the favour to consult my paper "On the Evidence of a Ridge of Lower Carboniferous rocks under the Plain of Cheshire,"¹ he will see how I explain the differences in the mineral characters of the lower division as it occurs in the Midland Counties, and in the Northern.

DUBLIN, 18th Sept. 1882.

IV.—NOTES ON THE POST-CARBONIFEROUS (DYASSIC) AND TRIASSIC DEPOSITS OF THE ALPS.

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THE purpose of this communication is to supplement the author's paper on the "Classification of the European Rocks known as Permian and Trias," which has appeared in recent numbers of this MAGAZINE. It is based on a short communication made to Section C. of the British Association at the recent meeting at Southampton, and has been expanded into the present paper at the request of the President of the Section, R. Etheridge, Esq., F.R.S.

Reasons were given in the former paper for not considering the names 'Dyas' and 'Permian' as altogether suitable as general terms applicable to the European area as a whole, since they severally connote the respective facies of the rocks of this age in particular areas. It is with geological history as with an imperfectly known country, one feels the desirability of great and distinctive landmarks; and such a land-mark is furnished for later Palæozoic times by the great Carboniferous system. The name 'Post-Carboniferous' was therefore proposed as a general term, and this name is here retained, until a better one is proposed, upon the high authority (among others) of Prof. Gümbel of Vienna as well as of that of Credner. It has been urged against the use of this term, that it applies to any and all of the formations which are later in time than the Carboniferous period. Such an objection is to my mind a feeble one; one might almost as well say that a 'postscript' to a letter includes all that the writer of the letter has since written. This, like so many other questions of nomenclature, cannot be settled by mere reference to a Latin dictionary: if it could be, a boy in a grammar school might perhaps decide it for us. One feels, and every one who has read Latin at all must feel, that in composition the prepositions acquire a flexibility which they do not possess to the same extent in their unagglutinated use. Surely 'post-' does sometimes mean 'coming after in importance' as well as in sequence of time; the term in question therefore implies that the series to which it refers, though having a sufficiently pronounced facies of its own to be entitled to be regarded as a system distinct from, is yet in some sense subordinated to, the Carboniferous system. Further, in considering the propriety of the use of the term now under discussion, it should be borne in mind that the strata, to which the name 'Post-Carboniferous' is here applied, are recognized as falling into the

¹ Quart. Journ. Geol. Soc. vol. xxv. p. 171.

category of the Palæozoic rocks: the notion of their comprehension in this great series precedes therefore, and guides, our apprehension of the meaning of the term as it is here used.

The main object of this paper is to draw attention to some of the latest results obtained by workers in Alpine geology, so far as they apply to our series: the results of the observations made by Gümbel, von Hauer, Mojsisovics, Emmerich, Zittel, Theobald, Fichler (not to mention others), should be better known than they are to the majority of English geologists. Maps published only a few years ago, in which a great portion of the limestone strata of the Alps was comprehended under the general name of 'Alpenkalk,' a name with which one is familiar in Cotta's "Die Alpen" (a highly suggestive work), and other writings of that period, are now practically obsolete for purposes of geological observation.

Post-Carboniferous (Dyassic) Strata.—On the northern side of the great east-and-west crystalline axis of the Alpine chain observations hitherto made seem to have failed to detect the presence of any very extensive deposits which can be referred to this system: the Triassic strata (according to von Hauer) follow at once upon highly metamorphosed rocks of Silurian age.¹ Von Hauer, however, includes certain deposits (Verrucano, etc.) among the Triassic strata, a proviso which must be borne in mind in comparing this statement with the dark streak which represents these deposits on his Map of Tirol, indicating their intervention between the crystalline and stratified series in N. Tirol. Further, a glance at the excellent Map of Switzerland by Studer and Escher von der Linth shows that, with the exception of these Verrucano deposits here and there, the Jurassic strata as a rule immediately succeed the crystalline rocks of the Central or Swiss Alps. In the southern zone the deposits thus far observed, which appear to be of Post-Carboniferous age, are comprehended also under the term 'Verrucano.' This may be defined as a series of grey and red-brown conglomerates and breccias, with red sandstones, and here and there coal-bearing strata. Von Hauer refers these to the lowest horizon of the Trias, but admits that they may with equal propriety be considered (in part at least) as belonging to the age preceding the Trias: Gümbel goes further, and recognizes in them the Alpine equivalents of the Rothliegende of Germany. The latter writer also points out that in places (*e.g.* in the Gailthaler Gebirge) limestone-strata containing marine fossils occur, which he considers to be comparable with the Zechstein, or at least with "strata recognized as of Dyassic age in the Nebraska region of North America."²

Accepting then the place assigned by Gümbel to the Verrucano and its associated deposits, we see that, as in the German and English areas, so in the Alpine area (or more correctly that portion of the earth's surface now occupied by the great Alpine mountain-system) the age of the Rothliegende was characterized by enormous

¹ *Vide* descriptive text of the *Geologische Uebersichtskarte der Oesterreichischen Monarchie*, Blatt No. 5, by Dr. Franz Ritter von Hauer.

² *Anleitung zu Geol. Beobachtungen in den Alpen*, von G. W. Gümbel.

volcanic activity. An example of this is seen in the extensive development of volcanic rocks (commonly known as 'quartz-porphyrries'), which form the principal feature of the Bozen district. Here we find probably the most extensive display of such rocks which the present surface of the earth furnishes. The *eruptive* character of these 'porphyries' is clearly illustrated in the case of the Rittner Horn, the culminating peak of a district between the valleys of the Sarn and the Eisack known as the Ritten. Walking from Bozen to the summit of the mountain, and more especially in the upper part above Klobenstein, one passes in succession over alternating 'quartz-porphyrries' (such as are extensively used for building purposes in Bozen) and ash-beds.¹ The stratification of these 'ash' deposits is brought out in the clearest possible manner by weathering, and frequently angular fragments (blown by steam along with finer débris from the ancient volcanic canal) are seen included in them: on the most highly weathered surfaces these fragments may be detached easily with a common alpenstock. In many cases a hand specimen (except on the point of hardness) could scarcely be distinguished from a specimen of tufa or peperino taken from the Roman hills, the colours of both these being here reproduced. The juxtaposition of the tuff-deposits and the ancient lava-flows may be frequently observed *in situ*. The summit of the mountain preserves the outline of a portion of the ancient crater, the remaining walls of which can be traced as distinctly as one can trace the remaining crater-walls of slaggy basalt of Tertiary age at Daun, or in the Moselberg in the Eifel. It would almost appear even that some of the beds were originally vesicular acidic lava-flows, and that the steam-cavities have been subsequently filled with quartz, perhaps (as M. Daubrée has taught us) by the action of super-heated water upon the siliceous materials of the rock. This hypothesis is, I think, warrantable, when we take into account the results obtained by M. Daubrée (especially the *deposition of crystalline quartz*) by heat from such a siliceous composition as we commonly call "glass," under sufficient pressure in mere super-heated water.² These Bozener volcanic rocks being in all probability of Dyassic age, the history of the Alpine mountain-system supplies ample data for the application of the physical principle so ably demonstrated by the great French savant.

The phenomena presented to us in this mountain seem to me to go altogether to confirm the view maintained by Prof. Credner, of Leipzig,³ that the true place of these rocks known as 'quartz-porphyrries,' in any system of classification of the crystalline rocks, is among the 'Older Eruptive Rocks,' and that they ought not to be

¹ The earth-pillars ('Erd-pyramiden') of the neighbourhood are, or have been, severally capped with blocks of quartz-porphyr, but I think the finer materials which constitute them are more largely derived from the tuffs (clastic rocks) than from the crystalline rocks; both those of the Finsterbach near Lengmoos, and the group lower down near Bozen.

² *Vide Etudes Synthétiques de Géologie Expérimentale*, par A. Daubrée, pp. 165-6.

³ *Elemente der Geologie*, 3rd edition, pp. 274, 275.

included among the rocks called 'plutonic' as they are in Lyell's *Students' Elements*.¹ The mountain appears to be nothing more than an ancient 'stratified cone,' in the sense in which this term is used by the writer just referred to.

It is on the margins of such districts as the Bozen volcanic region that the deposits known as Verrucano are commonly met with. In such a relation they occur (according to Gümbel) on Lake Lugano, in the Bündener Alps, in Windgälle, in the Mont-Blanc group, in Judicarien, in Val Lugana, near Cilly, and near Raibl. Since the above observations on the structure of the Rittner Horn were made by the writer two or three months ago, he has found the intimate relation in which the 'porphyries' are placed to the ash-deposits noticed by von Hauer.² The passage is worth quoting: "The oldest porphyries present (in the Bozen district) are younger than the clay-slates through which they have pushed their way, and upon the surfaces of which they are spread out, while the latest reach no further forward in time than the older Trias; since the tuffs, which on the one hand are placed in most intimate relation with the solid porphyries, pass on the other hand without any definite limit into the conglomeratic and sandy rocks of the Lower Trias." These 'Lower Triassic' strata of von Hauer are, as we have seen above, the strata referred by Gümbel to the age of the German Dyas, for the most part.

Transition Beds.—Of late the view has been propounded by some German and Austrian writers that the lower portions of the Werfener Schichten and the massive white limestone of Schwaz (in the Inn Thal) on the northern side of the Alpine chain, as well as the Grödner Schichten, the black 'Bellerophon Limestone' of the Puster Thal (abounding in Foraminifera), the Bröckel Dolomite, near Triente (rich in copper ore), on the southern side, should all be regarded as belonging to the upper horizon of the Dyas or Post-Carboniferous system. This view is controverted by Gümbel on the ground that the organic remains found in them do not give them "a pure Dyassic character, but very much more that of a transition series from the Dyas to the Trias." This, he points out, is particularly the case with the plant-remains recently found in the Grödner Sandstein at Neumarkt, near Bozen, and in the numerous recently-discovered fauna of the Bellerophon-Limestone of the Puster Thal. Of these remains the following are figured in his excellent little handbook before referred to.

a. Plant-Remains from the Alpine Red and White Sandstones, and the overlying Grey and Calcareous Strata at Neumarkt:—

Æthophyllum Fötterlianum, Mass.

Voltzia recubariensis, Mass., and *V. Messalongi*.

V. Bröckhiana, Heer, and *V. vicetina*, Mass.

Carpolithes Hungaricus, Heer, and *Carp. foveolatus*, Heer.

Baiera digitata, Heer.

¹ Third edition, 1878, p. 557.

² *Ibid.*, pp. 13, 14.

b. Fauna of the Bellerophon Limestone :—

Bellerophon peregrinus, Laube, and *B. Gumbeli*, Stach.
Archeocidaris ladina, Stach.
Gervillia ceratophaga, Schloth., and *Gervillia* (sp. ?).
Avicula peracuta, Stach., and *A. cingulata*, Stach.
Peeten partulus, Stach.
Pleurophorus Jacobi, Stach.
Edmondia rudis (?), M'Coy.
Aucella Hausmanni (?).
Spirigera peracuta, Stach.
Turbonella (sp. ?).
Valvulina alpina, Gumb.
Endothyra radiifera, Gumb., and *E. simplex*, Gumb.
Trochammina vulgaris, Gumb., and *T. crassa*, Gumb.
Bulimina contorta, Gumb.
Lingulina lata, Gumb., and *L. subacuta*, Gumb.
Cythere oviformis, Gumb., *C. navicula*, G., and *C. porrecta*, G.
Kirkbya alpina, Gumb.

In addition to the above, several forms of doubtful or at present undetermined genera are also figured, one of them being a doubtful form of *Anthracosia*.

The view taken by Gumbel, as to a 'transition series' between the Dyas and Trias occurring in the Alps, reminds one of the regular sequence of these strata in the German area, which was noticed in my former paper. It also brings to mind the way in which Mr. Twelvetrees tells us the Zechstein series in the Orenburg country is overlain conformably with sandstones and marls, apparently almost unfossiliferous.¹ The further investigation of both the Alpine and the Russian series seems therefore thus far to indicate that in these regions we may find the transition series which we know (on *à priori* grounds) must exist (or have existed) somewhere.

Triassic Strata.—What I have been able to observe during the past summer, added to the observations of former years, has impressed me more than ever with the profound truth of the remark by Prof. Credner, of Leipzig, that the true key to the geological history of Triassic times is to be found in the Alpine Trias.² The main results of the investigation of these strata, so far as it has proceeded up to the present, are given in the table at p. 500 of this paper. The chief authorities for it are von Hauer, Gumbel and Credner. It presents in one view both the stratigraphical order and the palæontology of the Trias of the Alps. It may be added that in the classification Gumbel (as representing the latest views) has been in the main followed, where he seemed to have good reasons for differing from von Hauer; but these differences are not of very great importance, except on the point to which reference has been already made, the geological age of the Verrucano. It will be seen that the three formations which constitute the German Trias have their equivalents in the Alps fairly well defined. The most noticeable thing about the distribution of the Triassic strata in the Alpine area is perhaps their absence, or at most their very feeble represen-

¹ *Vide* GEOL. MAG. Sept. 1882.

² *Vide* my former paper in recent Numbers of this MAGAZINE.

tation, in the Central Alps. It is only as we proceed eastward to the longitude of the eastern part of Lake Constance that we find any great development of the series; and this, progressing as we advance through the Vorarlberg, would appear to reach its maximum in the Salzburg country on the north side, and in the S. Tirol and West Venetian Alps on the south side, of the principal crystalline axis. The relations of these massive deposits, for the most part more or less of the character of limestones (their greatest development being either limestones, dolomitic limestones, or dolomites) to the more central crystalline rocks, have determined some of the most salient features of the orography of the Alps. Thus it is, broadly speaking, along the lines of strike of the Triassic strata that several of the finest and longest longitudinal valleys have been formed. Examples of this which at once occur to one are the Inn Thal (from Landeck to Schwaz), the Pinzgau, and the Enns Thal to the north, and the Puster Thal (the largest longitudinal valley of the Alpine chain) to the south of the crystalline axis. The splendid panorama presented to the view from the top of the Schmittenhöhe near Zell-am-See, shows very well the difference between the general physiography of the Triassic strata to the north, and the crystalline mountain masses (as represented by the Glockner Group) to the south. In a similar way the view from the top of the Rittner Horn enables us to make a comparison between the scenery of the beautiful region of the 'Dolomite Alps' in one direction, and that of the glacier-regions of the Ortler Group and the Oetz-Thal Group in the other.

Lines of anticlinal curvature of the strata on a large scale (though quite subordinated to the principal anticlinal of the whole chain) may be distinctly observed in places. Such an anticlinal for example is seen to extend through the upper part of the Grödner Thal by Cortina in the Ampezzo Thal to Piave di Cadore. In this line of valley two principal passes are crossed; and since neither of these is of sufficient elevation to be covered with glaciers, the structure of the valley along the whole line is easily observed. Instances in which there is such a clear connexion between the direction of a valley and a line of weakness amounting to actual *fracture*, along an anticlinal axis, are perhaps not often to be met with. Of course in this case the grass-grown floor of the valley, through the greater part of the line, leaves the origination of the valley to be inferred from the unmistakable dip in opposite directions, not only of the massive limestone strata, but also of the more thinly stratified Wenger Schichten and Bunter strata, which are seen in places dipping into the mountain-side beneath the dolomitic masses, which constitute the often grotesque elements of the scenery of the region; but on the passes the evidence is a matter of more direct observation. This is especially so in the case of the Grödner Joch, at the head of the Grödner Thal. The Pass itself is a rather sharp saddle, in the lowest part of which the strata are clearly exposed to view on both sides of the footpath, and the actual line of fracture of the beds is visible. The accompanying sketch (Fig. 1) will make this more clear (see p. 502).

OUTLINE TABLE OF THE ALPINE TRIAS.

UPPER TRIAS (=GERMAN KEUPER.)

[“Paleontologically considered these form a continuous whole, since the fauna of the lower stages does not differ essentially from that of the upper, and if the fauna is marked by considerable enfeeblement in the middle stages, this is to be ascribed much more to the influence of different conditions of life than to difference of age” (von Hauser).]

9'. *Upper Dachstein Limestone*.—Grey and white limestone, characterized by *Megalodus triquetus* (“Dachstein-bivalve”) and banks of Corals, *Lithodendron* (*Rhabdophylla*) *clathrata*, and *L. rhæticum*, with deep-sea Foraminifera. In the interior of the northern Alps forming the rugged masses of the Tâmen-, Dachstein-, Todten-, Watzmann-, Stein-, and Reutalp-gebirge.

9. *Rhetic Beds* (proper), including the ‘Kössener Schichten,’ mostly marly deposits rich in fossil-remains: *Avicula contorta*, *Cardium Rheticum*, *Pecten Valentinensis*, *Terebratula gregaria*, *Spirifer uncinata*, *Gervillia infata*, *G. præcursor*, *Ostrea intusstriata*, *Myophoria postera*, *Ostrea Haidingeriana*, *Terebratula norica*, *Anomia alpina*, *Rhynchonella fasciostata*, *Spirigertina oxycolpus*, *Mytilus minutus*.

8. *Hauptdolomit* (passing into the ‘Plattenskalk’ and the ‘Lower Dachsteinkalk’ of Gumbel). A finely granular distinctly stratified dolomite, developed to such enormous proportions that it forms vast mountain masses in the German and North Italian Alps. Poor in fossil-remains, but produces here and there a few traces of fishes (*Semionotus*, *Lepidotus*, *Pholidophorus*). *M. triquetus* characterizes the more calcareous portions. *Dicercocardium Jani*, *Avicula exilis*, *Turbo solitarius*, *Rissoa alpina*, *Cerithium Gumbeli*, and *Gyrogonella vesiculifera* also occur according to Gumbel.

IN THE FASSANA AND WEST VENETIAN ALPS, THE SO-CALLED ‘DOLOMITES.’

7. *Raibler Schichten* (= Upper St. Cassian Beds of Gumbel), including the Oolitic, calcareous, and sandy strata of the Schlern Plateau: fossils, *Myophoria Kasersteini*, *Perna aviculæformis*, *Corbis Mellingi*, *Ammonites floridus*, *Corbis Roethorini*, *Myophoria Whatelyæ*, *Anoplophora Mansueti* (the chief characteristic fossil of the Leirberg strata in the German Keuper, allied if not equivalent to the *Myacites* of England, Etheridge), *Pecten filicosus*, *Halobia rugosa*, *Cardita subarenata*, *Nucula sulcata*, *Solen caudatus*.

6. *Schlern Dolomite*.—A massive crystallo-granular dolomite (more than 1000 metres thick in the Schlern Mountains), forming by its erosion and splintery fracture the vast grotesque masses of the peaks of the ‘Dolomite Alps,’ which lie to the south of the Puster Thal, and to the east of the Eisack Thal. Contains insignificant remains of globose Ammonites, and a few impressions of Corals. In the Venetian Alps it assumes (in part)

IN BAVARIA, NORTH TIROL, VORARLBERG AND SALZKAMMERGUT.

7'. *Cardita crenata Group*.—These form a definite group of strata extending through Vorarlberg and the Eastern Alps, according to Credner, who considers it as comprehending:—

d. Rauchwacke with gypsiferous shales, passing upwards into the Hauptdolomite.

a. Cardita Beds (proper). Oolitic strata full of *C. crenata* and other bivalves, including *Pecten Helli*, *Corbis Mellingi*, *Corbis Roethorini*, *Ammonites floridus*.

b. Lunzer Sandstein, greenish-grey micaceous sandstones containing plant-remains (and even workable coal-seams towards the east), of which the chief are: *Perophyllum Jägeri*, and *Pecop. Stuitgartensis*.

a. Halobia Shales, with *Halobia rugosa*, and *Ammonites floridus*.

6'. *Wetterstein Group*.—An unusually massive development of white limestone, and whitish dolomites, Oolitic in places, forming the lofty masses of the Wetterstein Gebirge (with Zugspitz), and including the Hallstatt Limestone (often almost a marble). Corals occur in whole banks; *Ammonites* (more or less globular in form) are very common, including *A. Gaytani*, *A. tornatella*, *A. galeatus*, *A. Meiternichi*, *A. Jervas*; *Mulacoceras alveolare* (a thin-shelled

a facies resembling that of the Hallstätter Kalk on the north side of the chain.

5. *St. Cassian Beds* (Lower St. Cassianer Schichten of Gumbel).—Volcanic ash interstratified with marls and Oolitic marly limestones, with an extraordinarily rich Fauna containing 37 species of *Ammonites*, 3 of *Orthoceras*, 205 Gastropods, 70 Acephala, 33 Brachiopods, 29 Echinida, 10 Crinoids, 42 Corals, 36 Sponges. Of these the more common are as follows: *Cidaris dorsata*, *C. alata*, *Ammonites Aon*, *A. Jorbes*, *Orthoceras elegans*, *Dactylea undulata*, *Neritopsis ornata*, *Cardita crenata*, *Monodonta Cassiana*, *Nucula lineata*, *N. strigilata*, *Cassianella gryphaeata*, *Avicula Gea*, *Koninckia Leonhardi*, *Pontanus propinquus*.

MIDDLE TRIAS (=GERMAN MUSCHELKALK).

- ['Augite-porphyrries' (including porphyrite, diabase, and melaphyre) occur as eruptive rocks with their accompanying tuffs in several places, and in enormous proportions in the Faasa-Thal, to mark this horizon.]
4. *Wengener Schichten*.—Thin-bedded dark-coloured limestones, passing up into dark-coloured shales (indurated), siliceous limestones, and volcanic ash; containing *Halobia Lomelli*, *Pseudonoma Wengensis*, *Encrius Cassianus*, and numerous Ammonites, including *A. Aon*.
 3. *Willenalk Group*.—Under this term are included the Virgloria Limestone, the Recoaro Limestone, and the Raibling and Gösling Beds; bitumen and silica often occur, as well as layers and nodules of hornstone. In S. Tirol a massively-bedded dolomite (Mendola Dolomite) occupies this horizon over a considerable area. Fossils, *Rhynchonella decurtata*, *Terebratula vulgaris*, *Spiriferina Mentzeli*, *Ammonites bindensis*, *A. Studeri*, *Pecten discites*, *Lima striata*, *Gervillia socialis*, *Myophoria vulgaris*, *M. cardosoides*, *Natica gregaria*, *Amm. Duer*, *A. luganensis*, *Dacocrinus gracilis*, *Encrius hispidus*.
 2. *Campier Schichten*.—Similar to No. 4, with interstratifications of yellow dolomite, containing *Pleuromya Fassensis*, *Avicula Venetiana*, *Gervillia costata*, *Myophoria ovata*, *Naticella costata*, *Turbo recticostatus*, *Holopella gracilis*, *Pleuromaria triadica*.

LOWER TRIAS (=GERMAN BUNTER).

[These include the principal gypsiferous strata and part of the saliferous strata of the Alps. Petrographically, and in poverty of organic remains, they agree with the Bunter elsewhere.]

- *Bunteadätern Formation*.—Forms the true basis of the limestone series in the interior of the Alps; well exposed in the Gröden Thal (about S. Ulrich and in the Seiser Alp), and in the Etsch Thal. Includes the 'Werfener' and 'Gritenstein Schichten' of von Hauer, the 'Gröden Schichten' of Richthofen, and the 'Seiser Schichten' of Wissman. Most characteristic fossils: *Myophoria costata*, *Pseudonoma Clarae*. (In attempting to indicate the limits of this formation Gumbel has been followed; it should be borne in mind, however, that considerable difference of opinion exists as to its vertical limits both upwards and downwards. What is here given is provisional and tentative. The subdivision into 'Röth' and 'Hauptbuntsandstein' seems of little value.)

* Common to these Alpine strata and the German Muschelkalk.

variety of Belemnites); also *Orthoceras reticulatum*, *O. dubium*, *Monotis salinaria*, *Chemnitzia Escheri*, *Natica Meriani*, *Terebratula Ramsaueri*, *Gypoporella annulata*, and *G. multiserialis*.

This group includes also the Aribergerkalk (of Richthofen), and the principal limestone masses about Berchtesgaden, Hallein, and Aussee in addition to those of Hallstatt.

Marls (with St. Cassian fossils) are interstratified with the white Wetterstein Limestone: fossils, *Encrius Cassianus*, *E. propinquus*, *Terebratula indistincta*, *Cidaris dorsata*, *C. Hausmanni*.

5. *Partnach Beds*.—Dark-coloured (often micaceous) marl-slates and shales, and dark shaly limestone (occasional hornstone), with sandstone in the Upper part: fossils, *Calamites (Equisetum) arenaceus*, *E. columnare*, *Pterophyllum longifolium*, *Neuropteris remota*. (These are considered by Gumbel equivalent to the Lower Keuper.)

FIG. 1. Section across the Grödner Joch showing anticlinal fracture.

Sella Group.

Wengener Schichten.

A. Schlern Dolomite.

B. St. Cassian Series.

On the pass Valparola, the contrary dip of the beds is just as clearly seen, though the erosion has only proceeded down to the St. Cassian Beds. For the last hour or so of the ascent to this Pass one walks over the débris of these beds, and meets with plenty of detached blocks of the strata to impress one with their highly fossiliferous and often oolitic character. Looking down from the Pass into the valley beneath, with the village of St. Cassian lying below, the structure of the valley can be clearly seen as the eye traces the strike of the several series of strata in the side of the mountain. Subjoined is a section of one side of the Valley of St. Cassian. (Fig. 2).

FIG. 2.

The Raibler Schichten and Schlern Dolomite are seen in the neighbouring peak of Heiligkreuz passing underneath the Haupt-

dolomite. *Megalodus Triqueter* (in casts) abounds in these Upper Limestone strata.

A walk of two or three days through the Grödner Thal and on to Cortina offers an excellent study of a considerable portion of the Alpine Trias. Leaving the deep gorge-like valley of the Eisak, which presents us with splendid sections of the volcanic series, we find ourselves during the first part of the ascent of the Grödner Thal down among the metamorphic rocks. As we ascend the valley mounting up enormous heaps of moraine débris, we come again among the volcanic series. The enormous dimensions of the blocks of quartz-porphry and altered ash which make up these moraine-heaps is astonishing even to one who has seen a good number of moraines in other parts of the Alps. Here and there the sides of the valley are seen falling back into gentle curves, suggesting the incipient stage of the formation of *cirques* by the weathering away of rocks with transverse planes of weakness. The principal moraine, as it now appears, seems to explain the existence of a quondam lake, which some six centuries ago is said to have filled all that part of the valley in which S. Ulrich now lies. In the neighbourhood of this thriving village (the 'Hauptort' of the 'Gemeinde') the Verrucano may be very well observed. On mounting up the steep ascent from St. Ulrich to St. Jakob a capital study of the Bunter series is offered. These strata abound here in gypsum, and are in places fossiliferous, *Posidonomya Clarae* being rather abundant. The scenery along the line we have defined includes the magnificent Sella Group, and further to the east the Trai Sassi, Tofana, the Cinque Tori, Serapiss, etc. The rest may be gathered from the sections described above. What has been here said of a particular district affords a fair sample of the 'Dolomite Alps,' which occupy an extensive region extending eastward from the Eisak Thal and southward from the Puster Thal. The almost unique scenery of the region seems to result from (1) the nearly horizontal lie and position of the major portion of the dolomitic strata; (2) the almost vertical weathering through of the beds, partly as a consequence of (1); (3) the splintery fracture of many of the hardest and most compact beds; (4) the interbedding of marly deposits with the dolomitic masses.

In North Tirol the scenery, though not generally so striking as that of South Tirol, rises however to a high degree of grandeur. This, with the Salzburg country, is *par excellence* the region of valley-lakes, a very considerable number of which lie among the limestone strata of the Alpine Trias. The boring through these strata in the Vorarlberg Tunnel now in progress from Landeck to Bregenz, will doubtless throw much light on the succession of the series in their more western development. An example of the enormous extent to which these strata have in places undergone dislocation is presented to us in the Achensee. This beautiful lake appears to lie in a line of fault, the throw of which must be 4,000 to 5,000 feet. The evidence of this, so far as I have been able to observe it, is the dip of the strata at a high angle, on the west side from the lake, on

the east side towards the lake, coupled with the fact that while the Triassic Limestone strata strike north and south along a steep mountain-face on the western side, the slope of the valley above the lake on the eastern side of it, which is roughly-speaking parallel with the general dip of the strata, is composed of what appear to be strata of the horizon of the Dachstein series, abounding as they do with huge Corals of the genus *Rhabdophylla* (*Lithodendron*), which are characteristic of this horizon. This view of the structure of the valley is confirmed, when one ascends the Unnütz or the Hochiss, which rise above the Achensee on the east side, and gets a view of the strike of the strata, repeating those of the eastern side of the lake. Further, if this be the true explanation of the formation of this lake-basin (a view which is strengthened by the fact that the pass at Maurach at the southern end of the lake is not more than 40 feet above the level of its waters), it serves perhaps to explain why this lake, which is said to be 2,500 feet in depth, fell 4 feet during the great Lisbon Earthquake in 1755, and remained at that lower level for some 24 hours.

The section of the mountain-face above St. Cassian representing a thickness of more than 4,000 feet, which has been given above, may be compared with a typical section (after Mojsisovics) of the Triassic strata in the northern Alpine zone. This is drawn through the mountain-mass which rises above Saalfelden, and terminates in the rugged peaks and huge crags of the Steinernes Meer, the profile of which must remind an observer of the scenery of the so-called 'Dolomite Alps.' The section (which is given in Credner's textbook, fig. 273) is as follows :

i.	'Dachsteinkalk'	} Rhætic.	} Lower Keuper.
h.	'Korallenkalk'		
gd.	Dolomites of the Cardita-Schichten	}	
g.	'Cardita-Schichten'		
f.	White 'Wettersteinkalk'	}	
e.	Red 'Plattenkalk'		
d.	'Virgloriakalk'	} Muschelkalk.	
c.	Dark-coloured Limestone		
b.	'Rauchwacke' and dark-coloured Limestones	} Bunter.	
a.	Red 'Werfener Schichten'		

Figures 55, 56, 57, 58 in Gümbel's "Anleitung" give also well-chosen sections illustrative of the Alpine Trias.

To get a clear idea of the palæontology of the Alpine Trias, a visit should be paid to Prof. Zittel's splendid collection in the Munich Museum. The 'Klipstein Collection' in the Museum of Natural History at South Kensington requires yet many things to be added to bring it up to the completeness of Zittel's, which is perhaps the finest and most complete collection of the fossils of the Alpine Trias in the world.

The Triassic period was marked by the exhibition of considerable volcanic energy in the Alpine area. The eruptive rocks of this age are chiefly composed of augite-porphry (e.g. in the Seisser Alp), melaphyre (cutting through not only the strata of the Lower Trias, but even sometimes the augite porphyries themselves; e.g. about

Predazzo), monzonite, tourmaline-granite, and porphyrite. These are found, as well as the 'quartz-porphyrries' of the Dyas period (cf. *supra*) very commonly associated with interbedded tuffs and with contact breccias. As a natural consequence, the calcareous and dolomitic strata are often altered into a coarsely crystalline marble, while crystals of garnet, vesuvian, and spinel are developed in places by contact-metamorphosis.¹

Upon the whole, it would appear from the most recent observations that even in the Alps the distinction between the Post-Carboniferous (Dyassic) and Triassic systems is not very clearly defined, so far as any actual boundary-line is concerned: special importance from this point of view seems to attach to the views of Prof. Gümbel, to which reference has been made above, as to the *transition character* of the Bellerophon Limestone of the Puster Thal and the Sandstone series (with plant-remains) near Bozen. Anything like confident assertion on this matter would however be at present premature: we must await the results of further observations, results for which doubtless a few years will suffice to the many competent observers, who wend their way every summer from the universities and academies of Germany and Austria to the regions of the High Alps.

V.—SUPPLEMENT TO A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT, D.Sc., F.G.S.

(Continued from p. 452.)

1853.—Tazewell, Claiborne Co., Tennessee.²

Brezina points out that in the Catalogue prepared by Tschermak³ this iron is indicated as *Of*, showing fine-ruled Wiedmanstättian figures. It differs, however, very much from other irons of this group, like that from Lion River, Jewell Hill, Charlotte Co., etc., while it closely resembles the Butler iron. While, however, in the latter case the chief walls of the skeleton inclose very large chambers, here they are very small, so that the skeleton-character is far less marked. The characteristic of the two irons of Butler and Tazewell rests mainly on the very unusual smallness of the octahedral lamellæ, whereby the beam-iron, or its representative, almost vanishes, the irons consisting almost entirely of interstitial and band-iron (and of troilite inclosed in both, and schreibersite plates in Tazewell). Whether the almost infinitely thin nucleus of the lamellæ is identical with the ordinary beam-iron can only be decided by further investigation. The appearance of traces of granular structure renders it very probable.

Found 1858–59.—Staunton, Augusta Co., Virginia.⁴

In 1871 Mallet described three masses of meteoric iron which had been found near Staunton; another has now been brought to light,

¹ Credner: *El. der Geol.* p. 531.

² A. Brezina, *Sitzber. Akad. Wiss.* 1880, lxxxii. Oct.-Heft.

³ *Mineralog. Mitth.* for 1872, 165.

⁴ J. W. Mallet. *Amer. Journ. Science*, 1878, xv. 337.