsequently they will be found at other places within the ash-girdle. Beginning from the north the following localities are known where these veins occur:—

1. Gwegyi.
2. Toungni near Padeingon.
3. Chouk-paza-doung, close to Padeingon.
4. Theindoo-choung, near Pinlon.
5. Mayutha.

All these places are quite close to each other, the distance from Mayutha to Gwegyi being not more than 12 miles in a bee-line. So far as it has been observed the veins do not run in any particular direction, but I may be wrong here. Anyhow the small holes in which the veins were exposed, did not permit a definite opinion; only when their extent is known, can this question be decided. The

veins naturally vary in thickness, as well as in the quantity of pyritic ore which they contain. The thickest vein which I have seen is that of Toungni; the ore contained a comparatively small quantity of pyrites; on assay it yielded 4 dwt. 15 grs. of gold to the ton. The ore from Chouk-paza-doung which occurs in a vein of about 9 to 12 inches in thickness is much richer in pyrites, but it yielded only 1 dwt. 7 grs. of gold.

At Pinlon, of which Mayutha is probably only the continuation, the vein is about 4 inches in thickness, but consists nearly throughout of pyrites. On assay it yielded only a trace of gold, although there is seemingly a connection between the quantity of pyrites and gold contained in the ore; that is to say, the richer in pyrites the poorer in gold, this supposition requires however a great deal more confirmation before it can be accepted.

However it is not only the quartz veins to which the occurrence of auriferous pyrites is limited, much more frequently it is largely dispersed in small crystals through the ash; in fact we may say the occurrence in veins is only a concentrated form of the occurrence of the auriferous pyrites in the ash. Pinlon offers a good example of this; as above mentioned, there is a comparatively thin vein of pyrites traversing the volcanic ash, which itself shows not race of pyrites, at a distance of about 200 yards from the above place the ash, however, shows numerous small pyritic crystals and old diggings prove that the natives have been working here for gold. Typical localities of the second mode of occurrence of the pyrites are—

1. Gotama hill near Wepone, north of Wuntho.
2. Kyoukpyu, between the VII and VIII mile on the road from Wuntho to Pinlebu.
3. Nam-Maw east of Mawteik, Pinlebu Sub-division.

Besides the above there are undoubtedly numerous other places; for instance the frequent occurrence of crystals of pyrites in the streams near Gyodoung (north of Wuntho) prove that it must be found west of that place.

(*b*) *Galeniferous veins* (*argentiferous*).

Besides the pyritic ore there occurs on the western side of the Maingthon hill tract a galeniferous vein of Cerussite under very similar circumstances. The first locality where I found it is called Kaydwin (Kay-lead, dwin-mine) situated in the ravine of the Nam-Maw, east of Mawteik and still further to the east from the place where the pyritic ash had been observed. As far as I was able to ascertain without making extensive diggings it is a vein of, as Mr. Holland describes it, an igneous rock of the aphanite group being composed principally of lath-shaped plagioclase felspars, hornblende, and relics of augites with considerable quantities of granular magnetite. The whole rock has been considerably decomposed; epidote has formed and veins of other products of decomposition occur. The strike of the vein is apparently N. N. E.-S. S. W.; but owing to the unfavourable position of the outcrop this could not be ascertained. The thickness varies, but in the average it is not less than 4 feet. The cracks of this vein are filled with veins of Cerussite, which forms thin layers encrusting the rock. According to Mr. Holland it yielded 69·1 per cent. of lead and 33 oz. 16. dwt. 4 grs. of silver to the ton of lead.

Following up the direction of the strike in a south-westerly direction at a distance of about six miles in a straight line, another locality called Mawkwin

exists where the natives have been digging for lead. The mode of occurrence being the same, it is undoubtedly that this place represents the southern continuation of the Kaydwin outcrop.

(*c*) *Salt springs.*

Another most remarkable occurrence within the area of the volcanic ash on the western side of Mainthong hill tract, is that of salt springs.

They are usually found in the bed of the streams where the brine oozes out from the rock. Such places are :—

Kyatngat in the Nammaw ravine.
Kaydwin „ „ „
Taungmaw „ „ „
Natdaw „ „ „
Mangyi „ „ „
Mawkwin in the Tayaw ravine.
Senan „ „ „
Sagyin
Magyibin
Kya-wut-maw
Sinsamaw
Zibinmaw
Nayaungbinmaw
} Nam of stream unknown, but close to the above.

If the situation of these salt springs is fixed on the map it seems that they occur along a line which runs about north-north-west and that they are chiefly found at such places where the erosion of the streams has cut across it. It is therefore highly probable that these salt springs follow a line of fault, which seems in the main to run parallel to the Cerussite vein.

B.—THE YOUNGER FORMATIONS.

Maingthon hill tract is surrounded on all sides by tertiary strata, which in no way differ from those observed elsewhere in Burma. Yellowish soft sandstones and brown clays form the upper beds, and blue clays with ferruginous concretions, and grey sandstones, are predominant in the lower part. The tertiary strata come up quite close to Maingthon hill tract; in fact, they form part of it, and on its western side they compose the lowest spurs. Whether there is a line of disturbance between the tertiaries and the eruptive centre is difficult to say.

On the western side the older tertiaries or Chindwin group may be traced for a long distance; these beds are of small thickness comparatively, and form a narrow band which skirts the central massiv; it is followed by the upper tertiaries, the Irrawaddi sandstone, which is easily recognizable by its characterstic escarpments, facing east; there is no doubt that the Irrawaddi sandstone extends to the west as far as the Chindwin.

The general dip of the tertiaries is towards west.

On the eastern side the Chindwin sandstone has not been observed yet, but there is every reason to believe that it may yet be found. General dip towards east.

The way in which the tertiaries follow the contours of the central massiv convinces me that they were not only deposited along it, but that they once covered it entirely. The older eruptive massiv was only laid bare by the same action which

resulted in the folding of the tertiaries. Once laid open to denudation the softer tertiary strata were of course washed away easier than the hard diorite. As a result of this denudation the central diorite massiv protrudes in the form of a high, hilly tract from the surrounding low-lands of tertiary age. On the eastern side there are numerous outcrops of coal seams, which, beginning north, run as follows :—

1. Choukpyachoung between Mansigale and Pinmu.

The coal is exposed in the bed of a small stream ; it forms two seams separated by a clayey parting ; the following is the section in descending order :—

7 Clay.
6 Shaly coal, 18 inches.
5 Brown soft clay, 12 inches.
4 Shaly coal, 10 inches.
3 Good hard coal, 3 inches.
2 Shaly coal, 3 inches.
1 Clay of unknown thickness.

The coal, except the thin layer of 4 inch, is of very inferior quality, brittle, and very shaly ; in fact, it can hardly be considered as more than a bituminous shale.

2. Tabawda-Choung a feeder of the Tayaw-Choung, about three miles south-west of Mansigale.

The coal seam crops out in a narrow, nearly inacessible ravine ; the seam dips west at an angle of about 10°. The following is the section in descending order :—

9 Clay.
8 Shaly coal, 14 inches.
7 Brown bituminous clay, 12 inches.
6 Shaly coal, 7 inches.
5 Good coal, 6 inches.
4 Shaly coal, 1 inch.
3 Good coal, 6 inches.
2 Shaly coal, ½ inch.
1 Bluish clay of unknown thickness.

The coal is of good quality, but not of sufficient thickness to pay working.

3. Milaunggon, east of Pinlebu.

Here an outcrop of coaly shale, apparently in disturbed position, may be observed ; it is absolutely of no commercial value.

4. Subokom, about the 34th mile from Wuntho.

The outcrop is found in the bed of a very narrow ravine, unfortunately much covered by jungle ; unless exposed by trenches, not much can be said about this out-crop ; but judging from the others, it is not very probable that it will prove of particular value. The seam dips west at an angle of apparently 10°. The following is the analysis of a sample of this coal :—

Moisture	7·68
Volatile matter	34·42
Fixed carbon	53·58
Ash	4·32

According to this analysis, the coal should form a very good fuel provided it exists in sufficient quantity.

5. Moungaw Stream, near Yuyinbyet village, south of Pinlebu.

Two outcrops can be seen here: the lower one is a seam of shaly, brittle coal of about two feet thickness imbedded in clay, the second shows a seam of 4 to 5 feet good coal covered by about 8 inch of shaly coal; the out-crop was unfortunately partly covered with water, which prevented further examination. Dip about 10° towards west. The following is the analysis of a sample of this coal:—

Moisture	6·60
Volatile matter	34·24
Fixed carbon	52·22
Ash	7·04

The coal is so exactly similar in composition to that from Subokom, that, considering the position of the two localities, it is highly probable that both belong to one and the same seam, of which the Moungaw out-crop is the southern continuation.

6. Wetabin-Choung, about 1 mile west of Engwe village on the Yu river.

I discovered only a seam of shaly coal here which closely resembled that of Milaunggon. However, another seam must be *in situ* in the same stream, which is hidden under the detritus, for fragments of good hard coal have been washed out and prove its existence higher up. According to the analysis it contained—

Moisture	8·28
Volatile matter	36·14
Fixed carbon	48·58
Ash	7·00

It is therefore in no way inferior to the coal of the above named two places.

C.—Economic value of the minerals in the Maingthong hill tract.

1.—General Conditions.

Before going into the details of the value of the minerals mentioned in Section B., it will be useful to discuss such questions first, which would apply generally to all mining operations in Wuntho, namely, accessibility, labour, water and fuel-supply.

As regards accessibility, there can be no doubt that the opening of the railway line to Wuntho has greatly facilitated mining enterprise in those parts of Burma. Without the railway, mining in such a country would be out of the question altogether; the forty odd miles from Htygaing, the nearest river station, to Wuntho, across a country which is a swamp for the greater part of the year, would never permit any mining enterprise. But even supposing the necessary tool and plant having safely arrived by rail at Wuntho, there still remains a good distance to be covered by carts. The pyrites mines are more favourably situated, the railway line running nearly parallel to the eastern spurs of the Maingthong hill tract; but there are still, in the most favourable case of Theindoo-choung and Mayutha at least 10 to 12 miles of very difficult country to be traversed by road; in the case of the other mines, the distance is greater still. It may be said, however, that, although the cost of transport is great, it would not be prohibitive in the case of the pyritic veins.

As regards the coal-mines, the nearest outcrop is 32 miles over a much broken country, from the railway station, a distance which in itself would render it an

unprofitable undertaking to work these mines, considering the favourable position of the Kabwet colliery, which is open to communication either by river or rail. The lead-mines are still more unfavourably situated, there is a cart road from Pinlebu to Wuntho (at present, however, only practicable during the dry season) ; but beyond Pinlebu, communication is rather difficult ; the total distance from the railway station to the Kaydwin being not less than 68 miles over very broken country, which in my opinion will enhance the cost of transport so much as to make it a most unprofitable concern even if the ore contained 33 ounces of silver to the ton.

With regard to labour, it may at once be said, that to rely on local supply would wreck any mining enterprise from the very beginning. Probably one or the other local coolie, attracted perhaps by high wages, will for some time work in a mine, but it is more than doubtful whether they would take up the work in any number, and, what is the most important point, would persevere in it. The population consists chiefly, if not entirely, of agriculturists, who are not likely to give up their comparatively easy work, which affords them a sufficient if not ample livelihood, with plenty of spare time. If they could be induced to take up working in a mine, they would most probably only do so during the off season, and return to the cultivation of their fields when their presence is required. Labour must therefore be imported at undoubtedly considerable expense, if ever mining operations were started in those parts of Burma. Finally, another point must not be overlooked ; Wuntho, in fact the whole of the Maingthong hill tract, is an excessively unhealthy and feverish country, as I have experienced myself. The death-rate amongst the coolies would be sure to rise to such a point that exorbitant wages would have to be paid to the labourers to induce them to stay on. The sanitary conditions would undoubtedly improve immediately the jungles were being cleared and the coolies fairly housed, but at the beginning the death-rate would certainly be a high one. There is plenty of water all the year round, an important matter, if it were to come to the setting up of stamping batteries, and there would be no lack of fuel, at any rate within the first twenty-five years, the country being thickly stocked with wood.

To sum up, accessibility in all cases, except the coal and lead mines, fairly good. Water and fuel plentiful ; local supply of labour next to none.

2.—Value of the minerals.

Having dealt with the general conditions, on which mining enterprise in Wuntho will depend, it remains to discuss the value of the different minerals which are likely to be exploited. These are—

1. Auriferous pyrites.
2. Argentiferous Cerussite.
3. Coal.
4. Salt.

1. *Auriferous Pyrites.*—It must be understood that all the gold found in the Maingthong hill tract has been derived from the decomposition of iron pyrites, whether gold be found in specks, in the surface soil, or in small grains inclosed in the quartz. The sooner it is understood that the gold found in the quartz is not primary, but a residue of a chemical process, *i. e.*, the decomposition of the

iron-pyrites, the more will the difficulties be realized which will have to be encountered when exploiting these auriferous ores. I do not doubt that at the outcrop of the pyrites-veins metallic gold has been found, although I did not find it myself; the Choukpaza lode for instance shows unmistakeable signs that its outcrop had been worked by some body and for some purpose, and if the natives state that this purpose was the extraction of gold this statement is probably correct. I have also no doubt that the same may be the case with other localities, for instance, Toungni near Padeingon or Gwegyi. But my opinion is, that I do not believe that the occurrence of metallic gold at the outcrop of these lodes will continue to any great depth. Sooner or later it will disappear, and be replaced by undecomposed iron-pyrites. Then the difficulty of dealing with a "refractory" ore will have to be faced. This is the point which I want to put stress upon. We have, therefore, to answer the question: does the iron-pyrites contain a sufficient percentage of gold, so as to make its extraction a profitable business? This may be answered with *no*, as far as our present knowledge enables us to form a judgment. The richest ore contained a little over 4 dwt. of gold to the ton; but although as small a quantity as 3 dwts. is sufficient to pay some of the Australian mines, it is hardly beyond a doubt that in Wuntho the expenses will be too high to make gold-mining a payable concern, unless a higher percentage of gold to the ton of pyrites ore could be proved. I quite believe that should gold mining be really started some of the mines would pay a small dividend during a couple of years or so, but when the small supply of metallic gold, prepared in the chemical laboratory of nature, has been exploited, and when it comes to extract the gold from the pyrites, which holds it with an iron grip, every single one of the mining concerns will ingloriously break down. It may be argued that the natives have extracted gold at various localities in the Maingthong hill tract. True enough, and countless old and deserted diggings prove that they actually did, but it must not be forgotten that a native feels himself amply paid if he gets a few annas weight of gold after a month of hard work. The native does not employ expensive mechanical labour, and an equally expensive staff; a primitive pickaxe, a wooden shovel and a pan made on the spot, an ample supply of water is all he requires. With that outfit he sets to work, diligently, day per day; and when he thinks he has exhausted one place, he moves on to another. Small as his earnings may be there is no question that they sum up, if we suppose, that this work has been steadily going on for years and years. The gold which eventually comes to the market is perhaps the accumulated result of years of work. But if the same quantity were to be obtained within a short period of time, the working expenses would simply be higher than the value of the gold extracted.

2. *Argentiferous Cerussite.*—The results of the analysis prove that this is a highly valuable ore, and so far as I have observed there is a large quantity still available, but as I have already said, it must remain doubtful whether under the present conditions of railway communication and costly labour these ores could be worked profitably.

3. *Coal.*—According to the analysis the coal is of good quality; but not largely in excess of that from Kabwet or the Chindwin. It is in fact up to the average coal from the Burmese Territories, which makes a fairly good fuel, provided there is a sufficient quantity of it. But so far my examination of several localities

where such coal exists, does not warrant a very hopeful view, and in fact, except at one or two places, the seams are of wretchedly poor quality, consisting chiefly of coaly shale.

4. *Salt.*—In conclusion I may mention in few words how the natives utilize the salt springs. I have already stated that these springs are almost always found along the stream beds; and the natives have overcome the difficulty of obtaining a strong brine for evaporation in a most ingenious way. A fairly sized log of wood is hollowed out in the centre, and driven into the bed of the stream over the spring, whilst the space between this hollow cylinder and the rock is safely plugged with clay. A bamboo-wicker work is then placed round the wooden cylinder and the space between the two filled with clay, well rammed in; a few heavy boulders, on the top protect the clay from being washed away. The brine then rises in the wooden tube sometimes above the level of the surrounding stream. It is pumped out in the ordinary way by means of a pot, and then boiled down, in the way as described by me in a previous note on a salt spring near Bawgyo in the Shan States.

G. I. C. P. O.—No. 20 D. G. Survey.—26 11 94.—30.

Dr. Noetling.

Records, Vol: XXVII. Pt. 4. Pl. I.

SKETCH GEOLOGICAL MAP
of
PORTION OF WUNTHO SUBN.
Katha District

Scale 1" = 16 Miles

REFERENCES.

- *Diorite (trappoid)*
- *Diorite*
- *Palæozoic Limestone*
- *Lower* } *Miocene*
- *Upper* } *Miocene*
- (4) *Auriferous locality*
- *Outcrop of coal seams*
- *Salt springs*

Narnaw ch.
Man-sigaing
Kan-kyi
Pin-le-bu
Milmmin-gon
Mu R.
Wuntho
Tha-da-gyin
Mo-gyi-bin
Nyaung-bin-gon
Psin-ni-gon
Let-pan-gyin
Wun-tho
Kyauk-pya
Kawlin
5073
5380
5510
5420
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5384
4085
1951
2279
3986
1642
3103
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1143
1609

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