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THE

CANADIAN

NATURALIST AND GEOLOGIST.

Vol. VIII. OCTOBER, 1863. No. 5.

Art. XXIV—*On the Origin of Eruptive and Primary Rocks*; by Thomas Macfarlane. *Part II.*

(Presented to the Natural History Society.)

II. The eruptive formations.

In referring to these formations, it will be impossible altogether to avoid mentioning many matters, which are very generally known regarding them. Still the connection of eruptive rocks on the one hand with the constitution of the interior of the earth as adverted to in the last chapter, and on the other hand with certain slaty modifications of themselves, will be kept in view as much as possible. The rocks of these eruptive formations possess, as is well known, characters which distinguish them sharply from rocks of sedimentary origin. While the latter have been made up of the debris of rocks pre-existing on the earth's surface, the eruptive formations have derived their material from beneath the earth's crust. Hence they have been respectively termed by Humboldt exogenous and endogenous rocks. The eruptive rocks are more or less crystalline, generally but not always unstratified. The sedimentary rocks possess opposite characters. Each eruptive rock is in a high degree homogeneous and shows nearly the same characters and composition throughout its whole mass. This is much less the case with sedimentary rocks. The eruptive rocks occur in very irregular forms, as enormous irregular masses, (typhonische stöcke) covers or caps (Kuppen or Decken), veins, streams and layers. Sedimentary rocks occur only in the latter form. Eruptive rocks are totally destitute of fossils and their ages are determined by the relations of contact, which exist between them and sedimentary rocks. Fossils constantly occur in the latter, and constitute the principal means of determining their age. Eruptive rocks resemble in the mode of their formation the slags, which run out of smelting furnaces; sedimentary rocks the slimes deposited in stampworks and allowed to consolidate.

The eruptive formations have been arranged in the order of their antiquity by Naumann as follows:

1. The granulite formation.	
2. The granite	do.
3. The syenite	do.
4. The greenstone	do.
5. The porphyry	do.
6. The melaphyr	do.
7. The trachyte	do.
8. The basaltic	do.
9. The lava	do.

This arrangement is however general and approximative. Not only do the rocks of these formations in their lithological character graduate into each other, but the latter part of one formation may have been erupted simultaneously with the earlier rocks of the succeeding one. Thus trachytes and basalts are almost of contemporaneous origin, and porphyries have been protruded through the earth's crust in the same periods as certain greenstones and melaphyrs. I shall therefore class several of these formations together and refer to them in the following order:

1. Trachyte, Basalt, and Lava. The volcanic formations of Naumann.

2. Phorphyry, greenstone and melaphyr,	The plutonic formations of Naumann.
3. Granite, syenite, and granulite,	

Trachyte, Basalt, and Lava. I have already adverted to the distribution of volcanoes as constituting a proof of the existence of a molten zone betwixt the central metallic globe and the crust of the earth. I do not deem it necessary to enlarge much upon this point. As Naumann remarks: "Volcanoes exist in every part of the earth, under every latitude, under the equator and near to the poles, in the torrid as well as in the temperate and frigid zones. They are confined to no climate, because in Iceland, Kamschatka and the Aleutian Island, between a latitude of 50° and 66° they exist as numerously as in the Sunda isles, Galapagos and in Quito between 0° and 10° lat. But we find them especially frequent on the coasts of continents or rising out of the depth of the ocean, proving that there the conditions are especially present which are necessary to their development and activity. From all this we may conclude that the material cause of Vulcanism is present everywhere beneath the earth's crust, although it may only have been able to break out along certain lines and at certain points." By means of volcanoes and the subterranean canals connected with them, a communication is established between the molten zone beneath the earth's crust and the atmosphere. This communication is liable to be interrupted by various circumstances, and when this is permanently the case the volcano is extinct. But even the active volcanoes are far from being continually in a condition of violent eruption, their usual activity is rather of a very temperate character, and F. Hoffmann very correctly remarks that the energetic eruptions are more the exception than the rule. Volcanoes in a state of rest exhale steam and other gases and it is even the case, that a quiet effusion of lava can take place unaccompanied by any extraordinary phenomena. Generally however the ascent of the lava in the canal and crater of the volcano is the immediate cause of all the sublime effects and terrible devastations, which accompany and follow volcanic eruptions. It is still a matter of doubt among philosophers as to what is the real cause of the ascent of the lava from its home in the depths of the earth. The oldest hypothesis is that which attributes the force, which expels the lava to highly compressed steam, resulting from the access of water, and especially of sea water, to the regions filled with igneous fluid beneath the earth's crust. In later times this view has been adopted by very many philosophers such as Gay Lussac, Von Buch, Angelot, Bischof, and Petzholdt. On the other hand, Humboldt does not at all regard the problem as completely solved,* and Naumann does not consider it probable that the expansive force of the steam derived from sea-water is the cause of the ascent of the lava, although he considers it as quite certain, that sea and other water obtains access through the eruptive canals of volcanoes to very great depths, and on the ascent of the lava plays a very important part in the phenomena of volcanic eruptions. Naumann's view so far as re-

* Cosmos I, 243.

gards the part played by water seems very reasonable. We can readily conceive that it would be difficult for water, even under considerable pressure, to obtain access by means of fissures or otherwise through the solid crust of the earth to the smelted mass beneath. As previously remarked, it would be impossible for it to penetrate the highly heated rocks constituting the inner part of the earth's crust. But it would seem very possible, especially in those volcanoes situated on the coasts of continents, for water to obtain access to great depths in the craters and subterranean canals. As to the cause of the rise of lava in these, Naumann propounds the following theory:

"The solidified crust encloses the fluid interior of our planet, and at their junction the same solidifying process, by which the crust of the earth was formed, must still be going on. Because however imperceptible the radiation of the internal heat may now be, it still continually takes place although in a lesser degree; and it cannot be doubted that on the inner side of the earth's crust fluid matter is continually assuming the solid form. It is indeed the case that the greatest number of fluid bodies experience a diminution of their volume, and only a few of them, such as water and bismuth, expand, while solidifying, but we must reflect that the relations as to density of the bodies existing in the great depths of the earth where vulcanism has its seat, must be essentially different from those, which they possess on the surface, where we can experiment with them. The pressure of the superincumbent masses must compress the materials existing at these depths. But fluid bodies are gifted with a much greater degree of compressibility than solid bodies, and therefore it can easily happen, that the most and perhaps all fused material which solidifies on the inside of the earth's crust experiences in this solidification an increase in its volume. The unavoidable consequence of this can be no other than that during this slowly progressing solidification a diminution of the capacity of the earth's crust takes place, that consequently the the space enclosed by it and filled with fused material is contracted. The next consequence will be, that a part of the fluid material will be pressed up sometimes through one and sometimes through another volcanic canal, until the weight of the column of lava equalizes the pressure in the interior. In this way the first conditions are given by means of which volcanic eruptions become possible."* The objections to this theory lie in the following

* Lehrbuch I. 289.

considerations. The difference in the compressibility of fluid and solid bodies does not seem to be very considerable. Water is but slightly compressible. According to Oerstedt, the compression produced by a pressure of 2000 atmospheres amounts only to 1-12th.,* and one would suppose that fluid lava would be even less compressible than water. The decrease of compressibility which may accompany solidification would therefore seem inadequate to the production of such stupenduous effects as are observable during volcanic eruptions. Further, if this were the cause of the ejection of the lava, the latter would be poured forth only by volcanoes of inconsiderable height, but by these simultaneously. Its ejection would also keep pace with the very slow and gradual solidification in the interior, and violent volcanic paroxysms would not occur.

Sartorius Von Waltershausen likewise assumes, that expansion takes place, but he does not attribute it to the mere difference in the compressibility of the igneous material before and after solidification. He supposes that the expansion takes place in the act of crystallization i, e. while the various minerals form and separate themselves from the fluid magma.† He fails however to adduce any conclusive evidence in support of this supposition, which it might be possible to sustain, in the event of its being possible to show that melted rock rapidly cooled to a fine grained crystalline mass, had a lesser specific gravity than the same slowly cooled and distinctly crystallized. He indeed shows that the specific gravities of the minerals which result in the cooling of igneous rocks, are invariably less than those which result in calculating their specific gravities from the quantities and densities of their constituents; as the following instances show:—

Substance.	Density. by experiment.	Density. from calculation.
1. Anorthite from Selsfjäll	2. 7	3.225
2. Labradorite from Egersund	2.705	3.212
3. Orthoclase from Baveno	2.555	2.935
4. Augite from Monte Rosso	2.886	3.208
5. Hornblende from Ætna	2.893	3.447
6. English crownglass	2.487	2.721
7. Guinands Flintglass	3.77	5.64
8. Bohemian glass	2.396	2.735

* Gmelin, Hand-book of Chemistry, II. 62.

† Uber die vulcanishen Gesteine, etc., p. 333.

But this does not prove that a fused silicate, the constituents of which are already in chemical combination with each other, experiences a dimunition of density or increase of volume in cooling *and crystallizing. The only instance of the cooling of* a fused silicate, which has been made the subject of observation so far as regards density is the formation of Reaumur's porcelain from glass, but this goes rather to prove the opposite of Von Waltershausen's theory. Many kinds of glass, after exposure for several hours to a heat at which they become soft, pass into a condition resembling porcelain, become opaque, doubtless from the separation of fine particles, whose composition differs from the mass. The resulting "Reaumur's porcelain" is specifically heavier than the glass from which it is prepared. Moreover, this substance when again fused and *rapidly* cooled yields an enamel the specific gravity of which is to that of the substance before fusion as 2,625 is to 2,801.* From this it would appear that instead of an increase a diminution of volume takes places in the slow cooling or crystallization of fused silicates.

If we reject both the hypotheses just mentioned, the only explanation left, whereby the ascent of the lava column may be accounted for is that which is regarded as the cause of the more widespread earthquakes, viz. the fluctuations of the surface of the fluid interior of the earth.† While those earthquakes which occur simultaneously with volcanic eruptions and in volcanic districts may be considered as a consequence of the lava rising in the volcano, the same can scarcely be said of those earthquakes which occur in the midst of continents far distant from any volcanic region. According to Naumann, the most probable cause of these "plutonic" earthquakes is "a fluctuation of the surface of the "fluid kernel of the earth commencing from a line or a point, "and progressing according to the laws of the motion of waves." The cause of such fluctuations he leaves undecided, but in commenting upon von Hoff's, Merian's and Perrey's investigations as to the greater frequency of earthquakes in certain seasons of the year he propounds a question, the consideration of which would seem to yield the most important results. The investigations referred to established the fact that in the northern hemesphers in winter earthquakes are of greater freuency than during any other seasons. Von Hoff found that of the 115 earthquakes which, during the 10 years

* Gmelin III, 385.

† Naumann: Lehrbuch, I, 291.

from 1821 to 1830, had been experienced in that part of Europe lying north of the Alps, 21 had occurred in summer, 34 in autumn, 43 in winter, and 17 in spring. In the same way Merian arranged all the earthquakes, which had been observed in Basle up to the end of 1836, with the following results:

Summer 18.
Autumn 33.
Winter 41.
Spring 22.

The most important statistics of this character have however been furnished by Perrey of Dijon, who seems to have given special consideration to this subject. He has classified, according to the seasons of the year, 2,979 earthquakes, which have taken place in Europe and the immediately adjoining parts of Africa and Asia from the year 306 to the year 1844, and found:

653	to have taken place in	summer
705	"	autumn
911	"	winter
710	"	spring

The maximum falls in the coldest and the minimum in the warmest season of the year, while in spring and autumn the numbers are almost equal. Naumann considers that these observations almost conclusively prove that "at least in Europe and the coun- "tries immediately bordering on it, autumn and winter must "be regarded as the seasons, in which earthquakes most frequent- "ly occur." He adds that it is difficult to find a satisfactory explanation of this fact, that the cause ought perhaps to be sought for more in cosmical than in meteorological relations, and finally asks "*May not the position of the earth in the winter, i.e. in the perihelion exercise an influence?*"* This question he leaves unanswered contenting himself with declaring that the mere difference of temperature in the seasons of the year can not explain the matter. If, as is supposed in the first part of this paper, there exists in the interior of the crust a central metallic globe surrounded by a fluid zone, it is quite reasonable to suppose that the former may be influenced by the heavenly bodies, that it is attracted by the sun and moon and that the attraction exerted is the more powerful the nearer these bodies approach the earth. Since the sun is nearest to the earth in the winter, there would appear to be grounds for attributing earthquakes partly to the attraction exercised

* Lehrbuch, I, 213.

by the sun upon the fluid interior, and the consequent pressure excercised by the latter on the earth's crust. It moreover appears from investigations made by Perrey subsequent to those above mentioned, that the moon also exercises an influence.*

Quenstedt† thus refers to the latter investigations: "A. Perrey "has found from 7000 observations during the first half of the "present century that earthquakes are much more frequent in the "conjunction and opposition of the moon than at other times; "more frequent, when the moon is near the earth than when it is "distant, more frequent in the hour of its passage through the "meridian than at any other. From this it would appear, that "the moon is not without influence; that it occasions tides in the "central lava in the same manner as in the ocean, which tides "press against the earth's crust and seek an outlet." The latter part of this quotation seems to contain the explanation least liable to objection, of the rise of the lava in volcanoes. Not only may plutonic and volcanic earthquakes be attributed to this cause, but volcanic eruptions also, and with equal justice. If we adopt this explanation it is easier to comprehend why the lava should press forth at one in preference to another volcano, or burst open the obstructed canals of extinct volcanoes rather than seek an outlet through the vents already existing in the earth's crust.

Having thus discussed the various explanations of the cause of the rise of the lava in volcanic canals, the phenomena which attend volcanic eruptions may next be adverted to, with the view of ascertaining the origin of certain volcanic products. The lava gradually ascending from the depths of the earth, comes in the upper part of the canal and in the crater into contact and conflict with the water, which has found its way down from the surface, and which may have collected in subterranean reservoirs, or merely saturated the side walls of the vent. The water is by the heat of the lava resolved into steam, which then forces its way through the fluid to the surface, when the bubbles containing it explode. A similar phenomenon may be observed on a small scale at blast furnaces, when the slag runs out of the breast and over a place upon which water had been previously thrown. The slag boils up until it cools, and becomes too stiff to allow of the passage of the steam. This production and escape of steam in the craters of volcanoes takes place with a violence and intensity of which few

* Bronns Jahrbuch, 1855, 72

† Epochen der Natur, p. 812.

but eye witnesses can form any idea. Sartorius Von Waltershausen thus describes a volcanic eruption principally in relation to the various products formed by it: "During an eruption the melted "matter ascends from the deeper lying regions of the earth into "the volcano where it serves both for the formation of volcanic ash and of lava. Steam prodigiously compressed tries, where it "can, to break through the column of lava to the atmosphere. "This escape of steam is the principal cause of that subterranean "noise known as volcanic thunder. A continual struggle takes "place between the elastic fluid, the fused mass and the solid "walls of the volcanic canal, which struggle lasts so long as the "development of steam in the latter continues. During this "violent ascent of the enormous steam bubbles, which burst on "reaching the surface of the lava reservoir, pieces of lava already "cooled or still fluid are violently torn off from the latter and "thrown high up in the air out of the crater. When the eruption "is at its height, millions of these pieces, mostly red hot, from the "size of mere miscroscopic particles to those with a diameter of "one or more yards, fill the air above the crater, rising in myriads "with each explosion, and falling again in perpetually changing "motion. When the intervals between each explosion are short, "as is the case with all violent eruptions, it frequently happens, "that during a lapse of about 20 seconds, which time the glowing "stones frequently take to complete their passage through the air, "six to ten new explosions take place. It is evident that an uninter-"rupted volley and shower of stones mixed with the dense smoke of "finer particles will thus be sustained, and this it is, which, partly "glowing itself, and partly lighted up by the glow of the melted lava, "in the crater, resembles a permanent flame. The fragments of "lava thus thrown out of the crater differ from each other in size, "in external form, (which is frequently determined by the tempe-"rature at which they were formed,) and in chemical composition. "Blocks have been observed measuring 4 to 5 metres each way, "smaller ones about the size of a cubic yard occur frequently, "while from this size there are innumerable gradations down to "the finest dust. During an eruption, gravitation and the force "of the wind effect a separation of the fragments according to their "sizes. The largest of them fall back into or close around the "crater, the small pieces are thrown further, while the finer par-"ticles are borne off by the wind and gradually deposited from it, "the coarser particles first, and ultimately the finest dust, which is "often carried off several leagues from the volcano. This fine "dust is termed volcanic ash, and furnishes the principal material "for the formation of the layers of tuff which are so abundant in "volcanic districts. The fragments of lava possess at the moment "of their ejection from the crater very different temperatures. "Some of them, especially at the commencement of the eruption, "are scarcely warm, and possess the dark colour of scoriæ; others "in greater quantity are red and white hot—the latter remain for "a short time fluid and perfectly plastic, form themselves into "rotating ellipsoids, or adopt some times abnormal long drawn "forms. These latter singular pieces have been termed volcanic "bombs. Decreasing in size, and becoming mixed with small "angular fragments, they graduate into what has been called by "the Italians, Lapilli, or volcanic sand." *

When the eruption has reached its climax, and the whole of the crater to a certain level has become filled with lava, the latter breaks out from beneath the dark crust that generally overlies it, at the lowest point of the bank of the crater, and rolls down the sides of the volcano, forming what appears as a stream of fire by night, and a thick viscid stream of slag by day. The lava leaves the crater red hot and as fluid as melted metal, but shortly afterwards the stream cools and becomes solid on the surface, while it remains for a long time fluid in the inside, the heat there hidden showing itself here and there through the cracks in the solidified crust. As the stream rolls on, these cracks close up, while others form at other places. "The whole surface is in continual motion; at "one point large bubbles are observed swelling up, which finally "burst and leave their rugged sides behind standing erect in "the most curious forms; at another point cakes of slag in the "most varied positions are carried along ploughing furrows as "they go, or tearing half fluid lava with them and drawing it out "and winding it round in curious rope like forms (the so called rope "lava). At some points the surface folds itself into deep cylin-"drical canals, which run on beside each other and parallel with "the direction of the stream; and at others, crossfolds and depres-"sions are formed. Thus these lava streams present, in that part of "their course where this struggle between their fluid interior and "the solidified crust has taken place, an extraordinarily wild and "rugged appearance." †

* Die vulcanishe Gesteine in Sicilien und Island, p. 155.

† Naumann, Lehrbuch, I, 161.

According as a fused silicate cools more or less slowly, the structure of the resulting rock becomes more or less crystalline. No lava shows on its suface distinct mineralogical characters. Although traces of felspar or augite crystals make their appearance sometimes, they are nevertheless rendered unrecognizable by pieces of slag, the cavernous structure of the rock, atmospheric influences, etc. The non-crystalline character of the lava crust is of course attributable to its having been rapidly cooled. The great stream of 1669 from Etna, which is often 60 feet thick is at several places in the neighbourhood of Catania intersected by quarries, in which the structure of its various parts may be studied. It is only at the depth of several feet, that the lava begins to be compact and homogeneous. It here consists of a light gray felspathic mass in which crystals of black augite and grains of green olivine are disseminated.* Many trachytic lavas of recent production possess distinctly crystalline characters containing in the compact mass crystals or grains of glassy felspar (sanidine).

From this sketch of various volcanic processes it would appear, that there are being formed at the present day rocks entirely analogous to the basalts and trachytes, which have protruded themselves almost uninterruptedly through the earth's crust since the commencement of the tertiary period. We observe them solidifying from a condition as undoubtedly igneous as that of the slags which flow from our furnaces, and we observe them generally assuming the form of streams radiating from volcanic craters or as layers on the more horizontal ground around these, which latter form of deposition forcibly reminds the observer of the basaltic layers of much earlier date and non-volcanic origin. Lava is not so frequently observed in the form of veins as are the earlier trachytes, nevertheless it is sometimes observed in this form on the sides of craters. The earlier eruptions of trachytic and basaltic rocks seem to have taken place through fissures in the earth's crust, somewhat in the same manner as the older eruptive rocks. The masses thus erupted assumed the form of isolated dome shaped hills or wide extended coverings or even of whole stratified systems. In later periods we find these rocks gradually associating themselves with volcanic openings and occurring in the form of lava streams, many of which are even traceable to the craters, which emitted them. Fissures seem to have become more difficult of formation in the crust of the earth and in their place those

* Sart. Von Waltershausen: Gesteine in Sicilien und Island, p. 100.

canals of eruption seem to have been developed, which terminate on the surface of the earth in the craters of volcanoes. The transition from the earlier massive forms of deposition to the present peculiar volcanic type is so gradual and evident, that it is impossible to ascribe the former to any other cause than that from which the latter has been derived. Moreover it is impossible to discover any lithological difference between the trachytes of many lava streams and other rocks of the same class, which occur constituting whole mountain masses.

It is further a very remarkable circumstance connected with basaltic intrusions that they have exerted upon the neighbouring strata effects which could only have been produced by great heat. These effects, such as the re-crystallization of limestone, the carbonizing of coal, etc., are too well known to require particularisation. Another fact which speaks for the igneous origin of basalts is the following:—In many basaltic veins their sides or selvages are composed of a crust of glass or slag, which gradually alters towards the centre of the vein into the granular rock. This circumstance is entirely analogous to that observed in many slags. These are often quite vitreous on the surface where they have cooled quickly, while beneath they assume a granular and even crystalline texture.

In the first part of this paper I have referred to the chemical composition of certain rocks of the trachytic and basaltic groups. The analyses there given were however of the extremely siliceous trachytes and basic basalts. In Bischof's Chemical and Physical Geology there are recorded 27 analyses of trachytes containing from 52·8 to 72·24 per cent. of silica and averaging 62·91 per cent. In the same work there are given 22 analyses of dolerites and basalts, the content of which in silica ranges from 32·5 to 52·96 and averages 76·16 per cent. For the sake of completeness I insert here a list of the various species of the trachyte and basalt families as given by Cotta, preparatory to adverting to certain peculiarities in the structure of some of them, which peculiarities will again be referred to towards the close of the present chapter in discussing the relation which exists betwixt granite and gneiss.

Massive Trachytic Rocks. *

Name.	Mineralogical constituents and principal characters.
Trachyte,	Sanidin (glassy felspar) and albite with hornblende or mica—granular.

* Cotta: Gesteinelehre, p. 78.

Trachytic porphyry,	Impalpable fundamental mass with crystals of sanidine, &c.
Perlite,	Enamel-like mass—globular.
Obsidian and pumice stone,	Vitreous mass—impalpable to porous.
Phonolite,	Impalpable schistose, fundamental mass
Andesite,	Friable mixture of albite, oligoklase, hornblende and magnetic iron ore.

*Tufaceous Trachytic Rocks.**

Name.

Trachytic-breccia.
Trachytic conglomerate.
Trachytic tuff.
Phonolotic conglomerate.
Pumice stone tuff.
Trass.
Pumice stone boulders.
Pumice stone sand.
Alumstone.

Massive Basaltic Rocks.†

Name.	Mineral constituents and general characters.
Dolerite,	Augite and labradorite, granular. phanero-crystalline.
Anamesite,	Augite and labradorite, constituents crypto-crystalline.
Basalt,	Augite and labradorite, impalpable, crypto-crystalline.
Nepheline dolerite,	Augite and nepheline, granular to impalpable.
Leucitrock,	Augite and leucite, granular to impalpable.
Analcimite,	Augite, labrador, analcime, do.

Tufaceous Basaltic Rocks.‡

Basalt conglomerate.
Basalt tuff.
Piperine.
Palagonite tuff.

The rocks above mentioned belong to a class, the igneous origin of which is regarded by geologists generally, as controvert-

* Naumann: Geognosie, p. 709.
† Cotta; Gesteinlehre, p. 34.
‡ Naumann: Geognosie, I. p. 712.

ibly established. Nevertheless there are to be found among them instances of rocks possessing a characteristic hitherto almost exclusively ascribed to those of sedimentary origin. This is no other than the arrangement of some of the constituents of these rocks in a direction parallel to certain planes or lines. There exist numerous instances of undoubtedly igneous rocks possessing parallel structure as marked as that of many sedimentary rocks. Many trachytic porphyries possess this, especially those from the Island of Ponza and Palmarola, from the foot of the Oyamel in Mexico and from the mountain Pagus near Smyrna.* Hoffmann also describes a trachyte from the Island of Pantellaria betwixt Sicily and Africa which consists of a light greenish grey compact fundamental mass with crystals of sanidine and another mineral, which by their form, position and distribution occasion a marked schistose structure. Trachytes of this nature have been observed in the Island of Basiluzzo betwixt Stromboli and Lipari, and in the Duchy of Nassau. † Slaty trachytes are also of frequent occurrence and have been observed by Leopold von Buch at Angostura and near Perexil in Teneriffe, and in the Canary Islands at the Caldera of Tiraxana and at Mogan on Grancanaria. Also by Burat in Velay, especially at St. Pierre Eynac at the Pas-de-Compain and in the Monts-Dores.‡ The slaty trachytes described by Burat are classed by other geologists among the Phonolites, which latter also furnish most remarkable instances of parallel structure among igneous rocks. Phonolites as a class possess this slaty structure, which is caused by the parallel position of the tubular looking crystals of felspar contained in it and on this account the rock can often be split up into slates and flags. This slaty structure stands also in connection with the form in which these rocks have been deposited. In phonolitic mountains it is generally observed that the flags and the layerlike subdivisions of the rock corresponding to them are arranged around the axis of the mountain in a bellshaped system of strata, the inclination of the latter decreasing as the summit of the mountain is approached. This would seem to indicate that the parallel structure was occasioned by the flow of the phonolitic material from the opening in the summit over and down the sides of the mountain. This view is further supported by the fact that many lavas possess a marked linear parallel structure, sometimes com-

* Lehrbuch, I, 632.
† Lehrbuch, I, 634.
‡ Lehrbuch, I, 635.

bined with an evident distension of their crystalline constituents in a direction parallel with the course of the lava stream. According to Spallanzani and Dolomieu this phenomenon is of great importance, since it was doubtless occasioned by the moving forward and the distension of the half-fluid lava, an explanation amply confirmed by the elongation in the direction of the stream of the cavities filled with gas which are contained in the lava. In the Leucit-lava of Borghetto the crystals of Leucit in spite of their tesseral form are even drawn out in the direction of the stream.* These instances of parallel structure among the trachytic and basaltic rocks have been specially dwelt upon, because of the analogy they present to gneiss and other schistose rocks of the primitive gneiss formation.

Porphyry, Greenstone, and Melaphyr.—It has been already mentioned, that the trachytic and basaltic rocks first make their appearance about the commencement of the tertiary period. Instances of such rocks occur however even earlier in the trias formation, in passing backward through which we find that their character gradually changes. Porphyries result on the one hand, and melaphyrs, or commonly called traps, result on the other. The rocks usually comprehended under the name melaphyr are, according to Cotta, of a very indefinite character, and resolvable partly into basalt, partly into greenstones, and partly into porphyrites (porphyries free from quartz). On this account it would appear advisable to classify most of the eruptive rocks, which have been protruded during the Silurian, Carboniferous and Permian periods into two great divisions, viz: porphyries and greenstones. With regard to the igneous origin of these, I cannot do better than quote the argument of Naumann.† "We "have seen, that if the rocks of the lava family (as no one doubts) "must be regarded as pyrogenous formations, then the rocks of "the basalt and trachyte families have a similar origin. If now "the melaphyrs (or traps) are compared with the basalts, and "the felsitic porphyries with the trachytic porphyries, an aston-"ishing similarity will be observed to exist between them; a "similarity which renders it often quite impossible to distinguish "the one from the other, when hand specimens of them merely "are examined. According to Bergmann and Delesse, we may "recognize the same mineralogical constituents in melaphyr as in

* Lehrbuch, I, 468.

† Lehrbuch, I, 737.

"dolorite, anamesite, and basalt. It shows quite similar amygdaloidal forms to those of the latter rocks. It is a massive rock sometimes with columnar development, a completely non-fossiliferous rock like basalt. All these coincidences, from a lithological point of view alone, appear completely to justify the view, that the melaphyrs like the basalts must be numbered among pyrogenous rocks. In the felsite-porphyries, it is true that common orthoclase takes the place of the glassy felspar of the trachytes, still the difference betwixt these two minerals must be looked upon as trifling, especially when it is remembered, that most orthoclases contain some soda besides the potash. Moreover, the remaining constituents, albite, oligoclase, mica, and quartz are common to the trachytic-porphyries and to the andesites, as well as to the felsitic-porphyries, while the labradorite brings certain porphyrites in very close relationship to the melaphyrs, from which they are sometimes almost undistinguishable. The unprejudiced enquirer will therefore surely without hesitation regard the felsitic porphyries as rocks quite analogous to the trachytic porphyries, with which they also correspond in many other properties. There are also other rocks, regarding the origin of which we must come to similar conclusions. The diabases consist essentially of oligoclase or labradorite and pyroxene; the diorites of albite, hornblende, and quartz; both classes therefore of exactly the same minerals as we observe occurring in lavas, basalts and trachytes. In mineralogical and chemical respects therefore, no objection can be taken to the supposition that they have been formed in a manner exactly similar to these latter rocks. When we add to this that these greenstones are always completely non-fossiliferous, *generally massive and supplied with structures and forms of* deposition quite similar to those of the basalts and lavas, the above supposition would appear to be in every respect justifiable." With regard to the chemical composition of these rocks we find, that if we take the analysis of three hornblendic porphyries, and of a similar number of felsitic porphyries, as given in Bishop's Chemical and Physical Geology, the contents of silica of these will range from 77.9 to 59.87 and average 67.77 per cent. If we further take the analysis of greenstones and melaphyres contained in the same work, we find their percentage of silica to range from 55.29 to 42.72, and average 50.9.

The porphyries seem to have been formed principally during the Carboniferous and Permian periods. They often occur in the midst of granites and syenites, in which they form veins, so that they are generally newer than these latter rocks. A few of them are decidedly older than the coal period, and several have been formed simultaneously with the Bundtsandstein of the Triassic, and even in the Jurassic and the chalk formations, but the height of their development falls in the Carboniferous and the first part of the Permian period, in the German Rothliegendes. In the latter formation the porphyries have played a very important part, furnishing the material for many of its sedimentary rocks, and dislocating its strata considerably by their intrusion. In the carboniferous system porphyries break through and materially disturb the strata, forming veins or dykes, and inserting themselves horizontally as layers. While, as we have already mentioned, the basalts and trachytes exert a powerful chemical action on the rocks with which they come in contact, the influence of the prophyries seems to have been almost exclusively of a mechanical nature. It seems as if the porphyritic material on its arrival in the upper parts of the earth's crust did not possess such a high temperature or such a great degree of fluidity as the basalts. On the other hand, the rocks broken through by the porphyries, show evidence of the enormous violence to which they have been subjected, huge pieces having been broken off, surrounded by the porphyritic material, carried off by it and crushed and pulverized in its further progress. In this way have been formed the numerous breccias which occur in veins and masses of porphyry, where they adjoin the side-rocks. Sometimes the mechanical action has been so violent as to produce even a more finely divided material, which in the form of a sandstone-like or clay-like substance constitutes the selvages of many porphyritic veins. By far the most conclusive proofs however of the enormous forces which were at work during the eruption of the porphyry, are to be found in the dislocations which whole systems of strata have undergone. The neighbouring beds have been raised up, folded and fractured, while friction-grooves, and surfaces worn smooth by the sliding of one mass upon another occur at the junction of the erupted rock with the neighbouring strata. These effects furnish almost as conclusive evidence of the igneous origin of the porphyries as the chemical changes on the adjacent rocks do, as to the igneous origin of basalt.

With regard to the greenstones, they seem to have made their appearance in very great profusion during the Silurian and Devonian periods, and even earlier, although in lesser quantity among the primitive slates. In the Carboniferous system, they are intruded almost as frequently as the porphyries; but towards the commencement of the Permian period, they seem to be replaced by melaphyres, which continue to be erupted even as late as the Triassic period. The circumstances attending the protrusion of the greenstones and melaphyres are essentially the same as in the case of the porphyries. The strata which the former have broken through furnish abundant evidence of the extraordinary force which ejected them, and the dislocated strata also occasionally furnish proofs that they have been chemically acted on by the plutonic rock. This latter is especially the case with the melaphyres, which have frequently carbonized the coal and hardened the clay slates with which they have come in contact, in the same manner as more recent eruptive rocks. In the following tables will be found the names and characters of the rocks referred to in this paragraph.

*Massive rocks of the Porphyry class.**

NAME.	CRYSTALS OCCURRING IN THE PASTE.	CHARACTER OF THE PASTE.
Quartz porphyry.	Quartz and Feldspar.	Yellow, brown and red colored.
Syenitic porphyry.	Quartz, Chlorite Feldspar, sometimes Mica.	Brown or green; somewhat granular.
Granitic porphyry.	Quartz, Mica, Feldspar.	Sometimes granular.
Micaceous porphyry.	Mica and Felspar.	Brown coloured.
Minette.	Mica and Felsite.	
Hornblendic porphyry.	Hornblende & Feldspar.	Dark coloured.
Felspathic porphyry.	Feldspar.	
Felsite rock.	Sometimes Quartz.	Yellowish, reddish, or greenish-grey.
Pitchstone, and Pitchstone porphyry.	Glassy Feldspar, Quartz and balls of Felsite.	

Rocks made up of Porphyritic debris.†

Porphyry breccia.
Porphyry conglomerate.
Porphyry sandstone (psammite.)
Porphyritic tuff or felsite tuff. Claystone.

Massive rocks of the Greenstone and Melaphyre class.‡

NAME.	ESSENTIAL CONSTITUENTS.	TEXTURE.
Diabase.	Augite, Labradorite, and Oligoclase.	Granular, porphyritic and slaty.

* Cotta, Gesteinslehre, p. 97.
† Naumann, Lehrbuch, I, 706.
‡ Cotta, Gesteinslehre, p. 47.

NAME.	ESSENTIAL CONSTITUENTS.	TEXTURE.
Calcareous Diabase.	Augite, Labradorite or Oligoclase & Calcite.	Granular impalpable, slaty concretionary.
Gabbro.	Diallage or Smaragdite with Labradorite and Saussürite.	Granular, slaty and concretionary.
Hypersthenite.	Hypersthene and Labradorite.	Granular.
Augite-rock.	Augite.	Granular to impalpable.
Norite.	Hornblende and Feldspar Hypersthene and Feldspar.	Granular.
Diorite.	Hornblende and Albite	Granular, slaty.
Globular Diorite.	Hornblende and Anorthite.	Granular and globular
Micaceous do.	Hornblende, Oligoclase. Orthoclase and Mica.	Granular.
Hornblende rock.	Hornblende.	Granular or impalpable.
Hornblende-slate.	Hornblende.	Slaty.
Actynolite slate.	Actynolite.	Slaty.
Kersanton.	Horblende and Mica.	Granular.
Eklogit.	Smaragdite and Garnet.	Granular, slaty.
Disthene rock.	Disthene with Garnet and Mica.	Granular, slaty.
Aphanite.	Feldspar and Pyroxene or Amphibole.	Impalpable, porphyritic, slaty, cellular, amygdaloidal.
Serpentine.	Serpentine.	Impalpable, porphyritic slaty.
Schiller rock.	Schillerspar and Serpentine.	Granular.
Garnet rock.	Garnet, Hornblende, and Magnetite.	Granular.
Eulysite.	Garnet, Pyroxene, and iron oxide.	Granular, impalpable.
Epidosite.	Pistazite and Quartz.	Granular, impalpable concretionary.
Labrador rock.	Labradorite and Hornblende.	Granular, porphyritic.

*Fragmentary rocks of the Greenstone and Melaphyre class.**

Greenstone conglomerate and greenstone breccia.

Greenstone sandstone (psammite.)

Greenstone tuff.

Schalstone.

It will be observed from the foregoing tables, that by the action of water on the porphyries and greenstones rocks have

* Naumann, Lehrbuch, I, 703.

been formed similar to the conglomerates and tuffs of the volcanic formations, and probably in a similar manner. Moreover just as in these formations we find among the massive rocks above enumerated many instances of undoubtedly igneous rocks possessing a slaty structure. Many feldsitic porphyries possess a streaked texture caused sometimes by bands of varying colour, and oftener by the arrangement of the quartz grains or crystals in parallel layers, or the presence of thin laminæ of quartz in the paste.* The instances of a similar modification of structure among the greenstones are very numerous, and they are even more important as showing more clearly the cause of this structure among igneous rocks. The diorites usually occur in the form of veins, irregular masses (typhonische Stöcke,) and layers. The veins sometimes exhibit the following remarkable phenomena. In the middle they consist of granular diorite, and at the sides of slaty diorite or hornblende slate, a gradual transition being generally observable from the granular to the stratified rock. Somewhat similar instances of this nature have already been referred to in the paragraph concerning the basaltic rocks. The cause of these phenomena may most reasonably be sought for in the circumstances attending the cooling of the rock, and they are most likely the same as those which occasioned a similar structure among the porphyries. The fluid rock of the diorite vein was probably in motion in the centre, while the parts adjoining the side walls were solidified. The current in the centre would have a distending and arranging action at the junction of the fluid with the solidified parts, and an elongation and parallel grouping of the minerals there being formed would be the consequence. Not only has this slaty texture been observed in connection with veins, but it has also been remarked, that the more irregular masses of diorite assume a slaty structure towards their junction with the other rocks, the stratification being, as in the case of the veins, parallel with the line of such junction. Naumann adduces numerous instances of this sort;† and from a former paper of mine it will be observed, that they often occur in Norway.‡ Among the melaphyrs or traps the same circumstance is often remarked. In the melaphyr region south of the Hundsrück this rock, when it occurs in veins, often possesses a degree of parallel structure sufficient to cause it to separate into flags, which

* Lehrbuch, I, 616.

† Lehrbuch, II, 403.

‡ Canadian Naturalist, VII, 115.

lie parallel with the walls of the vein. The trap of Kerrera described by Macculloch is another instance of slaty texture in trap veins. In this case the rock constituting the sides of the vein is filled with scales of mica, which all lie parallel to the enclosing walls. The same author also remaks concerning the hypersthenite of Sky, that the crystals of hypersthene "are laminar and "placed in a position parallel to each other, and as in gneiss to the "plane of the bed in which they lie." Another peculiarity, which shews the influence of igneous flow on the structure of a rock is the following: The amygdaloidal varieties of melaphyr sometimes possess an arrangement of their cavities corresponding to that possessed by the gas bubbles of lavas. They are often elongated, in which case their longest axes lie parallel to each other, and we may suppose as in the case of lava, to the direction of the flow of the igneous material.

Granite and Syenite.—These formations include the oldest eruptive rocks, the granites and gneiss-granites, which during the primitive period seem to have broken through the comparatively thin crust of the earth then existing. Later granitic eruptions seem to have taken place with great frequency throughout the Silurian, Devonian and Carboniferous periods, after which they gradually disappear. Syenite does not seem to appear in the Primitive Gneiss formation until long after the first general dislocation of the same and the protrusion of the granite had taken place. The principal syenitic eruptions seem to have occurred during or shortly after the deposition of the Silurian and Devonian rocks, although there are many instances of much younger syenites. The rocks appear after their protrusion to have assumed all the forms of occurrence, which we are accustomed to observe in plutonic and even volcanic formations; irregular masses, covers, (nappes), layers and veins; every form except the stream of the volcanic rock. But it is to be remarked that instead of veins or dykes being the most common form, as in the newer plutonic formations, the irregular masses preponderate. These masses are not to be confounded with the covers or cap rocks of the basalt and trachyte formations. They are huge islands of granite as it were, possessing generally an elliptical shape, and occurring in the midst of stratified rocks, which are sometimes vertical, and which often lean against the granite as if it were the immediate cause of their inclined position. One of the most important phenomena observable with regard to granite in all its forms of occurrence is the extent to which it contains huge masses and smaller fragments of other rocks. This is one of the most conclusive proofs of the power of the forces at work during the protrusion of the granite, and taken in connection with its forms of deposition furnishes incontrovertible evidence of its eruptive origin. Among the objections which have been made to this view, the most important is that founded on the circumstance that the quartz of granite has been the last of its constituents to solidify. Many theories have been proposed to account for this circumstance but it would seem necessary before attempting its explanation to enquire whether this alleged behavior of the quartz is really the fact. It is doubted by a few geologists, and altogether denied by Sartorius von Waltershausen, who remarks that according to his experience in the primary rocks especially in granite as well as in the volcanic rocks, quartz corundum and periclase have always first been separated. "For instance," he says, "I have minutely examined the granites from "Baveno, from various districts of the Grimsel, from Mont Blanc, "from the Oker valley (Harz), from the Island of Mull and many "other places, and those rocks show that the quartz solidified "first, then the mica and finally the feldspar."* In the face of such a distinct statement it might not be safe to regard as thoroughly established the fact whereon the above objection to the eruptive origin of granite is founded.

With regard to the chemical composition of granite, its content in silica, according to 18 analyses mentioned by Bischof, ranges from 63.3 to 76.02 per cent., and averages 69.33 per cent. Only two analyses of syenite are on record, the silica being estimated as 61.72 and 66.39 per cent.; average 64.05. If we compare these figures with the average content in silica of other eruptive rocks we find generally a diminution in the quantity of silica as the rocks become more and more recent, provided always that their classification into two great series of siliceous and more basic rocks is kept in sihgt. Thus the acid series comprehend:

Granites	69.33	per cent. of silica.
Porphyries	67.77	" "
Trachytes	62.91	" "

The basic series on the other hand consist of:

Syenites	64.04	per cent. silica.
Greenstone and Melaphyrs	50.65	" "
Dolerites and Melaphyrs	46.16	" "

* Die Vulcanische Gesteine, &c., p. 225.

Bunsen and Streng are inclined to extend the theory of the normal trachytic and basaltic magmas, mentioned in the first part of this paper, so as to include the plutonic rocks, and to maintain that granites, porphyries and the older eruptive rocks are capable of being also regarded as mixtures of the two hypothetical melted masses. Of course the same objections which apply to this theory so far as basaltic and trachytic rocks are concerned, apply also in the case of the older rocks. On the other hand von Waltershausen's theory, also previously described, furnishes a complete explanation of the cause of the more siliceous character of the older rocks. The same increase of density and of basic constituents, which he supposes now to take place from the surface to the centre of the earth, existed in the oldest geological periods. The fused material; which, on breaking through the earth's crust solidified to granite, was the uppermost concentric layer then existing. It was lightest in weight and richest in silica. Beneath it lay successive layers graduating into each other, and with the depth increasing in density and basic constituents. But according to this theory, the magmas from which granites, porphyries, and trachytes resulted ought to have had a position nearer the surface than the fused matter which on its eruption yielded syenites, greenstones, melaphyres, and basalts. Hence the former rocks ought to have been the first to appear upon the earth's surface. Porphyries ought to have preceded syenites, and trachytes ought to have broken through the earth's crust and solidified prior not only to basalt but to greenstone and melaphyre. This is, however, not the case, and Sartorius von Waltershausen fully appreciates the difficulty, mentioning that the trachyte of Esia near Reikjavik, "which according to its mineralogical character "belongs to a higher-lying zone nevertheless intersects in the "form of a vein the strata of Icelandic trap, which in general "originate from deeper regions."* To explain the difficulty he resorts to the theory "that the earth's crust possesses different "thicknesses in different places, or that the surface of separation "between the already solidified and the still fluid masses represents "a relief turned inwards, of mountains and valleys. Now where "such a mountain accidentally reaches down into greater depths, "melted masses might be able, through fissures in it, prematurely "to escape to the surface, which masses might be broken through "later by rocks of higher zones which had remained longer fluid.

* Die Vulkanische Gesteine, etc. p. 337.

"The anomalies in the Esia trachyte formation might perhaps "also be explained by movements of the fluid matter in the "interior, or by alterations in the relief forms of the surface of "separation just mentioned." The method of explaining these anomalies by movements in the fluid matter existing beneath the crust would appear to be the most reasonable, and I shall endeavour as briefly as possible to refer to it more minutely.

We have already seen in referring to the cause of earthquakes and volcanic eruptions, that it is not impossible that movements take place in the interior of the earth similar to tides in the ocean on its surface. We shall suppose the two lines within the dark coloured crust in the subjoined figure (1) to represent respectively

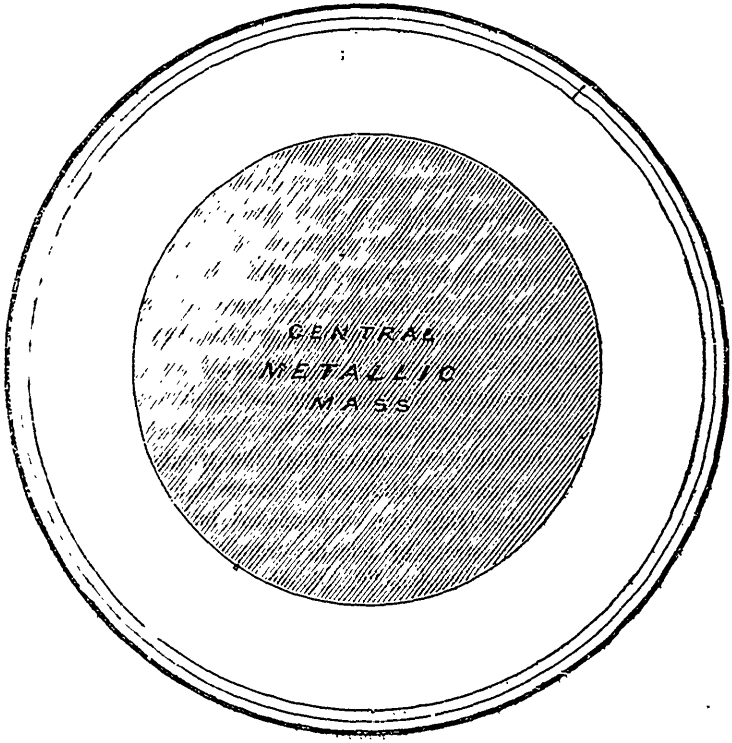

Fig. 1.

the normal limits towards the interior of the acid, and the more basic melted matter, which in the earliest periods as now, may be supposed to have graduated into each other and yielded all the varieties of eruptive rocks now visible on the surface. We shall suppose further that a change comparatively slight takes place in the position of the metallic centre. It is evident that the consequence of this would be to press the higher zone against the solidified crust, and further to each side, bringing the lower zone in contact with the crust at *a*, as shown in figure 2. If at this

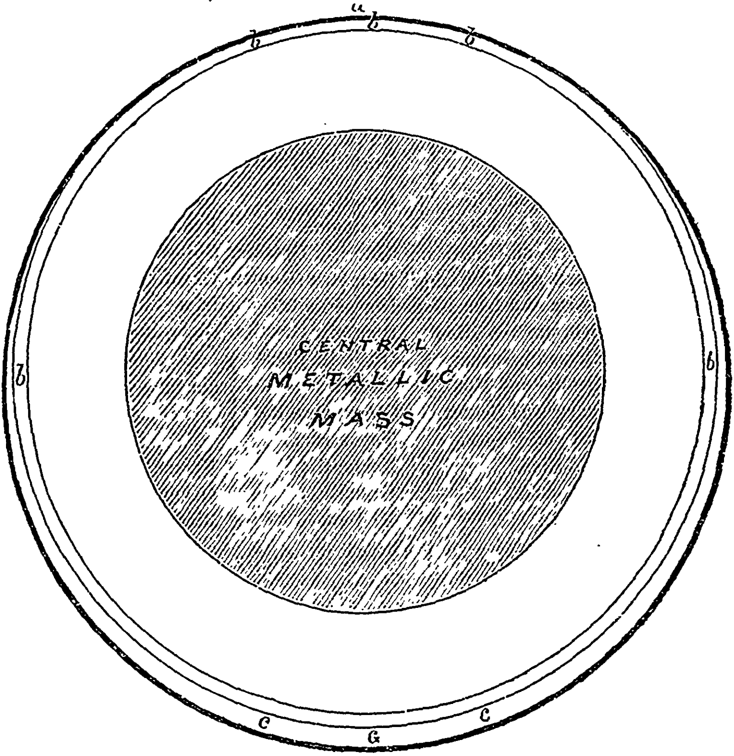

Fig. 2.

part of the crust there existed fissures or volcanoes, the denser *and more basic mass*, *b* would be erupted, while the acid mass, *c* would remain in the interior. As soon, however, as the central mass resumed its normal position the conditions would be re-established for the protrusion of the more acid rock of the superior zone. In this way the alternate eruptions of highly silicified matter and then of extremely basic rock with all the innumerable gradations that exist between them, would seem to be capable of explanation. The amount of divergence of the metallic mass from the centre necessary to produce the effect above described is so inconsiderable, that it does not appear unreasonable to attribute to the heavenly bodies the power of causing it. Still it would be very desirable if mathematicians would devote some attention to the subject.

The rocks of the granite family have been arranged by Cotta* according to their granular and slaty varieties, as follows:

ESSENTIAL CONSTITUENTS.	RESULTING ROCKS.	
	GRANULAR.	SLATY.
Feldspar and Hornblende.	Syenite.	Slaty Syenite.
Feldspar, Quartz, Mica and Hornblende.	Granitic Syenite.	Syenitic Gneiss.
Feldspar, Quartz and Mica.	Granite.	Gneiss.
Feldspar, Quartz and Talc.	Protogine.	Protogine Gneiss.
Feldspar, Quartz and Chlorite.	Chloritic Granite.	Chloritic Gneiss.
Feldspar, Quartz and Graphite.	Graphitic Granite.	Granitic Gneiss.
Feldspar, Quartz and Iron Mica.	Iron Granite.	Iron Gneiss.
Feldspar, Dichroite and Mica.	Dichroite Granite.	Dichroite Gneiss.
Dichroite, Mica and Garnet.	Dichroite Rock.	not known.
Feldspar, Elæolite and Mica.	Miascit.	not known.
Feldspar, Quartz and Schorl.	Schorl Granite.	not known.
Quartz, Schorl and Topaz.	Topaz rock.	
Oligoclase and Mica.	Kersantite.	Kersantite.
Feldspar and Quartz.	Granulite.	Granulite.
Quartz and Mica.	Greisen.	Mica slate.

The sedimentary rocks of the granite family are as follows:†

Granitic conglomerate.
Syenitic do.
Gneiss breccia and gneiss conglomerate.
Arkose (Feldspathic sandstone).

These latter rocks, however, bear but little analogy to the tufaceous rocks of later eruptive formations. Instead of being formed and deposited simultaneously with their corresponding massive rocks, they have generally been derived from the abrasion of these, long after their eruption and solidification, and deposited with the rocks of comparatively recent sedimentary formations. There do not seem to exist or have been formed with granitic eruptions any rocks of a tufaceous character. The obvious inference to be drawn from this circumstance is, that during at least the older granitic eruptions no water or ocean existed on the earth,

* Gesteinslehre, p. 114.

† Lehrbuch, I, 702.

from the conflict of which with the fluid granite such rocks could result. At the time of these eruptions, therefore, the temperature of the earth's surface must have been higher than the boiling point of water, and the whole of the latter now condensed on the surface must then have existed only in the atmosphere.

With regard to the stratified varieties of granitic rocks it will be seen from the above table, that such have been abundantly developed. Even syenites occasionally possess parallel structure, as is the case of those of the Plauensche Grund near Dresden, of Ullern-Aasen, near Christiania, and of the Odenwald. A banded structure has been observed in the syenites of Brotterode in Thuringia, of Jurgojaskaja in Asiatic Russia, and of the Malvern Hills. Phillips regards this structure, in the latter instance, as having been produced during the original solidification of the rock.* He remarks that "the laminar and banded structures may be regarded as indications of crystallization under restraint, such restraint having reference to particular planes in consequence of the pressure of preconsolidated parts adjacent." One of the most important transitions observable among these rocks, however, is the stratification of granite, whereby it gradually assumes the character of gneiss. The most abundant and striking examples of this are to be found in the Primitive Gneiss formation, where granite occurs in beds between gneiss strata, and forms gradual but distinct transitions into these, by the laminæ of mica gradually arranging themselves parallel to each other, and parallel to the direction of the strata generally. But the irregular masses of granite to which we have already referred have also often been observed to assume a slaty structure as they approach the rocks adjoining them. One of the most remarkable examples of this occurs in the Primitive Slate formation of Upper Tellemarken in Norway, especially in the neighbourhood of Aamdal, Vraadal, Hvideseid, &c. In the interior parts of the granitic protrusion, the rock is thoroughly crystalline. Towards its limits, gneissoid granite is developed, the foliation of which is invariably parallel with the line of its junction with the adjoining rocks. That the rock here referred to is decidedly eruptive is proved by the numerous fragments of neighbouring slate enclosed in it.† Instances of exactly the same phenomenon have been observed near Taubenheim, in Saxony, and in the valley of the Schwarza, in Thuringia. At the latter place the granite is

* Mem. of the Geol. Survey of Great Britain, II. 1, p. 74.

† Dahll: Om Thelemarkens Geologie, p. 7.

in the form of a long drawn mass, in the centre of which it is distinct and characteristic, while towards the hanging wall it graduates into gneissoid rock. The central granite or protogine of the Alps, according to Delesse, also graduates at its limits into gneiss, and this, according to Raymond and Charpentier, is the case with the colossal granite masses of the Pyrenees. These various instances furnish good grounds for maintaining that gneiss bears the same relation to granite, that diorite slate or hornblende slate bears to many granular diorites, the micaceous selvage of the Kerrera trap vein to its granular centre, and the numerous instances of stratified or banded porphyrites or trachytes, to the corresponding granular rocks. In short there would appear to be reason for assuming that gneiss is as much an igneous rock, as are the banded or stratified varieties of igneous rocks just mentioned. The instances just given prove at least that certain gneisses are eruptive, because they are nothing else than an outward covering, a contact modification of the eruptive granitic masses. There are, moreover, instances on record of gneisses occurring in veins, and sometimes enclosing fragments of other rocks. Humboldt mentions an instance occurring near Antimano, in Venezuela, where mica slate is intersected by veins from thirty-six to forty-eight feet thick, and consisting of gneiss filled with large crystals of feldspar; and Fournet maintains that in the mountains of Izeron, true eruptive gneisses occur in veins intersecting other gneissoid rocks.* Darwin relates that the granitoid gneiss of Bahia contains angular fragments of a hornblende rock, and that a similar gneiss occurring in Botofogo Bay, near Rio Janeiro, contains an angular piece seven yards long and two broad, of a very micaceous gneiss.† Instances of the same nature have been observed by Naumann near Ullensvang in Norway and by Boethlingk near Helsingfors in Finland.‡ The most satisfactory explanation which can be given of the formation of the gneissoid selvage to granitic masses is that which is given by Phillips in the case of syenite, and already quoted. It is a consequence of crystallization under restraint or pressure, accompanied by a movement of the solidifying mass somewhat in the same manner as indicated in the case of greenstone. Naumann adopts almost the same explanation in referring to the formation of igneous

* Naumann, Lehrbuch, II, 180.

† Geological Observations on South America, p. 141.

‡ Lehrbuch, II, 113.

strata. His remarks on this point are as follows: "Let us imagine that an igneous mass crystallizing as it slowly cools, is confined between two parallel planes, which exert both pressure and resistance; the cooling, and consequently the solidification will commence at and proceed from these enclosing planes. Now, if in the solidifying mass the conditions exist for the development of many lamellar bodies (such as crystals of mica) then each of those bodies will, in consequence of the pressure, assume a position parallel with the enclosing surface, and the rock will be furnished with a plane parallel structure more or less distinct. If, further, the process of solidification does not progress regularly, but with periodic interruptions, then the rock would be divided into layers lying parallel to the enclosing planes. If the whole mass, during the progress of the solidification was in regular motion up and down, then there would be developed in each a linear parallel structure or distension of the rock more or less distinct."* Whether the parallel structure of the gneiss of the Primitive formation may be attributed to causes similar to those here indicated, is a question reserved for consideration in the third part of this paper. Meanwhile it may be remarked that the granite occurring in beds in that formation, between the zones or layers of gneiss is so intimately connected with the latter rock by lithological transitions that it would seem to be altogether inseparable from it, and that the same origin attributed to the one must belong to the other. In the gneiss-granite of the mountains of Lower Silesia, the granular and slaty modifications of that rock are, according to Von Raumer, regularly interstratified with each other. In Podolia, according to Von Blöde, granite and gneiss together form a whole, to which a contemporaneous and similar mode of formation is ascribable. In Scandinavia and Finland, in the central plateau of France, in Scotland, in Brazil, and Hungary the same relations betwixt granite and gneiss exist. "En Hongrie,"† says Beudant, "ces deux roches se montrent toujours ensemble et uniquement ensemble, elles ne forment pas des couches alternatives, mais une seule et même masse." If, therefore, granite, as we have seen, is undoubtedly igneous, then the primary gneiss must be of the same origin, and in this manner we obtain a proof of the original state of the igneous fluidity of our globe. Gneiss is the oldest formation, and if it can be reasonably shown to be igneous, then it must have been the rock first solidified; and previous to this, it, as well as all

* Lehrbuch, I, 496.

† Voyage en Hongrie, III, p. 19.

subsequent eruptive formations, and the material of all sedimentary rocks must have been in a state of igneous fusion. The theory of the igneous state of the original globe is, however, probably so well established as to require no further proof. It is an axiom without which it is impossible satisfactorily to account for the phenomena of volcanoes and hot springs, the elevation of mountains, the increase of temperature on penetrating into the earth, the phenomena of terrestrial magnetism, the formation of crystalline rocks, and the flattening of the earth at the poles. In the third and concluding part of this paper I shall advert more fully to this hypothesis, of the conditions which must have co-existed with the earth's original fluid state.

ART. XXV.—*Roofing Slate as a Source of Wealth to Canada. A visit to the Walton Slate Quarry;* by ROBERT BELL, C. E., of the Geological Survey of Canada, and interim Professor of Natural Sciences in Queen's College, Kingston.

The rarer treasures of the mineral world are not always those which yield the largest returns for the working. According to Darwin, it is remarked in South America, that " a person with a copper mine will gain ; with silver, he may gain ; but with gold he is sure to loose." Continuing this sort of comparison to the coarser mineral products, it could not be difficult to show that there are many of them which pay better, even than copper mines. In the midst of the excitement about copper and gold in the Eastern Townships, our valuable treasures in roofing slate have not been altogether overlooked. But before proceeding to point out the importance of this source of wealth, let us consider for a moment the value of slate quarries in other parts of the world, and ascertain how others turn their advantages, in this respect, to profitable account. The slate quarries of Wales are perhaps the most extensively wrought in the world. The Penrhyn Quarry, six miles from Bangor in North Wales, and owned by the Hon. Colonel Pennant, has been worked to a depth of nearly 900 feet by successive benches or chambers, each sixty feet below the next above. The lowest of these have been reached by sinking shafts and running horizontal adits or drifts, from which the material has to be raised perpendicularly. The cost of working is thus much increased, but notwithstanding this circumstance, the quarry is believed to pay nearly a hundred per cent. profit, and the annual net gains amount to upwards of £100,000. This quarry was opened about fifty years ago. It employs 2,500 men in the various operations connected with its working, and produces 13,000,000 slates a year. The Lanberris quarry employs 2,000 men and returns a net annual profit of about £70,000. The Welsh Slate Company's quarry, owned in part by Lord Palmerston, employs 400 men, and yields an annual profit of about £25,000. The Rhewbryfair Slate Company's quarry, gives employment to 350 men, and affords an annual net profit of £13,000, or fifty per cent. on the original capital. A quarry belonging to the Festiniog Slate Company is now being further developed, and it is proposed to make it furnish 50,000 tons per annum at a profit of £37,000 and a minimum dividend of from 30 to 40 per cent. These and other quarries, employing from 250 to 300 men, and yielding equally great returns, in proportion to their production, are situated on a slate band or "vein," as it is locally termed, in the Festiniog district in North Wales. There are besides, about a dozen other quarries in operation in Wales, all making the most satisfactory returns, when judiciously worked, although some of them have to contend against great difficulties, arising from the unfavorable underlie of the cleavage for working, or from disadvantages in the positions and locations of the quarries, some of which are between twenty and thirty miles distant from a port or railway. The slates are paid for at the quarries by the thousand, but the Welshmen reckon 1,200 to the "thousand." The Welsh quarries are estimated to produce an aggregate of from 350 to 400,000 tons of slate every year, of which fully one-half is furnished by the two first mentioned. The selling price of manufactured slates is about fifty shillings a ton, so that if the latter figure be correct, the yearly value of the slates produced in Wales, will be equal to a million of pounds sterling.

A cubic yard of slate rock weighs about two tons, and when we know the proportion to allow for waste in quarrying and dressing, we can calculate approximately the quantity of slates which can be produced in a volume of slate rock whose dimensions are given. As these dimensions can be ascertained in each case, the profits of slate quarrying may be reduced to a certainty, and thus it has the character of a sure branch of business—a great advantage over the more hazardous enterprise of mining. Some of the slate quarries in Wales have a horizontal surface of from 1000 to 2000 square yards, and are capable of being worked, in many instances, to great depths. It will presently be shown that some of the workable slate bands in Canada are very much more extensive.

In Britain all the best slate quarries have been opened long ago, and capitalists are now spending large sums in developing indifferent locations; still with proper management, fortunes are being made in working even comparatively new places. The large yearly profits derived from roofing slates have already enabled the owners of the quarries to amass immense sums of money, and the increasing demand, not only for roofing, but also for sanitary and other purposes to which slate has been applied, foreshadows the brightest prospects for the future. Great as is the number of slates manufactured, the supply is not equal to the demand, and hence the producers have of late, been able to dictate all the terms and conditions of purchase to the buyers. The "rules and regulations" respecting the sale of slate at some of the quarries have very much the tone of the laws in the statute books.

Some quarries have orders booked for forty to sixty weeks in advance. In consequence of the enormous demand, prices have lately advanced several times, and if they were again raised 20 per cent, (says the Mining Journal from which these facts are principally derived) the sale would not be affected—so many new markets are continually opening. In addition to the rapidly increasing demand in Britain itself, orders for slates are sent from all parts of the world. Large numbers are constantly shipped to Russia, France, Spain, Germany, Denmark, Prussia, Austria and America, although the demand from the last mentioned quarter has not been so great for the last two years.

Slates, equal to those of Wales, are obtained in the west of Scotland and in the Delabole district, parish of Tintagel, in the north of Cornwall, where quarries are now worked paying 30 per cent. profit on the outlay. It would be needless here to enter into the merits of the slates of these regions, since my object is merely to shew the great value of this source of wealth in Great Britain, for which it is hoped the facts given in regard to Wales are sufficient.

The roofing slates of Great Britain and France belong to Lower Silurian strata, which are believed to be equivalent to the Quebec Group of this continent, and which comprises many of the slate bands of Eastern Canada and New England.

Since competition in the slate market of this continent, and perhaps also to some extent in that of the old world, is to be expected mainly from Vermont, it may not be uninteresting here to refer to the slate resources of that state. Three belts of slate rock occur in the state running southward down its eastern, middle and western portions. In the first, which keeps near the boundary of New Hampshire, the slate is of a dark color, and the cleavage generally corresponds with the planes of stratification. Although the belt has a great thickness, but little of it is available for working owing to contortions, the presence of foreign ingredients, imperfect cleavage and cross joints. An occasional band, however, is found to be suitable for roofing slates, and upon one of them the Guilford quarries are situated. The slates of this locality are sufficiently durable, but owing to their thickness, require a heavily timbered roof to support them. They are also liable to become rusty from the presence of oxide of iron. The situation of these quarries is such as to prevent their produce competing successfully with the slates imported from Wales. The slate bands in the eastern belt dip at high angles to the horizon, and thus have an advantage for working, over those of the western belt.

The middle slate belt extends from the Canada line at Lake Memphremagog about half way down the middle of the state. In places it is found to split into thin sheets, and is of a uniform color, —nearly black—differing in these respects from the slate bands of the eastern belt. Northfield, near the centre of the state, is the only place at which it has been worked. Here the price of slate delivered on the cars is $3.75 a square, or 50 cents more than Mr. Walton's price, on the Grand Trunk cars at Richmond. It may not be generally known that a square of slates is a hundred square feet, and that the greater the number required to make this area, the smaller the price per square.

The workable seams of the westerly belt are largely quarried for roofing and other purposes in the southwestern part of the state, where slate manufacturing forms a leading branch of industry. The slate is of a more uniform character than that of the eastern or the middle belt, and more exempt from foreign matter, which renders it capable of being sawn, as slab slate, and used for a great variety of purposes. The color of most of the western Vermont slates, like that of the Welsh, is dark purple, sometimes mottled with green spots. Bands of green, and sometimes of red slate are likewise found in this part of the state. Whatever may be the cause of the green spots in the purple slate, they form a very objectionable feature, being liable to decompose under the weather, and allow the rain to leak through the roof. A small speck of iron pyrites can generally be detected in the centre of each of the spots, and these may have had something to do with their formation. The slate quarries of western Vermont have a common disadvantage, in the low underlie of the cleavage, which in several cases is less than 20 degrees, thus requiring a much larger expenditure in working, than when the cleavage is vertical, or underlying at a high angle to the horizon. In some of the quarries the underlie, which is always to the eastward, is from 20 to 40 degrees, but unless the angle is sufficiently high to give a self-supporting hanging wall, a great loss is incurred in removing or supporting the superincumbent mass.

About a dozen quarries are worked on the western belt. The principal one is the Eagle Slate Quarry, situated a mile south of Hydeville, and which produces about 10,000 squares a year. Here the underlie of the cleavage, which nearly coincides with the dip of the strata, is at an angle of only 17 degrees. Roofing slates alone are made at this quarry, and bring from $2.50 to $3.50 a square at Hydeville depot. In the township of Castleton, the West Castleton Railroad and Slate Company manufacture 150 squares of slate a month, besides sawing from 15 to 16,000 square feet of slab slate. The cleavage here underlies to the eastward at an angle of 40 degrees. In 1857, the second year of operation, the sales of the produce of this quarry amounted to $60,000.

A planed surface of slate is found to retain remarkably well the compounds used in enamelling, even in the presence of heat or acids, and hence slab slate can be marbleized and used in a great variety of ways. The western Vermont slate is marbleized for jambs and mantelpieces, table and bureau tops, billiard beds and kerosene lamp bottoms. These are successfully made to imitate all kinds of ornamental marble, and are sold in immense numbers at one fourth the price of real marble. The cost of marbleized mantels varies from 10 to 125 dollars, according to the workmanship which has been expended upon them. Writing slates are also prepared in great numbers at the western quarries; and there is a large demand for unplaned slabs for sanitary and other purposes. The foregoing facts in regard to the slates of Vermont are condensed from Prof. Hitchcock's report on the geology of the state.

In Canada, no clay slates have yet been discovered among the Laurentian rocks, the strata of this series which approach nearest clay slates in composition, being always massive, and usually of a crystalline character. Slaty rocks, approaching argillites, have been found in several places among the Huronian series. For example, specimens from the Montreal River, about five miles from its junction with Lake Temiscaming, have the characters of roofing slate, but the plates into which they split are scarcely as thin as desirable. Among these rocks, on the north side of Lake Superior, greenish-black and greenish-blue slates, some of which may be fit for roofing, are found on the Kaministiquia River above the Grand Falls, and slates which are said to be available for this purpose, occur on the Slate Islands, and at Anse à la Bouteille.

In Eastern Canada the argillaceous bands of the Quebec Group, in many places yield good roofing slates, which have already been successfully wrought in a few localities. The most important of these is the Walton Slate Quarry, in Melbourne, to be described further on. The Melbourne Slate band, in its northeastward extension, crosses the St. Francis River into Cleveland, where, in 1854, a quarry was opened on the 6th lot of the 9th Range, but after a time abandoned, from the band being too narrow to pay to overcome the difficulties in the way of working it. The slate produced was nearly black in color and of the best quality. The locality is on the Grand Trunk Railway, about three miles south of the village of Richmond. On the 4th lot of the 1st range of Kingsey, reddish-purple slates of a good kind are found in the high eastern bank of the St Francis River, about seven miles below Richmond Station. The Kingsey slates are not so hard and smooth as those of Melbourne and Cleveland. A Montreal company attempted to work this quarry, but abandoned it after grading a railway track down the bank of the St. Francis from the Grank Trunk at Richmond. The failure to carry out this enterprise, appears to have prejudiced Montreal capitalists against slate quarrying generally, and to Mr. Benjamin Walton remained the honor of first demonstrating its profitable nature, and of developing a great slate quarry in Canada—a quarry which is unsurpassed by any in the world, either in the quality of the slates produced, or in the facilities for working. The Kingsey slate band is continued into the Township of Durham, on the west side of the St. Francis, and has been worked to a small extent on the 6th lot of the 4th range. At the slate rapids on the Black River, on the 12th lot of the 10th range of Ely, an attempt was made some years ago to open a quarry on a band of very fossile bluish-black slate. The cleavage is vertical and strikes S. 56° W. Bands of apparently good roofing slate are met with on the 14th lot of the 1st range of Halifax, and further to the northeast, in the Township of Frampton. For some distance above and below the junction of the Rivière du Loup with the Chaudiere, good clay slates are largely developed. On the Rivière du Loup, half a mile above the junction, a band of the rock exceeding half a mile in breadth, would, in several places, afford good writing and roofing slates. A locality for slate occurs on the 18th lot in the 3rd range of Tring. In the continuation of the Quebec group to the northeastward, slates apparently fit for roofing, are found on the Marsouin River in the northern part of the County of Gaspé, a few miles back from the St. Lawrence. The above mentioned slate bands in the Eastern Townships also belong to the Quebec group of the Lower Silurian System. In the Upper Silurian rocks, on the 2nd lot in the 5th range of Orford, dark blue roofing slates are found, not unlike those of Melbourne, but less smooth in cleavage; and again on the 29th lot in the 5th range of Brompton, on what appears to be a continuation of the last mentioned band. Similar slates occur in West Bury on the St. Francis River. Blackish slates, which may be suitable for roofing, are met with among rocks of the same age on the Patapedia River in the county of Bonaventure. The information just given in regard to the slate rocks of Canada is to be fond in the reports of the Geological Survey.

The Walton Slate Quarry.

A short time ago the writer accompanied Mr. Walton from Melbourne village on a visit to his slate quarry, and obtained most of the following notes respecting it when on the ground.* For the information of those not acquainted with the geography of this part of the country, it may be stated that Melbourne is on the west side of the St. Francis River opposite to Richmond, from which the Grand Trunk Railway diverges in three directions—to Montreal, Quebec and Portland; the branch to the last mentioned, running or a number of miles up the east side of the river.

After a drive of three miles along the main road upon the west bank of the river, we come to the quarry road, turning west at right angles,

* Mr. Walton's property has been examined by Charles Robb, Esq. Mine Engineer, and his report, (an abstract of which was published in the Journal of the Upper Canada Board of Arts and Manufactures) has been consulted in preparing this article.

while the scow-ferry, by which the slates are conveyed to the railway depot on the other side of the river, lies on the left. Following the quarry road we ascend a steep incline all the way, which, although difficult to surmount, is, as Mr. Walton remarked, a necessary feature in order to have a good slate quarry. A strip of the woods has been cleared on either side to allow of the access of the sun and wind to dry the road. In making these clearings and constructing the road, the proprietor expended about twelve hundred dollars. At the end of about a mile, we come to the cluster of buildings attached to the quarry, and leaving our conveyance at one of the boarding houses for the employés, proceed to inspect the works.

The quarry itself is not seen from the approach, being concealed by a band of serpentine which flanks the slate band on the north. It was found necessary to drive a tunnel, a hundred feet in length, from the slope of the hill through the serpentine, in order to expose a workable face of the slate rock behind. In front of the tunnel are the sheds for manufacturing the slate, and a dump or spoil bank, composed of the refuse from the dressing process. Beautiful specimens of asbestus are seen on either side in passing through the tunnel, from which we emerge on the level of the floor of the quarry and find ourselves in a great roofless chamber, the four walls of which rise to the height of seventy feet. The cleavage of the slate is about perpendicular, and runs in the direction of the greatest length of the quarry. As in the best quarries in other countries, the slate is found to improve in all the desirable qualities in descending, and the waste, due to surface influences, to diminish continually. Owing to the vertical cleavage, the surface influences have penetrated to an astonishing depth. In the upper forty feet the rock was injured to such an extent, that fully half the material quarried was wasted, and even at the present depth, the same influences are still discernible, but rapidly dying out.

At first the rock was so fissile that it could with difficulty be split into sufficiently thick sheets, but now the plates can be split to any required thickness with perfect uniformity and beautifully smooth surfaces. No difficulty is to be apprehended from imperfect cleavage in slate of this character, at the greatest depth to which the quarry can be worked. Since it is always found that in working a good band of slate the quality improves in respect to smoothness, regularity of cleavage, color and hardness, in going down, it will be perceived that a first rate quarry requires to have such a situation that it can be advantageously worked to a great depth. The great depth of the principal quarries in Wales is one of the reasons which cause the Welsh slates to be so highly prized.

The peculiarly favorable position of the Walton Quarry and the perpendicular cleavage of the slate, offer every facility for the most extensive and advantageous working. The top of the quarry is 451 feet above the St. Francis River at the depot, so that ample room is afforded for working by horizontal galleries driven from the side of the hill, thus avoiding all expense for pumping and hoisting. For future working, it is proposed to run an adit at a level of forty feet below the present one, and ultimately, one from the bank of the river at about 360 feet below the same level. From this last an almost unlimited supply of the finest slates might be taken out at the level of the railway. The quarry, in its present state, is capable of yielding 20,000 squares a year, so that the galleries referred to may be looked upon as work to be performed by another generation. It measures 24 yards in depth, 14 in breadth and 32 in length, giving a total of 10,752 cubic yards which have been excavated. The yield of slate up to the present time has been about 10,000 squares. The proportion of waste to manufactured slate has of course very much diminished in the lower portion of the quarry, and there now remain 381 feet between the bottom of the quarry and the level of the St. Francis, in which even better slate may be expected than that hitherto obtained.

The position of the quarry is about the centre of the 22nd lot in the 6th range of Melbourne township. The property to which it belongs comprises 1180 acres, extending in every direction from the quarry—as far as the railway, to the eastward—and including the ground around the depôt. The great band of serpentine in contact with the slate has a steep slope to the north, while to the south of the slate band, the ground falls away gradually, and the rock is seldom seen. The roofing slate has been ascertained to have a breadth of at least a third of a mile at the broadest place, and the whole of it appears to be equally good, as far as can be determined from surface trials. The quarry is situated on the widest part, and the band is traceable on the surface (westward from the river) for about a mile and a half; at the end of which distance it appears to be cut off by the serpentine, but reappears further on. East of the river, it is again met with in the strike, with a greatly reduced thickness. It was on this part of the band that the quarry in Cleveland, already mentioned, was opened.

The whole series in this neighbourhood is tilted to a vertical attitude, and strikes S. 45° to 55° W., or at right angles to the river. The serpentine affords many varieties of green and greenish-black marble, of which a few have been proved by Sir William Logan, to be of good quality; and the specimens in the Geological Museum are generally admired. On the west end of the quarry lot, there occurs a bed of chromic iron, of the hard, dark, crystalline variety, worth fifty dollars a ton in the English market, containing, as it does, 53 per cent. of the sesqui-oxide of chromium.* It appears to be obtainable in sufficient quantities to work at a profit. On the north-east end of the adjoining lot (22 in the 5th range—part of the same property) vitreous copper ore is found along a crack or vein in the serpentine; and further on in the strike, larger deposits of copper ore are found in the township of Orford, associated with the same rock.

The average price of the Melbourne slates delivered at the railway is $3.25 per square. They are made by contract at the quarry at $1.75, leaving a difference of $1.50 per square. From this is to be deducted 25 cents for cost of carriage to the railway. All other contingencies are covered by 15 cents more, giving upwards of a dollar a square, or 50 per cent. as the net profit to the proprietor. It is to be observed, that this calculation of profit is based on the present working expenses, and makes no allowance for past expenditure or future development. The quarry is now brought into good working order, and, at the present rates the contractors are making large profits. It is calculated that in future, by a different system of working, the proceeds to the proprietor will be not less than 100 per cent. upon the cost after delivering on the cars.

It is scarcely necessary to notice the superiority of slates, both in regard to appearance and excellence, as a roofing material, over shingles, compositions, and even metals. The original cost of slate is about one-third more than shingles, although cheaper in the end; it is one-half less than tin and one-third less than galvanized iron. The reason of slate not being adopted in preference to these latter, is often attributable to prejudice, arising from examples

*Mr. Robb's analysis.

where slates had been unskilfully employed. In our towns and cities they are now displacing these materials, and since good wood for shingles is becoming scarce in the agricultural districts, we may look foward to the time when slates will form the principal roofing material used in Canada.

But outside of our own country, the market for slates is unlimited. For instance, after being sold at Richmond, at the large profits just mentioned, they can be delivered in Portland for $4.14 per square and sold in Boston and New-York at from $8 to $10. The western cities in the United States could be more easily supplied from the slate quarries of Eastern Canada than from any others and the prices in the old world are such, that our slate could probably be sent there and sold to advantage.

Among the desirable qualities of a good slate, are uniformity of color, smoothness of surface, durability and strength with lightness; all of which are possessed in an eminent degree by those of the Walton Quarry, the slates from it being equal to any in the world, They are of a bluish-black color, contain no carbonate of lime. are unaffected by acids and almost perfectly non-absorbent, and thus can, in no way, be affected by the weather. The rock is fine grained and splits with great facility when newly taken from the quarry, but the slates harden rapidly and acquire great toughness and strength. From analyses by Dr. T. S. Hunt, the Melbourne slates are shown to have a very striking resemblance in composition to those from Bangor in Wales, and also to those from Angers in France. Slates from the latter place have been exposed for a hundred years, without perceptible deterioration, on the roof of the seminary building at the corner of Notre Dame and St. François Xavier Streets in Montreal, which proves that a slate covering is well adapted to resist the influence of the Canadian climate.* It is to be regretted that no analysis of the Vermont slates is available for comparison, but the purple varieties are more liable than our bluish black slates, to fade and give the roof a checkered and unsightly appearance, and hence the latter are the more desirable, especially where artistic arrangement is required. While the bands or "veins" of workable slate in the principal Vermont quarries are said to be only about 18 to 24 feet thick, the Melbourne band has been ascertained to have a thickness of at least 1700 feet, opposite the Walton Quarry, and to occupy a

* Descriptive Catalogue of the Economical Minerals of Canada sent to the International Exhibition of 1862.

surface area in this neighborhood of about a hundred acres. Such a volume of slate is practically inexhaustible, and judging from appearance it is all of a uniformly good quality. Mr. Walton contemplates manufacturing writing and slab slates at his quarry, for both of which the Melbourne band is admirably adapted.

It may not be out of place here to describe the process of manufacturing the roofing slates at the Walton Quarry. The rock is blasted by experienced workmen, in such a way as to give regularly shaped masses, which are conveyed on a tram-way to the dressing sheds. Here, the blocks, fresh from the quarry, are split by a mallet and chizel into sheets of the required thickness and thrown into a heap ready for trimming. The slate dresser, who is seated, places the sheet upon a horizontal steel bar in front of him, and with a thick-bladed knife or cleaver, cuts off at a blow the part projecting over the edge of the bar, the knife and the bar forming, as it were, a pair of shears. The undressed sheets are received on the left side, and the finished slates piled on the right, each size being kept separate. Mr. Walton has adopted sixteen sizes, varying from 6 by 12 to 14 by 24 inches. From long experience, the slate dresser perceives at a glance the largest size that a sheet will produce, and in a second, trims two of its edges, and having marked off the other two with a measuring gage, squares them with two blows, the whole process being performed in a twinkling.

Mr. Walton commenced opening his quarry in 1860, and having himself every confidence in the undertaking, pushed it steadily forward, in the face of many obstacles, to the present successful result. The outlay incurred in buying and developing the property, amounted to about $36,000, but the quarry and all its machinery are now in a condition for profitable working for a long time to come. At first it yielded no adequate returns, and Mr. Walton was obliged to work on through many a dreary day, without sympathy or encouragement. It must therefore be a great satisfaction to him, that his most sanguine hopes have been realized. The quality of the slate has proved to be all that could be desired and the demand is already in excess of the supply, the proprietor having been obliged, just the other day, to refuse, amongst others, an order for a thousand squares. We admire the enterprise and perseverance, and rejoice at the success of the gentleman, who embarked his fortune, and bestowed his time and attention, to develop so important, but hitherto untried source of wealth to our country

Melbourne, Canada East, October 8, 1863.

Art. XXVI.—*On the genus Stricklandia;—proposed alteration of the name;* by E. Billings.

In April 1859, I described and published in this Journal a genus of fossil Brachiopoda under the name of *Stricklandia.* In the Geologist for the present month, there is a figure of a fossil plant under the name of *Stricklandia acuminata,* with a note by Mrs. Strickland directing attention to the fact that the species was figured in the geology of Cheltenham, and also on the title-page of the Memoir of the life of Strickland.

Of this I was not aware until reading Mrs. Strickland's note, never having seen the two works cited. As it will be inconvenient to have two genera with precisely the same name I propose to change my genus to *Stricklandinia.* The difference in the termination will be quite sufficient to distinguish the two, while no one can regret that H. E. Strickland should have two genera named after him.

Art. XXVII—*On some Mineral Waters of Nova Scotia;* by Prof. How, D.C.L., University of King's College, Windsor, N.S.

Little has yet been done in the chemical examination of the mineral waters of Nova Scotia from the want of a systematic geological survey of the Province. They are, as appear from the following notices and analyses, of varied character; and there would be much scientific interest in an extended and thorough investigation into their qualities and composition. At the same time, if the results were duly published, the medicinal virtues which reside in some of the waters would be made generally known; it is probable too that new medicinal springs might be discovered. This is obviously a mat'er of sufficient importance to the Province, both in a sanitary and economic point of view, to demand the care and attention of an enlightened government. Mineral springs have been and are still so frequently the sole means of rendering localities famous and wealthy by attracting residents for more or less lengthened seasons, that it is well worth while to possess any water of great curative value, and to make its merits known as extensively as possible. Nova Scotia appears to be able to add valuable medicinal waters to her mineral resources awaiting exploration and development. I propose in the following paper to give some facts about these mineral springs, and the results of my analyses.

Bras d'Or Saline Water, Cape Breton.—This water has an extraordinary and apparently well grounded reputation for procuring alleviations and effecting cures in various maladies; authentic cases being known of much benefit resulting from its use in rheumatism and severe headaches. A gentleman of high standing and of scientific reputation informed me that he had obtained a good appetite and increased strength by taking about five gallons of it; and by further use a moderation of the violence of asthmatic attacks to which he was subject; and in fact that its employment had proved a real blessing to him. A water possessing such qualities would of course be much resorted to, and it was considered worth while to erect a house for the accommodation of visitors soon after the merits of this water became somewhat known.

There appear to be three springs at this locality, situated "near Kelly's on the high road from Sydney to St. Peters, in a brook that empties into the Salmon River, distant some two or three miles from the source of the river, six or seven from the southern shore of the Bras d'Or lake." On referring to the map accompanying Dr. Dawson's Acadian Geology, at about the spot so indicated, Devonian and Silurian rocks are found to come in contact with syenite and other igneous rocks; and I have direct information that the water rises in syenitic rocks. The flow is said to be not more than a gallon in a minute. Whether all the springs become mingled in one stream I do not know; the analysis which follows was made on a quantity of the water most esteemed, I apprehend, for medicinal virtues. The amount at my disposal did not enable me to make a thorough investigation, so that no doubt I do not give all its ingredients. The results were calculated for the English imperial gallon of 70,000 grains.

The water was clear and of neutral reaction.

	Grains.
Iron and Phosphoric Acid	Traces.
Carbonates of Lime and Magnesia	0.60
Sulphate of Lime	0.94
Chloride of Sodium	343.11
Chloride of Potassium	4.55
Chloride of Calcium	308.90
Chloride of Magnesium	4.47
	662.57

Specific Gravity at 54° = 1007.397.

The carbonates of lime and magnesia were thrown down by boiling. It was assumed that two thirds of the precipitate thus obtained consisted of carbonate of lime, and the calculation made accordingly; the precipitate was so small that no great error could arise in this way. No iodine was detected in the saline residue from 1500 grains of the water.

The composition of this water is very remarkable, quantities of sulphates and carbonates so very small being rarely met with: the large amount of chloride of calcium is also very unusual. On looking over a large number of analyses of mineral waters, belonging to different parts of the world, I find none to resemble the present excepting certain Canadian waters analysed and described by Hunt.* These form the first of the six classes in which he has arranged the mineral waters of Canada, and are characterized by "containing chloride of sodium with large portions of chlorides of calcium and magnesium, sometimes with sulphates. The carbonates of lime and magnesia are either present only in very minute quantities, or are altogether wanting. These waters are generally very bitter to the taste, and always contain portions of bromides and iodides." It is also remarked, by the same authority,† that these brine springs are altogether unlike any hitherto studied; and particularly instanced are those of England, Germany, and the State of New York, in which the chloride of sodium greatly preponderates, and which are supposed to arise from the solution of rock salt. The brine springs of the Lower Silurian limestones (such as the Canadian waters in question), on the contrary, may be supposed, according to Hunt, to represent the composition of the ancient ocean, in which these early strata were deposited. I have mentioned that the Bras d'Or water is said to arise in syenitic rocks. Crystalline limestones may exist at the locality: I have seen them in some parts of the rocks of Cape Breton coloured of the same tint in Dawson's map.

II. Renfrew Brine Spring, Hants Co.—This spring flows near the gold diggings of this place. I found it to yield about 1439 grains of solid matter to the imperial gallon, consisting principally of chloride of sodium, with but a small proportion of earthy salts.

III. Brine Spring of River Philip, Cumberland Co.—A spring exists here affording a dry salt of good taste and colour; some pounds of which were sent to the Exhibition at London in 1862. No information was furnished as to the spring; it arises no doubt in

* Report on Geology of Canada, 1863, p. 531.
† Loc. cit p. 563.

carboniferous rocks, in which formation salt springs are known to exist in several parts of this and other counties. Nothing however has yet been done in their examination; and the River Philip spring is the only one, so far as I know, that has been turned to any account.

IV. Wilmot Springs, Annapolis Co.—These, situated about 100 miles from Halifax, afford a water which has been much resorted to. Rev. Dr. Robertson, rector of the parish of Wilmot, has obligingly furnished me the following information. "The water of the Wilmot springs is cold, with an abundant flow, and is highly charged with mineral substances, chiefly iron and copper (?) No correct analysis of it, I rather think, has yet been made. It is said to contain a small proportion of iodine. In former times the springs were much frequented, but of late years very few visitors have come to them. The water however is remarkably efficacious in curing cutaneous complaints or eruptions. In my own opinion the Wilmot springs deserve to be better known and more frequented than they are at present. If the proprietors were men of substance and energy, I have not a doubt but that their locality would be one of the best known places in all Nova Scotia."

V. *Thermal? Spring near Chester, Lunenburg Co.*—Amos F. Morgan, Esq., has furnished me with the following details of a spring of clear water issuing in the centre of a rising ground or small hillock in the woods in the neighbourhood of Chester. The temperature of the atmosphere at the time of finding the spring, in the beginning of March, was below the freezing point; but of the water, as far as could be judged, about that of new milk, the pool having no appearance of having been frozen over the whole winter. The basin filled with the water was considered to be about eight feet square. The mud at the bottom was covered with small holes about the size of a man's finger, and out of these rose continually bubbles of gas. The water tasted slightly bitter, or perhaps was imagined to taste so, but was peculiarly soft, so much so, that it felt more like oil than water in the mouth. It is possible that this water is decidedly thermal; and it would seem, from its described taste and oily character in the mouth, to be highly alkaline. The gas arising appears to be abundant. This water would be well worth investigation.

VI. *Spa Spring Water, Windsor, Hants Co.*—This is a water rising in a field in a district in which gypsum is one of the prevailing rocks, the geological age being Lower Carboniferous.

The water has long been considered chalybeate, and has been taken medicinally by a number of persons, with what effect I do not know. It is well known as a favorite drink for horses and cattle. The chalybeate character of the water was inferred from its possessing a strong inky taste, and also from a certain red deposit found in the conduit pipes through which it ran, both of which were justly attributed to the presence of iron. There is however very little iron in the water as it issues from its outlet, as is seen in the following analysis made of the water carefully collected in a small reservoir filled immediately from the spring rising beneath.

The water was perfectly colourless and clear; it had little taste, and that not inky; its temperature was 49° F., that of the air being 31°. It afforded the following constituents in an imperial gallon:

	Grains.
Carbonate of Lime	17.50
Carbonate of Iron	0.40
Carbonate of Magnesia	0.31
Sulphate of Lime	106.21
Sulphate of Soda	0.68
Sulphate of Potassa	0.38
Sulphate of Magnesia	11.02
Chloride of Sodium	0·90
Phosphoric Acid and organic matter	traces
Silica	0·60
Grains in a gallon	138.00
Free Carbonic Acid (1.35 cubic inch at 32°)	0.64
Specific Gravity at 49° Fah.	1001.858

This water would be placed in the sixth class of Hunt,* being rich in sulphates. The sulphate of lime (derived no doubt from the prevailing gypsum,) which is the characteristic ingredient, is present in larger amount in only one out of fifteen waters from Cheltenham in England, and is by no means a common constituent of waters in such large proportion. The water is known to possess purgative properties when taken freely, owing in part no doubt to the sulphate of magnesia present. The inky taste and the red deposit from the water are due to its action on the soil, and to its admixture with surface water, and are only observed when precautions are not taken to keep the spring-water pure. The chalybeate

* Report on Geology of Canada, 1863, p. 532.

impregnation thus obtained is of course valuable, but will be subject to variation.

From the well marked characters of the waters mentioned in this paper it is evident that, in a systematic survey of the Province, the inquiry into its mineral springs would form a very interesting and useful part of the work involved in so desirable an undertaking.

BRITISH ASSOCIATION.

SPEECH OF SIR WILLIAM ARMSTRONG.

The British Association commenced its labours for the year by the introductory speech from the President. Sir W. Armstrong spoke as follows:—*

Gentlemen of the British Association,—I esteem it the greatest honour of my life that I am called upon to assume the office of your President. In that capacity, and as representing your body, I may be allowed to advert to the gratifying reception which the British Association met with on their former visit to this region of mining and manufacturing industry; and, as a member of the community which you have again honoured with a visit, I undertake to convey to you the assurance of a renewed and hearty welcome. A quarter of the century has elapsed since the Association assembled in this town, and in no former period of equal duration has so great a progress been made in physical knowledge. In mechanical science, and especially in those branches of it which are concerned in the application of steam power to effect interchange between distant communities, the progress made since 1838 has no parallel in history. The railway system was then in its infancy, and the great problem of Transatlantic steam navigation had only received its complete solution in the preceding year. Since that time railways have extended to every continent, and steamships have covered the ocean. These reflections claim our attention on this occasion, because the locality in which we hold our present meeting is the birthplace of railways, and because the coal mines of this district have contributed more largely than any others to supply the motive power by which steam communication by land and water has been established on so gigantic a scale.

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THE COALFIELDS.

The coalfields of this district, so intimately connected with the railway system, both in its origin and maintenance, will, doubt-

* Cited from the "*Weekly Review*."

less, receive much attention from the association at their present meeting. To persons who contend that all geological phenomena may be attributed to causes identical in nature and degree with those now in operation, the formation of coal must present peculiar difficulty. The rankness of vegetation which must have existed in the carboniferous era, and the uniformity of climate which appears to have prevailed almost from the poles to the equator, would seem to imply a higher temperature of the earth's crust, and an atmosphere more laden with humidity and carbonic acid than exist in our day. But, whatever may have been the geological conditions affecting the origin of coal, we may regard the deposits of that mineral as vast magazines of power stored up at periods immeasurably distant for our use. The principle of conservation of force and the relationship now established between heat and motion enable us to trace back the effects which we now derive from coal to equivalent agencies exercised at the periods of its formation. The philosophical mind of George Stevenson, unaided by theoretical knowledge, rightly saw that coal was the embodiment of power originally derived from the sun. That small pencil of solar radiation which is arrested by our planet, and which constitutes less than the 2,000-millionth part of the total energy sent forth from the sun, must be regarded as the power which enabled the plants of the carboniferous period to wrest the carbon they required from the oxygen with which it was combined, and eventually to deposit it as the solid material of coal. In our day, the reunion of that carbon with oxygen restores the energy expended in the former process, and thus we are enabled to utilize the power originally derived from the luminous centre of our planetary system. But the agency of the sun in originating coal does not stop at this point. In every period of geological history the waters of the ocean have been lifted by the action of the sun and precipitated in rain upon the earth. This has given rise to all those sedimentary actions by which mineral substances have been collected at particular localities, and there deposited in a stratified form with a protecting cover to preserve them for future use.

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IS COAL THE MOST ECONOMIC HEAT POWER?

The causes which render the application of heat so uneconomic in the steam-engine have been brought to light by the discovery of the dynamical theory of heat; and it now remains for mechanicians, guided by the light they have thus received, to devise improved practical methods of converting the heat of combustion into available power. Engines in which the motive power is excited by the communication of heat to fluids already existing in the aeriform condition, as in those of Sterling, Ericsson, and Siemens, promise to afford results greatly superior to those obtained from the steam-engine. They are all based upon the principle of employing fuel to generate sensible heat, to the exclusion of latent heat, which is only another name for heat which has taken the form of unprofitable motion among the particles of fluid to which it is applied. They also embrace what is called the regenerative principle—a term which has, with reason, been objected to, as implying a restoration of expended heat. The so-called "regenerator" is a contrivance for arresting unutilized heat rejected by the engine, and causing it to operate in aid and consequent reduction of fuel. It is a common observation that before coal is exhausted some other motive agent will be discovered to take its place, and electricity is generally cited as the coming power. Electricity, like heat, may be converted into motion, and both theory and practice have demonstrated that its mechanical application does not involve so much waste of power as takes place in a steam-engine; but, whether we use heat or electricity as a motive power, we must equally depend upon chemical affinity as the source of supply. The act of uniting to form a chemical product liberates an energy which assumes the form of heat or electricity, from either of which states it is convertible into mechanical effect. In contemplating, therefore, the application of electricity as a motive power we must bear in mind that we shall still require to effect chemical combinations, and in so doing to consume materials. But where are we to find materials so economical for this purpose as the coal we derive from the earth and the oxygen we derive from the air? The latter costs absolutely nothing; and every pound of coal which in the act of combustion enters into chemical combination renders more than 2½lbs. of oxygen available for power. We cannot look to water as a practicable source of oxygen, for there it exists in the combined state, requiring expenditure of chemical energy for its separation from hydrogen. It is in the atmosphere alone that it can be found in that free state in which we require it; and there does appear to me to be the remotest chance, in an economic point of view, of being able to dispense with the oxygen of the air as a source either of thermodynamic or electrodynamic effect. But to use this oxygen we must consume some omdizable substance, and coal is the cheapest we can procure.

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MISCELLANEOUS USES OF COAL.

I have hitherto spoken of coal only as a source of mechanical power, put it is also extensively used for the kindred purpose of relaxing those cohesive forces which resist our efforts to give new forms and conditions to solid substances. In these applications, which are generally of a metallurgical nature, the same wasteful expenditure of fuel is everywhere observable. In an ordinary furnace employed to fuse or soften any solid substances, it is the excess of the heat of combustion over that of the heated body which alone is rendered available for the purpose intended; the rest of the heat, which in many instances constitutes by far the greater proportion of the whole, is allowed to escape uselessly into the chimney. The combustion also in common furnaces is so imperfect that clouds of powdered carbon, in the form of smoke, envelope our manufacturing towns; and gases, which ought to be completely oxygenized in the fire, pass into the open air with two-thirds of their heating power undeveloped. Some remedy for this state of things, we may hope, is at hand in the gas regenerative furnaces recently introduced by Mr. Siemens. In these furnaces the rejected heat is arrested by a so-called "regenerator," as in Stirling's air engine, and is communicated to the new fuel before it enters the furnace. The fuel, however, is not solid coal, but gas previously evolved from coal. A stream of this gas raised to a high temperature by the rejected heat of combustion is admitted into the furnace, and there meets a stream of atmospheric air also raised to a high temperature by the same agency. In the combination which then ensues, the heat evolved by the combustion is superadded to the heat previously acquired by the gases. Thus, in addition to the advantage of economy, a greater intensity of heat is attained than by the combustion of unheated fuel. In fact, as the heat evolved in the furnace, or so much of it as is not communicated to the bodies exposed to its action, continually returns to augment the effect of the new fuel, there appears to be no limit to the temperature attainable except the powers of resistance in the materials of which the furnace is composed. With regard to smoke, which is at once a waste and a nuisance, having myself taken part with Dr. Richardson and Dr. Longridge in a series of experiments made in this neighbourhood in the years 1857-58, for the purpose of testing the practicability of preventing smoke in the combustion of bituminous coal in steam-engine boilers, I can state with perfect confidence that so far as the raising of steam is concerned, the production of smoke is unnecessary and inexcusable. The experiments to which I refer proved beyond a doubt that by an easy method of firing, combined with a due admission of air and a proper arrangement of fire-grate, not involving any complexity, the emission of smoke might be perfectly avoided, and that the prevention of smoke increased the economic value of the fuel and the evaporative power of the boiler. As a rule, there is more smoke evolved from the fires of steam-engines than from any others, and it is in these fires that it may be most easily prevented. But in the furnaces used for most manufacturing operations the prevention of smoke is much more difficult, and will probably not be effected until a radical change is made in the system of applying fuel for such operations. Not less wasteful and extravagant is our mode of applying coal for domestic purposes. It is computed that the consumption of coal in dwelling-houses amounts, in this country, to a ton per head per annum of the entire population; so that upwards of 29,000,000 tons are annually expended in Great Britain alone for domestic use. If any one will consider that 1lb. of coal applied to a well-constructed steam-engine boiler, evaporates 10lb. or one gallon of water, and if he will compare this effect with the insignificant quantity of water which can be boiled off in steam by 1lb. of coal consumed in an ordinary kitchen fire, he will be able to appreciate the enormous waste which takes place by the common method of burning coal for culinary purposes. The simplest arrangements to confine the heat and concentrate it upon the operation to be performed would suffice to obviate this reprehensible waste. So also in warming houses, we consume in our open fires about five times as much coal as will produce the same heating effect when burnt in a close and properly constructed stove. Without sacrificing the luxury of a visible fire, it would be easy, by attending to the principles of radiation and convection,, to render available the greater part of the heat which is now so improvidently discharged into the chimney. These are homely considerations—too much so, perhaps, for an assembly like this; but I trust that an abuse involving a useless expenditure, exceeding in amount our income-tax, and capable of being rectified by attention to scientific principles, may not be deemed unworthy of the notice of some of those whom I have the honour of addressing.

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NEW FORM OF CARBURETTED HYDROGEN.

Before dismissing the subject of coal, it may be proper to notice the recent discovery by Berthelot of a new form of carburetted hydrogen possessing twice the illuminating power of ordinary coal gas. Berthelot succeeded in procuring this gas by passing hydrogen between the carbon electrodes of a powerful battery. Dr. Odling has since shown that the same gas may be produced by mixing carbonic oxide with an equal volume of light carburetted hydrogen and exposing the mixture in a porcelain tube to an intense heat. Still more recently, Mr. Siemins has detected the same gas in the highly-heated regenerators of his furnaces, and there is now every reason to believe that the new gas will become practically available for illuminating purposes. Thus it is that discoveries which in the first instance interest the philosopher only, almost invariably initiate a rapid series of steps leading to results of great practical importance to mankind. In the course of the preceding observations I have had occasion to speak of the sun as the great source of motive power on our earth, and I must not omit to refer to recent discoveries connected with that most glorious body.

MATERIALS OF WHICH THE SUN IS MADE.

Of all the results which science has produced within the last few years, none has been more unexpected than that by which we are enabled to test the materials of which the sun is made, and prove their identity, in part at least, with those of our planet. The spectrum experiments of Bunsen and Kirchhoff have not only shown all this, but they have also corroborated previous conjectures as to the luminous envelope of the sun. I have still to advert to Mr. Nasmyth's remarkable discovery, that the bright surface of the sun is composed of an aggregation of apparently solid forms, shaped like willow-leaves or some well-known forms of Diatomaceæ, and interlacing one another in every direction. The forms are so regular in size and shape as to have led to a suggestion from one of our profoundest philosophers of their being organisms, possibly even partaking of the nature of life, but, at all events, closely connected with the heating and vivifying influences of the sun. These mysterious objects, which, since Mr. Nasymth discovered them, have been seen by other observers as well, are computed to be each not less than 1,000 miles in length and about 100 miles in breadth. The enormous chasms in the sun's photosphere, to which we apply the diminutive term "spots," exhibit the extremities of those leaf-like bodies pointing inwards, and fringing the sides of the cavern far down into the abyss. Sometimes they form a sort of rope or bridge across the chasm, and appear to adhere to one another by lateral attraction. I can imagine nothing more deserving of the scrutiny of observers than these extraordinary forms. The sympathy also which appears to exist between forces operating in the sun and magnetic forces belonging to the earth merits a continuance of that close attention which it has already received from the British Association, and of labours such as General Sabine has with so much ability and effect devoted to the elucidation of the subject. I may here notice that the most remarkable phenomenon which was seen by independent observers at two different places on the 1st of September, 1859. A sudden outburst of light, far exceeding the brightness of the sun's surface, was seen to take place, and sweep like a drifting cloud over a portion of the solar face. This was attended with magnetic disturbances of unusual intensity and with exhibitions of aurora of extraordinary brilliancy. The identical instant at which the effusion of light was observed was recorded by an abrupt and strongly marked deflection in the self-registering instruments at Kew. The phenomenon as seen was probably only part of what actually took place, for the magnetic storm in the midst of which it occurred commenced before and continued after the event. If conjecture be allowable in such a case, we may suppose that this remarkable event had some connexion with the means by which the sun's heat is renovated. It is a reasonable supposition that the sun was at that time in the act of receiving a more than usual accession of new energy; and the theory which assigns the maintenance of its power to cosmical matter plunging into it with that prodigious velocity which gravitation would impress upon it, as it approached to actual contact with the solar orb, would afford an explanation of this sudden exhibition of intensified light in harmony with the knowledge we have now attained that arrested motion is represented by equivalent heat. Telescopic observations will probably add new facts to guide our judgment on this subject, and, taken in connexion with observations on terrestrial magnetism, may enlarge and correct our views respecting the nature of heat, light, and electricity. Much as we have yet to learn respecting these agencies, we know sufficient to infer that they cannot be transmitted from the sun to the earth except by communication from particle to particle of intervening matter. Not that I speak of particles in the sense of the atomist. Whatever our views may be of the nature of particles, we must conceive them as centres invested with surrounding forces. We have no evidence, either from our senses or otherwise, of these centres being occupied by solid cores of indivisible incompressible matter essentially distinct from force. Dr. Young has shown that even in so dense a body as water, these nuclei, if they exist at all, must be so small in relation to the intervening spaces, that 100 men distributed at equal distances over the whole surface of England would represent their relative magnitude and distance. What then must be these relative dimensions in highly rarefied matter? But why encumber our conceptions of material forces by this unnecessary imagining of a central molecule? If we retain the forces and reject the molecule, we shall still have every property we can recognize in matter by the use of our senses or by the aid of our reason. Viewed in this light, matter is not merely a thing subject to force, but is itself composed and constituted of force.

DYNAMICAL THEORY OF HEAT.

The dynamical theory of heat is probably the most important discovery of the present century. We now know that each Fahrenheit degree of temperature in a pound of water is equivalent to a weight of 772 lbs. lifted one foot high, and that these amounts of heat and power are reciprocally convertible into one another. This theory of heat, with its numerical computation, is chiefly due to the labours of Mayer and Joule, though many other names, including those of Thomson and Rankine, are deservedly associated with its development. I speak of this discovery as one of the present age because it has been established in our time; but if we search back for earlier conception of the identity of heat and motion, we shall find (as we always do in such cases) that similar ideas have been held before, though in a clouded and undemonstrated form. In the writings of Lord Bacon we find it stated that heat is to be regarded as motion, and nothing else. In dilating upon this subject, that extraordinary man shows that he had grasped the true theory of heat to the utmost extent that was compatible with the state of knowledge existing in his time. Even Aristotle seems to have entertained the idea that motion was to be considered as the foundation not only of heat, but of all manifestations of matter; and, for aught we know, still earlier thinkers may have held similar views. The science of gunnery, to which

I shall make but slight allusion on this occasion, is intimately connected with the dynamical theory of heat. When gunpowder is exploded in a cannon, the immediate effect of the affinities by which the materials of the powder are caused to enter into new combinations is to liberate a force which first appears as heat, and then takes the form of mechanical power communicated in part to the shot and in part to the products of explosion, which are also propelled from the gun. The mechanical force of the shot is reconverted into heat when the motion is arrested by striking an object, and this heat is divided between the shot and the object struck, in the proportion of the work done or damage inflicted upon each. These considerations recently led me, in conjunction with my friend Captain Noble, to determine experimentally, by the heat elicited in the shot, the loss of effect due to its crushing when fired against iron plates. Joule's law, and the known velocity of the shot, enabled us to compute the number of dynamical units of heat representing the whole mechanical power in the projectile, and by ascertaining the number of units developed in it by impact, we arrived at the power which took effect upon the shot instead of the plate. These experiments showed an enormous absorption of power to be caused by the yielding nature of the materials of which projectiles are usually formed; but further experiments are required to complete the inquiry.

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ASSIMILATING OF MEASUREMENTS.

Another subject of a social character which demands our consideration is the much-debated question of weights and measures. Whatever difference of opinion there may be as to the comparative merits of decimal and duodecimal division, there can, at all events, be none as to the importance of assimilating the systems of measurement in different countries. Science suffers by the want of uniformity, because valuable observations made in one country are in a great measure lost to another from the labours required to convert a series of quantities into new denominations. International commerce is also impeded by the same cause, which is productive of constant inconvenience and frequent mistake. It is much to be regretted that two standards of measure so nearly alike as the English yard and the French metre should not be made absolutely identical. The metric system has already been adopted by other nations besides France, and is the only one which has any chance of becoming universal. We in England, therefore, have no alternative but to conform with France, if we desire general uniformity. The change might easily be introduced in scientific literature, and in that case it would probably extend itself by degrees among the commercial classes without much legislative pressure. Besides the advantage which would thus be gained in regard to uniformity, I am convinced that the adoption of the decimal division of the French scale would be attended with great convenience, both in science and commerce. I can speak from personal experience of the superiority of the decimal measurement in all cases where accuracy is required in mechanical construction. In the Elswick Works, as well as in some other large establishment of the same description, the inch is adopted as the unit, and all fractional parts are expressed in decimals. No difficulty has been experienced in habituating the workmen to the use of this method, and it has greatly contributed to precision of workmanship. The inch, however, is too small a unit, and it would be advantageous to substitute the metre, if general concurrence could be obtained. As to our thermometric scale, it was originally found in error; it is also most inconvenient in division, and ought at once to be abandoned in favour of the Centigrade scale. The recognition of the metric system and of the Centigrade scale by the numerous men of science composing the British Association, would be a most important step towards affecting that universal adoption of the French standards in this country which sooner or later will inevitably take place; and the Association in its collective capacity might take the lead in this good work, by excluding in future all other standards from their published proceedings.

DISCOVERY OF SOURCES OF NILE.

The recent discovery of the source of the Nile by Captains Speke and Grant has solved a problem in geography which has been a subject of speculation from the earliest ages. It is an honour to England that this interesting discovery has been made by two of her sons; and the British Association, which is accustomed to value every addition to knowledge for its own sake, whether or not it be attended with any immediate utility, will at once appreciate the importance of the discovery and the courage and devotion by which it has been accomplished. The Royal Geological Society, under the able presidency of Sir Roderick Murchison, was chiefly instrumental in procuring the organization of the expedition which has resulted in this achievement, and the success of the Society's labours in connexion with this and other cases of African exploration shows how much good may be affected by associations for the promotion of scientific objects.

DARWIN'S AND SIR C. LYELL'S WORKS.

The science of organic life has of late years been making great and rapid strides, and it is gratifying to observe that researches both in zoology and botany are characterized in the present day by great accuracy and elaboration. Investigations patiently conducted upon true inductive principles cannot fail eventually to elicit the hidden laws which govern the animated world. Neither is there any lack of bold speculation contemporaneously with this painstaking spirit of inquiry. The remarkable work of Mr. Darwin, promulgating the doctrine of natural selection, has produced a profound sensation. The novelty of this ingenious theory, the eminence of its author, and his masterly treatment of the subject, have, perhaps, combined to excite more enthusiasm in its favor than is consistent with that dispassionate spirit which it is so necessary to preserve in the pursuit of truth. Mr. Darwin's views have not passed unchallenged, and the arguments both for and against have been urged with great vigour by the supporters and oponents of the theory. Where good reasons can be shown on both sides of a question the truth is generally to be found between the two extremes. In the present instance we may without difficulty suppose it to have been part of the great scheme of creation that natural selection should be permitted to determine variations amounting even to specific differences where those differences were matters of degree; but when natural selection is adduced as a cause adequate to explain the production of a new organ not provided for in original creation, the hypothesis must appear to common apprehensions to be pushed beyond the limits of reasonable conjecture. The Darwinian theory, when fully enunciated, founds the pedigree of living nature upon the most elementary form of vitalized matter. One step further would carry us back without greater violence to probability, to inorganic rudiments, and then we should be called upon to recognize in ourselves, and in the exquisite elaborations of the animal and vegetable kingdoms, the ultimate results of mere material forces left free to follow their own unguided tendencies. Surely our minds would in that case be more oppressed with a sense of the miraculous than they now are in attributing the wondrous things around us to the creative hand of a great presiding Intelligence. The evidences bearing upon the antiquity of man have been recently produced in a collected and most logically-treated form by Sir Charles Lyell. It seems no longer possible to doubt that the human race has existed on the earth in a barbarian state for a period far exceeding the limit of historical record; but, notwithstanding this great antiquity, the proofs still remain unaltered that man is the latest as well as the noblest work of God. I will not run the risk of wearying this assembly by extending my remarks to other branches of science. In conclusion I will express a hope that when the time again comes round to receive the British Association in this town its members will find the interval to have been as fruitful as the corresponding period on which we now look back. The tendency of progress is to quicken progress, because every acquisition in science is so much vantage ground for fresh attainment. We may expect, therefore, to increase our speed as we struggle forward; but however high we climb in the pursuit of knowledge we shall still see heights above us, and the more we extend our view the more conscious we shall be of the immensity which lies beyond."

Chemical Science.

We give the President's address in full:—"Before the Section enters upon the business for which it meets—that is to say, the consideration of Papers and Reports upon Special Branches of Chemistry and the Chemical Arts—it may not be unacceptable to cast a brief and cursory glance at some few topics illustrative of the tendencies of chemical science during the last few years and of its applications to some of the manufacturing arts. One of the most remarkable features of the progress of our science is the rapid rate at which materials have been accumulating by the labours of chemists in the so-called organic department of the science. The study of the transformation of organic bodies leads to the discovery of new acids, new bases, new alcohols, new ethers, and at a constantly increasing rate which is truly wonderful. Some of these new substances are found to possess properties which can at once be applied to practical manufacturing processes, such as dyeing,&c.; but the greater number of them remain in our laboratories, and museums, and text-books, and serve to teach us new instances of the combining forces of matter. The influence of this rapid growth of materials upon our knowledge of principles and laws of combination, which constitute the science of chemistry, has been simultaneous with the discoveries of the materials themselves; and the material and intellectual progress of organic chemistry have gone on so regularly hand in hand that it is impossible to say which has done most in helping the other. It is, accordingly, observed that the science has been simplified by every important addition to her materials; instead of isolated unmeaning substances, with formulæ so complex and unintelligible as to be troublesome to chemists and truly distressing to learners, we have now definite and intelligible families of bodies, cf which the members are most harmoniously united together by some law of composition, and whose connection with neighbouring families is similarly clear and satisfactory. New discoveries are constantly coming in to fill up the gaps which still disfigure our growing system. In mineral, or inorganic chemistry, there is not the same scope for discovering at present, inasmuch as the elements which belong to it do not combine in those numerous proportions which occur among the chief elements of organic bodies. But yet, mineral chemistry has not been standing still: for even the heavy metals most remote in their properties from those volatile and unstable substances of organic chemistry, have been got in many instances to combine with them; and the organo-metallic bodies thus formed have not only proved most valuable and powerful agents of decomposition, but they have served as a connecting link between the two branches of chemical science. A system of classification of elements is now coming into use, in which the heavy metals arrange themselves harmoniously with the elements of organic bodies, and in accordance with the principles which were discovered by a study of organic compounds. It is now many years since the attention of chemists was directed by a French professor to some inconsistencies which had crept into our system of atomic weights. Gerhardt showed that the principles which were adopted in fixing the atomic weight of elementary bodies generally required us to adopt for oxygen, carbon, and sulphur numbers twice as great as those generally in use for those elements. The logic of his arguments was unanswerable; and yet Gerhardt's conclusions gained but few adherents. It is to be observed that for some years Gerhardt represented chemical reactions by so-called synoptic formulæ, which took no account of the existence of organic radicles. These synoptic formulæ represent in the simplest terms the result of a chemical reaction; but they give no physical image of the progress by which the reaction is brought about. The introduction, in this country, of the water-type in connection with poly-atomic as well as mon-atomic radicles, was found to satisfy the requirements of the synoptic formulæ. Gerhardt was the first to adopt them from us He gave, in his admirable 'Traité de Chimie Organique,' a system of organic chemistry on that plan; and his book has been of immense service to the development of our science. The extension of these principles to mineral chemistry had been commenced in the cases of the commonest acids and bases; but their general introduction met with difficulties, and sometimes seemed wanting to their complete success. I must now travel southward for a short time, and ask you to accompany me to the sunny land of glorious memories, and to its southern dependency—the Island of Sicily. It was reserved for Professor Cannizzaro, of the University of Palermo, to show us how the remainder of the knot could be untied. He argued, upon physical as well as chemical grounds, that the atomic weight of many metals ought to be doubled, as well as those of oxygen, sulphur, and carbon. His conclusion is confirmed by the constitution of those organo-metallic bodies which I mentioned just now; and it certainly does seem to supply what was still wanting for the non-metallic elements to the heavy metals themselves. The elements are now arranged into two principal groups:—1st. Those of which each atom combines with an uneven number of atoms of chlorine or hydrogen. 2nd. Those of which each atom combines with an even number of atoms of chlorine or hydrogen. Like every classification founded upon nature, this one draws no absolute line, as some elements belong to both classes. The first group includes the mon-atomic elements of the chlorine family, the tri-atomic elements of the nitrogen family, hydrogen and the alkali-metals, silver and gold—in all about eighteen elements. The usual atomic weights of these are retained. The usual atomic weights of all the other elements, biatomic, tetratomic &c., are doubled. The second group includes the oxygen family—carbon, silicon, and the alkaline earths; the metals, zinc, iron, copper, lead, &c. Every step in our theoretical development of chemistry has served to consolidate and extend the atomic theory; but it is interesting to observe that the retention of that theory has involved the necessity of deprving it of the absolute character which it at first possessed. Organic compounds were long ago discovered, containing atoms of carbon, hydrogen and oxygen, in proportions far from simple; and the atomic theory must have been abandoned but for the discovery that the atomic, or rather molecular weights of these compounds correspond invariably to entire numbers of the elementary atoms. We now use the term molecule for those groups which hold together during a variety of transforformations, but which can be resolved into simpler constituents: whilst we receive the word atom for those particles which we cannot break up, and which there is no reason for believing that we ever shall break up. Amongst the most brilliant extensions of our means of observation have been the researches in spectrum analysis. The application of these beautiful methods to the investigation of minerals has already led to the discovery of three volatile metals which had previously escaped observation, whilst its extension to the investigation of the light which reaches our planet from the heavenly bodies has led to the recognition, in several of them, of elements identical, in this respect at least, with some of our elements in this earth. An eminent French chemist has recently taken occasion, in reporting the results of some researches on the new metal 'Thallium,' to volunteer insinuations against Mr. Crooke's claim to that discovery. M. Dumas considers it corroborative of his views that Mr. Crooke did not refer the consideration of his claims, on the first opportunity, to a jury of gentlemen, formed for examining products of manufacturing industry at the National Exhibition of 1862. I have felt it my duty to allude publicly to this proceeding, because it occurred in a report of a commission of the French Academy, published by the order of that distinguished body. Before proceeding from the scientific and intellectual progress of chemistry, I must beg leave to refer briefly to the educational effects of the progress. Little, indeed, would our conquests over nature avail us if they are only known to the systematic cultivators of science and only used by them; and, unless the popular dissemination of knowledge keeps pace with its extension, the chief fruits of that extension will be lost. It would be unjust to deny that some important steps have been taken of late years by various governing bodies in this country towards giving to experimental science a position in national education; but these steps are only the beginning of a reform in education which must go much farther in order to be effectual. In illustration of what has been done, I may mention the admission of chemistry and physics into the list of subjects of examination for various Government appointments, civil and military; but the small value which the framers of the schemes placed upon these sciences, compared to mathematics, is but too plainly shown by the small number of marks which they assign to the utmost recognized proficiency in them; so that the effect of the recognition is tantamount to saying, 'We can't help acknowledging these sciences, but we want to encourage the study of them as little as possible.' The medical corporation, who influence the studies of the rising generation of practitioners by their examinations, have not only recognized the necessity of a thorough knowledge of chemistry, but many of them require the knowledge to be acquired in the lecture-room, but partly also in the laboratory. The University of London is expressly to be noticed for the beneficial influence which it has exerted in this direction in its medical examinations; but more particularly for the institution of new degrees of Bachelor and Doctor of Science, which acknowledges, for the first time in this country, the physical and natural sciences as entitled to equal recognition with classical and mathematical studies for purposes of general education. These influences have no doubt contributed materially to the introduction of chemical instruction, and even of practical chemistry, into junior schools, which has been going on so extensively of late years. It is, however, consolatory to observe that a more powerful influence than any of these is at work—viz., the popular appreciation of its real value, gradually raising physical science to the prominent place in national education which it is destined to occupy. If education is intended to prepare young people for a life of usefulness, in which their various faculties may be employed to the benefit of their fellow-men, and consequently to their own, there can be no doubt of the value of teaching them to observe, to recollect, to arrange the phenomena of the physical world, and to apply the knowledge and skill thus acquired to practical purposes. No phenomena that can be brought within the observation of everybody by inexpensive experiments are so simple in their nature, no reasonings, more definite and tangible, or more easily controlled by special observations than those of chemistry; and the science affords probably scope for more thorough training of the various faculties of the mind than can be supplied to schools by any other means. Among the chemical arts much has been doing; but, as usual, in a quite undemonstrative way. First and foremost among improvements I must mention the introduction into one manufacture after another of those admirable furnaces invented by Mr. Siemens, and generally known as regenerative furnaces. Whether we consider them from the point of view of the economy of fuel, or whether as affording the means of attaining temperatures beyond the range of other furnaces, there can be no doubt of the immense value of this invention.

Heat is the great source of power in almost all our dealings with inorganic matter; and I have not the slightest doubt that the power over heat given by these regenerative furnaces will revolutionize many a chemical art. The manufacture of iron, and its subsequent treatment for the removal of impurities, has been of late years the subject of many experiments. Various plans have been proposed for avoiding the injurious effects of the mineral impurities of our coal, by using gas for the reduction of the iron ores. In this country, however, the manufacture of cast iron is carried on in such vast quantities that changes in the processes must meet with great resistance. The laborious and expensive process of puddling, hitherto adopted for burning out the carbon from cast iron, is being gradually superseded by one or other of the following:—either by treating the molten pigs with oxide of iron until the carbon is removed as carbonic oxide; or by Bessemer's process of blowing air through the molten coast iron. In either case it is desirable to add some carbon to the malleable iron in order to render it more fusible; and for this purpose the best material is the manganiferous carburet of iron, known by the name of 'Spiegeleisen,' of which enough is used to make a low steel of about half per cent. of carbon. One of the most interesting novelties in metallurgy is the manufacture of aluminum, now carried on chiefly for the sake of its alloy with copper, by the distinguished gentleman who holds the office of Mayor of Newcastle. The mechanical properties of this so-called aluminum bronze give it great value; and it seems likely to find much favour for its appearance. Mr. Bell has also rendered no small service to science by collecting and preparing a large quantity of that wonderful new metal, thallium. Among alloys, a variety of brass containing a small quantity of iron has recently attracted considerable attention. The alloy is by no means new, though hitherto known but to few persons. It combines tenacity with elasticity to a remarkable degree, and can be easily forged. Most of the members of the Section are probably aware of the admirable series of agricultural experiments which have been proceeding for the last twenty years under the directions of Mr. Lawes of Rothansted; yet many are probably unaware of the vast importance of the results already established by those experiments Few things are perhaps more difficult than to conduct scientific experiments in any practical art like farming, to find how the resources which science discovers can be profitably turned to account, or how the defects which theory points out in ordinary working processes can be profitably remedied. It is almost proverbial that the greater number of persons who attempt the introduction on their farms of plans suggested by abstract science, succeed only in finding how to lose money. It does indeed require a rare combination of enthusiasm with caution, of knowledge of theory with practical experience of the conditions of ordinary working, to carry such experiments to a definite and useful issue. Such rare combinations of qualities have existed in Mr Lawes; and, when we recollect that, by associating Dr. Gilbert with his labours, he obtained the co-operation of an able and accomplished chemist, we have no longer reason to wonder that the results of twenty years' continuous experiment, conducted on an ample scale, with the most scrupulous care and systematic order, should have led to the establishment of results so numerous and important as to secure for Mr. Lawes the highest rank among the founders of scientific agriculture. In speaking of the chemistry of agriculture, I cannot omit alluding to the writings of Liebig, which have rendered such important services by bringing vividly before the English agriculturists what was known of the chemistry of farming, and several ingenious and suggestive theories relating to practical agriculture. In the introduction to the last German edition of his Agricultural Chemistry, Liebig refers in terms of studied disrespect to the investigation of Mr. Lawes, and, while misquoting a paragraph in one of Mr. Lawes' publications, endeavours to convey the impression that that gentleman was unacquainted with the correct use of the term 'mineral,' and had misunderstood Liebig's mineral theory; which he is generally considered to have disproved. I mention this circumstance with pain, and have no doubt that all who value Liebig's truly important scientific labours will regret it as much as I do. Another practical question which science has latterly brought prominently before the attention of the public is that of the utilization of the drainage of towns. It is estimated that the quantity of nourishment for plants wasted in London alone in this form is worth about a million sterling per annum; but this valuable material is contained in so large a quantity of water that no plan has come into working for separating it out profitably for use. Some persons are of opinion that the sewage might with advantage be conveyed through pipes for use in the fields, especially on meadow-land, to which it is most easily applicable. Baron Liebig has written a letter on the subject, which was forwarded by Alderman Mechi to the *Journal of the Society* *of Arts*, containing a proposal to mix the liquid with superphosphate of lime before distributing it, by which he considers that the value of the constituent already contained in the liquid will be practically increased. It is, however, not likely that the opinion of a chemist will decide the authorities to adopt an experimental scheme of the kind, as it is really rather an engineering and commercial than a chemical question. The practical test of value commercially is how much an article will fetch; and the data of this kind before us do not lead to the anticipation of a profit at all approaching to what theory suggests from the sale of this refuse. At Croydon (a town of about 18,000 inhabitants) it appears that the sewage is sold for something over a thousand pounds per annum. Another refuse material which has already come to possess great value is coal tar. Not only is our chief supply of ammonia, the food of plants, derived from that source, but those brilliant and varied colours, which are now so much in use for dyeing silk, also owe their origin indirectly to the same source. There is, perhaps, no more striking instance of the benefits which ultimately arise even to the manufacturing arts, from every complete investigation of chemical substances than is afforded by those beautiful dyes which have sprung up to-day from aniline, which yesterday was a chemical novelty in the hands of a first rate investigator."

NATURAL HISTORY.

THIRD REPORT OF THE SCIENTIFIC CURATOR.

Since the annual meeting of the Society on May 19th, 1863, from which this report dates, the annual report for the last season has been issued to the members. Last year the published list of members was very inaccurate, and special care has been taken to remedy this defect. The list of donations to the museum during the past year has been prepared very carefully, and the proper scientific name of each specimen has been recorded.

The co-operation of members of the Society is requested, in the endeavour to make the annual reports in future as reliable as possible. The compiler will be thankful for the correction of any error, or for the rectification of any omission—more especially in the list of members.

In consideration of Sir W. Logan's valuable donation to the Society of marine shells, sea urchins, crustaceans, corallines, &c., (collected mostly in the Gulf of the St. Lawrence, by the officers of the Geological Survey,) it was voted by the council that it be part of my duty to distribute the duplicate specimens in this series, with a view partly of rendering the cases containing them, available for other purposes. I have therefore selected, labelled, and packed up five sets which have been sent (at the expense of the Geol. Survey) to the following Institutions: .

University College,............................Toronto.
Queen's College,................................Kingston.
McGill College,..................................Montreal.
Museum of the Literary and Historical Society,...Quebec.
Laval University........ ....Quebec.

Letters acknowledging the receipt of these, and containing votes of thanks, have been duly received. The remainder of the duplicates, belonging to the Geol. Survey, have been put away.

The Society's collection of shells and bryozoa has been thoroughly arranged and named. On the left hand side of the gallery all the North American species have been grouped in twelve cases. The general collection occupies the whole of the right hand side of the gallery, and one large case at the end of the gallery has been devoted to such large shells as could not conveniently be classified in the side cases.

The Society's collections of foreign shells now fill fourteen cases. Printed labels have been procured, explanatory of the contents of each case.

The corals, sponges, crustaceans, and in fact all the invertebrata except the insects, have been classified and arranged in one large case at the south end of the gallery. The specimens are partly named, but the labelling of the specimens in this case is not quite finished. I have endeavoured to procure from friends such specimens as were wanting to complete the above mentioned series, with what success the printed lists of donations to the museum will show.

In the lower room the whole of the Society's collection of birds has been re-arranged, and large printed labels have been affixed to each case descriptive of its contents. This collection has been carefully gone over, and all those species that were previously unnamed, have been properly labelled.

The foreign birds have been partly named. I have written to England for printed labels to affix to each species in our collection of British birds and their eggs. The birds' eggs belonging to the Society have been thoroughly arranged and named, and, in many cases, new specimens procured. It is much to be desired that a proper cabinet be voted for their reception, as exposure to light materially injures the specimens by causing their colours to fade.

The mammalia have also been carefully gone through, and the whole collection properly named and labelled. Two large cases of Canadian fishes have been prepared by Mr. Hunter; these have been named, and proper printed labels have been affixed to each species.

Dr. Hunt has promised to render his valuable assistance in naming our collection of minerals.

Sir W. Logan has kindly promised to give us a series of the most typical Canadian rocks, minerals, and fossils, some time during the ensuing winter.

The council of the Society have voted that a large case be made to contain all the mammalia, including those specimens on the floor in the centre of the room, many of which sadly want cases; also that a proper insect cabinet be procured, large enough to contain the whole of the Society's collection of insects.

Much remains to be done; the collection of insects as yet is untouched, as also are the reptiles. Many of the foreign birds are still unnamed, and most of the foreign fishes. The fossils, anatomical preparations, and the whole historical, archæological and miscellaneous collections of the Society are still in a state of chaotic confusion.

It is to be hoped, however, that in time the museum may be made more worthy of the city and indeed of the whole province, both as a place of reference for special students, and as a medium for imparting general information.

J. F. Whiteaves, F.G.S., &c.,
Scientific Curator and Recording Secretary.

DEATH OF PROFESSOR EMMONS.

"Died, at Brunswick, North Carolina, on the 1st October last, in the 65th year of his age, Ebenezer Emmons, M.D., late of the city of Albany.

" This announcement will fill many hearts with sadness. Dr. Emmons was long a resident of this city, and by long holding professorships in two institutions, viz: the Albany Medical College and Williams College, at Williamstown, Massachusetts, he has become intimately acquainted with great numbers of young men, then students, but now engaged in professional and other avocations. Dr. Emmons was an early graduate of Williams College, and commenced life as a physician. His tastes, however, almost immediately led him into the domain of science, more especially in that department known as Natural History. He was early elected professor of Natural History in Williams College. So high a reputation had he acquired, that when the Geological Survey of this State was undertaken, he was selected as one to whom in part its Geological, and wholly its Agricultural department would be the most safely confided. How well and thoroughly his work was done is attested by his valuable reports on Geology and Agriculture, which have forever connected his name with the growth of Science and the development of the physical resources of this State. He was also for a long time the editor of an agricultural journal, and the author of a valuable work on American Geology. For the last few years he has been engaged in a Geological survey of North Carolina, and was thus engaged at the time of his death.

"Dr. Emmons exhibits a life long devotion to Science. Patient, persevering, cautious in his facts, rigid in his deductions, he has always carried into all the departments of Science he has investigated a strong common sense, which has essentially influenced his conclusions. Among the scientific men of this country he held a high rank. Although disagreeing with many of them on some important points in Geology, especially the Taconic system, of which he was the originator and supporter, yet more recent investigations have tended to show his sagacity and correctness. His name will long live in the scientific annals of this country.—Albany Journal, Nov. 6, 1863.

DEATH OF PROF. EILHARD MITSCHERLICH.

Prof. Mitscherlich has recently died at Berlin at the age of sixty-nine. He had long been known as one of the ablest philosophical chemists of the day, and the estimation in which he was held was exemplified by the numbers who attended his classes in the University of Berlin, and the Friederich-Wilhelm's-Institut in in that city. The mere titles of his writings would occupy nearly two columns of this journal; they embrace a wide range in chemical science, and may be found in the publications of the

Academy of Sciences of Berlin, of which he was a member, and in German periodicals. Besides these, he was the author of a 'Lehrbuch der Chemie,' in two volumes, which has passed through two editions, and has been translated into French. Dr. Mitscherlich was elected a Foreign Member of the Royal Society in 1828; and in 1829 one of the Royal Medals was awarded to him for his "Discoveries relating to the Laws of Crystallization and the properties of Crystals." It is, perhaps, by his researches into the phenomena of dimorphism that he will be best remembered.—Athenæum, No. 1876, p. 470.

AMERICAN TEA PLANT.

A newspaper announcement states that the Tea Plant has been discovered by a Chinaman (or, as some say, by an Englishman formerly engaged in the tea culture in Assam), in the United States, "covering a large area of land in the central counties of Pennsylvania;" and that tea of excellent quality and various sorts, green and black, has been made for the market by a company organized for the purpose. We are told that the agent of this company exhibits in this connexion a drawing, which is recognized as representing a genuine Tea-Plant.

A specimen of the prepared tea has been shown to us; by which we recognize that this American Tea-Plant is the well known *Ceanothus Americanus*, the *New Jersey Tea*, the leaves of which were used for this purpose at the beginning of the American revolution. Some one has remarked that the substituted beverage must have tried the patriotism of our great-grandmothers; but others report more favourably of its qualities.—PROF. GRAY, in *Silliman's Journal.*

A Natural History Association has just been established in Ottawa, which we hope will prove active and successful in advancing the interests of Natural History in connection with that interesting region. The following extract appears in one of the Ottawa, newspapers:

The public meeting, called for the purpose of organizing a Natural History Association, met, according to adjournment, at the Mechanics' Institute, on Saturday evening last; and after adopting a constitution and code of by-laws, proceeded to the selection of officers, when the following gentlemen were elected for the current year:—President, A. Billings, jr., Esq.; 1st Vice-President, N. B. Webster, Esq., A.M.; 2nd Vice-President, George Hay, Esq., Secretary, Thomas Austin, Esq.; Curator and Librarian, E. Vancortland, Esq., M.D.; Committee of Management: J. Thorburn, Esq., A. M.; Duncan Thompson, Esq., and Thomas Daniel, Esq.

CORRESPONDENCE.

Description of Elephantine Molars in the Museum of the University. By Prof. A. WINCHELL.

(In a letter to one of the Editors of this Journal.)

ANN ARBOR, Mich., Aug., 1863.

MY DEAR SIR,

Your favour of 25th June was duly received, and I thank you for its various items of information. Relative to the remains of fossil elephants in the museum of the University, I regret to say that you have been misinformed. We have a cast of an entire lower jaw and a tusk of a mastodon from near St. Thomas, C. W., obtained from Thomas Barret, of Niagara Falls, and not unlikely you are in possession of similar casts. Probably this jaw has given rise to the report of which you speak. Of elephant remains the museum contains only three molars. As a description of these may furnish some items of desirable information for you, I have delayed somewhat my reply to your letter with the view of obtaining time to make such observations as might be necessary for a description of them.

1. The first is a cast of a left upper molar received by me from Prof. Tuomey, of Alabama, who had the cast executed from a specimen found in that state.

The anterior extremity of the tooth seems to have been broken off, and I think it is proper to allow one inch (including two plates) for this loss. The alveolar portion of the tooth is furnished with several fang-like prolongations, the anterior one of which reaches a length of nearly two inches. The outer side of the tooth exhibits a curvature having a radius of about eight inches; the inner side is nearly straight. The crown presents a slight convexity longitudinally, and is flat transversely. The plates extend with slight, irregular undulations, continuously from side to side. The posterior ones—especially those behind the grinding surface—are somewhat curved in their prolongation from the crown to the roots of the tooth.

2. A well-preserved left lower molar from a peat bed in Jackson county, Michigan.

This tooth presents a marked longitudinal convexity on the outer side, while the inner side, in the vicinity of the crown, is nearly straight to the posterior third, when it becomes somewhat concave internally. The grinding surface is deeply concave—the middle being depressed nearly an inch below the extremities, and about one third of an inch below the adjacent sides. The grinding surface, moreover, is twisted so that its plane, near the posterior extremity, makes an angle of about 15° with the same plane near the anterior extremity, the crown being more turned outwards posteriorly. The five posterior plates still present traces of the digitations; in the third from the extremity are five equidistant circular digitations. The posterior plate, as it penetrates the body of the tooth, curves backwards and then forwards, presenting a posterior convexity. The hinder plates are placed at right angles with the crown-axis, but in proceeding forwards the outer ends are most rapidly advanced, so that near the middle of the crown the plates make an angle of only about 80° with the crown-axis, and the 10th plate is duplicated in its outer half to fill up the enlarged space in the outer curvature. When the tooth rests on its crown and is viewed from the side, the profile is nearly an equilateral right-angled triangle, truncated two fifths of the way down from the apex. The hypothenuse, or anterior slope of the alveolar portion of the tooth is furnished with six short fangs produced by deep folds of the dentine. The truncated portion, viewed from the side opposite the crown appears to be an irregularly long cup or crater of dentine, covered externally by cement, and filled with the same substance to within two-thirds of an inch of the rim. The cement of this tooth is nearly black, and is about .075 of an inch thick on the exterior; the dentine is light-coloured immediately beneath, and quite white in its deeper substance. The enamel, which projects in the plates, above both the cement and the dentine, retains a fine chalcedonic colour and lustre.

3. Cast of a left lower molar, found near Toronto, C. W., and obtained from Thomas Barret, of Niagara Falls, C. W.

This tooth is curved on both sides, with the convexity turned outwards. The grinding surface is strongly concave both longitudinally and transversely. One strong fang on the anterior portion of the tooth seems to have been removed. Posteriorly the apparent removal of the deeper alveolar portion has exposed ten of the plates.

The following table exhibits the dimensions and other precise characters of the three teeth :

	No. 1. Alabama	No. 2. Michigan	No. 3. C. W.
Total length	11 in*	16.25 in.	7 in.
Length of grinding surface	9 "	10.50 "	5 "
Projection posteriorly beyond the grinding surface	1.25 in.	0.75. "	2 "
Whole number of plates	28 "	19 "	19 "
Number of plates on the grinding surface	21† "	19 "	15 "
Mean distance of plates on grinding surface	0.43 "	0 55 "	0.33 in.
Greatest width of crown	4 "	3.64 "	2.50 "
Average thickness of plates	0.20 "	0.33 "	0.20 "
Greatest height when resting on crown	8.50 "	6.50 "	4.75 "
Ratio of length and breadth of tooth	2.75 "	3.09 "	2.80 "

*Allowing one inch for apparent loss.

† Allowing two plates for portion lost.

The foregoing examination of three elephantine molars in my possession shows that they probably agree sufficiently well to belong to one species. The mean distance of the plates conforms also with the data which you have given in the *Canadian Naturalist*, and seems, as you conclude to point to a distinction between *Elephas primigenius* and the remains commonly found in the United States and Canada West. The Michigan tooth presents the most marked peculiarities, and these may be enumerated as follows:

1. A greater mean distance of the plates.
2. The oblique position of the middle and anterior plates.
3. A remarkable twisting of the grinding surface.
4. A smaller relative thickness.
5. A different disposition of the dentine in the deeper or alveolar portion of the tooth, especially as contrasted with the Canadian molar.

Very truly yours,

A. WINCHELL.

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