consideration show the small pineal plate ("posterior ethmoid" of Traquair) fused with the large ethmoid ("anterior ethmoid" of Traquair) in front, but separated by a distinct sutural line. The great pineal pit at the hinder angle of the "rostral" plate thus formed is well indicated in Pl. I. Fig. 8.

Several plates of the body cuirass are also contained in the latest collection from Campbellton. There are examples of the lateral and ventrolateral plates (Whiteaves, *loc. cit.* pl. ix. figs. 3, 4); and two groups of smaller, sparsely tuberculated plates cannot even be provisionally determined. Further discoveries must be awaited before any definite information concerning the disposition of the armature is obtainable.

EXPLANATION OF PLATE I.

Fish-remains from the Lower Devonian of Campbellton, New Brunswick.

FIG. 1. *Protodus Jexi*, sp. nov.; tooth, outer and lateral (1*a*) aspects.
„ 2. *Diplodus problematicus*, sp. nov.; tooth, outer aspect, three times nat. size.
„ 3. *Acanthodes semistriatus*, sp. nov.; fin-spine.
„ 4. *Gyracanthus incurvus*, Traq.; spine, lateral aspect.
„ 5. Ditto; abraded apex of spine, lateral aspect.
„ 6. *Cephalaspis campbelltonensis*, Whiteaves sp.; scale, external aspect, three times natural size.
„ 7. *Phlyctænaspis acadica*, Whiteaves sp.; head-shield, external aspect. *c.* central; *e.* ethmoid; *e.o.* external occipital; *m.* marginal; *m.o.* median occipital; *p.* pineal; *p.mx.* premaxilla; *p.o.* preorbital; *pt.o.* post-orbital.
„ 8. Ditto; ethmoidal (*e*) and pineal (*p*) plates, visceral aspect.

All the specimens are preserved in the Geological Department of the British Museum (Natural History), and, unless otherwise stated, the drawings are of the natural size.

II.—Remarks on Prof. Bonney's paper "On the Crystalline Schists and their Relation to the Mesozoic Rocks in the Lepontine Alps."

By Dr. F. M. Stapff.

I VENTURE to offer some remarks on the above-mentioned paper of Prof. Bonney, which appeared in the Quarterly Journal of the Geological Society for May, 1890 (vol. xlvi. pp. 187–240).[1] As the result of ten years' geological researches in the St. Gothard district, I have become familiar with most of the statements and arguments brought forward by Prof. Bonney; many of them, I am glad to see, agree with my own observations and views, already made known in official and other publications; others, however, I feel bound to dispute.

I.—*The black schists.*—Prof. Bonney's view that the "*black garnet schists*" of the St. Gothard (Nufenen to Lukmanien) are not identical with the *belemnitiferous black "spotted" schists* of the Nufenen (Bonney, *l.c.* pp. 214, 218, 220, 221) has been held by me since

[1] It will, we are sure, gratify our readers to learn that Dr. Stapff, the writer of the present article, was the eminent engineer of the St. Gothard tunnel. By accident Prof. Bonney has referred to him in the Quart. Journ. Geol. Soc. 1890, vol. xlvi. p. 196, as "the *late* Dr. Stapf" (for Stapf read Stapff). We are glad to be able to state that Dr. Stapff is alive and well.—EDIT. GEOL. MAG.

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1875, and I am glad to find it supported by so high an authority. In a paper I read at the 58th annual meeting of the Schweizerische Naturforschende Gesellschaft, held at Andermatt, September, 1875 (Jahresbericht, 1874–5, pp. 127—156), is the following:—

"Worthy of attention is the frequent association (in the southern section of the Gothard tunnel, 700—800 m. from the mouth) of this calc-mica schist with dark, dense, often phyllitic mica schists which resemble some of the Nufenen 'Knotenschiefer' in having knobs of small garnets. But it should be kept in mind that two different kinds of spotted schists occur in the Nufenen pass. In one of them the knobs are garnets; in the other one cylinders and hail-like grains of a zeolithic[1] mineral, and the belemnites are exclusively found in this last-named variety" (*l.c.* p. 140). Further, the following will be found in the text to "Profil géologique du St. Gothard dans l'axe du grand tunnel établi pendant la construction (1873–1880) par F. M. Stapff, ingénieur-géologue de la Compagnie du St. Gothard" (Annexe spéciale aux rapports du Conseil fédéral Suisse sur la marche de l'entreprise du St. Gothard; Berne, 1881), "The *black schists* of the *Oberalp road* (north side of the Gothard) might be paralleled with certain *black garnet schists of the south side* (Nufenen schists in part.)—Footnote. The belemnites do not appear in the black garnet schists of the Nufenen pass, but in a kind of black schist which much more reminds one of those from Altkirche (likewise on the north side of the Gothard, not far from the Oberalp road). The cylinders in this rock are composed of a zeolitic mineral (comp. *von Fritsch*, p. 127) which probably accounts for the hydraulic qualities which calcined lime exhibits when mixed up with slightly burnt and ground belemnite-schist from the Nufenen. If this parallelization be correct, and the metamorphosed sedimentary rocks of the Ursern valley properly determined, then we may draw the conclusion that the series of the originally sedimentary rocks on the south side of the Gothard begins, at the bottom of the Ticino valley, with *Jurassic* deposits and includes *Carboniferous* at about

[1] I am well aware that these grains and cylinders in the Nufenen schists are usually considered to be *couseranite*; but the existing chemical analyses allow them to be equally as well regarded as f. i. *prehnite*, and this interpretation is not contradicted by Prof. Bonney's microscopic analysis, though the shape of the prisms does not agree with the usual habit and mode of occurrence of prehnite.

Comparative analyses:—

	Mineral in the Nufenen schists.		To be compared with	
	knobs	prisms	Prehnite	Couseranite
SiO_2:	53·09	40·07	43·63	52·37
Al_2O_3:	19·45	22·05	24·87	24·02
Fe_2O_3:	5·93	5·66	(6·81—7·38 in some varieties)	—
CaO:	10·95	22·29	27·14	11·[illegible]5
MgO:	1·03	1·20	—	1·40
H_2O:	6·06	8·89	4·36	KaO,NaO 9·48
Loss	3·49	—	—	—
	100·00	100·16	100·00	99·12

I observed the hydraulic character of the Nufenen schists whilst searching for hydraulic lime in the neighbourhood of Airolo, and made some laboratory tests with them.

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1833 m. inside the mountain, counted from the mouth of the tunnel" (*loc. cit.* French text, p. 56; German, p. 51, 52). Describing the glacial and alluvial gravels in the Ticino valley ("Geologische Beobachtungen im Tessinthal, während Tracirung und Baues der Gotthardbahn," Berlin, 1883), I have likewise pointed out the difference between the ordinary black garnet schists and the Nufenen 'spotty' schists: whilst the former are spread far down the valley, the Nufenen 'spotty' schists were not met with beyond five or six kil. below the pass (*loc. cit.* p. 83).

The fact is, that schists and slates which are coloured by graphite or other coaly material, sometimes phyllitic, sometimes calciferous, and often garnet-bearing, occur on the Gothard under various conditions, and in widely separated geological horizons. On his map of the Gothard district, *von Fritsch* indicated by the colouration of the Nufenen schist, a patch of *black garnet schist* in the upper part of the Unteralpthal. On examination I found it to be a slender intercalation in the micaceous gneiss of the Sorescia type, which, on the summary profile to my geological map of the Gothard railway, is designated by III., and which has been cut by the tunnel between 3000 and 4000 m. from the southern entrance. This occurrence of black garnet schist in the brown micaceous gneiss III. is not an isólated one. I have mapped a quite analogous instance in the upper Val Cadlimo, close by the Lago Scuro.

On a higher horizon, we meet with the *black schists* (without macroscopic garnets) of the Oberalp road, which were exposed in the tunnel between 3650 and 3800 m. N.; probably they are of *Carboniferous age* and equivalent to the *black garnet schists* on the south side, at 1466 and 1808–1833 m.[1]

Some seams of *black schist* were met with in the tunnel at 3263 and 3274 m. N., between the Altkirche schists and the above-mentioned Oberalp schists, which have not been traced at the surface; they probably correspond with the *black garnet schists* on the south side at 700–800 m. The bed-rocks are calcareous on *both sides* of the mountain; I consider them to be of *Triassic* age, as well as the bulk of the calc-mica schists on the opposite side of the Ticino river, which also inclose several belts of *black garnet schists*, one, for example, in the Stalvedro railway tunnel.

Finally we arrive at the highest horizon of *black schists*, viz., those of Altkirche on the north side, met with in the tunnel at 2582, 2637, 2766 m. N., which I consider to be of *Liassic* age and to correspond with the *Nufenen belemnite schists*. These have not been seen in the southern section of the tunnel, though it is possible that they may be represented there by some geological equivalent.

These *different black schists* do not completely agree in their petrographic characters, not even if comparison is made with those which

[1] These and other intercalations of special geological interest have been purposely very prominently marked on the profil géologique in order to attract attention to them. For exact measures and details refer to my record: "Geologische Tabellen und Durchschnitte, über den grossen Gotthardtunnel; Specialbeilage zu den Berichten des Schweizerischen Bundesrathes über den Gang der Gotthardbahn-unternehmung, 1873–1882."

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presumptively belong to the same geological age, and at present their presumed horizons are rather guessed at than accurately determined. But the *black schists* which are easily recognized, and in which fossils may be expected to occur, will one day prove valuable criteria for geological classification, and I have therefore indicated them, wherever they occur, not only in the profile of the Gothard tunnel, but also in the "Geologische Uebersichtskarte der Gotthardbahnstrecke Kil. 38–149 (Erstfeld-Castione); 10 Blätter im Maasstab 1:25000; im Auftrag der Direction der Gotthardbahn, 1885." In the title and index-sheet of this map, three distinct designations are given for at least four different sorts of black schists; the colours referring to similar petrographic characters, the letters and numbers to geological position. In this way (which, however, cannot be fully explained without the help of a descriptive text to the map) I have endeavoured to bring the beds together in the order in which they might be expected to succeed each other, without prejudicing the *final* geological grouping, or making the map useless in case some of my views respecting the geological position of some of the beds should subsequently prove erroneous.

II. *The gray mica schists, calc-mica schists, disthene schists.*—I have divided the rocks of the Ticino valley from the mouth of the tunnel inwards to the micaceous gneiss of the Gothard, into the following four groups:

37—90 *m.*;	characteristic rocks	:	*dolomites.*
90—1142 m.;	,,	,, :	*gray garnet-mica schists.*
1142—1833 m.;	,,	,, :	*green and black garnet-mica schists.*
1833—3178 m.;	,,	,, :	*felspathic-mica schists and amphibolic rocks.*

Prof. Bonney's "Val Piora schists" belong to the second of these groups (that of the gray garnet schists) and his "Val Tremola schists" to the third and fourth groups (green, black felspathic mica schists and amphibolic rocks). On my geological map of the railway, this whole series is marked by the figures IV. and V. and the *sericite* schists of the Ursern valley are understood to be equivalent to the *gray mica schists* of the south side. (Text to profile, French, p. 47; German, p. 43.)

In the composition of the gray mica schists, two species of mica, at least, take part; of these the gray is the characteristic one. In the text to the profile (German, p. 45; French, p. 49) this is described as "not positively identical with *paragonite,* though containing soda, as shown by blow-pipe tests; potash-mica also occurring in the same schist. When fused to a yellowish white enamel, it becomes intumescent giving a yellow tint to the flame. It has a silky lustre and talcose appearance under the microscope; with a silver-white or grey colour, which often assumes a greenish hue. In the immediate neighbourhood of quartz-veins with copper pyrites, ironspar, cyanite, tourmaline, muscovite, calcspar, etc., this same soda-mica often turns apple-green like that of *pregrattite;* this green colour is of dubious origin (NiO, CuO, Cr^2O^3?), and seems to fade on long exposure to light. The blackish-tint and semi-metallic lustre in the black garnet schists and in many calc schists is due to graphite; not only is this the case in this group of the mica-schist series (700—800 m.), but also in the following (green schists at 1318, 1466, 1808, 1828 m., etc.) and in the black schists of the north side. Garnets are seldom absent, but in the schists close to the dolomites they are small, rare, and sometimes scarcely visible. The second constituent mica is brown magnesian; it is in part original, in part a pseudomorph, after hornblende.

Disthene, cyanite, staurolite (rarely, for example, at 632 and 753 m.) occur in certain beds throughout the gray mica schists, whilst they are but sporadic or microscopic rarities in the succeeding green amphibolic and felspathic mica schists. Real staurolite schists comparable with the typical beds of Alpe Sponda have not been met with in the tunnel (text to profile, French, p. 50; German, p. 46) and large radiant prisms of disthene are commonly connected with quartz veins (180, 190, 397 m.), which at the same time carry copper pyrites, pyrrhotine, ironspar and tourmaline (rare). The beds in which disthene and kindred minerals can be recognized at a glance, *e.g.* at 190, 397, 536, 606, 632, 732, 792, 808, 854, 868, 912, 1119 mètres from the mouth, are usually connected with the calc-mica schists and black garnet schists; but it would be premature to assert that certain geological horizons in the gray mica schists are characterized by the appearance of disthene, etc.

The complex of gray mica schists containing garnets, disthene staurolite (tourmaline), appears again *on the opposite side of the Ticino valley* (up in the mountains), whence it enters Val Chironico, with the renowned Sponda Alp; and it may be seen from the geological map of the railway, plates vi. vii., that even here these mica schists are underlaid by micaceous gneiss and overlaid by real calc-mica schists, with intercalations of black schists, quartzites, and (last but not least) by dolomites, rauchwacke, marble, etc., in repeated beds.

The so-called *calc-mica schists* of the Gothard tunnel (south side, text to profile, French, p. 50; German, p. 45) differ to some extent from the calc-mica schists on the opposite side of the Ticino valley; the calcspar being scarce and often absent in the rusty outcrops of the small seams; which are then hardly recognizable as continuations of the corresponding calcareous mica schists in the tunnel (pl. v. of the geological map along the railway line). The calcspar usually occurs together with quartz or felspar, in thin crumpled, broken and faulted lamellæ, which by the decomposition of pyrites or carbonate of iron are often rusty and carious. Some quartzitic beds of this mica schist series and some amphibolites (*hemithrènes*) also yield grains and lamellæ of calcspar, and it would be interesting if there were means of distinguishing the original constituent from the secondary calcspar, so as to be able to decide whether these intercalated seams are real or pseudo calc-mica schists. With regard to their designation in the profile of the tunnel, I refer to the remarks made above respecting the black garnet schists.

Certain seams of the sericitic schists of the Ursern valley (north side) are also calcareous (3255–85; 3560–70; 3650, 3666 m. N.,

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German text to profile, p. 22; French, p. 24) and thus comparable with the described calc-mica schists of the south side. Macroscopic garnets, disthene, etc., are lacking on the north side, where *anhydrite*,[1] *gypsum*, and gunpowder-like *magnetic iron* are interesting accessory constituents of the calcareous sericite schists; and the presence of *rolled grains of quartz* prove them to be originally psammitic rocks.

It should, moreover, be kept in mind that sporadic intercalations of calcspar are by no means rare in the crystalline schists of the St. Gothard. They frequently occur in the green felspathic and amphibolitic schists of the south side; in the black schists of the Oberalp road on the north side; sometimes also in the micaceous gneiss of the Gothard massif. Intercalations of limestone always point to an original sedimentary formation of the surrounding schist. A direct proof of this is the existence of *rolled gravels* in the amphibolic mica schist at 396 m. S. (text to profile, French, p. 52; German, p. 48. Geolog. Durchsch., Südseite, Nos. 55, 56); of *rolled quartz grains* in the sericitic schist (text to profile, French, p. 25; German, p. 20. Geolog. Durchsch., Nordseite, No. 64, 68, 69, 72, 74, 76, p. 83), and of *psammitic quartz rock* (talc quartzite; verrucano?) between the beds of black schist at 3733, 70, 80, 94 m. N.

The calc-mica schist at the mouth of the Moësa, in the Ticino (pl. x. geol. map along railway), is in a greatly advanced condition of metamorphism, but though changed into calcareous gneiss with accessory disthene, garnets, actinolite, and titanite, and including beds of marble and cipoline, it must be considered as the equivalent of the calc-mica schists of Airolo (tunnel), and of the mica-schist with imbedded calcareous rocks of the Jorio pass (summary profile of the railway on title sheet of the map).

Continuing the parallelization of the schists on the south side of the St. Gothard with those on its north side, we have to place against the *green garnet-mica schists* with their intercalations of *black garnet schists, calc-mica schists*, and *quartzites*, the *black schists of the Oberalp road* with their belongings, and against the *felspathic mica schists* and *amphibolic rocks* of the Scipsius (IV. in the scheme on title plate of the map) the slaty gneiss of the north side for which I have proposed the name *Ursern-gneiss* (see sub-section V.).

An analogous rock, with striking intercalations of *hälleflinta*, is passed by the railway line near Gurtnellen on the northern flank of the granitic gneiss belonging to the Finsteraarhorn massif (Geol. Map, pl. iii. and title sheet), and southwards from Airolo a corresponding gneiss underlies the gray mica schists below Passo Sassella (pl. vi.), and between Monte Piottino (Daziogrande) and *Monte Olina* (Val Chironico). But amphibolic rocks, which abound near Airolo, are rare or altogether absent in the other localities (Ursern valley, Gurtnellen, Val Chironico).

III. *Dolomite, rauchwacke, marble, cipoline, and subordinate rocks.*—The detailed section between 37 and 90 mètres from the southern entrance of the tunnel, shown on a scale of 1 : 200 on plate i. of the

[1] Zeitsch. d. deutsch. geol. Gesellsch, 1879, p. 407.

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Geol. Durchschnitte, Südseite, is highly instructive for the interpretation of the rather irregular or lenticular masses of rauchwacke which figure on the geological maps of the country. The same rock which, in the ragged cliffs N.E. and S.W. of the tunnel, appears almost homogeneous (though greatly decayed), is, in the tunnel, unrolled in a long series of alternating concordant strata of *rauchwacke, saccharoidal dolomite, marble, breccia, 'ash,' quartzite,* and *mica schist,* this last named forming not only some well-defined beds at the end of the series, but also thin separating sheets between the different calcareous layers, and patches in their mass. I am not convinced that these fragments are, in all cases, the detritus of pre-existing mica schist inclosed in the lime rock; sometimes the white, gray, or greenish coatings of talcose mica appear to have been formed contemporaneously with the calcareous material or even subsequently; in other instances they are certainly torn and crushed fragments of the intercalated mica schist which have been squeezed into the dolomite by mechanical forces. Prof. Bonney lays stress upon the occurrence in the dolomites, etc., of fragments of mica schist, which indicate their psammitic nature. With the reservation just mentioned, I share this view, which I have already published in the "Geol. Durchschnitte und Tabellen, Südseite," specially with reference to No. 10 ("dolomitic ash," a dirty greenish medley of dolomite, talc, etc.) and to No. 14 ("breccia" at 78·5 m., which is thus described, "Yellowish, ashy, cavernous rauchwacke, inclosing sharp-edged fragments of talcose mica schist and of saccharoidal dolomite, with white or rusty saccharoidal or sandy dolomite in the cavities. This bed, so far as it is not a vein, *proves that the dolomitic strata are younger than the mica schist on their hanging wall*"). Very similar remarks are made in the text to the Geological profile (German, p. 44; French, p. 48, and in "Verhandl. der Schweiz. Naturf. Gesellsch." 1874–75, p. 139): "the occurrence of this mica-dolomite breccia seems to prove that the dolomites are younger than the surrounding mica schists."

Dolomitic material is predominant in the chequered line of thin strata in this section of the tunnel, which have together been subjected in common to contortion, faulting and squeezing, so that it is difficult to understand why the same mechanical forces should not have exercised similar metamorphic effects on every individual bed of the whole series, which they are believed to have exercised on *some* of them; why, for example, mechanical "marmorization" has taken place in No. 17 at 82·3—83 m.; but not in the preceding bed of white loose saccharoidal dolomite, nor in the following one of white and red dolomitic bands which alternate with strings of quartz and mica-schist? How are we to explain the alternation of beds of rauchwacke with saccharoidal limestone if the transformation of one of these substances into the other were due to pressure which has acted through the whole complex? Leaving on one side the formation of breccias, it does not seem probable that petrographic metamorphosis by mechanical forces has played an important rôle in our case; I am inclined to consider that the chemical or physical

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constitution of the different beds was originally dissimilar, so that the course and the results of any metamorphic action would necessarily have varied in different parts of the whole complex. Further, it is not necessary to assume that any *chemical* metamorphosis must have embraced an entire complex of calcareous or dolomitic strata; it might equally as well have been restricted to certain regions, (marked off by stratification, fissure, or other lines) thus producing heterogeneous mass-shaped intercalated deposits, such as for instance *gypsum* and *anhydrite* imbedded in rauchwacke. As a matter of course, these irregular intercalations are not then of marked value as geological horizons. At the Airolo mouth of the tunnel, *gypsum* or *anhydrite* only appeared as accessories in the quartzite beds, No. 20 and 22, belonging to the dolomitic series, and in fissures in the adjoining rocks. In the calcareous rocks of the Ursern Valley, the occurrence of gypsum was restricted to lumps of alabaster imbedded in the clayey southern wall-rock.

Having regard to the petrographic variety in rocks belonging to one and the same calcareous series, it seems hazardous to ascribe, *à priori*, a definite geological age to such rocks when they are met with isolated. For this reason I have indicated on the geological map of the railway line, by a single colour, all limestones ranging between the Jurassic and Archæan, noting by index letters their special petrographic characters (dolomite=D.; rauchwacke=R.; marble=M.; cipoline=C.; calc-schist=Cas.), and leaving the question of their exact geological range to future exploration. I have paralleled the limestone series of the Ursern valley, which is considered to be *Jurassic*, with the dolomitic series of the south side, in spite of considerable petrographic differences—rauchwacke and saccharoidal dolomites are, for instance, wanting in the tunnel below the Ursern valley, whilst cipoline predominates there, though absent on the south side, etc. The appearance of quartzitic beds in the foot-wall of the Jurassic (Liassic) rocks affords a means of identifying them on both sides of the St. Gothard. It has already been remarked in "Verhandl. der Schweizer Naturfor. Gesellsch." 1874–75, p. 139, and in the text to the "Geol. Profile" (French, p. 47; German, p. 43) that beds of quartzite (resp. sandstone) are regularly associated with the limestone series north and south; they occur, for instance, at the Nufenen pass (à la Cruina), in the tunnel, near Lago Ritom, near Prato, and, on the other side, on the Längisgrat, Furka, near Realp, and Altkirche.

The description given by Prof. Bonney on p. 210 of his paper of a section along a ravine in Val Canaria agrees in its principal features with my own surveys in the same ravine and the adjacent areas, which have been used for the construction of plate v. of the geological map of the railway; and on principle I cannot object to this author's explanation of repeated identical beds (rauchwacke, in this case) by faults instead of by folding, though I have based the construction of this part of the map on the supposition of folds. The construction of ideal folds on ideal sections means for me nothing but a way of indicating the supposed identity of certain beds, of which only the outcrops are known, and nothing more. From the same point of view I also constructed (on the profile of the line of the tunnel) two troughs and an intervening saddle in the Ursern valley, remarking (French text, p. 28; German, p. 26), "The saddles and troughs drawn indicate no more than *une manière de représenter* the course of the beds in the Ursern valley." The same remarks are applicable to the general section on plate vi. of the geological map, which represents an ideal connexion of repeated seams of dolomite, calc-schists, and black and gray mica schists, between Val Piora (Lago Cadagno) and Campolungo. I wish to say, that I am not now satisfied with that profile, as it was not necessary to compress the three or four beds between the Ticino valley and Campolungo in a complicated system of folds, since they can quite as well be representatives of different horizons of a couple of beds repeated by faulting.

It must be admitted that the probability of faulting is, *à priori*, greater than that of folding; this agrees with the mechanical conditions of contraction as explained by the Rev. O. Fisher in his "Physics of the Earth's Crust," and a most demonstrative example of this same view is shown in that part of the profile of the Gothard tunnel which represents the central part of the massif. The upheaval of the mountain, the swelling, uplifting and overthrow of the strata, are not so much due to wave-like folding of the crust, as to its crushing and to the shoving and squeezing of the flakes over and through one another.

IV. *Organic remains in the Calcareous beds of the St. Gothard.*—Though I have not succeeded in finding *crinoids* at every spot in the Ursern valley indicated on the geological map of *von Fritsch*, there is no doubt of the existence of imperfect fragments of these organisms in those and other places in the calcareous series of the valley (see pl. iii. of the geological map of the railway line). Cylindrical or elliptical sections of stems of crinoids or spines of echinoderms, have been observed also in the tunnel; for example, in the gray cipoline, No. 43, at 2593 m., and in the black schist, No. 46, at 2637 m., and in this latter undetermined *fucoids* were also present. In addition to these, microscopic globules of coaly matter and peculiar rod-like pyritic bodies, which in section resemble some forms of *foraminifera*, have been noticed (black schist, No. 42, at 2582 m.). Some laminæ of calcspar intersecting the crystalline limestones and cipoline, were not infrequently covered with a network of graphite (or other coaly material) so as to resemble organic forms, but they are not organic, and have never been represented as such by me (Geol. Durchsch. u. Tabellen, Nordseite, p. 54–59; text to geol. profile, French, p. 23, 24; German, p. 21, 22).

Only after a thorough examination of 26 slides taken from different beds of the calcareous series between 2582 m. and 2783 m. N. did I discover in two of them (No. 43 at 2593 m. and No. 45 at 2682 m.) traces of microscopic organic fragments,[1] which I have

[1] Faint traces of structures, resembling those on No. 43, have also been lately noticed in a section of No. 47.

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referred to in the "Zeitsch. d. deutsch. geol. Gesell." 1878, p. 138, as follows: "Only in Nos. 43 and 45 have those puzzling microscopic structures been noticed, of which I sent a drawing to Prof. Desor, 26th Feb. 1877, and to which I drew the attention of Prof. Zirkel by letter of 29th Oct. 1877. In the text to the geological profile (German, p. 22; French, p. 24) they are described as blackish indistinct points (pores) arranged in rows, so as to form four-rayed stars by their intersection at right angles to each other. Professor Gümbel, who examined my slides, declared them to be unequivocally structures of crinoids, and this accords with the occurrence of circular or elliptic sections of crinoid stems in the cipolines, both inside and outside the tunnel (Ruestli; heap E. from Altkirche). The woolly threads of graphite in No. 45 are partly grouped in polymorphous net-works, one of which I have copied in Zeitsch. d. deutsch. geol. Gesellsch. vol. xxx. 1878, p. 138. No palæontologist who has seen this slide has doubted the organic nature of the form contained in it; but the interpretations of its character have varied between corals, sponges, and bryozoa—Prof. J. Hall inclines to this latter view of their origin.

I believed the question of the organic character of the fragments in this highly crystalline micaceous limestone to have been settled; but finding that Prof. Bonney (*loc. cit.* p. 198, footnote) declared them anew to be *pseudo*-organic, I submitted the slides to Professor Möbius, Director of the Royal Museum at Berlin, so well known for his investigations on the structure of Eozoon, and he has given me permission to state that "*these forms in his opinion are of organic nature,* so far as can be judged from a hasty examination of only *two* slides, without comparing them with analogous structures." I have lately had taken microscopic photographs of the structures in the slides referred to, Nos. 43, 45, and the accompanying figures have been reproduced from them by autotypic process (see p. 16).

With regard to No. 45, I may remark that the light gray cross lines of the net-work seem in part to follow the cleavage faces through the calcspar, and would thus agree with Prof. Bonney's description of crinoidal microstructure in preparations from Scopi (*loc. cit.* p. 234–35). If No. 45 should beget any scruples as to its real nature, they would not affect No. 43, in which the black points and blisters are arranged in slightly curved lines, which intersect one another at angles of about 80° and 100°.

Though these microscopic traces of organisms in the Altkirche cipolines indicate the existence of crinoids, which were already known macroscopically and are without special value for the fixation of geological horizons, yet they are of great general interest as showing how the structure of fragmentary Jurassic fossils can be preserved in highly metamorphic micaceous limestone. It is now fourteen years since they were first noticed.

V. *Classification of the crystalline schists in the St. Gothard (and their relation to the Mesozoic rocks).*—The first arrangement of the beds passed through in the St. Gothard tunnel, which I sketched in the "Neues Jahrbuch für Mineralogie, etc.," 1878, has since re-

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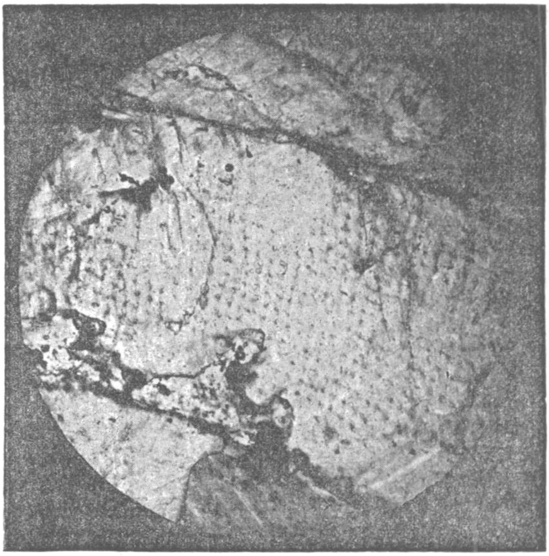
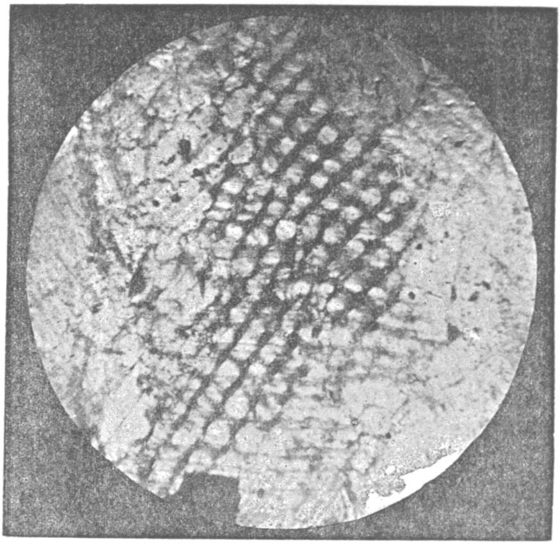
From Bed No. 43.



From Bed No. 45.



Microscopic Sections of Micaceous Limestone from the St. Gothard Tunnel.

EXPLANATION OF AUTOTYPE FIGURES ON PAGE 16.

Microscopic sections of micaceous limestone from the St. Gothard tunnel, showing traces of organic structures. Reproduced by Autotypic process. Enlarged to the scale of 180 diameters. The upper one is from Bed No. 43; the lower from Bed No. 45.[1]

mained the groundwork for the subsequent classifications published in the geological profile of the tunnel (1880), and in the title sheet of the geological map along the railway line (1885). The summary profile between the Lake of the four Cantons and that of Lugano, as there delineated on the scale of 1:250,000, affords an insight into the structure of the Lepontine Alps which differs materially from others drawn up before the construction of the tunnel. Space would not permit me to give detailed references to this profile, and I shall therefore restrict myself to a sketch of the classification of the crystalline schists for which I wish to maintain my priority.

1. The *micaceous gneiss* with predominant magnesian-mica, which in the central part of the Gothard massif occupies the Guspis valley between Greno di Prosa (dividing ridge of the St. Gothard) and Älpetligrat, and extends in the tunnel for a distance of 2270 mètres, from 5450 m. S. to 7200 m. N., is the oldest or deepest of the crystalline schists of the St. Gothard, and as such is marked by *I*; *Guspis glimmergneiss.* One peculiarity of the same beds is the occurrence of black *tourmaline* together with garnets. Gneissic, micaceous, amphibolic, and quartzitic varieties, exist in it, as well as in the succeeding groups, and they have been carefully set out in the Geol. Durchsch. (1:200), and summarily in the profile of the tunnel, not only for engineering purposes, but also to serve as marks for the identification of crystalline strata on either side of the mountain.

The presence of *rolled* quartz grains (*sand*) in some beds of the Guspis micaceous gneiss, which have been duly noted in the Geol. Durchsch. (for instance No. 130 N. at 7262 m. p. 178, 9), and in the text to the geol. profile (German, pp. 28, 31, 36; French, pp. 31, 34, 39), proves beyond doubt the original sedimentary character of this gneiss, and this view is corroborated by the occurrence of occasional small bands of limestone (at 6100—6110, 7352 N.), frequently containing microscopic globules of graphite or other coaly material.[2] As a consequence, all the succeeding crystalline schists of the St. Gothard must also be considered to be metamorphosed sediments, so far as they cannot be shown to be of plutonic origin.

2. The *Sellagneiss*, southwards of the micaceous Guspis-gneiss and the Gamsboden-gneiss (a term introduced by *v. Fritsch*) northwards of it, occupy the second horizon of the crystalline schists, which is marked by *II*. I consider them equivalent to the Ticino gneiss south of the St. Gothard, which is crossed by the railway line between Daziogrande and Claro, and noted on pls. vi.—x. of the map

[1] As already mentioned by Prof. Bonney (*loc. cit.* p. 198) hand-specimens of these St. Gothard rocks are preserved in the Mineralogical Collection of the British Museum (Natural History), and sections, taken from the one marked No. 43, show precisely similar structures to those in the accompanying figure.—EDIT. GEOL. MAG.

[2] There is no question here about graphitic mirrors on fissures.

as Piottino[1] and Tessiner gneiss; and also equivalent to the gneiss in the neighbourhood of Erstfeld, north of St. Gothard (pl. i. of map). In the tunnel this gneiss with its varieties and occasional intercalations of micaceous and amphibolic rocks, occupy about 1000 mètres (4000—5000) on the south side, and 1400 m. (6000—7400) on the north side, but it should be observed that frequent repetitions and transitions of the terminal beds tend to make these limits rather elastic. The *Sella gneiss II.* is a highly crystalline felspathic rock, containing both potash- and magnesian-mica, and it has a veiny, uneven or lamellar, glandular structure.

3. The Sella gneiss is succeeded by the *micaceous gneiss III.*, named after the *Alpe Sorescia* on the south side, and after the *Gurschen Alp* on the northern side. It occupies in the tunnel 800 m. (3200–4000) on the south, and 1700 m. (4300–6000) on the north side. The predominant mica is brown or grey magnesian; that of the north side often assumes a green colour, and from this and from the occurrence of sericite it passes over into Ursern gneiss, whilst accessory garnets and hornblende in its boundary beds on the south side indicate a relation to the felspathic mica schist of the Scipsius. Moreover the rocks of this series have more frequently the character of mica schist than of gneiss.

The gneissic series *III.* is better characterized from a geological than from a petrographic standpoint. The peridotic and pyroxenic *serpentines* of the St. Gothard make their appearance in it, as also certain of the *black garnet schists* and some insignificant *ore deposits*. The *serpentines* which crop out along the Ursern valley, between the Unteralpthal, Gige, Hospenthal, and Zumdorf (pls. iii. and iv. of geol. map) were passed in the tunnel between 4870 and 5310 m. N.; and an analogous series of lenses of serpentine has been followed on the south side, in the same micaceous gneiss, on both slopes of the Val Tremola, near Seara Orell and Fieudo (pl. v. of geol. map), though not met with in the tunnel. Beyond the northern slope of the St. Gothard on the other side of the granitic Finsteraarhorn gneiss. *diallagic* (?) *rock* appears near Gurtnellen and down on the railway line near Meitschlingen in the same series III. (or IV.?). Finally, we find *serpentine* south of the Gothard in the neighbourhood of Bellinzona, at Castanetta, E. of the railway, and at Sementina W. of it—in both cases in micaceous gneiss belonging to III., which also is the prevailing rock of Mount Ceneri and in the Agno valley downwards to Gravesano and Manno, where it meets the Palæozoic rocks. (Profile on title-sheet of map.) The *black garnet schists* of the Unteralpthal and Val Cadlimo (Lagoscuro), which are imbedded in the micaceous gneiss III. have been mentioned

[1] "Piottino gneiss" means the uppermost beds which on Mount Piottino (Daziogrande) dip under the mica schist formation. Tessiner gneiss is an old term of Studer's, which refers to the nearly horizontal strata of gneiss along the Ticino, Near the railway station Claro they abruptly assume a sharp southward dip, and are then overlaid by a newer gneiss formation (See pls. ix. and x. of the map and Explanation of the same in Zeits. d. deutsch. geol. Gesells. 1884, vol. xxxvi., also Neues Jahrb. f. Mineral., 1882, vol. i. p. 72, where also the relation between the parallel structure and the stratification of the Piottino gneiss is treated of.

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under § I. Insignificant amounts of *zincblende, galena,* and *pyrites* have been found in the same gneiss, not only at the surface (mining trials in Val Cadlimo), but also in the tunnel at 3250–70, 3376, 3955 m. S., and at 4410 m. N. The zincblende formerly found near Hospenthal ("im Saum") and, together with mispickel, in the Tiefthal near Meitschlingen, on the north side of the Gothard, may also appertain to the same micaceous gneiss, as also that near St. Nazaro on the Lago Maggiore, where some small adits have been commenced in former times.

4. The fourth group of crystalline schists, comprising transition rocks between the gneiss-formation and the mica-schist formation, has already been mentioned in connexion with the last named (§ *II.*). The *Ursern gneiss* of the north side, and the *felspathic mica schists of the Scipsius* (south side) were passed in the tunnel between 2000—4300 m. N. and 1850—3200 m. S. respectively; the former enveloping the troughs of the Altkirche limestones and of the sericitic schists with the black schists of the Oberalp road. The appearance of slaty gneiss or felspathic mica schist northward and southward from the St. Gothard at Gurtnellen (probably also near Amsteg), in the Ticino valley south and west from Faido, between the Moësa and Bellinzona, at the foot of Mount Ceneri is recorded on plates ii. vi. viii. x. and on the summary profile of the geological map. Whilst the Ursern gneiss north of the Altkirche limestones is a genuine slaty felspar-gneiss, it has, south thereof, more relation with mica schist. Sericitic mica (besides the magnesian) and intercalations of quartzitic and gray-green micaceous beds indicate an analogy between these rocks on both sides of the limestones; but I should not be opposed to a separation of the same, if the deciphering of the geological structure of the Ursern valley would thereby be promoted. The felspathic mica schist of the Scipsius (south side) differs from the Ursern gneiss in containing abundantly beds of amphibolite; on the other hand, green micaceous and calcareous strata *are common* to the Scipsius schists and to the micaceous Ursern gneiss near its boundary with the Gothard massif.

In the summary profile I have made an attempt to parallel these groups of crystalline schists with the previous classifications of *Favre, von Hauer*, and *Gastaldi*, without being convinced that such a parallelization is practicable in detail; and a further attempt to fit these different crystalline schists into the frame of the American classification of the Archæan, I now recognize to be a mistake, since the Gothard rocks, from I. upwards, are decidedly *younger* than Archæan.

5. The rocks belonging to the fifth series, viz. gray and green mica schists, with or without garnets and disthene, sericite schists, black schists, calc schists, dolomites, cipoline, marble, rauchwacke, have been characterized in § I.–III., where it is pointed out that they extend from the Carboniferous to the Jurassic age. They occupy the trough of the Ticino on the south side, and on the north side that of the Ursern (pls. v.–vii. and iii.–iv. of the map; summary profile on title sheet); but they are represented also north of the Gothard,

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between Gurtnellen and Amsteg (pl. ii.), and south of it in the Jorio pass, E. of the railway line; and the calcareous gneiss near Castione, with imbedded seams of marble (pl. x.), probably belongs here, though it is in a more advanced state of metamorphism.

O. The Ursern gneiss IV. is broken through by the *granitic gneiss* belonging to the *Finsteraarhorn massif*, over which the railway line runs from Göschenen to Gurtnellen (pls. ii. iii.). It differs from the gneiss of the St. Gothard and Ticino valley, not only by its compact structure, and the peculiar habitus of the quartz and felspars, but also by the predominant iron-magnesian-mica on the side of pellicular potash mica. I have marked it on the summary profile by O^o, thus indicating that it belongs to a series distinct from I.–IV. It is not eruptive or plutonic in the ordinary sense of the words, but it belongs rather to an horizon deeper than the lowest (I.) opened in the tunnel, and if thrust up in a solid state, it must consequently have been *after* the Gothard series, either in immediate connexion with the general disruption of the mountain or during subsequent paroxysms. Granulitic contact rock limits the granitic gneiss on its northern and southern boundaries (pls. ii.–iii.).

Eruptive rocks ?—In connexion with the upthrusted but not eruptive granitic gneiss of the Finsteraarhorn massif, we have finally to consider two rocks of the St. Gothard which *seem* to be *intrusive*, viz., the *serpentines* and the *granite*. The peridotic *serpentines* already mentioned as embedded in the micaceous gneiss III. have been described petrographically in the Geol. Durchs. u. Tabellen, Nordseite, p. 114–123, and in the text to the geol. profile, German, p. 34; French, p. 38. With regard to their mode of occurrence some diagrams are given in "Materialen für das Gotthard profil; Verhandl. der Schweiz. Naturf. Gesellsch., 1878." In spite of the seeming discordance between the serpentine and the surrounding micaceous gneiss, which is very plainly seen in the figures of the treatises quoted above, I believe that the serpentine originally formed lenticular beds in the sedimentary series of crystalline schists, which in the process of general destruction have been severed in pieces and together with the wall-rock thrust along on the fissures. Wherever such a faulted fissure forms the local boundary between serpentine and micaceous gneiss, the former appears to penetrate the latter.

Granite.—A belt of granite extends eastwards from the Pizzo Rotondo on the north side of the Ticino valley, and disappears, after passing the Val Tremola, without reaching the line of the tunnel (pl. V.). It is a typical granite which does not belong to the St. Gothard series of crystalline schists; it has a compact granitic structure, and is distinguished by the light rose colour of its quartz. On the Alpe Fieudo (below the Fibbia), in Val Tremola, and near the Sella bridge (below the hospice), direct contacts between this granite and the micaceous gneiss (III.) show its intrusive character (sketch on pl. V. of geol. map. along the railway line), but stepping over the granite from its point of contact south of the Sella bridge, towards the Hospice, one observes a gradual transition into the so-called Gothard granite (Fibbia gneiss), or what I have designated as Sella

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gneiss (II.). Here the relation between the granite and gneiss becomes rather puzzling; I have shown its details in a profile (1 : 10,000) on pl. V. of the map, and described them in a paper ("Ueber das Verhältniss des Granits zum Gneiss am Gotthard") read at the 55th meeting of Deutsche Naturforscher u. Aerzte, held at Eisenach, 1882.

WEISSENSEE, BERLIN, 7 *Oct.*, 1891.

III.—THE FAUNA OF THE OLENELLUS ZONE IN WALES.

By HENRY HICKS, M.D., F.R.S., Sec.G.S.

IN his recently published excellent Memoir on the "Fauna of the Lower Cambrian or Olenellus Zone,"[1] Mr. Walcott has referred briefly to the presence of the fauna in Wales. The following additional facts bearing on the question may therefore be of some interest, and they will, I think, show that there is strong evidence in favour of the conclusion arrived at, that the Olenellus fauna occurs in the Caerfai Group of St. Davids, and in beds at the same horizon in North Wales.

South Wales.

In the year 1871, in a paper printed in the Q.J.G.S, vol. xxvii. p. 399, I described and figured some fossils which I had discovered near the base of the Lower Cambrian Rocks at St. David's. They were *Lingulella primæva*, *Discina pileolus*?, *Leperditia*? *Cambrensis*, and "part of the head of a Trilobite from a bed at the base of the purple rocks about 3000 feet below the Menevian Group" (*i.e.* in the beds immediately following the basal Cambrian Conglomerate, which rests unconformably on the Pre-Cambrian rocks). The Trilobite (head) (fig. 18, pl. xv.) was too indistinct for identification, and I refer to it now mainly to note the interesting fact that a Trilobite had been discovered at that time at the very base of the Cambrian at St. David's. What, however, has proved since to be of more importance was the discovery, about the same time, in a highly cleaved red slate near the same horizon, of several small fragments which I recognized to be portions of a Crustacean, but which I then incorrectly associated under one name in my description of *Leperditia*? *Cambrensis*. These fragments and others I have since obtained have now satisfied me that they are portions of heads of a species of *Olenellus*. In referring to them I said that some of the specimens "show a reticulated ornamentation." This form of ornamentation of the surface has now been shown by Professor Schmidt,[2] Mr. Walcott, and others to be characteristic of *Olenellus*. I am hoping that, ere long, another zone may be discovered, in beds which have suffered less from cleavage, and that it might be possible to give specific identifications, but at present it is only possible to say that the genus does occur there,

[1] Extract from the Tenth Annual Report of the Director of the U.S. Geological Survey, Washington, 1890.

[2] "Ueber eine Neuentdeckte Untercambrische Fauna in Estland," St. Pétersbourg, 1888.

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