Reviews and Notices.

Chapters on the Mineralogy of Scotland, by PROF. M. FORSTER-HEDDLE.

Trans. Royal Soc., Edinburgh, Vol. XXVIII, Chap. IV. Augite, Hornblende and Serpentinous change. Read April 1st, 1878.

IN this elaborate monograph we have another portion of Prof. Heddle's laborious undertaking, which is no less than a complete Mineralogical and geognostic description of Scotland. In the present paper 40 folio pages are devoted to a consideration of Augite from 20 localities, occurring in the following situations, in

Granular limestone
Gneiss.
Diallage Rock.
Diorite ? } (The queries are Dr. Heddle's.)
Hyperite ? }
Volcanic Rocks of the Coal formation.
Volcanic Rocks of the Old Red Sandstone.

Dr. Heddle gives a useful comparative table of his analyses (Table 1)

He then goes on to the consideration of some alterations of augite into serpentine, pseudo-augite, pseudo-enstatite, pseudo-diallage, totaigite, and Schiller--spar, devoting 10 pages to this part of the subject and giving seven analyses (Table II.)

Having dealt almost exhaustively with the Augites, Dr. Heddle goes on to describe the hornblende occurrences (23 pages), including Amianthus, Asbestus, Tremolite, Actinolite, Edenite, Pargasite and Nephrite—in

Granular Limestone
Diallage Rock
Serpentine
Hornblendic Gneiss
Diorite

His analyses are given in Table III.

He then devotes 12 pages to the description of a number of alteration products of hornblende, such as hydrous anthophyllite, hydrous asbestus, picrolite, baltimorite, chrysotile, hydrated hornblende &c., and includes in the accompanying table (Table IV) analyses of the minerals known as mountain cork, mountain leather, and mountain silk, which he has since included under his new species pilolite.

TABLE I.

AUGITE.

	S.G.	$\ddot{Si}$	$\dddot{Al}_2$	$\dddot{Fe}_2$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}_2$	$\dot{Na}_2$	$\dot{H}_2$	Total.
Malacolite												
Shinness, white	3·15	53·06	·19	1·77	·47	·15	23·63	19·29	...	...	1·546	100·12
Totaig, blue	3·2	50·69	·03	·93	...	·07	25·78	18·09	·5	1·43	2·62	100·12
Ben Chourn, white	3·16	51·59	·11	·33	...	...	22·01	19·59	·49	1·01	4·64	99·75
Glen Tilt, white	3·16	53·24	...	2·71	...	·13	22·77	18·86	...	...	2·18	99·89
Glen Muick, blue	3·18	51·	...	1·37	1·59	·38	26·36	17·08	·63	1·12	·26	99·89
Sahlite.												
Ben Chourn	...	54·48	...	...	3·13	·24	22·82	17·58	·44	·79	·42	99·91
Tiree	...	50·54	4·69	4·14	·08	·69	23·59	14·4	·31	·63	1·48	100·51
Eslie	...	49·5	1·96	...	11·06	·4	24·08	10·81	·57	·8	·69	99·86
Coccolite.												
Gruagach	3·05	49·04	6·09	1·39	2·94	·46	23·34	15·12	·82	·79	·17	100·15
Diallage.												
Balta	2·96	50·23	5·84	...	5·22	...	11·23	21·59	1·2	·58	4·17	100·07
Pinbain	3·25	51·77	2·1	...	2·96	·31	22·1	18·46	·63	·58	1·08	99·98
Augite.												
Glen Beg	3·24	54·22	·17	...	6·7	·4	19·57	16·97	·5	·45	·96	99·96
Halival, Rum	3·48	50·54	3·25	1·34	4·42	·23	21·42	17·05	·25	·53	·71	99·83
Craig Buirock	3·28	50·33	4·48	3·92	5·76	·31	17·57	16·62	·19	·89	·38	100·45
Pseudo-Hypersthene.												
Corry-na-creech, green	3·33	53·05	4·82	...	11·39	·08	19·81	11·58	...	...	·63	101·34
Hart o'Corry, bronzy	3·33	51·36	1·66	...	8·97	·33	20·84	16·47	...	...	·54	100·17
Drum-na-Rabm	3·34	51·94	1·32	...	13·9	·25	19·36	13·85	...	$\ddot{Ti}$ ·38	·2	101·25
Loch Scavig	3·32	49·27	·22	2·17	12·15	·38	20·26	14·81	...	...	·72	99·98
Cuchullins (Muir)	3·34	51·35	...	...	33·92	...	1·84	11·09	...	...	·5	98·70
Skye (Haughton)	...	50·8	3·	...	9·61	1·08	19·35	15·06	...	·66	·6	100·16
Cuchullins (Rath)	3·34	51·30	·76	...	13·92	·25	20·15	14·85	...	...	·21	101·44
Augitic Glass.												
Elie	3·33	49·04	9·71	1·25	5·16	·31	16·25	16·88	·31	·79	·3	100·01
John o'Groat's	3·36	46·08	11·39	..	7·92	·46	16·07	15·65	·82	1·06	·38	99·82

TABLE II.

ALTERATION PRODUCTS OF AUGITE.

CONVERSION INTO SERPENTINE.

	S.G.	$\ddot{Si}$	$\dddot{Al}_2$	$\dddot{Fe}_2$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}_2$	$\dot{Na}_2$	$\dot{H}_2$	Total.
Typical Suhlite	...	53·7	...	...	8·	...	24·9	13·4	...	...	...	100·00
Hydration—Loss of $\dot{Ca}$, $\ddot{Si}$—*peroxidation partial.*												
Pseudo Augite, Portsoy	...	37·33	1·13	4·36	4·05	·38	1·2	36·71	·88	·73	13·37	100·14
Pseudo-Enstatite (?) Green hill	2·16	37·78	2·12	5·07	2·1	·76	...	37·01	tr.	tr.	16·07	100·22
Hydration—Loss of $\dot{Ca}$,$\ddot{Si}$—*total peroxidation.*												
Pseudo-Diallage, Portsoy ...	2·62	34·54	1·16	15·2	·33	·28	...	36·38	...	...	12·2	100·09
Pseudo-Enstatite ? Balhammie	...	37·41	...	13·54	·06	·24	·2	34·76	...	...	13·59	99·78
Totaigite, yellow; Totaig ...	...	37·22	·76	...	1·05	·23	5·24	44 97	...	...	10·64	100·11
Do. black	2·87	36·19	·26	·29	2·96	·45	3·27	45·57	·25	·42	10·2	99·97
The same, with no peroxidation.												
Schiller Spar, Black Dog Rock	2·65	38·19	2·18	·07*	8·48	·51	2·91	32·42	1·4	·07	14·03	100·49
Typical Serpentine	...	44·14	...	...	...	...	...	42·97	...	...	12·89	100·00

* $\dddot{Cr}_2$=·28

TABLE III

HORNBLENDE.

	S.G.	$\ddot{\mathrm{Si}}$	$\dddot{\mathrm{Al}}_2$	$\dddot{\mathrm{Fe}}_2$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{K}}_2$	$\dot{\mathrm{Na}}_2$	Fl	$\dot{\mathrm{H}}_2$	Total.
Amianthus.													
Balta	2·95	56·15	1·54	·39	3·11	·77	11·72	22·46	·19	·69	...	...	99·52
Asbestus.													
Shinness	...	56·85	·23	·48	2·12	·23	12·54	23·92	·44	·54	tr.	2·53	99·87
Portsoy	2·99	56 31	·77	·53	2·32	·15	12·58	23 31	·44	·63	tr.	2·94	99·98
Nephrite.													
Balta	2·96	55·73	·05	...	5·2	·01	13·24	22·7	·14	1·12	...	...	100·62
Schistose.													
Leegarth, Fetlar	2·95	56·92	·22	...	4·65	·08	12·32	22·08	tr.	tr.	...	3·4	99·66
Tremolite.													
Shinness	2·96	56·15	·86	1·62	·72	·07	13·31	24·14	·44	·21	tr.	2·5	100·01
Glen Urquhart...	...	57·31	6·68	1·08	3·23	·31	12·36	16·62	...	...	tr.	2·5	100·08
Actynolite.													
Hillswick	...	55·	1·51	·99	3·46	·31	10·38	23·31	1·12	1·1	...	2·9	100·07
Edenite.													
Urquhart, green	...	50·31	8·54	·12	2·76	·08	11·63	20·77	·5	1·16	none	4·13	99·99
Do. black	...	51·31	2·21	·16	7·66	·49	11·17	20 87	2·2	·46	...	2·12	99 65
Pargasite.													
Errins...	...	52·69	2·56	4·09	9·77	·23	11·42	15·77	·57	·69	...	2·13	99·91
Hornblende.													
Balta	3·11	45·87	8·78	...	14·15	·13	9·82	14·4	·82	1·43	...	2·3	97 7
Fetlar	3·09	41·63	11·63	1·85	8·95	·31	9·25	18·51	·63	1·22	...	...	99·37
Portsoy	3·25	52 07	2·57	...	9·72	tr.	19·05	14·41	·75	·57	...	·85	99·99
Glen-bucket	3·22	45·	9·41	1·55	16·76	·33	11·24	11·19	1 36	1·66	...	1·34	99·85
Durness	...	51·46	2 97	2·45	9·66	1·08	20·07	10·46	·68	1.31	...	·68	100 83
Elie	3 37	40·38	19·01	2·12	7·28	·46	11·54	17·5	...	...	...	1·17	99·48

TABLE IV.

ALTERATION PRODUCTS OF HORNBLENDE.

	S.G.	$\ddot{Si}$	$\dddot{Al}_2$	$\dddot{Fe}_2$	$\dot{Fe}$	$\dot{Mn}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{K}_2$	$\dot{Na}_2$	$\dot{H}_2$	Total.
Hydration, Loss of Ca, peroxidation												
Hydrated Hornblende, Green Hill ...	3·01	50·92	1·89	9·43	2·09	·31	8·65	21·58	·34	·43	4·54	100·17
Hydrous Anthophyllite, Scoorie	2·92	45·51	6·39	...	14·29	...	4·44	22·14	tr.	tr.	6·72	99·44
Mountain Cork, Portsoy	...	51·43	7·52	2·06	2·49	1·3	·58	9·35	...	...	25·04	99·76
Ditto Lead Hills	...	51·45	7·98	·97	3·29	1·49	1·97	10·15	...	...	21·7	99·
Mountain Leather, Tod Head	...	52·48	6·33	·6	2·11	2·88	1·34	11·95	...	...	21·7	99·4
Mountain Silk, Partan Craig	2·11	54·37	11·27	·21	1·09	·33	·98	9·49	...	...	22·41	100·16
Hydration, Loss of Ca and bases—passage into Serpentine.												
Picrolite, Balta...	2·69	50·19	2·1	...	4·39	·01	5·07	29·23	...	·74	8·5	100·23
Do. Serpentinous, Balta	2·63	50·08	1·88	...	6·09	·23	·86	31·57	...	·34	9·3	100·34
Above, with removal of Silica.												
Hydrous Anthophyllite, Urquhart ...	2·81	47·72	3·84	·18	5·74	·16	5·64	28·75	·19	·26	7·65	100·12
Hydrous Asbestus, Portsoy	2·39	46·92	·63	·01	1·67	·77	9·91	25·85	·57	·58	12·84	99·75
Picrolite, Fethaland	2·65	42·93	1·85	5·1	...	·42	·8	36·19	·81	·37	11·5	99·97
Hydrous Anthophyllite, Ayrshire ...	2·81	39·75	·49	5·3	4·11	·23	6·27	26·25	·76	·11	16·83	100·1
Baltimorite, Killin	2·63	41·47	...	4·01	4·83	·26	...	37·14	...	...	12·5	100·2
Chrysotile, Fetlar	...	39·73	·1	...	2·92	...	...	41·61	...	...	15·66	100·02

In discussing the whole series of analyses, especially of the altered minerals, and of the method of serpentinous change, Dr. Heddle observes—

"These results demonstrate that the process of change consisted, in progressive order.

First, in a direct increment of the water.

Second, in a decrement of the lime.

Third, in a gradually increased decrement of the iron.

Fourth, in a decrement of the silica.

In same situations, however, there is no decrement in the iron, but a peroxidation thereof.

What the rationale of the change under the *first* of these heads may be, I could not, in the circumstances of so small an amount of matter to found on, attempt to show.

The circumstances under which some at least of the other changes may be effected we do know; and our knowledge thereof may be grouped under certain heads.

The leading summary of our knowledge may be stated thus:—

The primary agent of change is meteoric water, holding carbonic acid and oxygen in solution.

The secondary agent is spring water, holding less oxygen, more carbonic acid, and certain salts in solution.

The third agent is these same waters, sinking downward or rising upward, but now holding more complex salts—the products of the first operation of the waters themselves,—these salts being the agents of a second set, perhaps an endless cycle of changes, generally more potent than the originals.

As regards the substances operated on, we know that those most easily attacked are carbonates and silicates of the alkalies, the waters thus becoming charged with most potent graving tools.

Next we have silicates which contain lime, protoxides of iron, and of manganese.

Lastly, we know that silicates of alumina and magnesia are the most stable of all; for carbonated water has no action upon silicate of alumina, and but a slight one on silicate of magnesia.

In virtue of the above,—from compound silicates carbonated waters will abstract the silicates of lime, iron, and manganese; leaving the silicates of magnesia and alumina as residues.

In virtue of the above,—the rock masses which we find in nature to be least prone to decomposition, are either immediately silicates of alumina and magnesia, or they are such as have originated from the alteration of the less stable silicates. Such are—steatite, talc, silicate of alumina, clay, kaolin, and sand itself—among simple silicates; and mica, chlorite, serpentine, asbestus, and mountain leather—among compound ones.

These, however subject they may be to more complex changes induced by saline or alkaline waters, are no longer liable to further alteration through the operation of atmospheric agents—such as oxygen, carbonic acid, and water.

Thus it is, then, that serpentine *asserts itself* wherever occurring; protruding as lines of rugged eminences,—fitter types of the attribute assigned to the "everlasting hills" than the lordlier granitic masses around it; thus it is that the mica crystal, which, torn from that granite, and mechanically comminuted but intrinsically unchanged, has served its purpose of giving continuity and sparkle to sandstone of newer and still newer epoch, glitters yet untarnished mid the sands of the sea-shore; and thus it is that these sands themselves, buffetted by the waves of Cambrian, and Old Red, and Coal Measure, and Permian, and it may be still more recent epochs, amid many surrounding changes have known none, but atomies though they be, seem quite large enough and hard enough again to complete a like extensive cycle.

Thus it is that the clay which, as impure kaolin, the rain drop has gouged out of the felspar of that granite, which, soft as mud, gives way to everything, but can be changed by nothing,—is seized upon by man to be fashioned into a structure, harder, less compressible, more durable than stone itself.

Thus, then, the mere passage of a current of carbonated water over minerals containing, or rock containing lime, iron, and silica, is sufficient to sweep these substances in solution out of the rock, and to do so, moreover, with great rapidity.

It was Bischof who first clearly pointed the potency of carbonated waters in effecting decomposition of rocks containing the substances above noted as soluble therein; and its absolute want of power to remove magnesia from them on account of the insolubility of silicate of magnesia in carbonated waters or even in carbonated alkalies, supposing these to be formed as a first step in such a process.

Hence the direct and unfailing action of such waters upon augitic rocks must be their conversion into serpentine.

It has been shown that inasmuch as carbonic acid does not combine with alumina it can have no power to remove alumina; and so a serpentine formed by the alteration of an aluminous mineral must be a more or less aluminous serpentine. And inasmuch as it is in hornblende and not in augite that alumina replaces silica, we may if we find, on analysis that a serpentine is notably aluminous, be able to say that it was formed by the transmutation of diorite or other hornblendic rock.

Again, inasmuch as carbonic acid does not combine with the peroxide of iron, if that substance is either present, or once formed in a mineral, it cannot be removed by such a process; and so it is that we have the iron in these serpentinous products unremoved if it be thrown into the state of peroxide.

Its retention as such may even aid us in determining the depth at which the transmutation took place.

If the change was effected near the surface, we know that the transmuting water was aerial,—"meteoric water," as it has been called. Each gallon of such water holds in solution 2 cubic inches of oxygen and 1 of carbonic acid. This water, holding so small a charge of carbonic acid, could only effect the transformation with extreme slowness. We have seen that the lime was removed in the first place; if the quantity of acid did not suffice to remove both lime and iron, during the time that that acid was engaged in taking up the lime, the oxygen in solution would simultaneously be engaged in peroxidising the iron.

So we would be entitled to hold that serpentines with red or brown colours, and such as retained iron as peroxide, had been formed near the surface. So can we explain, also the ferruginous crust which is so characteristic of most serpentines at their outcrop.

Spring waters, again, much more highly charged with carbonic acid, but not carrying so large a supply of oxygen, would effect the change more rapidly, and sweep away, more or less, perhaps all of the iron as protocarbonate, leaving only residual traces of protosilicate, which impart the green coloration.

We have at Portsoy the most direct evidence conceivable of the conversion of diallagic rock into serpentine, in the fact that one end of the stratum still remains as gabbro; and in immediate contact with it we have limestone,.here very siliceous. Now, the frequent association of thin beds of limestones with serpentine supplies very direct evidence of the conversion of hornblendic and augitic rocks into serpentine. In that fact we have a ready answer to the question, "What becomes of the carbonate of lime necessarily formed during such an alterative process as the above?"

I will not say that limestone is always to be found in such association; we do not always find limestones even where we have indubitable evidence that they once existed; for here the very thing that makes can unmake, or sweep away. The carbonate of lime thus fashioned out of the rock forms a belt beneath the residual serpentine, thicker or thinner in accordance with the original thickness of the stratum of transformed rock; also thicker or thinner according to whether that rock was augitic or hornblendic; for the former can supply considerably more lime than the latter. This calcareous belt must lie beneath the parent rock, sealed against any great amount of further change, unless or until upheaval or denudation expose it to meteoric influences. *Then* water, flowing either downward or upward, may—nay, in time must—sweep it away in solution, leaving lime-sink, or collapsed-void to evidence its former existence. But if the limestones, so frequently associated with serpentines, are thus to be assigned to the decomposition of the rock which yielded these serpentines, we have a crucial test of the soundness of the theory of the change, in the inquiry as to whether *unchanged* gabbro, or other such rocks occur in contact with lime.

That it never does, I will not say; but in glancing at a sketch geological map which I have constructed of the district where these rocks occur, I find, as regards the great belt of diorite and diallagic rock which sweeps up central Scotland, that where either the limestone appears in contact with it, or a "wash-out" discloses its former existence, there the rock is serpentine; where it appears as unaltered rock there is no lime.

I find, moreover, that wherever the association can be observed, the lime invariably is beneath the serpentine. So it is with the loch of Cliff lime and the serpentine of Unst; both of the lime and serpentine beds at Polmally; both of the lime and serpentine beds at Portsoy; at Limehillock; Tombreck; the Green Hill of Strathdon; and Beauty Hill; and in enumerating these I have named all the most important masses in the country.

The evidence of our transmuted minerals thus goes a long way to prove serpentine to be a metamorphic, and not an igneous, rock, whether the chemical process proposed in explanation of the *modus operandi* of the change be or be not considered satisfactory.

But there are occurrences of serpentinous matter differently circumstanced, where the above explanation can by no means suffice.

By the dissolving out of the lime from a stratum either of gabbro or of labradoric diorite, we would obtain a great mass of limestone, it is true; but that mass, relatively to the simultaneously formed serpentine, should be comparatively small.

The hornblende of Portsoy would yield equal to about 34 per cent. of carbonate of lime—its labradorite would yield about 20 per cent.; and, as in the diorite rock, the hornblende is to the labradorite in about the proportion of 2 to 1, this rock as a whole would yield about 29 per cent.

of its original bulk; of which, however, there remains still 84 per cent., for 13 of the 29 consist of direct addition of carbonic acid. Here, then, we have a rock yielding by its metamorphoses about one-third of its original bulk of carbonate of lime.

But, in what are called the serpentinous marbles, quite a different state of matters exists. These marbles I know from one part of the bed in Tiree; from Loch Bhalumais, in Lewis; Rodal, in Harris; Dalnein, in Strathdon; Glen Elg; Glen Tilt, and some neighbouring localities. It is of these only I am entitled to speak.

In all, the appearance is the same,—granular imbedded particles of serpentine, from the size of a shot to that of a bean, sparsely sprinkled throughout a great mass of lime, in an amount which is altogether quite trifling

Unhesitatingly I say that these granulars are, one and all, pseudomorphs of pre-existent crystals of augite. That mineral may be seen unchanged and changing in the Tiree marble. In Glen Elg and other localities the pseudomorphic forms are so perfect that the crystalline form of the augite is indubitable.

These trifling specks could never have been the origin of a lime stratum tens of feet in thickness.

I would suggest the following explanation of the serpentinous formation of these pseudomorphs,—which had palpably pre-existed as augitic crystals imbedded in lime.

It is well known that when silica or silicates are heated along with carbonate of lime, there is, in the first instance, a disengagement of carbonic acid and a formation of silicate of lime; or, in the presence of other bases, of more complex silicates. Bischof found this decomposition to take place unfailingly even at the temperature of boiling water. No great depth in the earth's crust would suffice for the attainment of such a temperature. Thus at the point of contact of the lime with the including rock, and also with inclosed siliceous minerals, would there be disengaged the very acid which we have already seen to be the active agent in serpentinous change; and thus also would there be formed new silicates, such as Wollastonite, silicate of lime, and tremolite, which, in fact, are found associated with the pseudomorphs of the serpentinous marbles.

In the outset I directed attention to the fact that serpentines were occasionally formed by the transmutation of such rocks as diallage and diorite *as a whole*,—*i.e.* that the labradoric as well as the augitic ingredient had suffered conversion. The analyses afford one if not two instances of such conversion, and I now instance another which may be a case in point.

Beauty Hill, to the north of Aberdeen, is composed of serpentine, and in small quarrys on its north-east side it will be seen to be as distinctly bedded a rock as any recognised sedimentary deposit.

On its eastern slope some masses of gabbro protrude through the sward of a field. This gabbro is, for the most part, unaltered. It consists of dark somewhat granular crystals, apparently of augite, of the size of large shot, which are imbedded, singly or separately, in a waxy-looking massive labradorite.

In this rock a vein of a pale sap-green mineral was found by Professor Nicol and myself. This was set down by my friend as precious serpentine; to me it appeared somewhat too hard for this, as it cut with less ease than slate-pencil. It was translucent, tough, and had a specific gravity of 2·59.

On analysis it afforded—

Silica	34·731
Alumina	12·444
Ferrous Oxide	2·684
Manganous Oxide	1·17
Lime	1·595
Magnesia	34·098
Water	13·1
	99·822

Now this is precisely the composition of the massive variety of penninite which, from its resemblance to serpentine, has received the name of pseudophite. But it may also be regarded as a highly aluminous serpentine; for if that earth be abstracted the residue is just serpentine. The point of interest which attaches to this substance is, that although it formed a true exfiltration vein in the rock; if the rock in contact with the vein be examined, *the waxy labradorite is also seen to pass, within a space of about an inch, into this mineral by insensible gradation.* So it matters not whether it, in a systematic arrangement, be consistently classed with penninite or not, it is here unquestionably a transmutation product, the result of a serpentin*ous* change of the labradorite.

The *modus operandi* of the change of felspar into serpentine is much more subtle than that of the conversion of augite, and also, it must be said, much less certain. As labradorite contains much alumina, and no magnesia, we have in *its* serpentinous change, to account for the removal of alumina and the direct insertion of magnesia. The term "magnesian process" may with perfect fitness be applied to such a change.

Such an action as that above shown to suffice for the transmutation of augites could not in any degree effect a similar change in labradorite;

carbonated waters do not affect silicate of alumina, and carbonated waters cannot directly purvey magnesia.

It is true that immediately over the bed of serpentine at Portsoy which evidenced such a change, there is a washed out bed of *something*, and it might be argued that that something had been dolomitic limestone; which would yield bicarbonate of magnesia to waters passing through it;—which bicarbonate of magnesia, by a recognised interchange with silicate of lime, would yield silicate of magnesia. To such a view it has to be replied, first, that there is no evidence that the removed stratum was limestone,—the rock immediately beyond the void is a perfectly unaltered diorite, which therefore could not have supplied any lime;—secondly, that in Scotland at least, the limestones associated with serpentine are not dolomitic; and this because, according to the opposite view, the magnesia is retained in the resultant serpentine;—and lastly, that there is no provision, according to such a view, for the removal of the alumina.

For aid in the explanation, we must ascertain what are the circumstances in which silicate of alumina can either be decomposed or dissolved; and what those in which silicate of magnesia can in any way be introduced; we will then be in a position to say whether any of the said circumstances, in the case in question obtain.

Silicate of alumina can be decomposed by chloride of magnesium or sulphate of magnesium in solution,—silicate of magnesia being formed.

Silicate of magnesia, again, is also formed by the decomposition of bicarbonate of magnesia, by silicate of lime, or by silicates of the alkalies.

Now the two first of these salts are present in river water, more largely in spring water, and most largely in sea water; while bicarbonate of magnesia is very frequently present in spring water. Though it is unnecessary to call in the operation of sea water, in the presence of the fact that the waters which permeate all rocks are themselves charged with these potent agents of perpetual change, still, seeing that the altered rocks in question have been beneath the sea, and that their inmost pores would then be more urgently saturated by hydrostatic pressure, it may be very fittingly argued that diallagic rocks which have their felspar as well as their augite converted into serpentine, suffered the alteration during an epoch of marine submergence.

Bischof writes: "It would be very illogical to suppose that the calcareous and magnesian salts dissolved in sea water do not take part in chemical alteration, when it is so manifest that alteration is effected by these salts dissolved in much smaller quantity in the water percolating through rocks. It would be inconsistent with the relation of mutual compensation perceivable in all natural phenomena to suppose that saline substances were continually carried into the sea, without being consumed in the formation of new substances." To apply this to the present case, there would seem to be no readier way of accounting for the abstraction of the vast quantities of magnesian salt present in the sea, and constantly being added to it, than to use it up, so to speak, in the formation of serpentine. How else abstract so soluble a salt as chloride of magnesium? Its extreme solubility and deliquescence would negative its being abstracted through the direct formation of minerals; but, in virtue of the above interchange, lime salts replace it in the ocean, to be continuously removed in turn by crustaceans, mollusks, and coral insects.

Serpentines, as a rule, are denser, more solid,—give fewer and feebler evidences of being the result of change effected upon pre-existent rocks, when examined *in their depths* than on the exterior. Without entering upon the many and complex reactions which take place as secondary results of the interchanges already noticed, it may be sufficient to show that the products of surface change, as they percolate through the deeper portions of a rock, may effect a somewhat dissimilar change therein, and may also, in their passage through these rocks, plug up their pores.

Silicate of lime, formed by the action of meteoric water in the superficial portions of a rock, and meeting with magnesian salts within, would by interchange supply serpentinous matter in the solid form to the more porous portions of the deeper-seated beds, to render the whole mass more uniform in structure, while it might also therey be diversified in colour.

When we remember that the decomposition of both augite and labradorite is effected through the operation of what may be called the ordinary agents of exposure—carbonic acid, oxygen, and water—but that, in virtue of their difference in composition, the nature and rate of the decomposition varies, it is easy to explain how it is that the crystals of labradorite are protuberant from the general mass of the augite at Lendalfoot, while at Pinbain the augitic crystals stand in high relief above the felspar in that wave-washed situation.

Augite, containing iron in the state of protoxide, most prone to higher oxidation, rapidly and readily gives way when subjected alike to aërial exposure, where oxygen, carbonic acid, and water are free to operate upon it. Labradorite, containing little or no protoxide, is subject to the operation of the two last only, and so, in the air, is more enduring. When plunged beneath water, however, the oxygen is in great part shut off from the augite, which is thus protected; while here, the labradorite is subjected to the attack of water upon its alkaline silicates, suffering thereby rapid degradation."

After some pages of descriptive Geognosy, Dr. Heddle discusses the mutual associations of hornblende and augite.

"Turning our attention next to the modes of occurrence and lithological associations of the unaltered varities of augite and hornblende, the first direction our inquiry must take is as regards any evidence the analyses may afford, bearing upon the union of the two species into one.

It may be at once conceded that this question cannot be decided by any merely chemical evidence; the wide range of composition, hardly referable to anything closer than a general formula in either mineral, precludes such an hope. The little information that we do obtain tends in the direction of the separation of the two; it consists in this, that in what may be designated as "recognised individuals" of the hornblendic type we have here and again a distinct replacement of silica by alumina; and this we have not in recognised individuals of the augitic type.

Passing from this to the lithological information, we find that a consideration of the records above made by no means tends to strengthen certain of the lines of demarcation which have been drawn between them.

Put in a general form, two of these lines are thus defined: "These two minerals occur in distinct geognostic positions. Hornblende in rocks containing quartz or free silica, and mostly with minerals that are neutral compounds of silica, as orthoclase and albite. Augite in rocks that do not contain free silica, and mostly with minerals that are not neutral silicates, as labradorite, olivine, and leucite.

"Hence, there are two distinct series of igneous rocks; the hornblende series, including granite, syenite, diorite, &c.; and the augite series, or hypersthene rock, gabbro, dolerite, &c.

"In some rare instances these two minerals have been found together, either regularly conjoined or in distinct conditions."*

Here we have it clearly laid down that two "distinct series of igneous rocks" are established on the specific distinction between the two minerals; and secondly, that one argument for these minerals being themselves distinct is to be drawn from the fact that they are associated in but "rare instances."

It would appear at first sight to be an easy matter to enter at least upon the consideration of questions couched in language so precise as the above; but it proves to be not altogether so.

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* Nicol's "Manual of Mineralogy," p. 208. An epitome of the views of Gustav Rose.

We have it *first* laid down here that hornblende occurs in rocks with free silica, and along with orthoclase and albite.

Secondly, that augite occurs in rocks devoid of free silica, and,—in contradistinction to hornblende,—along with labradorite, olivine, &c.

Thirdly, that the hornblendic series of rocks,—granite, syenite, diorite,—are "distinct" from the augitic series,—hypersthene rock, gabbro, dolerite, &c.

Fourthly, that the two minerals, on the distinctiveness of which the above separations have been made, occur together in rare instances."

Dr. Heddle then gives examples shewing that postulate No. 1, is contradicted almost everywhere in Scotland, and postulate 3 and 4, very frequently, while postulate 2 is almost always true. He adds, "My own opinion is, that through insensible gradations—intermediate varieties—augitic and hornblendic rocks pass into one another more frequently than is imagined. The two minerals also, in certain circumstances, are so very similar that I do not believe that any mode of discrimination which can be applied in the field, or any more expeditious than the reflective goneometer, can serve to determine them; so that defective nomenclature may have been the cause of the drawing of too sharp a line of demarcation between the rocks which contain them."

The author concludes this most important contribution to Mineralogical literature as follows.

"One other point calls for brief notice,—the question as to augite being a volcanic or fusion-form of hornblende. It will be seen above that both of the minerals occur in granular limestones; these afford very distinct evidence of the operation of great heat.

Again, it will be observed that both occur together in the basalts and dykes of Elie and Kinkell; in these the one mineral—the augite—has undergone fusion; while the other—*the more fusible*—appears unchanged. This circumstance becomes a strong argument in favour of the latter having been formed *in situ*,—*i.e.*, after the eruption and cooling of the containing rock,—an exfiltration product in fact.

Here it may be the case that the fused augite has at one time been formed from hornblende, but the two could not here have been erupted together; so that no direct evidence is to be gleaned from this apparent paragenesis in space, which palpably was not a paragenesis in time."

The monograph will well repay every mineralogist and geologist who shall study it in its entirety.

THE WHITE MINERAL OF THE FOSSIL PLANTS, FROM THE TARENTAISE (*Min. und Pet. Mitt, Tschermak, Band II, p.* 191).—The peculiar silver-like shining covering of most of the plant fossils included in the carboniferous shale of Westphalia has not yet been carefully investigated, and its similarity to the substance forming the Graptolite petrifactions, first described by Gümbel and more extensively by Köbell, induced the present investigation—a peculiarly rich piece of the substance offered the opportunity of making an exact analysis.

This delicately scaly mineral is, like that associated with the Graptolites, not distinctly crystallised, but found only in little thin scaly leaves: these are fissile, somewhat elastic, flexible, soft, white, of a pearly lustre; fatty, talc-like to the feeling. Hardness=1, Sp. Gr.=2·8. Before the blow-pipe in melting exfoliates in a cauliflower-like mass similar to Pyrophyllite, and with cobalt solution gives a deep-blue color. In test tube yields water; not entirely dissolved by sulphuric acid. The purest material chosen with the greatest care under the lens gave the following analysis (A); there are also given analyses of the clay-slate of the Tarentaise (B), of Gümbellite (Köbell) (C), and lastly, of an additional Graptolitic mineral from Gräfenthal in Thuringer Wald (D).

CONSTITUENT PARTS.	A	B	C	D
Silica...	49·710	56·80	50·52	52·50
Titanic Acid	1·035	6·70	...	1·00
Alumina	28·620	25·45	31·04	29·50
Oxide of Iron...	2·688	3·05	3·00	3·00
Oxide of Manganese	trace	...	...	...
Lime	trace	trace	...	...
Magnesia	1·600	1·03	1·88	1·16
Potash	6·803	4·20	3·18	5·06
Soda..	2·208	1·36	...	
Water and Ash	7·384	8·00	7·00	7·75
	100·048	100·59	96·62	100·47

From the analysis the substance therefore approaches pyrophyllite. The similarity also of the analysis of the clay-slate in which the plant remains and the whole mineral lie imbedded, appears to show that the substance contained in the bituminous shale, during a process favourable for the formation of the mineral is forced into the cavities originated by the carbonisation of the substance of the plant. In fact, in sections perpendicular to the cleavage plane, it is observed that the slate consists of transparent, extremely thin layers strongly affected by polarised light which appear as minute bands, or bands with lens like thickenings: with them alternate others wanting in transparency, from masses of carbon or dust-like matting which are less distinctly doubly refracting. The chief mass of the slate consists accordingly of a substance very similar to that of the petrified plants. In sections parallel to the cleavage plane, they exhibit defined circumscribed layers clear as water, and doubly refracting, alternating with carbonaceous borderings and dust-like, cloudy, non-transparent spots, with indefinite optical relations. Of the transparent parts only a small portion is not doubly refracting. What is particularly interesting is the abundance of long, not exactly straight black needles resembling the Trichetes observed in clay-slate, roof-slate, and Phyllite. In addition, small transparent crystals show themselves, which exhibit bright colours in polarised light, and appear also to belong to the white mineral.

T. A.

URISITE—A. FRENZEL (*Min. und Petr: Mitt*; *Tschermak*, 1879, p. 133.) In an article on 'the "Minerals of the Caucasus," A. Frenzel draws attention to a new mineral named by him Urisite, and having the following peculiarities: color from citron to pomegranate-yellow; streak, ochre-yellow; soft; sp. gr. 2·22. Found in nodules and pulverulent, nodules yield to pressure by the finger, when a feeble lustre accompanied by a faint metallic glance is observed, dependent upon minute crystalline surfaces.

Urisite consists entirely of minute rhombic crystals such as Breithaupt has already observed in the similar mineral Raimondite. The crystals appear under the microscope broadly columnar; sharp-angled and well-formed, exhibiting frequently by combination $\propto\breve{P}\infty$. $\infty\bar{P}\infty$. ∞P. $\bar{P}\infty$. P. OP. The basal plane is occasionally absent: sometimes at one pole the basal surface is very great, at the other small or apparently not developed; so that the crystals then appear hemimorphous. Beneath the microscope the Urisite crystals appear transparent; the mineral has, after the deduction of 3 p.c. of an insoluble residue, the following composition:—Sulphuric Acid, 42·08; Ferric Oxide, 21·28; Soda, 16·50; Water, 19·80.

Sulphur is present in small quantities; and traces of carbonate of lime and talc exist. The ascertained composition corresponds to the atomic relation $Fe_2\ O_3$, 2 Na_2O, 4 SO_3, 8 H_2O, and this formula to

Fe_2O_3	160	21·39
2 Na_2O	124	16·58
4 SO_3	320	42·78
8 H_2O	144	19·25
	748	100·00

The result of the analysis thus corresponds almost exactly to the calculated composition, and Urisite stands near to Bartholomite.

T. A.

MILARITE,—E. LUDWIG (*Tschermak, Min. und Pet. Mitt.*, 1877).—This mineral has only been twice analysed, but with such varying results that a repetition of the investigation was absolutely necessary, and was rendered possible by the author having received about 2 Grams of a picked, well-formed, and perfectly transparent crystal of this rare mineral.

Milarite gives off water on being heated and continues to do so when the finely powdered mineral is heated in the platinum crucible for half-an-hour in the Bunsen flame, the mass becoming only slightly ash-like. In the hot blast of the blowpipe flame no marked diminution of weight is observed after heating, but a perfect fusion occurs, and if after this it is allowed to cool by degrees a transparent colorless glass-like mass is obtained not perfectly soluble in hydrochloric acid. Concentrated fluoric acid in the hot water bath dissolves the finely powdered Milarite in a short time.

A quantitive analysis gave the following results :—

	I.	II.	III.	AVERAGE.	CALCULATED.
Silica	71·85	..	71·88	71·81	72·66
Alumina	10·74	..	10·61	10·67	10·39
Lime	11·58	..	11·71	11·65	11·30
Magnesia	trace	..	..	trace	..
Potash	..	4·86	..	4·86	4·74
Soda	..	trace	..	trace	..
Water	1·35	..	1·38	1·36	0·91
				100·35	100·00

The calculated values correspond to the formula $HK, Ca_2, Al_2, Si_{12}, O_{30}$.

These results agree closely with those of Finkener, who probably did not possess an entirely pure mineral (the deviations being explicable by a small admixture of felspar.)

The crystalline form of Milarite as known to Kengott was described as an hexagonal combination of a prism and a pyramid of the second order. According to Tschermak's investigations it must now be referred to the rhombic system, the crystals being penetrative twins, similar to those of Chrysoberyl and Aragonite.

T. A.

ACCIDENTAL COLORS OF ZEOLITES.—WEBSKY (*Berlin*)—*Zeitschrift fur Kryst. und Min.*, *B. II*, *P.* 517.)—In addition to the red coloring matter of the Zeolites of Dumbarton and of Fassa, colors occur which are dependent on organic substances, as for example those of the Desmin and Heulandite in the magnetic iron veins of Arendal, in which also asphalt is met with. To this second class also belong the colors of the Zeolite lately discovered in the drusy cavities of the granite of Gräben at Striegau. At this locality Desmin of a pale leather-brown colour is of frequent occurrence. Chabazite, of a chestnut-brown hue, passing into orange-red frequently in the centre of the purer crystals is much rarer. The latter on heating becomes dark and a small quantity of tar-like substance distils off. The rare Heulandite of this locality is bright citron-yellow, whilst that of the rarely found laumontite is colorless. It appears, therefore, these chemical combinations though so similar in composition, possess very different capabilities for the reception of coloring organic matters. As to the origin of the latter, in this instance, it may be explained by the assumption that the Striegau granite is a metamorphic formation.

T. A.

APOPHYLLITE FROM HIMMELSFÜRST MINE, NEAR FREIBERG.—(*Neues Jahrbuch für Mineralogie*, 1879.)—Prof. Weisbach has lately described the occurrence of apophyllite near Freiberg. Zeolites, as is well known, have frequently been found in mineral veins, and especially silver lodes; for instance, at Andreasberg, Kongsberg, and Guanajuate; but none had been found at Freiberg till recently. In December last, at a depth of more than 500 yards, in driving a level, a little cavity or "vugh" was met with in the gneiss immediately adjoining a silver lode. The "vugh" contained crystals of quartz, and on these were crystals of calcite, surmounted by apophyllite.

C. L. N. F.

Obituary.

BERNHARD VON COTTA.—This distinguished geologist and mineralogist died at Freiberg on the 14th September, aged 71. He was elected a corresponding member of this Society on the 2nd June in the present year. His memory is dear to many of our members who have had the advantage of studying under him at Freiberg.