CONTRIBUTIONS

TO THE

GEOLOGY

OF THE

WENGEN AND ST. CASSIAN STRATA

IN

SOUTHERN TYROL.

BY

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Contributions *to the* Geology *of the* Wengen *and* St. Cassian Strata *in* Southern Tyrol.

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Note.—Various modifications have been embodied in the present paper which are the result of further work in Southern Tyrol undertaken by the Authoress from July to September 1892. The most important additions are those referring to the Dürrenstein district. The lists of fossils have also been largely extended from collections recently made in the field.

I. Introduction.

My interest in the Alpine Trias was first aroused by several geological excursions in Northern Tyrol during the summer of 1891. In response to a wish of mine to undertake some original research, it was kindly suggested by Freiherr F. von Richthofen, of the Berlin University, that I might make a detailed study of the

Wengen and St. Cassian Beds in the valleys of Enneberg and Ampezzo in Southern Tyrol, and with these valleys in particular the present paper deals.

I shall ever regard it as a peculiar honour that Freiherr von Richthofen, whose early work, 'Geognostische Beschreibung der Umgegend von Predazzo, St. Cassian, und der Seisser Alpe,'[1] still holds the highest place in the literature of the Southern Tyrol 'Dolomites,' guided me in my first attempt in Alpine geology, that he himself taught me the chief points at issue concerning the district between Schlern and Ampezzo, and gave me, in a short space of time, a far clearer insight into the work which lay before me than falls to the lot of most young geologists.

In the course of my work during the two seasons of 1891-92, I have been led to extend somewhat my primary object, and to include some of the more interesting tectonic aspects of the whole group of Upper Triassic strata in the 'Dolomite Alps.'

My most grateful thanks are due to Herr Prof. von Zittel for the constant kindness he has shown me, and for his advice and encouragement during the two years of my studies in Munich. I am indebted to Herr Dr. Schäfer for frequent help and suggestion in carrying out the work of this paper, and also to Herr Dr. Rothpletz and to Freiherr Dr. von Wöhrmann for their kind response whenever I have had occasion to refer to them.

The Dolomite region of Southern Tyrol has long been one of the most famous in geology. Not only is it pre-eminent for its beautiful scenery, but in this district, as in Northern Tyrol (the Hallstadt district, the Bavarian Alps, and the Vorarlberg), are found the lithological and palæontological links which fill up the great hiatus between the Palæozoic and the Mesozoic formations in Britain.

In Britain, as every geologist knows, the zoological break between the Palæozoic and the Mesozoic is absolutely complete. No species is known to pass from the Carboniferous into the Jurassic across the great hiatus marked by our sparsely fossiliferous Permian and Triassic beds. Even in Central Germany, the rich limestone of the Muschelkalk only affords a few transitional genera of any consequence, and these by no means fill up the gap.

But, in place of the barren Triassic sandstones of our own land, masses of the richest limestone rise in the Tyrol, and our non-fossiliferous Keuper marls are represented locally in that province by extremely prolific fossil-bearing shales and limestones. No better example of such fossiliferous beds in the Alpine Trias can be found than the group which forms the main subject of this paper. Yet, while the fossils contained in these beds are of remarkable interest, and are well-known to all geologists, the stratigraphy of that district of Southern Tyrol in which they pre-eminently occur has always been a matter of dispute since the days of Leopold von Buch. I may here indicate shortly, for the English reader, the present state of opinion regarding the systematic position of these strata.

[1] This work was published at Gotha in 1860; a preliminary notice appeared in 1858, Jahrb. d. k. k. geol. Reichsanstalt, p. 466.

The Muschelkalk is succeeded in Southern Tyrol sometimes by an immense thickness of dolomitic rock, poor in fossils, sometimes by a non-dolomitic series of strata. The lowest of the non-dolomitic series are the Buchenstein Beds, a series of shales and limestones comparatively poor in fossils, but indicative of shallow-water conditions; next, a group known as the Wengen strata, consisting of sandstones and shales, formed apparently more or less by the washings of volcanic (sub-basic) material, and known usually as 'sedimentary tuffs.' These are cut through by augitic porphyry-dykes, or are interrupted at various horizons by flows of augite-porphyry, with volcanic tuffs. The sedimentary beds are fossil-bearing, and while the species are few, the individuals are numerous.

Next follow the most celebrated beds of the whole Triassic series, the marls and limestone-rocks of St. Cassian, which afford that curious mixture of older forms of life, as yet almost unique in the geological world.

Above the St. Cassian Beds, according to one opinion, follow at once the fossil-bearing Raibl Beds; in Southern Tyrol these are especially characterized by the brilliant colouring of the reddish and violet marls, which are interstratified with dolomitic flags in the upper horizons. According to another opinion, there is between the fossiliferous St. Cassian and the fossiliferous Raibl Beds a distinct horizon, formed by the same Schlern Dolomite as that which extends in some localities in Southern Tyrol from the Raibl Beds above to the Muschelkalk below.

The Dachstein Dolomite succeeds the Raibl Beds in all cases, and above the whole Triassic series follow the acknowledged Liassic strata.

The difficulty in Southern Tyrol arises in the anomalies presented by those beds which are above the Muschelkalk and below the Raibl strata. The dolomitic rock thickens out locally into mountain-masses or is suddenly replaced by shales. The very fossiliferous beds of one locality are represented, a few miles off, by strata wholly barren of organic remains.

As yet, comparison with the ascertained succession in Northern Tyrol lends little help. In Northern Tyrol, the Raibl Beds, as a series of marls and oolitic limestones often richly fossiliferous, and interbedded with unfossiliferous dolomite, limestone, and gypsum, rest upon the thick development of limestone known as Wetterstein Kalk. This limestone is generally regarded as the representative of the dolomitic rock below the Raibl Beds in Southern Tyrol. Below the Wetterstein Kalk and above the Muschelkalk are the Partnach strata, a series of dark thin-bedded shales which von Gümbel, von Hauer, and others have compared with the Wengen strata of Southern Tyrol, owing to the identity of some characteristic fossils, e. g. *Halobia Lommeli*, Wissm.

Thick beds of hard limestone are interstratified at various horizons in the Partnach shales and marls, and such limestones bear typical St. Cassian fossils, e. g. *Koninckina Leonhardti*, Wissm., and have hence been called 'St. Cassian limestones.' Several of the species

appear again at the higher horizon of the Raibl Beds, together with a certain number belonging to a distinct 'Raibl' fauna.

The Wetterstein Kalk in some places, however, lies directly upon the Muschelkalk, no Partnach strata being developed; and in its eastern and western extension the Wetterstein Kalk thins out. In Eastern Tyrol its place is taken by the Hallstadt Limestone,[1] while in the west the Raibl Beds lie conformably on the Partnach Beds.

The various opinions which have been held regarding the probable representative in Northern Tyrol of the St. Cassian strata of Southern Tyrol will be stated below in the review of the special literature. Suffice it to say that the name of 'St. Cassian strata' has now no value as indicating a sure horizon in the series of Alpine Upper Trias; at most it has retained clear association with the fauna found in the immediate neighbourhood of St. Cassian.

II. Previous Discovery and Speculation regarding the Upper Triassic Strata in the Tyrol (with special reference to the St. Cassian Beds in Southern Tyrol).

At a time when the historical geology of the British Isles, France, and Germany had been firmly based on the careful and comparative studies of geologists in those countries, the elements of Alpine geology were scarcely understood. Those immense masses of limestone and dolomite which characterize the northern and southern zones of the Alps seemed without parallel elsewhere in Europe.

As the limestone-rocks have outwardly much similarity, and the few fossils which they contain were for a long time unknown, the older writers believed them to belong to one and the same formation, and grouped them conveniently together under the title of 'Alpenkalk.' There are, however, here and there amidst the wonderful rock-scenery of the Tyrolese Alps, high-lying stretches of green meadow and 'Alm.'[2] Gradually geologists carried their researches into these remote 'Alpen,' and found the marls and shales to be, in many cases, fossiliferous. Fossils were collected and examined, and it became evident that the fauna occurring in the Alpine mountains of the Tyrol had a character quite different from that of any fossil fauna up to that time known in other parts of Europe.

It was on such high mountain-meadows that the *Avicula contorta*-zone was traced in Northern Tyrol soon after Leopold von Buch's[3] first discovery of the characteristic fossils at Hirschberg.

[1] The Hallstädter Kalk belongs to the development of Trias in the 'Juvavic Province' recognized by Mojsisovics, whereas Wetterstein Kalk occurs in the 'Mediterranean Province' (this embraces the Western and Southern Alps). Mojsisovics also distinguishes a Lower Keuper division of the Alpine Trias, the 'Noric zone,' including the strata from the Upper Muschelkalk to the Raibl Beds, and an upper division, the 'Karnic zone.'

[2] *Alm* or *Alp* is the German word for pasture-land in the mountains, where cattle remain the whole summer through in the open air. In Southern Tyrol hay is often grown and gathered into small huts, *Alpenhütten*, and for the convenience of herd-boys empty huts are left, the so-called *Kochhütten*. These huts help much in reading the maps, as they are always marked.

[3] 'Schichten mit *Avicula* . . . .,' Abh. d. k. Akad. Berlin, 1828, p. 84.

One definite horizon in Triassic strata was thus ascertained in the Northern Alps, namely, the Kössen Beds of Upper Keuper age.

The next important group of fossiliferous strata to be observed was a series of marls exposed on passes and mountain-meadows in the midst of the dolomite-rocks of Southern Tyrol.

As early as 1834 Graf Münster[1] described the favourable exposure of these strata in the neighbourhood of St. Cassian in Enneberg; and not long afterwards he and Wissmann[2] published their well-known work, in which they described 400 species from the St. Cassian strata, and figured them in a masterly manner.

Klipstein[3] in the following years much increased the number of known species. The remarkable fact was that no single species agreed with species described from countries north of the Alps.

In 1844 Emmrich[4] examined the strata of Enneberg and came to the conclusion that the St. Cassian strata were at any rate above the Alpine Muschelkalk, the age of which had shortly before been determined. In the course of a warm discussion, which arose after the publication of Klipstein's[5] work, Bronn[6] wrote a short editorial note which deserves to be mentioned. In it he promulgated the opinion, still current among many geologists, that the fauna of St. Cassian had lived in the neighbourhood of rocks and cliffs in a shallow sea, where coral-banks were numerous, and gasteropods, sponges, brachiopods, etc. associated under conditions favourable alike to all. In extra-Alpine formations of nearly all ages the local occurrence of special faunas, and more particularly of the fauna of a coral sea, had frequently been proved. And Klipstein was so far misled by receiving from the collectors some Liassic ammonites among the St. Cassian fossils, and by a general resemblance in the characteristics of the St. Cassian fauna to that of the Upper Jurassic Coral Rag at Nattheim or Kelheim, as to attribute a Jurassic age to the St. Cassian strata. Bronn, on the contrary, thought from palæontological evidence that the St. Cassian strata were equivalent to the Muschelkalk.[7]

Between 1850 and 1860 a marked advance was made in the knowledge of the Triassic strata in Northern Tyrol through the energy of Austrian and German geologists. A letter from Escher

[1] 'Ueber das Kalkmergellager von St. Cassian in Tyrol und die darin vorkommenden Ceratiten,' Neues Jahrb. 1834. p. 1.

[2] 'Beiträge zur Petrefaktenkunde,' Bayreuth, 1841–43.

[3] 'Beiträge zur geologischen Kenntniss der östlichen Alpen,' Giessen, 1843.

[4] 'Ueber die Schichtenfolge der Flötzgebirge des Gaderthales, der Seisser Alpe, und insbesondere bei St. Cassian,' Neues Jahrb. 1844, pp. 791–803; 'Gervillienschichten bei Lienz,' Zeitschr. d. Deutsch. geol. Gesellsch. vol. vi. (1854) p. 668.

[5] 'Schichtenfolge in Süd-Tirol,' Amtl. Ber. über die Naturforscherversammlung zu Mainz, 1843; Neues Jahrb. 1845, pp. 799–801.

[6] Neues Jahrb. 1845, pp. 504–508.

[7] [In 1847 Sir R. Murchison made an excursion to St. Cassian, with von Buch and de Verneuil (see Q. J. G. S. vol. v. (1849) pp. 165–167; where reference is made to the work of Emmrich and others). Mr. W. J. Hamilton, in his Anniversary Address for 1855, discussed 'The Position of the Fossiliferous Beds of San Casciano,' Q. J. G. S. vol. xi. pp. lxiii–lxix.—Ed.]

von der Linth[1] in 1854 tells how he and others convinced themselves that the Raibl strata ('Schiefer u. Sandstein') of the Vorarlberg and of Northern Tyrol were of Keuper and not of Liassic age; that similar strata with *Cardita crenata*, Goldf., occurred near Hall, in Lavatsch Thal, and in several other localities, in close association with strata containing *Halobia Lommeli*, Wissm.; that these represented without doubt true St. Cassian strata, and must be regarded as a marine equivalent of a part of the Keuper.

In a paper written by Merian[2] from Basel, a series of greenish-grey sandstones with plants, now recognized as Raibl strata, was included with dark-grey or black fossiliferous limestones, and beds with *Halobia Lommeli*, Wissm., as 'Lower St. Cassian Formation' below the horizon now called 'Hauptdolomit.'

Following a preliminary contribution made by von Hauer[3] in 1855, Foetterle[4] gave in 1856 subdivisions of the Raibl strata from observations which he and the first-named author had made in the country from Raibl to Dogna. The succession he regarded as:—

Raibl Strata.
- Uppermost horizon.
- Marly shales and limestones: characteristic fossils—*Astarte* (*Corbula*) *Rosthorni*, Boué, sp., *Ostræa montis-caprilis*, Klipst., etc.
- Marls with *Myophoria Kefersteini*, Goldf., sp.
- Bituminous shales with plant- and fish-remains, forming the lowest horizon.

While he remarked that the fossils, even up to the *Corbula Rosthorni*-beds, much resembled the St. Cassian fossils, he gave to the whole group the name of 'Raibl strata,' and defined them as the series of beds above the Hallstädter Kalk (=Wetterstein Kalk of Gümbel) and below the Dachstein Kalk (=Hauptdolomit of Gümbel).

In the following year, Hauer[5] gave a complete description, with plates, of the mollusca of the Raibl strata as exposed at Raibl, at Agordo in Lombardy, at Schlern, and at other places.

The fossils of the lowest horizon of Raibl strata in Foetterle's subdivision were handled by Bronn.[6] In reviewing Bronn's work and combining the results of previous research, Hauer came

[1] Zeitschr. d. Deutsch. geol. Gesellsch. vol. vi. (1854) p. 519. In 1853 his important work appeared (*cf.* pp. 49-52), 'Geolog. Bemerkungen über d. nördl. Vorarlberg u. einige angrenzenden Gegenden,' Neue Denkschr. d. allg. Schweizer. Gesellsch. für die Naturwissenschaften. [See Abstract in Quart. Journ. Geol. Soc. vol. xi. (1855) Misc. p. 16.—Ed.]

[2] 'Ueber die St. Cassian-Formation im Vorarlberg und im nördlichen Tirol,' Zeitschr. d. Deutsch. geol. Gesellsch. vol. vi. (1854) p. 642. [See also Quart. Journ. Geol. Soc. vol. xi. (1855) p. 451.—Ed.]

[3] Jahrb. d. k. k. geol. Reichsanstalt, 1855, pp. 744 & 745.

[4] *Ibid.* 1856, pp. 372 & 373.

[5] 'Ein Beitrag zur Kenntniss der Fauna der Raibler Schichten,' Sitzungsber. d. kais. Akad. d. Wissensch. Wien, vol. xxiv. (1857) pp. 537–566.

[6] 'Beiträge zur triasischen Fauna u. Flora d. bitum. Schiefer v. Raibl,' Neues Jahrb. 1858; 'Nachtrag über die Trias-Fauna von Raibl,' *ibid.* 1859.

to the conclusion that these Raibl strata were identical with the *Cardita*-beds of Northern Tyrol.

Von Gümbel[1] had in 1857 stated that the *Cardita*-beds overlying the Wetterstein Kalk were the true equivalent of the St. Cassian strata.

In 1859 von Richthofen,[2] who had been working in the St. Cassian district and in the Vorarlberg, expressed his opinion that the *Cardita crenata*-beds in the last-named area ought to be included with the Raibl strata; but that in Northern Tyrol, and in the Northern Alps generally, the *Cardita*-beds ranged lower than the Raibl strata in Southern Tyrol, and that therefore their fauna more closely resembled the St. Cassian fauna.

In the literature of this period the Raibl, *Cardita*-, and St. Cassian strata were understood to belong generally to the same horizon, and the various names began to be rather loosely applied to fossiliferous beds in the Upper Triassic Series of Northern and Southern Tyrol.

Before leaving this subject, it ought to be mentioned that the subdivisions made by Hauer and Foetterle for the Raibl strata near Raibl were corroborated some 10 years later, and considerable clearness attained, by means of the detailed examination of these beds made by Suess[3]; this author also suggested an interesting comparison with the strata in Southern Tyrol.

A further paper on the subject was contributed by Stur,[4] who published with it the first map of the Raibl and Kaltwasser district. The opinion of Stur that the lowest subdivision of Raibl strata made by Foetterle corresponded with the Wengen Beds containing *Halobia Lommeli* in Southern Tyrol has not since been accepted, the palæontological evidence adduced by him being afterwards corrected by Mojsisovics. Comparison is now made between this horizon, the so-called 'Fischschiefer,' in the Raibl Beds and 'Aonschiefer,' a horizon of St. Cassian strata (see a footnote in Moisisovics' work 'Dolomit-Riffe,' p. 61).

By means of the work of Sandberger[5] and Gümbel[6] on extra-Alpine Keuper in Bavaria, comparison was made between the Raibl strata in the Alps and the 'Gypskeuper' of Franconia.

Pichler,[7] in several papers published before 1862, placed the strata with *Cardita crenata*, Goldf., between what he called 'upper and middle Alpenkalk,' corresponding respectively to Hauptdolomit

[1] 'Die Aequivalente der St. Cassianer Schichten im Keuper Frankens, Jahrb. d. k. k. geol. Reichsanstalt, 1859, p. 22.

[2] 'Die Kalkalpen von Vorarlberg u. Nord-Tirol,' *ibid.* p. 101.

[3] 'Studien über die Gliederung der Trias- und Jura-Bildungen in den östlichen Alpen,' von Eduard Suess und Edmund von Mojsisovics, *ibid.* 1867, p. 553.

[4] 'Beiträge zur Kenntniss der geol. Verhältnisse der Umgegend von Raibl und Kaltwasser,' *ibid.* 1868, p. 71.

[5] 'Die Stellung der Raibler Schichten in dem Fränkischen und Schwäbischen Keuper,' Neues Jahrb. 1866, p. 34.

[6] 'Bavaria,' vol. iv. I. p. 53 (Geology by Gümbel).

[7] 'Zur Geognosie der Tyroler Alpen,' Neues Jahrb. 1857, p. 691.

and Wetterstein Kalk. But in later papers (1862, 1866, etc.[1]) he changed his opinion, mainly on stratigraphical grounds, and gave two horizons with *Cardita crenata*, Goldf., the succession being as follows :—

Upper horizon of *Cardita crenata*, Goldf.
= *Cardita*-strata of Gümbel.
= Raibl strata of Hauer.
Strata with *Chemnitzia Rosthorni*, Hoern.
= Wetterstein Kalk.
Lower horizon of *Cardita crenata*, Goldf.
= St. Cassian strata of Richthofen.
= Partnach strata of Gümbel, or strata with *Halobia Lommeli* of Gümbel and other authors.

Mojsisovics[2] accepted, in the main, Pichler's horizons and gave (in 1869) the following succession (in descending order) :—

Seefelder Dolomit (= Hauptdolomit).
Wetterstein Kalk.
Cardita (= St. Cassian)-beds.
Dolomitic limestone (Haselgebirge and Reichenhaller Kalk).
Partnach dolomite.
Partnach strata with *Halobia Lommeli*, Wissm., and St. Cassian fossils.

In 1871 Mojsisovics[3] recognized even three *Cardita crenata*-horizons, although they were lithologically and palæontologically the same. The third of these horizons he introduced above the Wetterstein Kalk as being the equivalent of Raibl strata. A year later[4] he struck out the *Cardita*-zone *below* the Wetterstein Kalk, saying that the *Cardita*-beds *above* the Wetterstein Kalk were the equivalent of St. Cassian strata. But, in 1874,[5] Mojsisovics returned to his opinion that the *Cardita*-beds above the Wetterstein Kalk were Raibl strata, containing a fauna which would probably on closer study be found to differ from the St. Cassian fauna.

As may be seen from the above references, the question of the relative ages of these fossiliferous strata has given rise to great confusion in the literature. This is largely owing to the difficulty of attaining a sound knowledge of the stratigraphy of the Triassic rocks. Like other formations in the Alps, they have been much folded and faulted, and names were given to the fossiliferous beds before any comparison of the succession in different regions could be reasonably made. In every case the succession must be determined for itself, as no formation in Northern and Southern Tyrol or in Bavaria presents so many-sided a development as the Trias.

A careful study of the *Cardita*- and Raibl strata of the Northern

[1] 'Zur Geognosie Tirols,' Jahrb. d. k. k. geol. Reichsanstalt, 1862, p. 531; '*Cardita*-Schichten und Hauptdolomit,' *ibid.* 1866, p. 73.
[2] 'Ueber die Gliederung der oberen Triasbildungen der Alpen,' Verhandl. d. k. k. geol. Reichsanstalt, 1869, p. 65.
[3] 'Ueber die Stellung der Nord-tiroler *Cardita*-Schichten,' *ibid.* 1871, p. 213.
[4] 'Parallelen in der oberen Trias der Alpen,' *ibid.* 1872, p. 7.
[5] 'Faunengebiete und Faciesgebilde der Triasperiode in den Ostalpen, Jahrb. d. k. k. geol. Reichsanstalt, 1874, p. 81.

areas was made a few years ago by von Wöhrmann.[1] He came to the following conclusions :—

(1) That in all the places where former writers believed Lower *Cardita*-strata (*i. e.* the *Cardita*-beds *below* the Wetterstein Kalk) to be present, these strata were none other than the Upper *Cardita*- or Raibl strata (*i. e.* the *Cardita*-beds *above* the Wetterstein Kalk) which had been brought by faulting into the apparently lower position.

(2) That these so-called *Cardita*-strata contain in their lower zones chiefly St. Cassian fossils; on the other hand, in the upper zones, nearly all the typical Raibl fossils are present.

The same author publishes this year, in co-operation with Koken, a special work[2] on the fossils contained in the 'Rothe Raibler Schichten' of Schlern.

Dr. T. Skuphos,[3] during the summer of 1891, examined the Partnach strata in the Northern Alps; his results prove that these beds lie under the Wetterstein Kalk and above the Muschelkalk, and that the plant-bearing sandstones (previously in several places included with the Partnach strata) belong to the Raibl horizon. He further concludes that the Partnach strata form an upper zone of Alpine Muschelkalk, while the Wetterstein Kalk probably represents the highest zone of the extra-Alpine Muschelkalk.

Before entering on the special stratigraphical work of this paper, a short summary may be given of the marked general features in the geology of the Southern Tyrol Dolomites and the explanation they have found in previous research. These are :—

(1) The dolomitic character of immense thicknesses of rock.

(2) The apparently rapid variations in the thickness of strata, noted chiefly in the dolomitic rocks.

(3) The occurrence of volcanic rocks, as flows and dykes, and the admixture of volcanic tuff with ordinary stratified detrital deposits.

(4) The local development of the rich and highly typical fauna of St. Cassian.

Leopold von Buch's[4] valuable researches first directed the attention of geologists to the neighbourhood of the 'Dolomites,' and various theories were propounded to explain the origin of the imposing masses of dolomite-rock. These I need not here recount. An exhaustive list of the literature which appeared during the first half of the century is given by von Richthofen.[5]

The stratigraphy of the district first found full and systematic treatment in the work of Richthofen above referred to. A coloured

[1] 'Die Fauna der sogenannten *Cardita*- u. Raibler Schichten in den Nordtiroler und bayerischen Alpen,' Jahrb. d. k. k. geol. Reichsanstalt, 1889, p. 181.

[2] 'Die Fauna der Raibler Schichten vom Schlernplateau,' Zeitschr. d. Deutsch. geol. Gesellsch. vol. xliv. (1892) p. 167.

[3] 'Die stratigraphische Stellung der Partnach- und der sogen. Unteren *Cardita*-Schichten in den Nordtiroler und bayerischen Alpen,' Jahreshefte d. kgl. bay. Oberbergamt, iv. 1891.

[4] 'Geognostische Beobachtungen auf Reisen durch Deutschland und Italien,' vol. i. pp. 263–320. Berlin, 1802.

[5] 'Geognostische Beschreibung der Umgegend von Predazzo, St. Cassian, etc.' Gotha, 1860.

geological map and several sections give additional value to his original work. A clear idea will be gained of the succession of Triassic strata adopted by that author from the important section over the Seisser Alpe and the Schlern mountain.[1]

After his examination of the Triassic strata over a large tract in the west and south-west of this district, Richthofen sought to explain the peculiar local features by the application of Darwin's theory of the origin of, and conditions attending, coral-reefs. Whereas in the older literature it had been suggested that the St. Cassian fossils, occurring in marly strata and limestone-beds, had the special character of coral-banks and represented the fauna of a shallow sea, Richthofen suggested that the dolomite mountains themselves were in truth altered coral-reefs, formed during subsidence of the land, while the fauna of the St. Cassian and of the Raibl strata had been developed in the restricted lagoons, bays, and channels of a coral sea.

This explanation[2] of the origin of the dolomite *massifs* in Southern Tyrol as a varying and disconnected reef-facies during continued deposition of sedimentary beds has been accepted and supported, after careful original investigations in the district, by the well-known geologists Stur[3] and Mojsisovics.

The publication of the latter's book, 'Die Dolomit-Riffe von Süd-Tyrol u. Venetien' in 1879 embraces the work of several geologists associated with him in a survey of the district. A large extent of country was mapped (scale 1 : 75000), and Mojsisovics entered fully into the question of facies. In this work the nomenclature of the strata differs somewhat from that of Richthofen, *e. g.* the 'Sedimentary Tuffs' and 'Cipit Limestones' of Richthofen in the Seisser Alpe section are included by Mojsisovics as Wengen strata, and the name of 'St. Cassian strata' is limited to the small upper series of beds containing the well-known and unusually rich fauna collected chiefly on the Stuores meadow, near St. Cassian, in the Enneberg Valley.

In developing and extending the application of the coral-reef theory of Richthofen, Mojsisovics emphasized the 'heteropic'[4]

[1] 'Geogn. Beschr. d. Umg. v. Predazzo,' pp. 40–43.

[2] In several cases Austrian geologists have found Richthofen's coral-reef theory applicable to the occurrence of thick masses of limestone elsewhere, and in other formations than the Trias. I may mention the recent work of Dr. Franz Wähner in the Rofan Group, near the Achen See, in Northern Tyrol. Dr. Wähner attributes the white Liassic limestones of Sonnwendjoch to the agency of corals, while a facies-development of foraminiferal limestone occurs quite near, on Pfons Joch. Zeitschr. d. Deutsch. Alpenver. vol. xxii. 1891.

[3] 'Eine Excursion in der Umgegend von St. Cassian,' Jahrb. d. k. k. geol. Reichsanstalt, 1868, p. 529.

[4] [On p. 6 of his 'Dolomit-Riffe,' Mojsisovics explains, as follows, 'heteropisch' (a compound apparently derived from ἕτερος and ὄψ, ὀπός):—'Ebenso wie sich zu gleicher Zeit und neben einander im selben Raume verschiedenartige Facies bilden, erscheinen in verschiedenen Räumen (Provinzen) und zu verschiedenen Zeiten gleichartige Facies. Die ersten nennen wir *heteropische*, die letzteren *isopische* Bildungen.' See also his paper 'Ueber heteropische Verhältnisse im Triasgebiete der lombardischen Alpen,' Jahrb. d. k. k. geol. Reichsanstalt, 1880, p. 695.—Ed.]

nature of the Upper Triassic rocks. He differed from Richthofen in assuming that the coral-reefs began to form in certain localities directly after the deposition of the Muschelkalk strata.

A case in point is offered by the dolomite-rock of the Schlern mountains. Referring to Richthofen's section (*op. jam cit.* pp. 40–43) this rock is regarded as a reef built on a subsiding portion of Muschelkalk rock after the period of the deposition of the Buchenstein and Wengen Beds exposed on the Seisser Alpe. The highest beds exposed on the Seisser Alpe contain a St. Cassian fauna, and these are the beds regarded by Richthofen as the time-equivalent of the dolomite-reef in part; he further believed that the reefs continued to grow after the St. Cassian period, and that Raibl Beds and a Raibl fauna spread themselves then irregularly above the reefs and above the St. Cassian Beds in the channels beyond. The name of 'Schlern Dolomite' was given by Richthofen to the dolomitic rock developed within these ages.

Richthofen's idea that after Muschelkalk time a gradual uprising of the rock, followed by subsidence, took place in the Schlern district and farther south, was not accepted by Mojsisovics, who held that the reefs grew upon the Muschelkalk during the deposition of the whole series of Buchenstein, Wengen, and St. Cassian sedimentary beds. Mojsisovics, therefore, gave up the name of 'Schlern Dolomite,' and introduced names for the dolomitic horizons in correspondence with the names of the non-dolomitic beds. The alteration thus introduced by him may be represented as follows :—

<table>
<tr><th colspan="3">Richthofen's Succession.</th><th colspan="3">Mojsisovics' Succession.</th></tr>
<tr><td rowspan="5">Conformable Succession.</td><td>Raibl Beds.</td><td rowspan="2">Raibl Beds.</td><td colspan="3">Raibl Beds.</td></tr>
<tr><td>Schlern Dolomite.</td><td>Schlern Dolomite.</td><td rowspan="4">Sedimentary Beds.</td><td>St. Cassian Beds.</td><td rowspan="4">Dolomitic Facies.</td></tr>
<tr><td>St. Cassian Beds.</td><td rowspan="3">(Unconformity.)</td><td rowspan="2">Wengen Beds.</td><td rowspan="2">St. Cassian Dolomite.
Wengen Dolomite.</td></tr>
<tr><td>Wengen Beds.</td></tr>
<tr><td>Buchenstein Beds.</td><td>Buchenstein Beds.</td><td>Buchenstein Dolomite.</td></tr>
<tr><td colspan="3">Muschelkalk (Mendola Dolomite).</td><td colspan="3">Muschelkalk.</td></tr>
</table>

Many cases are quoted by Mojsisovics as affording proof of the 'heteropism' of the strata, either by the thinning-out of the zones of sedimentary beds in the dolomitic facies, or by the conformable succession of the Raibl Beds, sometimes on the dolomitic, sometimes on the non-dolomitic facies of the St. Cassian horizon.

Ever since its first publication the coral-reef theory has had its opponents. In the year 1872 Gümbel[1] published a paper on the Mendola and Schlern mountains, in which he gave several sections, and made a comparison between the succession of Triassic strata in Northern and Southern Tyrol. He proved that the Mendola and Schlern Dolomites could be distinguished as palæontological horizons. In the Mendola Dolomite the fossil of most frequent occurrence is *Gyroporella pauciforata*, Gümbel, characteristic of the Muschelkalk in the Northern Alps, whereas in the Schlern Dolomite other species of *Gyroporella* occur, especially *G. annulata*, Schafh., common in the Wetterstein Kalk in Northern Tyrol. Gümbel defined the Schlern Dolomite in a twofold sense:

1. As the dolomite-rock equivalent in age to the whole series of sedimentary strata, from the lowest St. Cassian Beds exposed on the Seisser Alpe (Richthofen's 'Sedimentary Tuffs' included here) to the 'Red Raibl Beds' of the Schlern plateau.

2. As the dolomite-rock denoting a distinct palæontological horizon lying above the St. Cassian strata and below the Raibl strata.

Gümbel opposed Richthofen's coral-reef theory, chiefly on the ground that there was little proof of coral agency, corals being seldom found in the Schlern Dolomite, whereas algæ such as *Gyroporellæ* are often obtained and with their fine structure well-preserved. He also showed that the variation in thickness of the Schlern Dolomite was analogous to the variation in other rocks, such as the Wetterstein Kalk in the Bavarian Tyrol. These objections of Gümbel were replied to by Richthofen in a paper 'Ueber Mendola-Dolomit u. Schlern-Dolomit.'[2]

Loretz,[3] who published the first detailed study of the Ampezzo district in two papers (1874–75), did not accept the reef-theory. At the same time he recognized two equivalent facies of strata, a dolomitic and a non-dolomitic, representing the period between the Muschelkalk and the Raibl strata. In this he anticipated the view of the complete 'heteropic' development of the Buchenstein, Wengen, and St. Cassian zones held by Mojsisovics.

Lepsius,[4] in his work on the Nonsberg *massif*, south-west of the Schlern mountains, concluded that the Schlern Dolomite in that district was a stratified marine deposit, covering an immense area, and that the same deposit varied in thickness in the Schlern and Fassa districts, mainly owing to the outpouring, during its period of deposition, of masses of volcanic matter.

[1] 'Das Mendel- u. Schlern-Gebirge,' Sitzungsb. d. math.-phys. Classe d. k. bayerisch. Akad. d. Wissensch. vol. iii. (1873) p. 14.

[2] Zeitschr. d. Deutsch. geol. Gesellsch. vol. xxvi. (1874) p. 225.

[3] 'Das Tirol-Venetianische Grenzgebiet der Gegend von Ampezzo,' *ibid.* p. 377; 'Einige Petrefacten der alpinen Trias aus den Südalpen,' *ibid.* vol. xxvii. (1875) p. 784.

[4] 'Das Westliche Süd-Tirol,' Berlin, 1878; see particularly pp. 77–83.

III. Topography of the District.

In the valleys of Ampezzo and Enneberg, south of the Pusterthal, the Wengen and St. Cassian Beds are well exposed, and abundant opportunity is afforded of studying their stratigraphical position with regard to the overlying strata.

I mapped in detail three areas in the northern part of the 'Dolomite Alps.' [1]

(A) The classical district of St. Cassian in Enneberg and Sett Sass;
(B) The Falzarego Valley, west of Cortina d'Ampezzo;
(C) The Prags Valley and the Dürrenstein mountain near Toblach.

The field-work was done upon the Survey Maps of Austria-Hungary, scale 1 : 25000; the maps published with the present paper are reduced to the scale of 1 : 50000, or 1·267 inch to the mile.[2]

With the view of securing at once a series of typical sections I made several traverses of other districts, such as the Seisser Alpe, north of Schlern; the Sella Joch and the Gröden Joch; the Lower Enneberg; Tre Croci and Misurina. Only a part of my observations in these districts is given here.

The Enneberg Valley opens into the main east-and-west valley of the Pusterthal at Bruneck, while the Ampezzo Valley opens into the Pusterthal at Toblach.

The Gader stream flows north through Enneberg, cutting in its upper part through the Abtey slopes between Stern and St. Leonhardt (Abtey). At Stern the two branches of the Gader stream meet; these are the Pescadoi or Grosser stream from the west (on which Colfuschg and Corvara lie) and the Sore stream (on which St. Cassian lies) from the north. The Sore is joined higher up by the Eisenofen (or Valparola) and by the Stuores and Piccol streams.

The Gardenazza *massif* rises on the western side of the Enneberg Valley, and the Sella *massif* extends farther south, forming the watershed between this northern region and the Fassa district. Between these two dolomite-*massifs* the Gröden Pass leads from Enneberg to the Grödenthal. The latter is the narrow valley north of Lang Kofl, Platt Kofl, and Schlern, which joins the Eisack some distance north of Botzen.

On the eastern side of the Enneberg Valley the great *massif* of Kreuz Kofl, La Varella, Centurinus and Lagazuoi extends south to the Tra i Sassi Pass. The district of Sett Sass and Prelongei lies between the two sources of the Gader (Sore and Grosser streams), is bounded by the Buchenstein Valley in the south and south-east, and is surrounded on every other side by dolomite-*massifs*.

The Tra i Sassi Pass leads from Enneberg eastward to Cortina, between Sett Sass and Lagazuoi, and holds north of Nuvolau. The Ospizio in Falzarego is high on the eastern side of the Pass, and the

[1] These three areas are included within the Austrian Map. Scale 1 : 75000; Sheet Cortina, Zone 19, Col. vi.

[2] The sections are drawn to the natural scale, vertical and horizontal; but in some cases the dip of the beds, and therefore the thickness, has been slightly exaggerated.

road to Cortina continues to descend for the greater part of its length along the northern bank of the Costeana stream. Tofana Prima and Secunda form high dolomite-*massifs* north of the valley, while Nuvolau and Cinque Torri extend along the southern side.

Cortina lies in a deep basin where two tributary streams, the Costeana from Falzarego and the Bigontina from Tre Croci in the east, open into the Boita Valley. Ascending the Boita Valley the Ampezzo road leads north between Tofana and Pomagagnon, then turns eastward at Peutelstein and passes between Croda Rossa and Cristallo to Schluderbach. Here the road again turns northward and follows the course of the Rienz stream past Landro to Toblach. West of the road is the Dürrenstein *massif*, extending north and south between the Rienz Valley and the high mountain-pass of the Plätz Alp. Northward it is bounded by high-lying meadows; an outer band of dolomite, the Sarl Kofl and Sarl Brand, forms then the steep descent north of the Dürrenstein to the Pusterthal between Toblach and Niederdorf.

IV. The General Stratigraphical Succession.

The Triassic strata exposed within the district examined are, in descending order:—

8. The Dachstein Dolomite.
7. The Raibl Beds.
6. The Schlern Dolomite.
5. The St. Cassian Beds.
4. The Wengen Beds.
3. The Buchenstein Beds.
2. The Muschelkalk.
1. The Werfen Beds.

1. *The Werfen Beds.*[1]—A glance at the geological maps accompanying this paper (facing pp. 18, 28, and 32) shows that the Werfen Beds seldom have an outcrop in the districts examined. They are mainly exposed in the neighbourhood of the crystalline schists south of the Pusterthal, near Prags, and again in the Lower Enneberg Valley. In the Cortina district they are nowhere exposed. In the Upper Enneberg, an exposure of Werfen Beds occurs from the Gröden Pass eastward towards the village of St. Cassian, but their chief extent is farther south, along the valley of Buchenstein.

These strata are a series of dark-grey limestones and marls, argillaceous shales, reddish micaceous or sandy clays, attaining a thickness of 300 to 500 feet. Their characteristic fossils are *Posidonomya Clarai*, Emmrich, and *Naticella costata*, Münster.

2. *The Muschelkalk.*—In all the above-mentioned cases of outcrop of the Werfen or Lower Triassic Beds, they are conformably succeeded by beds of limestone and dolomite, containing characteristic Muschelkalk fossils.

[1] The name was given to this lowest horizon of Alpine Trias from the village of Werfen in Salzkammergut.

This series has been subdivided in Southern Tyrol into :—

- Upper Muschelkalk (=Richthofen's 'Mendola Dolomite').
  - Characteristic fossils:—
    - *Trachyceras trinodosum*, Mojs.
    - *Ptychites gibbus*, Benecke, etc.
- Lower Muschelkalk (=Richthofen's 'Virgloria Kalk').
  - Characteristic fossils:—
    - *Trachyceras binodosum*, Hauer.
    - *Ptychites Studeri*, Hauer.
    - *Terebratula vulgaris*, Schloth.

At both horizons occurs the representative fossil alga, *Gyroporella pauciforata*, Gümbel. Where exposed in the Buchenstein and Enneberg Valleys, the Lower Muschelkalk Beds are dark, bituminous, evenly-bedded limestones and shales varying from 40 to 60 feet in thickness. Near Prags, these beds are at least 300 feet thick; in the lower portion they are greyish or reddish limestones and bituminous shales, succeeded by a great thickness of greyish-white dolomitic limestone and dolomite containing *Gyroporella pauciforata* often in great number.

The Upper Muschelkalk is throughout a pure dolomite, drusy and crystalline, brittle, and forming débris of small angular fragments. Although well-bedded in thick massive layers, the planes of bedding are often less striking to the eye than those of the vertical joints and clefts, and are, moreover, in some measure obscured by the general effects of weathering. Like the Lower Muschelkalk, this dolomite also varies much in thickness; thus in Enneberg it is very little developed, not reaching more than 120–150 feet, while in the Prags district it reaches a maximum thickness of 1200 feet.

3. *The Buchenstein Beds.*—The village of Buchenstein or Pieve (from which these beds derive their name) lies in the Buchenstein Valley, south of Prelongei and Sett Sass.

The strata succeed the Muschelkalk conformably, and their fauna shows so great a similarity to that of the underlying formation that several authors[1] have included them as a higher zone of Alpine Muschelkalk. Besides such typical Upper Muschelkalk fossils as *Terebratula angusta*, Schloth., *T. vulgaris*, Schloth, *Pecten discites*, Schloth., sp., *Trachyceras binodosum*, Hauer, others specially characteristic of this horizon occur, e. g. *Tr. Reitzi*, Böckh, *Tr. Böckhi*, Roth., *Halobia Taramellii*, Mojs., etc.

Hard limestone-beds with siliceous concretions, and the 'Pietra Verde' rock so characteristic of Southern Tyrol, together with interbedded fossiliferous shales, predominate in the exposures found near Buchenstein and farther west. On the other hand, the 'Pietra Verde' and siliceous limestones, although present in the neighbour-

[1] See especially Loretz, *op. cit.* Zeitschr. d. Deutsch. geol. Gesellsch. vol. xxvi. (1874) p. 406, etc.

hood of Prags, are less developed and of less marked character, while thick beds of dark-blue limestones containing plant-remains, and more rarely the typical ammonites and brachiopods, are interstratified with dark bituminous shales, and form the greater thickness of the Buchenstein series.

4. *The Wengen Beds.*—The Wengen Beds, and indeed all the higher members of the Triassic succession, have a much wider distribution in the districts which I have mapped than the foregoing strata.

The conformable succession of Wengen Beds above Buchenstein Beds is proved in all the outcrops of Lower and Middle Trias already indicated. Enneberg is the classical district of Wengen and St. Cassian Beds. It was in the village of Wengen, lying in one of the transverse valleys of Lower Enneberg, that the characteristic fossils were first collected. The name of Wengen strata was then given by Wissmann ('Petrefaktenkunde,' p. 21). Emmrich had called these strata on the Seisser Alpe '*Halobia*-strata.' Farther south, in the vicinity of Spessa, on Armentara Berg, and throughout the whole Gader stream-cutting from Abtey (or St. Leonhardt) as far as the confluence of the Sore and Eisenofen streams, the outcrop of the Wengen Beds and of the St. Cassian Beds succeeding them on the higher ground has given rise to the slopes and meadows of Upper Enneberg. More favourable exposures of the Wengen Beds are found on the southern slopes of Prelongei, between the villages of Corvara and Buchenstein, and from these the sections to be presently described were mainly taken.

As the Cortina map shows (Map B, facing p. 28), true Wengen Beds are but little exposed in the Ampezzo Valley.

In the Prags district, the Wengen Beds have a wide outcrop on the Sarl Alp and Schafriedl, and on the Kameriod Wiesen.

5. *The St. Cassian Beds.*—These richly fossiliferous strata are spread over the Prelongei Alpe and occur on the higher parts of the surrounding slopes. In the other districts mapped, near Cortina and the western slopes of the Dürrenstein, the St. Cassian Beds extend, in my opinion, over a wider area than has hitherto been admitted.

I now enter into the details of the original maps and sections with regard to the Wengen and St. Cassian Beds; the strata lying above them will be described later on in this paper.

V. Stratigraphy of the Wengen and St. Cassian Beds.

The succession of these strata in the districts of Corvara, Prelongei, and Sett Sass is described in detail in the annexed Table, with reference to the three typical sections (figs. 1, 2, 3, on pp. 17, 19, 21) through the area of Map A.

Tabular Description of the St. Cassian and Wengen Beds (in descending order).

(Map A.)

Section I., p. 17.
Corvara and Ruones Wiese.
(Lower parallel section = cutting of Kirchen Bach.)

Low. St. Cas. — Middle St. Cassian.

15. Fossiliferous marls (characteristic Stuores fossils); thin shaly limestones with *Posidonomya*, n. sp.; ashy grits, unfossiliferous thin-bedded shales, limestones, and sandstones, with frequent unrecognizable plant-remains.

14. Thick-bedded grey-blue limestone, with augite-porphyry and tuff. The limestone is altered at both its contact-surfaces with the volcanic rocks.

13. Marls and hard thick-bedded limestone. This limestone has a rough, yellow-weathered surface, sometimes has no fossils, sometimes is full of cidarid spines and stem-fragments of *Encrinus cassianus*, Laube.

FAULT

Middle St. Cassian.

12. Fossiliferous marls and thin-bedded limestones. These are more favourably exposed farther south, in the Ruones Muren (see Additional Remarks on p. 17); here some thickness of beds is concealed under grassy meadows before the complex of beds No. 11 is reached.

11. Marls and limestones, the marls ferruginous, the limestones oolitic and containing a few characteristic Stuores or St. Cassian fossils, small gasteropods and brachiopods.

10. Dark bluish limestone, with a few doubtful ammonite specimens, along with one good specimen of *Trachyceras Aon*, Münst. sp., and several of *Posidonomya wengensis*, Wissm.

Augite-porphyry and tuff.

Lower St. Cassian.

9. Thin-bedded marls (unfossiliferous); volcanic bed, 1 foot thick (tuff), beds of aragonite, one oolitic limestone-bed with St. Cassian fossils.

8. Hard, thick-bedded, yellow-weathering Cipit Limestone with rough surface; in this are found occasional specimens of *Cidaris dorsata* (Braun) and other cidarid species.

Upper Wengen.

7. Blue, fissile marls (*Posidonomya wengensis*); thick beds of limestone, with veins of calcite, poor specimens of *Ammonites*, sp., and of *Posidonomya*, sp.; also stems of ferns.

Thin-bedded shales and limestone, often interbedded with aragonite-layers.

6. Beds of volcanic tuff and ashy calcareous grit (unfossiliferous).

Shales full of *Posidonomya wengensis* and the small variety of the same (?) species (originally known in the literature as *Avicula globulus*, Wissm.).

Lower Wengen.

5. Thin-bedded black tuffs, shales, marls, and limestones, occasionally with fragments of stems and leaves of plants. These beds vary constantly in strike and dip owing to bending and slight faults.

4. Fine breccias of tuff and calcareous material. Shaly limestones with *Halobia Lommeli*, Wissm., and *Posidonomya wengensis*, Wissm.

3. Hard thick limestone.

2. Augite-porphyry, of great thickness, and beds of volcanic tuffs.

1. Black *Halobia*-shale, with the well-known 'Wengen flora' from the Corvara locality.

Section II., p. 19.
Prelongei and Stuores Wiese.

Middle St. Cassian.

12. Fossiliferous marls (concealed in great measure by fallen blocks from the Dachstein Dolomite and Raibl Beds of the western part of Sett Sass) containing several fossils, especially ammonites; together with large blocks of limestone containing encrinite and cidarid fragments, and scattered over the whole meadows. These are probably the remnant of higher beds of fossiliferous St. Cassian strata now eroded from the ridge and slopes of Prelongei.

11. Fossiliferous marls, and thicker beds of fossiliferous oolitic limestone with yellowish-weathered surface; interbedded ferruginous marls and shales and layers of aragonite. This horizon is mainly that in which the great number of Stuores fossils occur (50–60 feet).

10. Less fossiliferous thin-bedded shales, marls, oolitic and shaly limestones. Beds of tuff and ashy sediment. Thin, blue, marly limestones, with calcite veins; light grey shales with *Posidonomya*, n. sp.; ashy rocks with fragments of fossils, especially thick shells of bivalves. Among the fossils actually found in position in these beds are:—*Nucula lineata*, Gdf.; *Terebratula cassiana*, Bittn.; *Mytilus Münsteri*, Klipst.; *Koninckina Leonhardti*, Wissm. sp.; several species of *Cidaris* and corals. The fossils occur in the marls and shales belonging to the higher portion of the series. The whole complex is exposed in a series of 'Muren' on the southern side of Prelongei, as well as in frequent slips on the northern side.

9. Blocks of augite-porphyry strewn singly; sometimes a bed of dark-blue limestone occurs in position, and augite-porphyry along with it.

L. Weng. Up. Weng. Low. St. Cass.

8. Unfossiliferous shales and marls; thick series of hard-bedded sandy-looking limestone. This is sometimes very fossiliferous (true St. Cassian fossils), and sometimes it is developed like the characteristic Cipit Limestone of the Seisser Alpe.

7. Thin-bedded unfossiliferous limestones and shales containing a few poor specimens of cidarid spines.

6. *Posidonomya wengensis*-shales, interbedded with grits, often ashy.

L. Weng.

5. Thick series of black tuffs.

4. Beds containing *Halobia Lommeli*.

3. Augite-porphyry and breccias.

2. Augite-porphyry and tuffs.

1. Buchenstein Beds.

Section III., p. 21.
Sett Sass and Monte Sief.
(Lower parallel section = Castello Wiese.)

Schlern Dolomite.

Middle St. Cassian.

14. Fossiliferous marls and thin beds of limestone, containing the fauna included in the fossil-list under Sett Sass (Forcella). Interbedded limestones contain almost solely corals and encrinites.

13. Lens-shaped mass of drusy, unfossiliferous dolomite, known as 'Richthofen Riff,' thinning out in the series of fossiliferous marls as thick beds of limestone (Cipit Limestone), with cidarid spines and, rarely, brachiopods.

12. Thin-bedded marls, covered largely by blocks of the higher dolomite and limestone. These beds are continuous with the strike of the beds on the Prelongei ridge, and agree with them in lithological and palæontological character (*cf.* Prelongei section, and fig. 2, p. 19). Yellowish shaly limestone and fossil-bearing marls.

11. Coarse grits with fragments of fossils and of volcanic rock (mixed together as a rock possibly better named a volcanic and calcareous breccia).

Typical oolitic limestone with St. Cassian fossils. Hard porphyry and ashy grits. Beds of aragonite; reddish grits with fossils and yellow-weathered limestones. Ashy grits and ferruginous marls.

Thin-bedded shaly limestone with *Posidonomya*, n. sp., which may be followed eastward under the blocks.

10. Beds of porphyry and tuff. Hard limestone with cidarid spines. Volcanic tuffs.

U.W. L.C.

9. Yellowish fossiliferous limestones and marls. Blocks of Cipit Limestone with corals.

8. Grits, shales, and ashy beds. Some poor specimens of *Posidonomya wengensis* found.

Lower Wengen.

7. Calcareous grits and shales, with *Halobia Lommeli*, Wissm., *Posidonomya wengensis*, Wissm., *Trachyceras Gredleri*, Mojs.

6. Argillaceous tuff, with plant-remains.

5. Grey limestone-bed.

4. Volcanic grits and agglomerates.

3. Augite-porphyry and agglomerates, with lenticular masses of irregularly-bedded felsitic rock.

2. Limestone (one thick bed), interbedded with rough slaggy conglomerate and true porphyritic rock.

1. Unfossiliferous greyish-blue crystalline limestone, followed as two thick bands of rock among interbedded shales and ashy, thin-bedded limestone. = Buchenstein Beds.

Note.—In the parallel section of Castello Wiese, the beds of series No. 11 (in part) and of Nos. 10 and 9 are wanting. The section then continues as follows:—

L. Cas.

9ª. Calcareous thick-bedded grits. Impure ashy limestone with coarse texture and yellow-weathered surface.

Upper Wengen.

8ª. Thin-bedded oolitic limestones and marls rarely containing fossils. *Cidaris dorsata*, encrinite-remains, and poor impressions of *Posidonomya wengensis* occur, together with frequent impressions of plants. (These series, Nos. 9ª and 8ª, are wanting in the upper section of Sett Sass and Monte Sief.)

8. Ferruginous earthy beds, interstratified with ashy grits. (*Cf.* No. 8 in upper section).

L.W.

7. *Halobia*-shales. (*Cf.* No. 7 in upper section.)

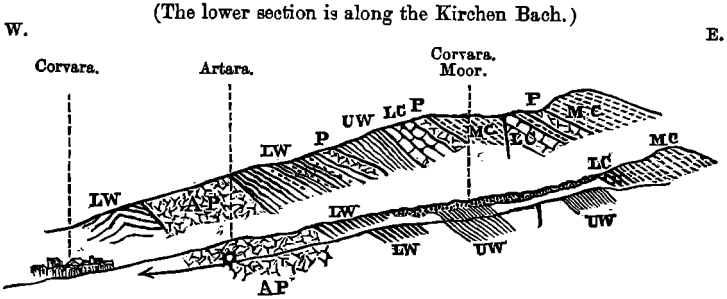
Tuffs and volcanic rocks.

[These lower beds strike through the Castello Wiese as a continuous series with Nos. 6–1 exposed on Monte Sief.]

Section 1. *Corvara and Ruones Wiese.* (See Table and Map A.)

Fig. 1.—*Section through the Ruones Wiese.*

(The lower section is along the Kirchen Bach.)



[Scale: $\frac{1}{37500}$=1·9 inch to the mile.]

For explanatory index, see p. 19.

Additional remarks.—In the Ruones Muren, between Kirchen Bach and Incisa Bach, very fossiliferous strata are exposed; they correspond to bed No. 12 (Middle St. Cassian) in the first column of the Table, and contain the same fossils as are found on Stuores Wiese. These strata are (in descending order):—

Series corresponding to No. 12 in the Table.

- Marls, often ferruginous, and thin layers of aragonite.
- Grey limestones and shales with irregular surface, sometimes ripple-marked.
- Oolitic limestone-beds, several inches thick, containing at intervals highly fossiliferous layers from 1 to 3 inches thick.
- Unfossiliferous marls, limestones, aragonite, etc.
- Fossiliferous, yellowish, oolitic limestone, sometimes crowded with corals and sponges.
- Fossiliferous marls and thin-bedded shaly limestones.
- Thick bed of limestone in which alternating layers, fossiliferous and non-fossiliferous, may be distinguished.
- Marls, etc., of the more ashy series denoted in the Table as Nos. 10 and 11, etc., containing fewer fossils.

In the succession of beds described for Section 1, Nos. 13 to 15 are identical with the beds of Nos. 8 to 12, and these relations continue for some distance north and south. A slight fault causes the fossiliferous series to occur at the two levels.

From the fossils which I carefully collected at the various horizons I classify the succession of beds in this section in two groups:—

St. Cassian Series = Nos. 15–8.
Wengen Series = Nos. 7–1. } See Table.

The Wengen Series is continued with a general north-and-south strike over the Incisa Pass, and has a wide distribution on the heights of Campolungo. In the woods towards Rudort Valley the exposures are unfavourable, and I found few fossils even in the higher slipped portions of rock. The beds dip slightly outward from the hill, and are at times much contorted. The best exposure of

Wengen Beds is seen along the Rudort stream where it bends towards Corvara, cutting through a conformable succession of rocks from augite-porphyry and *Halobia*-shales to St. Cassian Beds below the Crap de Sella rock. The occurrence of some slight throws does not seriously interfere with the succession. The 'contact' appearances in the beds of No. 6 are here very clearly shown.

Section 2. *Prelongei and Stuores Wiese.* (See Table and Map A.)

Additional remarks.—The beds form a shallow syncline, dipping more steeply on the southern side, 20° to 25°, and less on the northern, 5° to 10°; general strike east and west.

This section, described in the Table, offers peculiar difficulties, owing to the slips of larger or smaller portions of rock. On the southern side the beds of Nos. 11–7 are exposed in steep 'Muren,' and the débris from these are heaped up at all the lower levels, and on the banks of the Selvaza sources coming from Prelongei. Following the strike of the beds, frequent opportunities are afforded in the streams and on the slopes above Contrin of convincing one's self that there is a conformable series from Contrin to Prelongei, agreeing in the main with the series in Section 1. This section has the more value, as the underlying Muschelkalk and Werfen Beds, exposed along the Buchenstein Valley, follow conformably in downward succession.

On the Stuores side of Prelongei, the beds are so altered in their position by the small throws, associated with the slips, that in the meadows drained by the sources of the Piccol stream the exposures have a north-easterly strike. Lower down the strike is more regular.

While the most richly fossiliferous beds are limited to the comparatively thin series No. 11, from 50 to 60 feet, these are borne downwards as a cap, from the high ridge of Prelongei towards the lower-lying meadows of Stuores and Piccol, on the soft yielding mass of the underlying ashy and less fossiliferous beds. To this fact, as well as to the very slight dip of the strata, and the many minor throws they have undergone, we owe the ever-renewed abundance of the St. Cassian fossils strewn on the banks of the streams and on the hillocks of slipped material.

At the same time many fossils are found, belonging to true St. Cassian species, in beds Nos. 10, 9, 8 in the tabular description (facing p. 16), and according to their evidence the strata may be grouped as follows:—

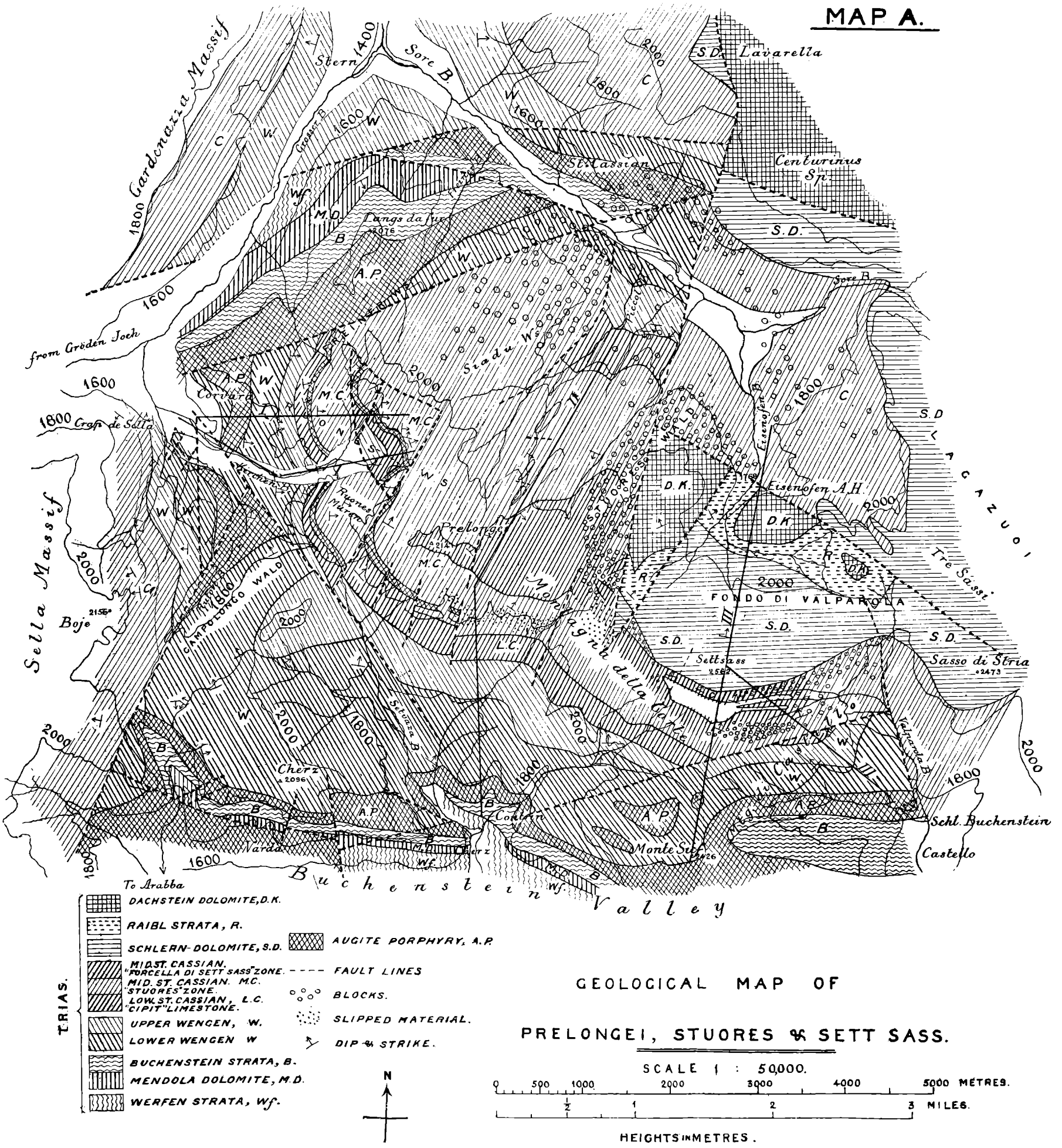
St. Cassian Beds = Nos. 12–8.
Wengen Beds = Nos. 7–2. } See Table.

Section 3. *Sett Sass and Monte Sief.* (See Table and Map A.)

Additional remarks.—The important fact here proved is that the fossiliferous series of St. Cassian Beds underlie conformably the dolomitic rock of Sett Sass. This is seen, not only on the Forcella between Sett Sass and the Richthofen Riff, but also in two or three places where Sett Sass bends round towards the west.

[To face p. 18.

MAP A.



GEOLOGICAL MAP OF PRELONGEI, STUORES & SETT SASS.

SCALE 1 : 50,000.

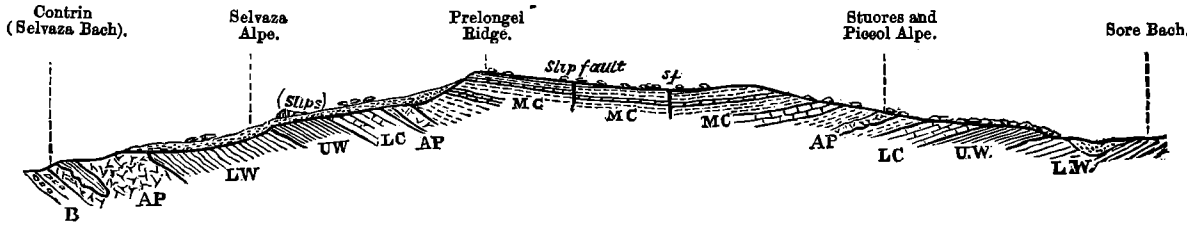
0 500 1000 2000 3000 4000 5000 METRES.

½ 1 2 3 MILES.

HEIGHTS IN METRES.

Note.—The area left white immediately south of Sett Sass is the Richthofen Riff.

Fig. 2.—*Section from Contrin over the Prelongei Ridge to the Sore Bach.* (See Table.) N.



[Scale: $\frac{1}{50000}$ = 1·267 inch to the mile.]

MC = Middle St. Cassian ('Stuores' horizon).
LC = Lower St. Cassian (Cipit Limestone).
UW = Upper Wengen Beds (*Posidonomya wengensis*-shales).
LW = Lower Wengen Beds (*Halobia Lommeli*-shales).
AP = Augite-porphyry.
B = Buchenstein Beds.

The fossiliferous beds of Prelongei continue in a general easterly direction with the strike, although often lost sight of under the long lines of blocks tumbled from Sett Sass Berg, and pass under the lens-shaped dolomitic rock of the Richthofen Riff. They form the slight hollow eroded between the Riff and the mass of blocks on the Castello Wiese, and are occasionally traced on the banks of streams flowing eastward to the Valparola stream. The series of beds, Nos. 10 to 8 in the Prelongei section, are however cut off on the Castello Wiese by an east-and-west line of fault, demonstrable in two ways:—

(1) The light-grey shales with *Posidonomya*, n. sp. (the species differs slightly from *Posidonomya wengensis*), which form a constant horizon in the St. Cassian strata of this district of Prelongei (see Section 1, No. 16, and Section 2, No. 10), pass over the ridge and are traced beneath the blocks on the Castello Wiese. This is true for other beds, such as the ashy series, the ferruginous marls, and the beds of hard Cipit Limestone. One after another, these beds are cut off, and beds of a different palæontological and lithological character appear in their place.

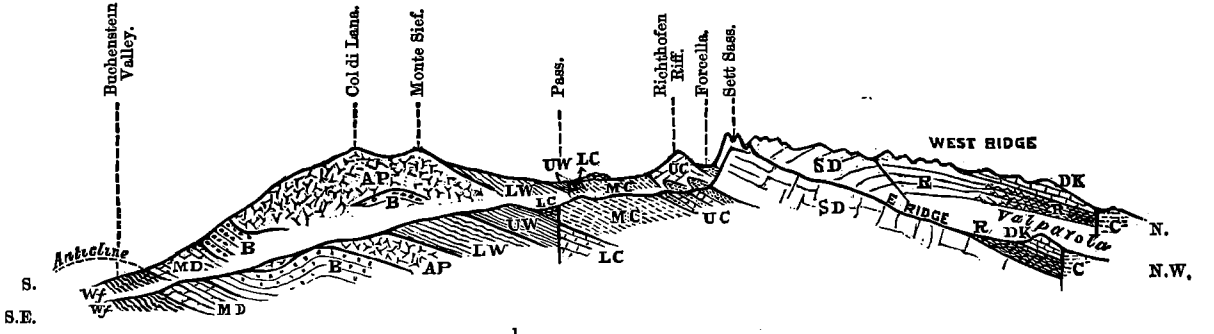
(2) The beds thus cut off have in the neighbourhood of the line of fault a strike N. 50° W., and the beds faulted against them strike N. 25°–30° E., the two systems meeting almost at right angles to one another.

The succession of beds in the section, although interrupted by this fault-line, fall into the main groups as before:—

	Sett Sass and Monte Sief.	Castello.	
St. Cassian Beds..	Nos. 14–9.	Nos. 14–11 (in part).	See Section 3 in Table facing p. 16.
	* * *	* * *	
	* * *	No. 9 *a*.	
Wengen Beds....	* * *	No. 8 *a*.	
	Nos. 8–2.	Nos. 8–2.	
Buchenstein Beds	..No. 1.	No. 1.	

The Wengen and St. Cassian strata of all three sections may be further subdivided into well-marked zones, based both on palæontological and stratigraphical evidence. A marked feature in the Prelongei district is the occurrence of thickly-bedded and sometimes massive limestones at the base of the St. Cassian Series. They have all the appearance of, and agree palæontologically with, the Cipit Limestones first recognized by Richthofen on the Seisser Alpe. In several traverses which I made over St. Cassian and Wengen strata exposed in various localities between the Seisser Alpe and the district of Prelongei, I observed such Cipit Limestones always at the horizon where the St. Cassian fauna begins to appear, and where the commonly occurring Wengen fossils begin to lessen in number. I have therefore accepted this horizon as the best stratigraphical limit between the Wengen and St. Cassian Beds.

Fig. 3.—*Section from the Buchenstein Valley through Sett Sass.*



[Scale: $\frac{1}{50000}$ = 1·267 inch to the mile.]

DK = Dachstein Dolomite.
R = Raibl Beds.
SD = Schlern Dolomite.
UC = Forcella Zone. } Middle
MC = Stuores Zone. } St. Cassian.

LC = Cipit Limestone—Lower St. Cassian.
UW = Upper Wengen Beds.
LW = Lower Wengen Beds.
AP = Augite-porphyry (with Agglomerates).

B = Buchenstein Beds.
MD = Mendola Dolomite (Muschelkalk).
Wf = Werfen Beds.

This horizon is further accentuated by a sheet of augite-porphyry in the fossiliferous marls and limestones immediately above the Cipit Limestone, and the subsequent intermixture of ashy rock with the ordinary marine sediments. The fossils in the ashy rocks are few and fragmentary, but passing upward they increase in number and variety, until in the beds on the Prelongei ridge the St. Cassian fauna as such reaches its highest point.

As appears from Section 3, a higher series of fossiliferous marls and shaly limestones succeeds, in which thick beds of limestone and a dolomitic rock thin out. The limestone-rock has been called 'Cipit Kalk,' and indeed it looks exactly like the Cipit Limestone of the lower horizon. Nevertheless, it is no constant bed at this horizon; the beds above and below have the same characters and the same fauna, whereas the Cipit Limestone group at the lower horizon has both a stratigraphical and palæontological value. Above this, the highest fossiliferous series, the rock is entirely dolomitic.

For palæontological reasons which are explained below, I have grouped the whole series of strata between the Lower St. Cassian zone and the Schlern-Dolomite rock of Sett Sass as the 'Middle St. Cassian' or 'Stuores' zone; farther east, a higher palæontological horizon succeeds above the 'Stuores' zone and below the Schlern Dolomite. In collecting the fossils in the St. Cassian district I was very careful to keep separate these of the Forcella di Sett Sass from those of Prelongei and Stuores meadows, the 'Forcella' zone having been more than once referred to Raibl age.

Local Development and Exposure.

Middle St. Cassian Beds.	The 'heteropic' strata of the Richthofen Riff and Castello conformably underlying the Schlern Dolomite. Fauna: see List of Fossils found on Forcella di Sett Sass.
	The series of fossiliferous beds on the Prelongei ridge.
	The less fossiliferous ashy beds forming the main mass of the strata on Stuores, Piccol, Ruones and Corte slopes. Fauna: see List of Fossils, pp. 48 *et seqq.*, under 'Stuores' (Prelongei, Stuores, Piccol, Ruones and Corte slopes included).
Lower St. Cassian Beds.	Hard thickly-bedded limestone, sometimes forming massive rock—occurring as a firm band throughout the lower level of the slopes mentioned above. Fauna: pre-eminently that of a reef-limestone, including: *Cidaris dorsata, C. Rœmeri; Encrinus cassianus, Pentacrinus propinquus; Thamnastræa Zitteli.*

The best exposures of Wengen Beds occur on Monte Sief and near Corvara; and, comparing these, a lower series, in which sedimentary tuffs, ashy grits, and *Halobia*[1] *Lommeli*-shales predominate,

[1] [In a recent publication—'Die Perm- Trias- und Jura-Formation auf Timor und Rotti' (Palæontographica, vol. xxxix. Aug. 1892), Dr. A. Rothpletz has shown (pp. 91–96) that the differences hitherto recognized between *Daonella* and *Halobia* are not of generic value; the older name of *Halobia* is therefore used throughout the present paper.]

may be distinguished from an upper series, where the rocks remain comparatively free from the black volcanic material and are filled with remains of *Posidonomya wengensis*.

		Ruones.	Prelongei.	Sett Sass and Monte Sief.
Wengen Beds.	Upper Wengen Beds (not more than 100 feet thick).	Nos. 7 & 6	Nos. 7 & 6	Nos. 8[a] & 8 (in Castello section)
	Lower Wengen Beds (not less than 200 feet thick).	Nos. 5–3	Nos. 5 & 4	Nos. 7–5 (Monte Sief)
	Augite-porphyry, tuffs, and *Halobia*-shales.	Nos. 2 & 1	Nos. 3 & 2	Nos. 4–2 (*ibid.*)
			Buchenstein Beds.	Buchenstein Beds.

It is more especially in the Lower Wengen Series of black tuffs and thin-bedded shales that the bending and faulting occur. The augite-porphyry is very thick, and, together with the tuffs and black *Halobia*-shales of Corvara, adds a considerable thickness to the Wengen Series.

Only after a detailed examination of the Wengen and St. Cassian Beds, such as has been above attempted, is it possible to attain a clear idea of the tectonic relations of the neighbourhood of St. Cassian. I could only map the main faults; while the numerous small disturbances in the beds of a single series could not be shown in the reduced map which accompanies this paper. But the fact that it is impossible to walk for half an hour in these meadows without meeting some apparently insignificant change in the strike and dip is, if in the beginning bewildering, in the end the surest testimony that the whole succession has been subjected at one time or another to great strain and pressure; the small faults within the series of softer beds have thus an important significance with regard to much greater faults in the near vicinity.

The outlying parts of the geological map of Prelongei and Sett Sass, those towards the Sella *massif*, Centurinus Spitz, and Lagazuoi, were not examined in the same detail as the central area, but only with the view of confirming the broad features of the succession and of determining the tectonic relations of the district.

Sections 4 *and* 5. *Enneberg* (*Abtey*). (See pp. 26, 28.)

The next two sections which will be considered are taken from the Abtey portion of Enneberg; they are to the north of the area included within Map A. The first is drawn in an east-and-west direction from the Kreuz Kofl (9500 feet) through the exposures beside the Heiligkreuz Kirche (a pilgrimage chapel at a height of 6600 feet), meets the Gader stream (4200 feet), and

ascends on the opposite side to the Gardenazza *massif* at a level of about 6200 feet. In the line of section the Gardenazza Berg does not reach a greater height than 7600 feet.[1]

Section 4 (see p. 26).

A. Gardenazza Slope.

Schlern Dolomite.

Middle St. Cassian.	A certain portion of marly beds almost entirely covered by the dolomite-blocks from above. Shaly thin-bedded limestones, with interstratified thick beds of fossiliferous limestone (the fossils are typical 'Stuores' St. Cassian). Beds of dark blue limestone with calcite-veins, less fossiliferous (about the 1740 met. contour-line). Ashy shales, and beds of tuff. (Sometimes fossils occur in the shales; plant-remains are very frequent.)
Lower St. Cassian.	Oolitic limestone-beds, especially full of corals and encrinites (*Encrinus cassianus*, Laube), various sponges and cidarid spines.
Wengen.	Grey shaly limestones and dark shales at the 1600 met. contour. Numerous well-preserved specimens of *Posidonomya wengensis* and of the previously mentioned small variety of *Posidonomya* (sp.?); *Trachyceras furcatum*, Münst., 1 specimen. Several ammonites were found, but not in good preservation. Rough marls and limestones, with plant-remains and unrecognizable fossils on the weathered surface. Some of these were cidarid spines. A series of ashy grits and sandy rocks, brown earthy tuffs, and impure limestones; not well exposed, except in the course of the Gader stream below St. Leonhardt (Abtey).

The St. Cassian Beds in this section strike through the Abtey 'Muren' towards Pescol, where the characteristic fossils are found both lying free and in the hard limestone-rock.

B. Heiligkreuz Slope.

Dachstein Dolomite of Kreuz Kofl.

Raibl Beds.

* * * * * * * *

Upper St. Cassian.	'Heiligkreuz Schichten'[2] (according to the original application of the name by Wissmann) = grey, thinly-bedded shaly limestones with (*Natica*) *Ptychostoma sanctæ-crucis*, Wissm. sp.; *P. pleurotomoides*, Wissm. sp.; *Nucula inflata*, Wissm.; *Avicula depressa*, Wissm.;

[1] I give these heights in the usual English measure, but the sections are more conveniently described with direct reference to the Austrian Survey Map, by using the 100-metre contours.

[2] The name of 'Heiligkreuz Schichten' was first used by Wissmann ('Beiträge zur Geognosie u. Petrefactenkunde des S.-O. Tirols,' Heft iv. pp. 19, 21, Bayreuth, 1841) to denote 'einige graue Kalksteinschichten, welche auf dem rechten Gehänge des Abteithals und zwar etwa in der Mitte zwischen der weithin sichtbaren Heiligkreuzkirche und St. Leonhardt (Abtei) ganz isolirt zu Tage gehen.' Wissmann then gives the list of fossils.

Upper St. Cassian.
Av. Gea, d'Orb.; (*Unionites*) *Anoplophora Münsteri*, Wissm.; *Omphalophyllia boletiformis*, Münst. sp.
The horizon containing these fossils extends some distance above and below the Heiligkreuz Kirche (thickness about 70 feet).

Middle St. Cassian.
Series of marls and concretionary shales, with occasional thicker beds of limestone much disturbed by slips.
Fossils:—*Nucula strigilata*, Goldf.; *N. lineata*, Goldf.; *Mytilus Münsteri*, Klipst.; *Halobia Richthofeni*, Mojs. sp.; *Koninckina Leonhardti*, Wissm. sp.; *Pentacrinus propinquus*, Münst.; *P. lævigatus*, Münst.; *Cidaris* (various); *Omphalophyllia cyclolitiformis*, Laube; *Lobites pisum*, Wissm.
[These beds were apparently included by Wissmann with the 'Heiligkreuz Schichten.']

Lower St. Cassian.
Thick beds of limestone below the 1900-metre contour (at this horizon the weathered stones and blocks scattered about had the Cipit Limestone character). *Encrinus cassianus* frequent.

Wengen Beds.
Limestones, thinly-bedded and full of *Posidonomya wengensis*, Wissm. (below the 1800-metre contour).
Ferruginous clays and shales.
Plant-bearing sandstones and shales.
Ashy rock, chiefly earthy unfossiliferous tuffs and grits.
Although the Wengen Beds on both sides of the valley have a large outcrop, they are seldom favourably exposed, and I did not succeed in finding good fossils.

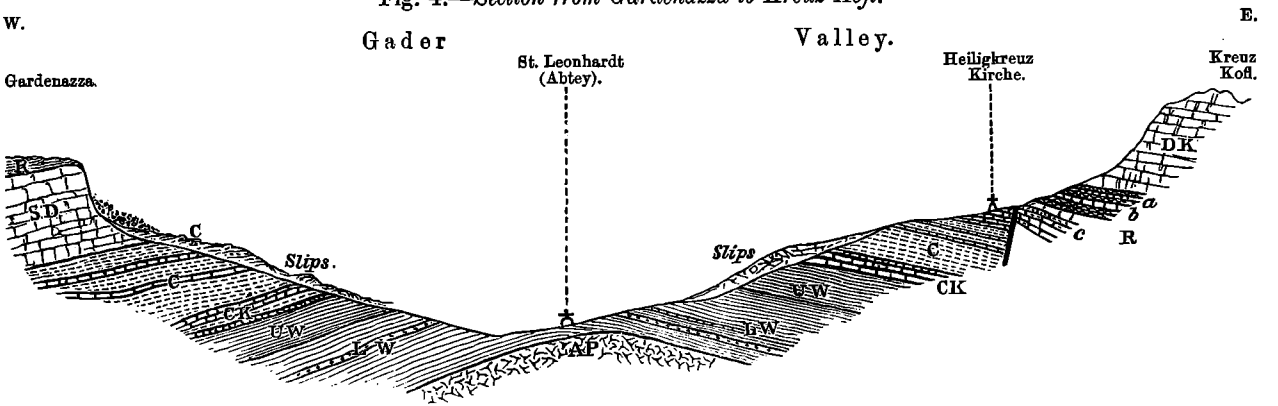
Having convinced one's self of the conformable succession of the Schlern Dolomite upon the St. Cassian strata at this part of the Gardenazza *massif*, it is the more striking to find this dolomitic horizon entirely absent in the section of the eastern side of the valley. This fact, no less than the special character of the fossils in the so-called 'Heiligkreuz Schichten,' has made the Abtey valley almost as interesting to geologists as the neighbourhood of St. Cassian.

The stratigraphical question will be discussed later, but the palæontological difficulty is to fix the age of the 'Heiligkreuz strata.' The beds immediately above them are indisputably of Raibl age; they are also very fossiliferous, and they have gradually become known in the literature as 'Heiligkreuz strata.' This confusion was largely due to a generally-held opinion that both series of strata were of Raibl age, and the main line of effort in the literature has been to determine with what horizons of the Raibl Beds they should be correlated.

Richthofen's sequence of strata from below the Heiligkreuz Kirche up to the Dachstein Kalk may be thus shortly quoted (in descending order):—

Limestone of Kreuz Kofl.
Red sandstone with lignite, interstratified with fossiliferous limestone (*Ostræa montis-caprilis*, Klipst.; *Fimbria* (*Corbis*) *Mellingi*, Hauer, sp., etc.).
Reddish limestone.
'Heiligkreuz Schichten' with *Anoplophora Münsteri*, Wissm., *Avicula Gea*, d'Orb., etc.
Dolomite-bank with baryta.
Fine-grained sandstone.

Fig. 4.—*Section from Gardenazza to Kreuz Kofl.*



[Scale : $\frac{1}{50000}$ = 1·267 inch to the mile.]

DK = Dachstein Dolomite.

R = Raibl Beds. { *a.* Dolomitic marls, breccias, and flags. *b.* Marls and dolomite. *c.* Fossiliferous beds.

SD = Schlern Dolomite.

C = Middle St. Cassian ('Stuores' zone).

CK = Cipit Limestone beds ⅝ (Lower St. Cassian).

UW = Upper Wengen shales and limestones.

LW = Lower Wengen ashy shales.

AP = Augite-porphyry.

Note.—The limestones shown at the Heiligkreuz Kirche are 'Heiligkreuz Strata' (Upper St. Cassian).

Richthofen described the stratigraphical position of the 'Heiligkreuz strata' as being above the St. Cassian Beds, and remarked that it was possible, owing to similarity of the fossils, to look upon the 'Heiligkreuz strata' merely as a higher stage of St. Cassian. However, influenced by other reasons, and from the fact that at that time the same fauna had not elsewhere been found either in the Raibl or St. Cassian Beds of the district, he concluded that they belonged in reality to a much higher horizon than the St. Cassian Beds.

Stur[1] found the same fossils as those collected by Wissmann, also *Myophoria chenopus*, Laube, and *Cardinia problematica*,[2] Klipst. A comparison of the fossils found at the horizon of the 'Heiligkreuz strata' and in the higher horizon of beds containing *Ostrea montiscaprilis*, Klipst., led Stur to group the whole series together as the probable equivalent in age of the 'Torer' horizon of Raibl strata (*i. e.* Upper Raibl). He noted, however, certain resemblances between the special mode of development of the 'Heiligkreuz strata' and the strata on the Forcella di Sett Sass—both he regarded as Raibl Beds. Mojsisovics, on the other hand, assigned the Heiligkreuz Series ('Dolomit Riffe,' pp. 263, 264) to *Lower* Raibl, resting conformably on St. Cassian strata containing *Halobia cassiana*, Mojs. sp., *H. Richthofeni*, Mojs. sp., etc.

After comparison of the fossils from the 'Heiligkreuz Schichten' of Wissmann (sections on pp. 24 & 25) I regard these beds as a true St. Cassian horizon, succeeded unconformably at Heiligkreuz by a true Raibl horizon (viz. the *Ostræa*-limestone, etc.). For there is no characteristic fossil in the 'Heiligkreuz strata' which has not been found in the St. Cassian strata, either on Stuores or below Sett Sass. *Anoplophora Münsteri*, Wissm., and *Avicula Gea*, d'Orb., occur in the strata below Sett Sass. The *Ptychostomata* occur on Stuores; *Myophoria chenopus*, Laube (identified by Wöhrmann with *Myophoria Whateleyæ*, Buch, sp., a characteristic Raibl form) is found both below Sett Sass and on Stuores Wiese, as also *Cardita crenata*, Goldf.

The peculiarity of the fauna rests alone in the fact that at Heiligkreuz the species are few and the individuals very numerous. In the main the fauna is of St. Cassian type, although some species are common to the later 'Raibl' period. The horizon of the 'Heiligkreuz Schichten' is higher than the St. Cassian strata of Prelongei and Forcella di Sett Sass, and may be called "Upper St. Cassian."

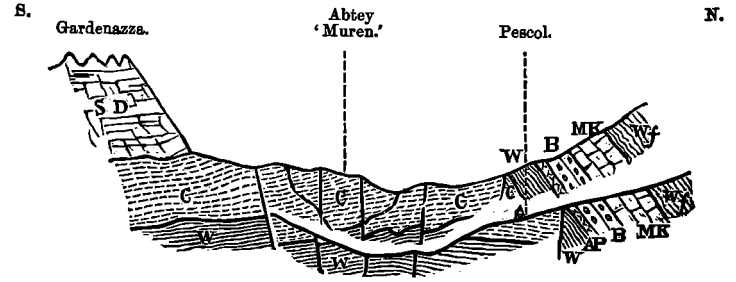
I must briefly mention Section 5 (p. 28) to the north of Gardenazza. On going over the pass between the Gader and Campil valleys, St. Cassian fossils are found among the rocks below Gardenazza. Just as on the eastern side, the marls and limestones on

[1] Stur, 'Eine Excursion in die Umgegend von St. Cassian,' Jahrb. d. k. k. geol. Reichsanstalt, 1868, pp. 555, 556, and 'Beiträge zur Kenntniss d. geol. Verhältnisse d. Umgegend von Raibl u. Kaltwasser,' *ibid.* pp. 111–117.

[2] *Cardinia* (*Unio*) *problematica*, Klipst. sp., is quoted by Klipstein as occurring in beds at a much lower horizon on the slopes; see his 'Beiträge zur geol. Kenntniss d. östlichen Alpen,' p. 265, Giessen, 1843.

the western side have given way in a number of places, although no such extensive landslip has occurred as on Abtey Muren. These beds are continued westward and underlie conformably the Schlern Dolomite of Zwischenkofl. (See p. 65 for further notes on this Section.)

Fig. 5.—*Section from Gardenazza northward.*



[Scale: $\frac{1}{37500}$ = 1·9 inch to the mile.]

SD = Schlern Dolomite.	B = Buchenstein Beds.
C = St. Cassian Beds.	MK = Mendola Dolomite.
W = Wengen Beds.	Wf = Werfen Beds.
AP = Augite-porphyry.	

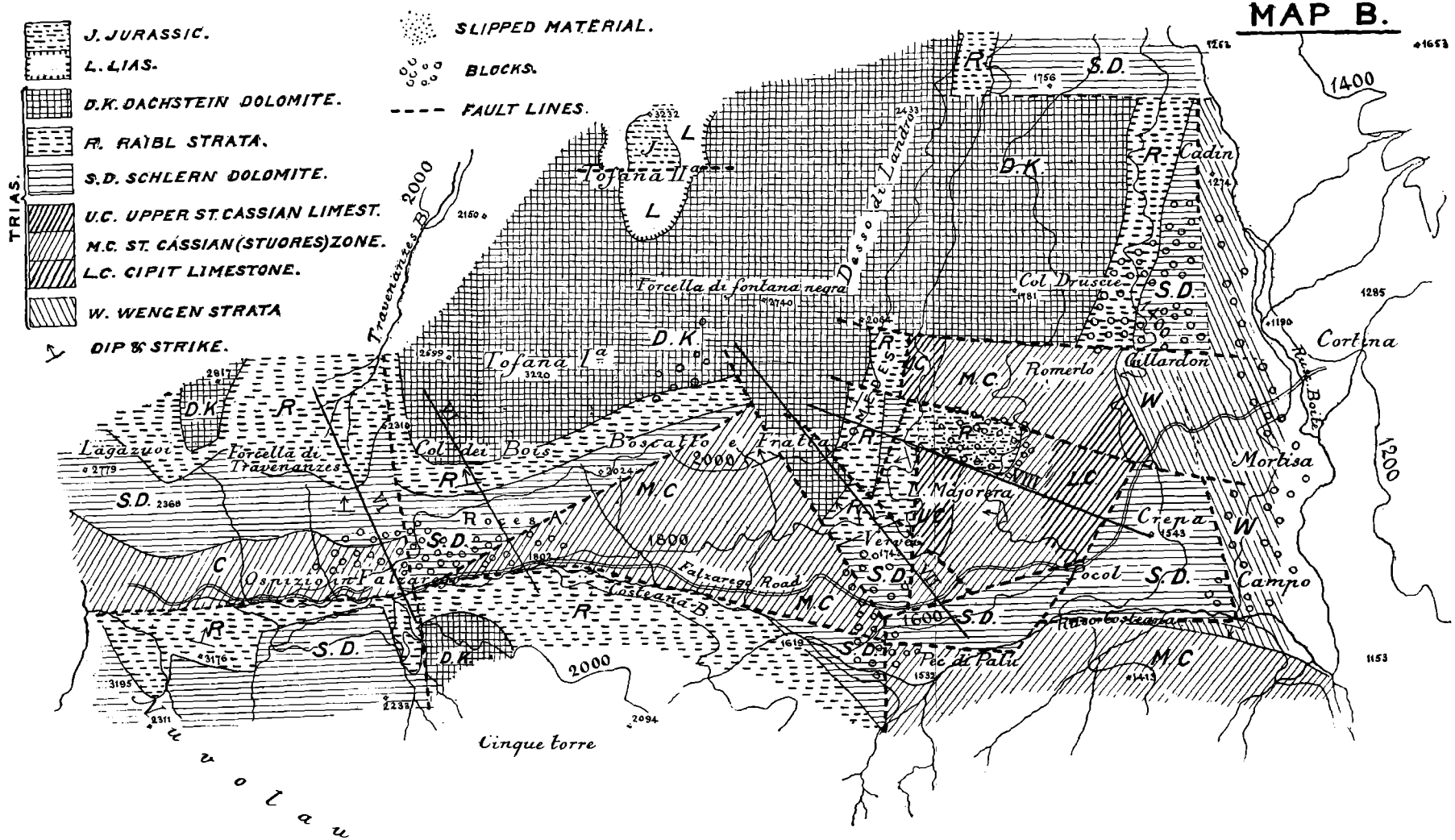
Cortina d'Ampezzo (*Map* B).

The district of Ampezzo has occupied a less important place in the older literature than Schlern and the Seisser Alpe or St. Cassian. Loretz, who first made known the fauna of the Falzarego Valley, Misurina, and Seeland Valley, laid the foundation of our knowledge of the Ampezzo dolomites; and the work of Hoernes in co-operation with Mojsisovics materially advanced the geology of the district.

The meadows and slopes west of Cortina d'Ampezzo proved of unusual interest for the study of St. Cassian strata, and I spent several days in collecting the fossils at various horizons. The localities where the fossils weather out of the beds in any considerable number are:—

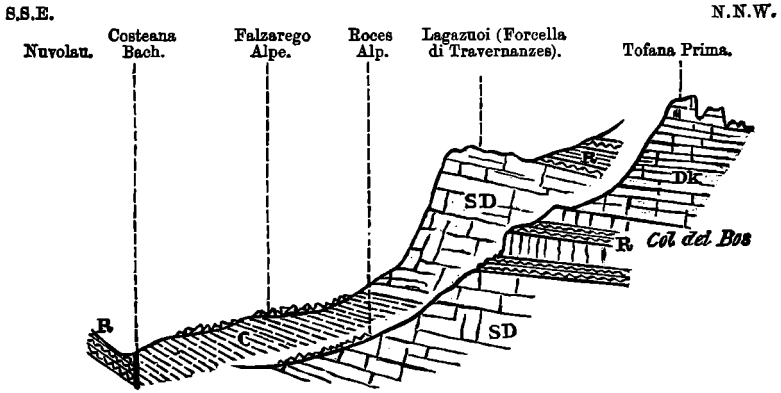
(1) On the hill above Romerlo.
(2) Below the Majorera ridge, in the stream-sources and the exposed slips of thick series of beds, facing Crepa.
(3) Among the wooded slopes of Roscatto e Fratta, from the highest beds below the rocks of Tofana to the Costeana stream in the valley.
(4) South of the Costeana stream, in a series of strips along its southern bank, eastward from Pec di Palu.
(5) West of Ospizio in Falzarego, in marls and limestones conformably underlying the dolomite-rock of Lagazuoi.

To face p. 28.



GEOLOGICAL MAP OF FALZAREGO VALLEY & CORTINA

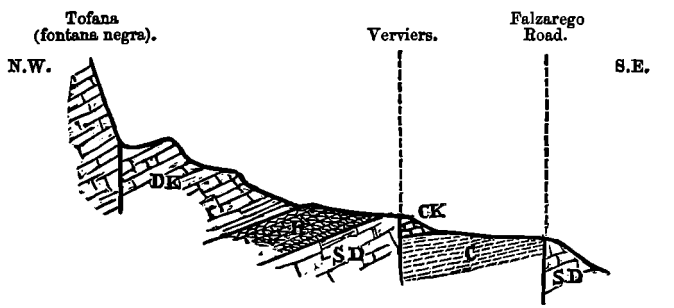
Fig. 6.—*Section through the Roces Alpe.*



[Scale: $\frac{1}{25000}$ = 2·534 inches to the mile.]

DK = Dachstein Dolomite.
R = Raibl Beds.
SD = Schlern Dolomite.
C = St. Cassian Beds.

Fig. 7.—*Section from Tofana (fontana negra) to the Falzarego Road.*



[Scale: $\frac{1}{50000}$ = 1·267 inch to the mile.]

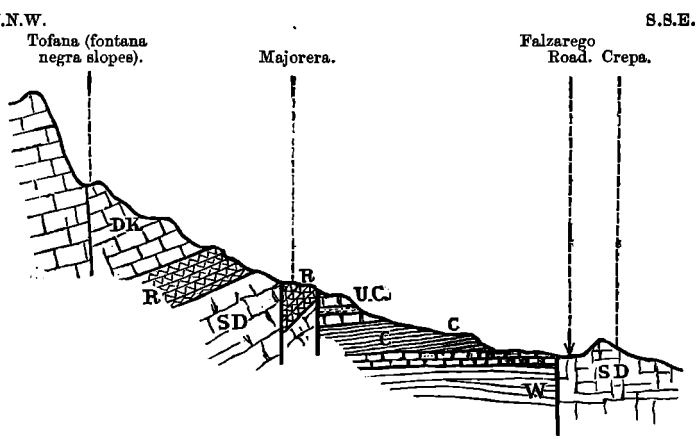
DK = Dachstein Dolomite.
R = Raibl Beds.
SD = Schlern Dolomite.
Upper St. Cassian. { CK = Cipit Limestone Beds. / C = Ferruginous Marls.

Fig. 6 (p. 29) has chiefly a tectonic interest, and will be referred to under Part VIII. of this paper (p. 67).

The strata on the Falzarego Alpe, which conformably underlie the Schlern Dolomite of Lagazuoi, and extend down to the Costeana stream, contain the typical St. Cassian fossils; and the series may be traced farther west, conformably underlying the Schlern Dolomite on both sides of the descent from the Tra i Sassi Pass towards Valparola. The same beds, containing an identical fauna, are exposed beside the Raibl Beds and the Dachstein Dolomite north of Sett Sass, and appear with their greatest outcrop freely exposed on the Stuores Wiese, Prelongei, and the Forcella di Sett Sass.

Fig. 7 may be compared with fig. 8; in the latter a conformable succession of the fossiliferous strata is shown from the Majorera slope, at about the 1800-metre contour, to the meadows at the base of Crepa, between the 1400 and 1500-metre contours. The beds strike north and south, and dip not more than 10° west.

Fig. 8.—*Section from Tofana (fontana negra) to Crepa.*



[Scale: $\frac{1}{50000}$=1·267 inch to the mile.]

For explanation, see index to fig. 9, p. 32.

Upper St. Cassian Beds (see 'Cortina' in the List of Fossils, pp. 48 *et seqq.*).

Below the 1800-metre contour a hard, light grey limestone-rock, sometimes slightly dolomitic, containing spines of *Cidaris dorsata*, and looking like the Cipit Limestone of lower horizons. In parts of the rock, bedding is more marked, and fossils weather out. Cidarid spines, small corals and gasteropods were found.

Shaly limestone-beds, breccias of tuff and limestone, highly fossiliferous. This rock is often coloured dark red by interstitial ferruginous earth.

Middle St. Cassian (see 'Romerlo' in the List of Fossils).	(About the 1600-metre contour) reddish-brown ferruginous marls, and black earthy beds, containing characteristic St. Cassian fossils and, in especial abundance, various species of *Cidaris*.
	Marls and thin-bedded limestones, aragonite and gypsum-bands, with sometimes large geodes; very good specimens of corals and sponges were found.
Lower St. Cassian.	Hard yellowish limestone, breaking up in large blocks; on the weathered surface of some of these, lithodendroid corals and encrinites are frequently seen.
Wengen Beds (part).	Ashy beds, exposed in the streams below Lacedel.
	Débris at lower levels.

The character of the fossils which occur in the five lowermost divisions of the above section; the great predominance in number of the small bivalves, gasteropods, cidarid spines, corals, and sponges; as well as the lithological character of the hard limestone, the marly beds and loose ferruginous earth in which the fauna occurs, enable one to refer these horizons with certainty to the St. Cassian Series.

The Middle St. Cassian strata are present on the hill and the 'Wiese' west of Romerlo, on the slopes west of the Verviers chalets, again south of the Costeana stream, and west of Ospizio in Falzarego. The Upper St. Cassian strata have their chief exposure south-east from Verviers and in the stream-sources below the Majorera ridge, conformably above the wide outcrop of Middle St. Cassian on the 'Wiese.' The fossils found in the last-named strata are at once recognizable as essentially a 'Stuores' fauna, but in the Upper St. Cassian, although many species of corals, gasteropods, etc., are characteristic of the 'Stuores' horizon, a certain number of species are common to both St. Cassian and Raibl faunas (e.g. *Grünwaldia* (*Cassianella*) *decussata*, *Myophoriopis lineata*, *Avicula Gea*, *Ptychostoma pleurotomoides*, *Cidaris dorsata*), while several species, such as the very commonly occurring *Avicula*, n. sp., and *Placunopsis*, n. sp., have not yet been found in any other locality.

The palæontological relations of these two horizons of St. Cassian strata are more fully discussed in Part VII. of this paper (p. 45).

As has already been said, the 'Heiligkreuz strata' of the previous section contain a limited fauna which seems to diverge from that of the Middle St. Cassian strata of Stuores. The fossils of the 'Heiligkreuz strata' do not definitely prove a higher horizon; they might be simply a local facies. It is therefore very important to find that two of the characteristic species found in the 'Heiligkreuz strata,' *Ptychostoma pleurotomoides* and *Naticopsis neritacea*, are common in these Upper St. Cassian strata of the Cortina district. This fact suggests that the 'Heiligkreuz strata' are the equivalent in part of the Upper St. Cassian horizon.

I have dwelt at some length on the St. Cassian strata of Cortina, chiefly because they have for the most part been included with the Wengen strata by Mojsisovics, with the Schlern-plateau strata (Raibl fauna) by Loretz, and also because the fauna up to this time was comparatively little known.

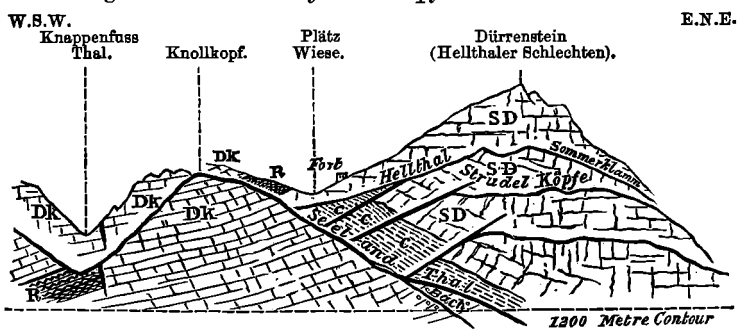
As the Cortina map shows (Map B, facing p. 28), St. Cassian Beds are faulted against all the higher strata—Dachstein Dolomite, Raibl Beds, and Schlern Dolomite, and the identification of the fauna is all-important for the tectonic relations of the valley.

Section 9. St. Cassian and Wengen Beds in the Dürrenstein Massif (Map C).

Although the fossils collected in the Seeland Valley, north of Schluderbach, have been familiar to palæontologists since Loretz's first examination of them in 1874,[1] the exact age of the strata in which they occur remains still doubtful. Loretz referred the beds, like those on Cortina and Falzarego meadows, to the horizon of the Raibl strata known generally as Schlern-plateau strata, while in Mojsisovics' 'Dolomit-Riffe' they are regarded as Wengen Beds, with the exception of a very small portion at the head of the Seeland Valley, which are recognized as St. Cassian Beds.

The strata of the Seeland Valley are composed of fossiliferous marls and shales, unfossiliferous beds of hard light-grey limestone with celestine or calcite-veins, and thinly-bedded unfossiliferous shaly limestones. In the higher horizons some thick limestones occur,

Fig. 9.—*Section through Knollkopf and the Dürrenstein.*



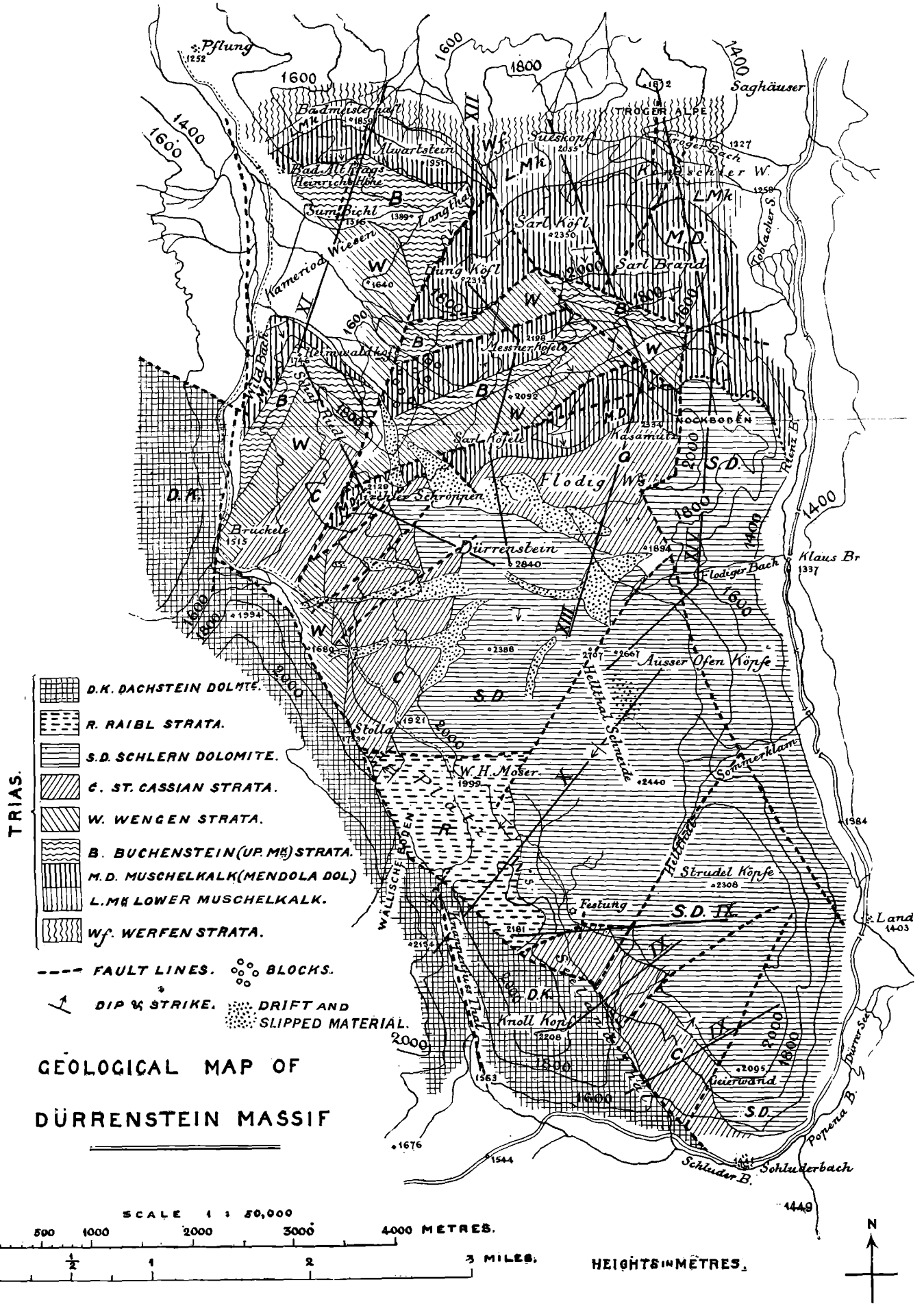
[Scale: $\frac{1}{50000}$ = 1·267 inch to the mile.]

[The Schlern Dolomite of the Dürrenstein should have been shown dipping to the W.S.W., and passing conformably under the Raibl Beds.]

DK = Dachstein Dolomite.
R = Raibl Beds (marls, limestone, rauchwacke).
SD = Schlern Dolomite.
UC = Upper St. Cassian Limestones.
C = St. Cassian Strata (marls of the Stuores zone in fig. 8; fossiliferous marls and limestones, unfossiliferous marls and shales in fig. 9).
W = Wengen shales and limestones.

[1] 'Einige Petrefacten d. alpinen Trias a. d. Südalpen.' Zeitschr. d. Deutsch. geol. Gesellsch. vol. xxvii. (1875) p. 784; see also *ibid.* vol. xxvi. (1874) p. 377.

MAP C.


TRIAS.
D.K. DACHSTEIN DOLMTE.
R. RAIBL STRATA.
S.D. SCHLERN DOLOMITE.
C. ST. CASSIAN STRATA.
W. WENGEN STRATA.
B. BUCHENSTEIN (UP. Mk) STRATA.
M.D. MUSCHELKALK (MENDOLA DOL)
L.Mk LOWER MUSCHELKALK.
Wf. WERFEN STRATA.
FAULT LINES.
BLOCKS.
DIP & STRIKE.
DRIFT AND SLIPPED MATERIAL.
GEOLOGICAL MAP OF
DÜRRENSTEIN MASSIF
SCALE 1 : 50,000
0 500 1000 2000 3000 4000 METRES.
0 ½ 1 2 3 MILES.
HEIGHTS IN METRES.
N
Pflung
Saghäuser
TROGER ALPE
Badmeisterhaus
Alwartstein
Bad Alt Prags
Heinrichshöhe
Sum Bichl
Sarl Köfl
Sarl Brand
Tohlacher W.
Tohlacher S.
Kameriod Wiesen
Lung Köfl
Alesser Köfels
Hellmauthköfl
Sarl Köfels
NOCKBODEN
Kasamütz
Flodig
Flodiger Schröpfen
Bruckele
Dürrenstein
Flodiger Bach
Klaus Br
Ausser Ofen Köpfe
Hellthal Schneide
W.H. Moser
Sommerklamm
Strudel Köpfe
Festung
Wallische Boden
Knoll Kopf
Geierwand
Popena B.
Schluderbach
Schluder B.
Dürrer See
Rienz B.
Land

full of corals and sponges, and larger blocks from these, weathering to a bright yellow colour, are strewn across the valley. The fossils in the marly beds weather out loose, and are found, as at Stuores, in a perfectly preserved state. If the ground here be carefully studied and the fossils collected in the individual beds, the extent and distribution of the various horizons may be clearly marked, and it is found that the confusion complained of in the Seeland Valley is largely owing to two small cross-faults which have brought the fossiliferous strata in immediate contact with less fossiliferous beds. I have attempted to represent these relations in Section 9 by drawing parallel sections in perspective through different heights of the Seeland Valley, from the Ampezzo road (at a height of about 4600 feet) to the prominent rock on which the new fort is built (height about 6600 feet).

The interest of the Seeland Valley centres in the fauna, and, referring to the List of Fossils (pp. 48 *et seqq.*), it becomes at once clear that, as in the case of Cortina, the greater number of species agree with the true Stuores fauna, but a certain number are new. To accept the Seeland Valley strata as a facies of Raibl Beds would be difficult on stratigraphical grounds, for they unquestionably dip under the Schlern Dolomite of the Dürrenstein. As St. Cassian fossils occur in greater or lesser number throughout the whole series of strata exposed in the valley, I have mapped these as St. Cassian, distinguishing the higher horizons, containing many new species, as Upper St. Cassian Beds. In recent palæontological work this view is already gaining ground. For example, Bittner[1] says, with reference to the brachiopods which he describes from Falzarego, Misurina, and the Seeland Valley:—"The strata of these three localities belong apparently to the same horizon, which, if not identical with that of St. Cassian, stands, as regards fauna and stratigraphical position, at any rate very near [to it]."

Kittl[2] says:—"Judging from the position of the St. Cassian strata on the Seeland Alpe, these seem to answer to the upper part of the *Aon*-zone of the Stuores-Wiese St. Cassian Beds, with which they agree in lithological characters."

In the second part of the same paper, Kittl, influenced by the occurrence of the same species in all three localities (Stuores Wiese, Heiligkreuz, and the Seeland Valley), says in a short note that probably, after all, the Heiligkreuz strata may not be far removed from the *Trachyceras Aon*-zone. The specimens in question were of *Ptychostoma pleurotomoides*: this species, and also the characteristic *Naticopsis neritacea*, I found on the Cortina meadows. Without doubt, the further examination of the fauna in all four localities will supply corroborative evidence of their close relationship.

[1] 'Brachiopoden der Alpinen Trias,' Verhandl. d. k. k. geol. Reichsanstalt, vol. xiv. (1890) p. 112.

[2] 'Die Gastropoden der Schichten von St. Cassian der südalpinen Trias,' Annal. d. k. k. Naturhist. Hofmuseums, vol. vi. pp. 166–262, Vienna, 1891.

Fig. 10.—*Section from Badmeister Kofl to the Dürrenstein.*

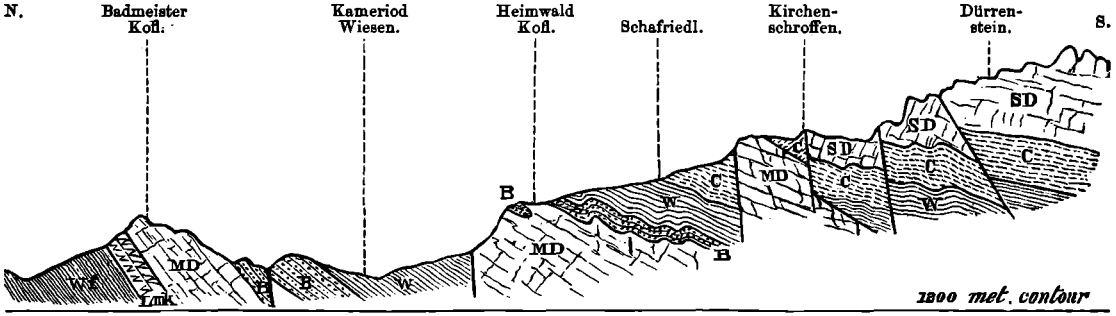
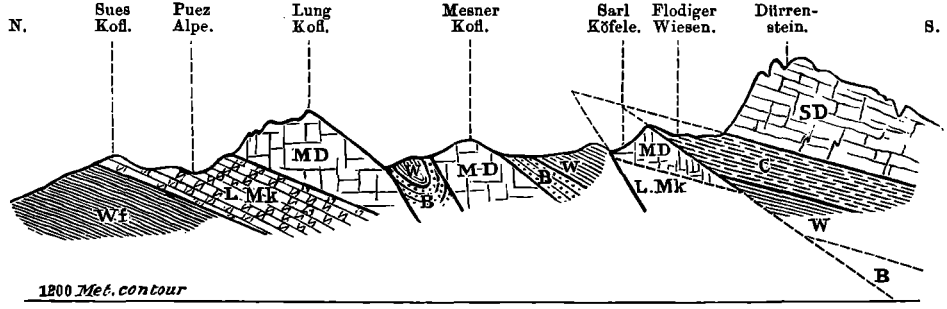


Fig. 11.—*Section from Sues Kofl to the Dürrenstein.*



SD = Schlern Dolomite.
C = St. Cassian strata.
W = Wengen Beds.

B = Buchenstein Beds and Upper Muschelkalk.
MD = Mendola Dolomite.

LMk = Lower Muschelkalk.
Wf = Werfen Beds.

Fig. 12.—*Section from the Dürrenstein to Sarl Kofl.*

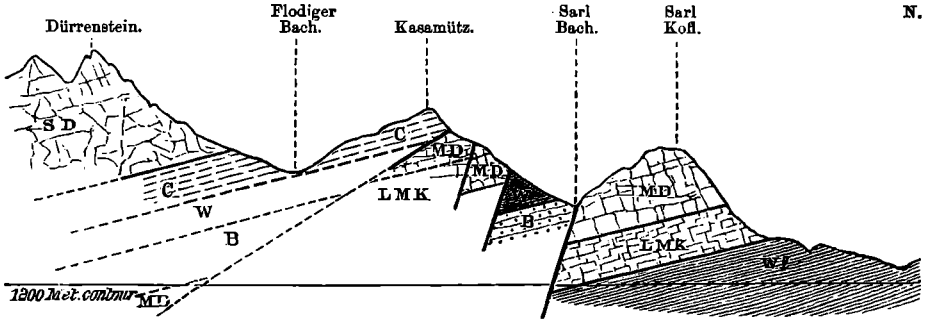
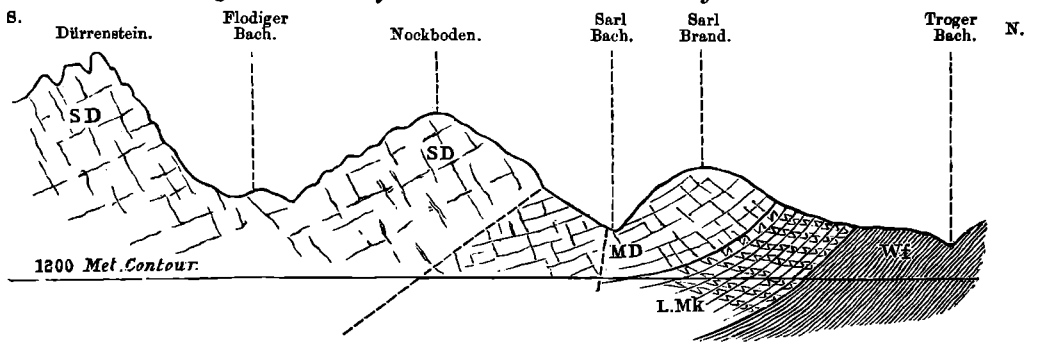


Fig. 13.—*Section from the Dürrenstein to the Troger Bach.*



[Scale of the above four sections: $\frac{1}{50000} = 1{\cdot}267$ inch to the mile. *Note.*—For explanatory index, see below fig. 11.]

On the Misurina Alpe, the fossiliferous strata are identical with those of the Seeland Valley, and they dip eastward beneath a low range of hills towards Rimbianco. In the stream at the bend of the Rimbianco Valley towards Monte Pian I found some particularly fine corals and sponges, small cidarid spines, and bivalves in dark earthy marls. Above these St. Cassian strata one finds dolomite in position on the low hills forming the Misurina and Rimbianco watershed; it occurs on the eastern slopes as blocks, sometimes massed together like huge ruins of a continuous wall.

The further occurrence of fossiliferous horizons below the Schlern Dolomite of the Dürrenstein *massif* is on the steep slopes between Stolla and Brückele and on Flodiger Wiese. Just above Stolla, at the 2000-metre contour, a thick bed of Cipit Limestone forms a prominent rock on the wooded slopes. It belongs to the highest horizon of the St. Cassian Beds. Lithologically, the beds have the same character as in the Seeland Valley, but except at one or two favourable points, such as the Stolla and the Brückele Alpen, the fossils do not weather out in the same abundance. This arises partly from the steepness of the incline on which they are exposed, and from the constantly increasing screes of débris from the overlying rocks; largely also because a scrubby vegetation of larch and dwarf-pine prevents the free exposure of the fossiliferous marls. Within the last two years new landslips have occurred just south of Stolla, and the St. Cassian Beds are now laid open below the Dürrenstein over a considerable area—so that in course of time fossils of that age may be readily collected there.

This case I emphasize, because it is analogous to several others, where the St. Cassian Beds underlie the Schlern Dolomite in their normal thickness, but are apparently poor in fossils, and where no favourable outcrop on a broad 'Alp' or 'Wiese' is afforded to them in the immediate vicinity.

The Wengen Beds are not exposed on the Misurina hills or in the Seeland Valley; but towards Prags the Wengen Series follows conformably below the St. Cassian. The distribution of the beds is shown in Map C, facing p. 32, and in figs. 10, 11, & 12 (pp. 34 & 35).

They are not of an ashy character, as in the exposures farther west, but are interbedded shales and limestones, containing few fossils except in certain brown, banded shales full of *Posidonomya wengensis* and more rarely containing specimens of characteristic ammonites and *Halobia Lommeli*.[1] The thin and unevenly-bedded limestone, often with a micaceous glance on the bedded surface, the thick blue limestone with strongly marked calcite-veins, and the comparative poverty of fossils, are the chief features of the Wengen Beds in this locality. On the other hand, the Buchenstein Series below them is more fossiliferous than in the western districts; as already mentioned, it also includes but little ashy rock.

[1] See Loretz, Zeitschr. d. Deutsch. geol. Gesellsch. vol. xxvi. (1874) p. 378.

Seisser Alpe.

The particular interest attached to the exposure of Wengen and St. Cassian Beds on the Seisser Alpe lies in their stratigraphical relations with the Schlern Dolomite of Schlern. These have been discussed at length in the works of Richthofen, Gümbel, Mojsisovics, and others.[1]

On entering the Seisser Alpe from the Pufels ravine, the augite-porphyry and tuffs of Lower Wengen age are succeeded by a series of ashy rocks, strike N. 70° E., dip slightly southward, as follows:—

Middle St. Cassian Beds (in part).	Cipit Limestone series, almost entirely eroded from the Alpe.
	Fossiliferous marls, interbedded with unfossiliferous earthy tuffs, and ashy shales and grits.
Lower St. Cassian.	Fossiliferous limestone=first Cipit Limestone-bed of Richthofen.
Wengen Beds.	Grey shales with *Halobia Lommeli*, fine breccia of tuff and limestone-fragments. Black earthy tuffs and shales.
	Plant-bearing sandstones, grey limestone, with rough weathered surface on which badly-preserved fossils are observed.
	Tuffs and augite-porphyry=the 'Regenerirte Tuffe' series of Richthofen; *Pachycardia rugosa* occurs in the tuffs.

The Cipit blocks scattered on the higher parts of the Seisser Alpe are yellowish-brown limestone full of lithodendroid corals and *Encrinus cassianus*. These are found in position near the source of the Cipit Bach, hence the name originally given by Richthofen.

The strata on the Seisser Alpe form a syncline, and the same beds bend upward and are found on the Günserbuchl and the Mahlknecht slopes below Rosszähne. The rocks west of Mahlknecht are interbedded breccias and tuffs dipping slightly north. Wedged in the breccias are irregular masses of the Cipit Limestone, and upon the whole system the Schlern Dolomite of Rosszähne rests with a slight unconformity.[2]

The term 'regenerirte Tuffe' was applied by Richthofen (*op. cit.* p. 91) to the development of tuffs and conglomerates in the Upper Fromm Bach on the Seisser Alpe, previously observed by Emmrich, and containing *Pachycardia rugosa* in great abundance. Richthofen took these beds for a local development of Raibl strata resting upon the sedimentary tuffs of the Seisser Alpe, but Stur[3] observed the continuation of the 'regenerirte Tuffe' over a wider

[1] Richthofen, 'Geogn. Beschr. d. Umg. v. Predazzo,' p. 40, 'Seisser Alpe-section'; Gümbel, 'Das Mendel u. Schlern Gebirge,' Sitzungsb. d. k. k. Akad. d. Wissensch. Wien, 1873 (Pufler Schlucht-section); Mojsisovics, 'Dolomit-Riffe,' p. 154; Fraas, 'Scenerie der Alpen,' Leipzig, 1892, pp. 137, 166, etc.

[2] I owe this observation at Mahlknecht and Rosszähne in the first instance to the kindness of Dr. Rothpletz; in 1892, on a later visit to Schlern, I myself saw the relations of the Cipit Limestone and the tuffs at Mahlknecht.

[3] Jahrb. d. k. k. geol. Reichsanstalt, 1868, p. 541.

area of the Seisser Alpe and underlying the marls containing St. Cassian fossils.

Mojsisovics quotes '*Pachycardia*-tuffs' in Wengen strata from other districts, referring them to a horizon immediately above the plant-bearing sandstones ('Dolomit-Riffe,' pp. 55 and 56).

Emmrich, in 1840, found certain fossils in the higher marls, and on a later visit he obtained a great number and recognized them as a thoroughly representative 'Stuores Wiese' (*i. e.* St. Cassian) fauna. The fossils however occur, comparatively speaking, seldom; some of the characteristic species in Emmrich's collection are: *Cidaris baculifera*, *C. Rœmeri*, *C. Buchii*, *C. trigona*, *C. dorsata*, *C. decorata*, *C. flexuosa*; *Encrinus varians*, *E. cassianus*, etc.; many *Terebratulæ*, *Koninckina Leonhardti*; *Cardita crenata*, *Nucula lineata*, and many gasteropods. Emmrich says, referring to the Stuores fauna:—"The agreement was complete; even their general appearance and their mode of occurrence were the same."

In other words, as a general conclusion from the above sections, the St. Cassian strata of the Seisser Alpe correspond only with a part of the St. Cassian strata of Stuores; the richly fossiliferous zones on the ridge of Prelongei and below Sett Sass are not present on the Seisser Alpe.

Another feature which is at least worthy of mention here is the occurrence of the fossiliferous marls and Cipit Limestones on the Seisser Alpe, interbedded with ashy rocks; this is exactly how those fossiliferous horizons are found which I was enabled to distinguish in the Prelongei and Stuores district as Lower St. Cassian, and the ashy, less fossiliferous portion of Middle or 'Stuores' St. Cassian.

Richthofen called the strata of the Seisser Alpe "sedimentary tuffs with interbedded St. Cassian Limestones and Cipit Limestones." This is analogous to the Northern Tyrol contemporaneous series—namely, the "Partnach marls and shales with interstratified beds of St. Cassian Limestone."[1]

Mojsisovics maps all the strata on the Seisser Alpe as Wengen Beds. While it is impossible to draw any but an arbitrary limit between the complex of Wengen and St. Cassian Beds in Southern Tyrol, I believe a clearer conception of the Upper Triassic succession will be gained by grouping these fossiliferous marls and limestones as a St. Cassian Series in which (at least throughout the wide district from Schlern to the Dürrenstein) St. Cassian fossils form the bulk of the fauna, while retaining the name of Wengen Beds for the thick ashy series underlying them, with a remarkably limited fauna and interrupted by dykes and flows of augite-porphyry. The occurrence of *Posidonomya wengensis* (which is quoted even from the Raibl Beds in the Esino district) in the St. Cassian Series, or, conversely, the occurrence of *Cidaris dorsata* and a few other forms of higher range in beds of Wengen age, need not preclude a convenient subdivision of the whole complex into the two main

[1] See Gümbel (*op. cit.* 1873): the 'St. Cassian strata' include a great part of the 'sedimentary tuffs' of Richthofen.

sub-groups recognized throughout the sections that I have just described.

VI. The Stratigraphy of the Beds above the St. Cassian Series.

6. *The Schlern Dolomite.*[1]—The Schlern Dolomite is a drusy, crystalline, greyish-white rock, less splintery than the Mendola Dolomite, and breaking up into débris of fairly large stones and blocks.

Within the districts of Ampezzo and Enneberg which I have examined, the conformable succession of the Schlern Dolomite upon the St. Cassian Beds has been observed at Zwischenkofl and Gardenazza, Sella, Sett Sass, Lagazuoi, Tra i Sassi, Dürrenstein, and the *massif* east of Misurina. The thickness is normally from 1000 to 1400 feet: but it varies, *e. g.* at the Dürrenstein it is 2000 feet.

In all these mountains, the Schlern Dolomite rests upon the St. Cassian Beds and is succeeded by Raibl strata. In districts south of those which I have personally examined, such as Schlern (south side), Rosengarten, etc., the Schlern Dolomite rests upon the Mendola Dolomite and has there a thickness of 3000 feet.

Other localities occur where the Schlern Dolomite is apparently wanting, or where it has a very slight thickness. One or two cases of the disappearance of the Schlern Dolomite come within the scope of this paper, and I shall refer to them in considering the tectonic details (Part VIII.).

Fossils are very rarely found in the Schlern Dolomite; but the occurrence of *Gyroporella annulata*, Schafh., is important, as it is a species frequently obtained in the Wetterstein Kalk of Northern Tyrol. Corals occur occasionally, but are not well preserved. Among other casts of gasteropods, a large species of *Chemnitzia* has been found.

7. *The Raibl Strata.*—The Raibl strata form a characteristic series, largely dolomitic, above the Schlern Dolomite, and below the Dachstein Dolomite. As their development is especially subject to local variation, a rapid review of a few sections noted within the districts examined is desirable. On the western slope of Sett Sass the Raibl strata are exposed below the Dachstein Dolomite in the following succession (in descending order):—

I. Sett Sass (western slope).

	Dachstein Dolomite.
Raibl Beds.	Pale greenish or white dolomitic flags.
	Variegated dolomitic marls, red, bluish purple, and greenish. Fossils rare; only one found :—*Myophoria*, sp.
	Fine conglomerate; fragments of brightly-coloured marls and of dolomite cemented by a whitish dolomitic sand. This rock is very striking, and occurs frequently at the same horizon.
	Variegated dolomitic marls as above, containing iron ore. Interstratified beds of dolomitic flags and dolomitic limestone.
	Brown sandstones containing *Myophoria Kefersteini*, Klipst.

[1] See Introduction (p. 3), where the different names hitherto applied by geologists to this dolomitic rock are enumerated and explained.

The whole series is not more than 200 feet thick and rests upon the Schlern Dolomite. The same series is again favourably exposed in the neighbourhood of Valparola Alphütten, north of Sett Sass. There I found more fossils, among them a small *Megalodon* (species not easily identified), *Corbis Mellingi*, and several specimens of *Myophoria Kefersteini*.[1]

Some beds, apparently at the base of the Raibl strata, were exposed in the course of the Eisenofen Bach some little distance above the huts—hard, yellow-weathering limestone, with spines of various species of *Cidaris* and fragments of *Pentacrinus tirolensis*, Laube; also a light-coloured dolomite and dolomitic limestone full of a lithodendroid coral.

II. Heiligkreuz. (*Compare* fig. 4, p. 26.)

The Raibl strata exposed below the Dachstein Dolomite of Kreuz Kofl consist essentially of three series. The uppermost horizons are thicker here than at Sett Sass. The succession is, in descending order:—

Variegated marls, interstratified with dolomitic shales and limestones.
Thick banks of limestone and dolomitic limestone, interstratified with dolomitic marls. Occasional beds of a reddish breccia and of a hard siliceous limestone, with a few cidarid spines and encrinite-remains.
Sandstones and breccias with plant-remains and lignite, *Ostræa*-limestone and Lumachellen-limestone, very fossiliferous: *Fimbria* (*Corbis*) *Mellingi*, Hauer, sp.; *Ostræa montis-caprilis*, Klipst., etc.

(See Part VIII. of this paper, p. 64.)

III. Falzarego,[2] Cortina. (*Compare* figs. 6, 7, 8, pp. 29, 30.)

The Raibl strata throughout this part of Ampezzo have much the same development as at Heiligkreuz. The higher beds form a series of terraces on Col dei Bos by the alternation of the variegated dolomitic marls with hard beds of dolomite corresponding to the two lower beds in the Heiligkreuz section (thickness about 360 feet). The fossiliferous lower horizon, with a thickness of 50–70 feet, rests conformably on Schlern Dolomite, here apparently not more than 300 feet thick. Below the escarpment of Schlern Dolomite, in the neighbourhood of the Roces Alphütten, is a wooded hill entirely made up of dolomite-blocks.

On the opposite side of the Costeana stream, the Raibl strata are again exposed. The beds of the lower fossiliferous horizon are seen striking towards Ospizio and dipping at a high angle. In these strata I collected a number of typical Raibl species, viz.:—*Trigonodus rablensis*, Gredl., sp.; *Ostræa montis-caprilis*, Klipst.; *Fimbria* (*Corbis*) *Mellingi*, Hauer; *Megalodon*, cf. *complanatus*, Wöhrm.; *Megalodon*, sp. indet.; *Placunopsis*, sp. indet.; *Cidaris Braunii*, Desor.

[1] See Loretz, Zeitschr. d. Deutsch. geol. Gesellsch. vol. xxvi. (1874) p. 378.
[2] *Ibid.* p. 448, etc.; and Mojsisovics, 'Dolomit-Riffe,' p. 260.

Conformably succeeding these beds on the Nuvolau slope are thickly-bedded dolomite, then marls with interstratified dolomitic flags, and the same breccia as that which occurs on Sett Sass.

On the Pomedes and Majorera slopes the Raibl Beds are unusually well exposed. In the higher horizon of thinly-bedded smooth dolomite and marls some beds are filled with casts of *Megalodon*, sp. (Loretz had previously found these); in the middle horizon gypsum occurs, interbedded with dolomite-layers; and the thicker banks of dolomite are remarkable for the very intimate combination they show of marls, dolomitic sand, and breccia.[1] The fine interlayering of these different materials forms a dolomite-rock differing essentially from the drusy, crystalline Schlern Dolomite.

The fossiliferous beds are reddish breccias with small fragments of silica, brownish sandstones with stems of plants, hard white sandstone, dark limestones with *Myophoria Kefersteini* and *Megalodon* sp., and greyish limestone with cidarid spines. These beds rest on a dolomite-rock 50–60 feet thick, and at other parts of the slope they succeed a bed of Cipit Limestone and St. Cassian marls. The difficulties presented by the succession here are much increased by an extensive slip, between Majorera and Romerlo, of the Raibl Beds and of the dolomite-layer beneath upon the St. Cassian marls, as also by the growth of trees and underwood upon the lower slopes.

IV. Plätz Wiese, Dürrenstein. (*Compare* fig. 14, p. 42.)

This broad meadow-land at the height of 6000 feet has for its soil the Raibl marls. A section drawn west and east from the Wällsche Boden and Knoll Kopf to the Dürrenstein gives, in conformable succession:—

	Dachstein Dolomite.
Raibl strata, 160–200 feet thick.	Rauchwacke, brownish-grey, very porous, sometimes still retaining enclosures of gypsum. Bituminous limestone and shales with layers of gypsum. Dolomitic limestone and breccia. Variegated dolomitic marls, intercalated with thin beds of dolomite and dolomitic flags. Gypsum layers occur frequently. Thicker beds of dolomite, of shaly uneven surface.
Dolomitic strata, probably of Raibl age.	Thickly-bedded dolomite, showing on close examination fine layers of red or greenish marl, between layers of dolomitic sandy breccia. Dolomite with smooth compact structure; a bed of lithodendroid coral-limestone occurs in this dolomite just below the fort.
	Drusy, crystalline Schlern Dolomite.

[1] Gümbel, 'Das Mendel- u. Schlern-Gebirge,' Sitzungsb. d. k. k. Akad. d. Wissensch. Wien, 1873, p. 14. Gümbel observed occasionally also in Schlern Dolomite 'dünne, oft nur haut-ähnliche Zwischenlagen von Mergel.'

There are no fossiliferous sandstones and limestones as in the Cortina and Heiligkreuz district, but the entire series is highly dolomitic, and the transition to the Schlern Dolomite very gradual. This explains in part the greater thickness of the dolomitic rock of the Dürrenstein.

V. Schlern Plateau: Raibl Beds.

These have been long familiar in the literature of Southern Tyrol, and have been again recently made the subject of special research.[1] I quote briefly the result of these palæontological studies for comparison with my sections elsewhere. The fossiliferous beds exposed in the Schlern Klamm pass on the plateau into a facies of coral-bearing dolomite, and farther on into red and bluish-purple ferruginous marls. These rest upon a stratified dolomite, in which a bed of augite-porphyry and tuff is locally present, and are succeeded by stratified dolomite, in which corals and cidarid spines, and, at higher horizons, small species of *Megalodon* often occur.

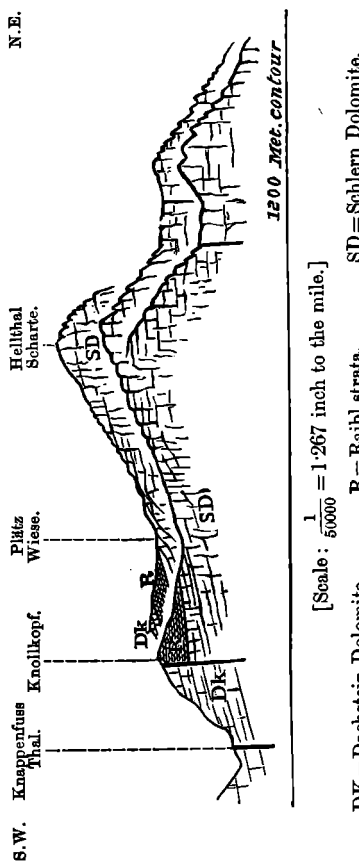


Fig. 14.—*Section across the Plätz Wiese.*

A full comparison of the fauna has been made by Wöhrmann, and the conclusion drawn that the fossiliferous Schlern-plateau strata correspond with the *Myophoria Kefersteini*-horizon at Raibl and the upper part of the *Cardita*-strata in Northern Tyrol.

A number of species are entirely peculiar to the one locality of the Schlern plateau; others occur in St. Cassian or Raibl Beds, or are common to both. But, as more St. Cassian species are present in the Schlern-plateau Beds than in the

[1] Wöhrmann u. Koken, 'Die Fauna der Raibler Schichten vom Schlern plateau,' Zeitschr. d. Deutsch. geol. Gesellsch. vol. xliv. (1892) p. 167.

fossiliferous Raibl horizon which I have mentioned in the above sections, one must conclude that the Schlern-plateau Beds are still older. The Raibl Beds of Southern Tyrol fall into the following sub-groups:—

Raibl Beds.	Variegated marls and *Megalodon*-bearing dolomitic flags.	
	Ostræa-limestone	passing into a dolomitic facies.
	Myophoria-limestone	
	Schlern-plateau strata, and dolomitic encrinite- or coral-limestone	

8. *The Dachstein Dolomite.*—The Dachstein Dolomite is the highest subdivision of the Triassic system in Southern Tyrol. It is a continuous development of dolomite and dolomitic limestone several thousand feet thick; and since it lies conformably above the Raibl Beds and below the Liassic strata it is the representative, in the Southern Tyrol Dolomites, of the 'Hauptdolomit' Kössen Beds, and the Dachstein Limestone of Northern Tyrol.

The rock is a crystalline dolomite, generally greyish-white in colour, but sometimes reddish. It is always well stratified, and may be either of compact or drusy structure. Fossils occur commonly enough, although in small variety. The typical fossil *Megalodon triqueter*, Wulf., is common also in the Dachstein Kalk of Northern Tyrol. Specimens of a very large *Megalodon* occur sometimes in great number in the Dachstein Dolomite of Tofana.

VII. Palæontological Conclusions.

The first nine columns of the List of Fossils (pp. 48 *et seqq.*), containing 345 species, include the various localities in Enneberg and Ampezzo where I worked. The tenth column, referring to Partnach Beds, etc., is introduced only to show the particular species in this list which are already known to occur elsewhere in other strata. The fauna of the Partnach Beds in Northern Tyrol is comparatively meagre, about half the known species being identical with St. Cassian and Wengen species in Southern Tyrol. On the other hand, only about 6 per cent. of the fossils given in the Wengen and St. Cassian horizons in the list have been found in Partnach strata. Comparing then the tenth column with the others, we find that 16·5 per cent. of the St. Cassian species occur also in Raibl Beds (including all the districts referred to). The faunal relations of the two series of Upper Triassic strata are readily seen from the following percentages:—Of St. Cassian sponges 13 per cent. are present in Raibl strata, of corals 5·9 per cent., of echinoderms 33·3 per cent., of brachiopods 3 per cent., of lamellibranchs 40·3 per cent., of gasteropods 8·2 per cent., of nautiloid and ammonite forms 19·2 per cent.

The writer collected also a number of fossils in the Raibl strata

exposed within the district of Enneberg and Ampezzo. These are:—

Ostræa montis-caprilis, Klipst.
Gervillia Bouéi, Hauer.
Hoernesia Johannis-Austriæ, Klipst.
Myophoria fissidentata, Wöhrm.
—— *Kefersteini*, Klipst.
Trigonodus rablensis, Gredler, sp.
Fimbria (Corbis) Mellingi, Hauer, sp.
Megalodon, sp. indet.
Megalodon, cf. *complanatus*, Wöhrm.
Placunopsis, sp. indet.
Halobia rugosa, Gümbel.
Thecospira Gümbeli, Pichler, sp.
Cidaris Braunii, Desor.
Pentacrinus tirolensis, Laube.

On the western slopes of the Dürrenstein, a bed of lithodendroid coral-limestone occurs, and may be followed for some distance between the thinly-bedded dolomitic flags belonging to the Raibl series.

In considering the list of Wengen and St. Cassian fossils, the extreme faunal poverty of the ashy Wengen strata calls for remark. Species of *Halobia* and *Posidonomya* frequently occur, but in addition to these I found only a few ammonites, the majority, unfortunately, too badly preserved for identification.

There are, among the 345 species of St. Cassian fossils found, 23 sponges, 51 corals, 30 echinoderms, 32 brachiopods, 62 lamellibranchs, 121 gasteropods, 26 nautiloid and ammonite forms, together with a number of polyzoa. The great preponderance of gasteropods, of which only about 10 per cent. continue into the Raibl period, is very striking, and they indeed give a quite peculiar stamp to the St. Cassian fauna. The brachiopods are mostly peculiar to Middle and Upper St. Cassian strata; the number present in Lower St. Cassian or in Raibl Beds being extremely limited.

The following table shows the percentages of St. Cassian species which occur at all the horizons in the list on pp. 48 *et seqq.*

Percentage Table.

	N. Tyrol.	Enneberg and Ampezzo.				N. & S. Alps.	
	Partnach Strata.	Wengen Strata.	St. Cassian.			Raibl.	
			Lower.	Middle.	Upper.	Lower.	Upper.
Corals	0	0	8	74·5	66·6	6	0
Echinoderms	26·6	6·6	26·6	86·6	63·6	30	16·6
Brachiopods	21·8	0	3·1	78·1	34·3	3	0
Lamellibranchs.....	6·4	5	6·4	64·5	54·8	38·7	17·7
Gasteropods	0	0	0	77·6	45·4	7·4	0·8
Naut. and Amm. sp.	7·7	?	11·5	80·7	15·3	19·2	0

A few typical Wengen fossils still continue in the Lower St. Cassian zone, which I identify with the first bed of Cipit Limestone on the Seisser Alpe. In this zone the first significant beginning of the St. Cassian fauna occurs; the fauna reaches its maximum development in Middle St. Cassian time; still continues strongly marked in Upper St. Cassian time; dwindles gradually, or sporadic-

ally reappears in a limited variety, during the Lower Raibl period, and is almost entirely absent from the highest or 'Torer' zone of Raibl strata.

Lower St. Cassian Zone.—Instead of the continuous stratified Cipit Limestone present at this horizon in the St. Cassian and Prelongei district, there is, at several places farther west, a characteristic blocky structure. Large blocks and masses of coralline Cipit Limestone are embedded in ashy strata; for instance, near the higher sources of the Cipit stream, at Mahlknecht, below Plattkofl on the Christiner Ochsenwald, on Sella Pass, at Val la Sties, at Cima Pasni, south of the Pordoi Pass, and again in the lower part of the Cortina meadows. Cidarid spines belonging to one or two species, and lithodendroid corals, are the only fossils which I found in these blocks or lenticular beds of Cipit Limestone.

Middle St. Cassian Zone.—In all cases, the marls and limestones immediately succeeding the 'Cipit' horizon contain St. Cassian fossils of the 'Stuores Wiese' type. The Middle St. Cassian Beds are not more than 150–200 feet thick in the Mahlknecht and Plattkofl district, and the 'blocky structure' recurs at several horizons. The dolomite-rock of Schlern Mountain and Rosszähne succeeds immediately above this comparatively slight thickness of St. Cassian Beds on the north-eastern side. Farther east, the St. Cassian Beds become thicker, until on the eastern side of the Sella *massif* the higher and very fossiliferous beds of Middle St. Cassian age reach their first complete development on the Prelongei ridge, and above the Richthofen Riff, continuing farther in the Enneberg Valley (Abtey slopes), on the Valparola Pass, and in the Falzarego Valley (west of Verviers, and at Romerlo, etc.).

I was inclined at one time to regard the fossiliferous beds exposed on Forcella, between the Richthofen Riff and Sett Sass, as of Upper St. Cassian age, but the material which I have now collected here and at Stuores does not justify a palæontological separation of the two horizons. The fauna on Forcella, excepting one new species of *Omphalophyllia*, has been entirely identified with the St. Cassian fauna described by Münster and Laube. At the same time, the absence of some of the fossils more characteristic of lower horizons on Stuores (e. g. *Koninckina Leonhardti*, Wissm.), and the presence in greater number of fossils characteristic of higher horizons (e. g. *Avicula Gea*, d'Orb., *Macrodon strigilatum*, Mnst., sp., *Anoplophora Münsteri*, Wissm.), mark the Forcella beds as a clearly higher horizon of the Middle St. Cassian fauna.

The difficulty of attaining a positive result arises from the fact that the fossils from Prelongei, Stuores, Sett Sass, Abtey, and Heiligkreuz could not be kept apart in the literature, for the fossil-collectors of the district mixed them all together. To take an example from the appended list of fossils: among 18 corals occurring on Forcella di Sett Sass 6 are identifiable only with Middle St. Cassian (Stuores) corals, 5 only with Upper St. Cassian corals, 1 with both Middle and Upper St. Cassian, and 6 were found only

on the Forcella. But as 5 out of these last-named 6 specimens are species described in the 'St. Cassian fauna' of Münster and Laube, they may or may not occur at Stuores, Prelongei, or Abtey. Two thirds of the gasteropods and brachiopods actually found on Forcella di Sett Sass are forms which I also found on Stuores; this and other results are in favour of including the Sett Sass-Forcella Beds with the Stuores or Middle St. Cassian zone.

Upper St. Cassian Zone.—In the Falzarego and Seeland Valleys (also in the district of Misurina and Rimbianco), strata which belong to the Middle St. Cassian or Stuores zone are succeeded by beds which I have distinguished as Upper St. Cassian on account of the occurrence of many new species. The percentages of species common to both Middle and Upper St. Cassian strata in the appended list are—sponges 21·7 per cent., corals 27·4 per cent., echinoderms 53·3 per cent., brachiopods 15·6 per cent., lamellibranchs 16·1 per cent., gasteropods 17·3 per cent., nautiloid and ammonite forms 11·5 per cent. At least 2 new species of corals are present from Cortina, and 7 new species from the Seeland Valley (one agrees with a new species of *Thecosmilia* from the Seeland Alpe previously described by Loretz). Of 10 brachiopods 6 species are common to both Middle and Upper St. Cassian horizons, while 4 species are confined to the Upper St. Cassian strata; among 20 species of lamellibranchs from Cortina, 10 are Middle St. Cassian forms and 10 are new species (1 of these is a Raibl form, and 3 have affinity with Raibl species). On the Seeland Alpe only 4 lamellibranchs were found; 3 are identified with St. Cassian forms and 1 is a new species. Of the gasteropods from the Cortina locality 10 are Middle St. Cassian forms, and 8 are either new species or of doubtful identity, while among 39 gasteropods from the Seeland Alpe 25 are Middle St. Cassian forms and 14 are indeterminate or new species.

The 'Heiligkreuz strata' (as explained on pp. 24–27) contain few fossils, but as they are all of frequent occurrence in the Upper St. Cassian of the Cortina district, it would seem best to refer the 'Heiligkreuz strata' to that zone.

Again, in comparing the Cortina and Seeland strata with one another, it is found that several commonly-occurring species are peculiar to them; but each locality bears the impress of a local faunal facies, further supported by the nature of the rock at both localities. The thick-shelled and other new species of lamellibranchs at Cortina are not found on the Seeland Alpe, whereas the great number of sponges and polyzoa at the last-named locality are poorly represented at the other. The gasteropods, brachiopods, and corals show, however, a closer relationship between the fauna of the two localities.

Summarizing the above palæontological facts, we conclude—

(1) That the St. Cassian strata are present throughout a wide extent of country, from the Seisser Alpe in the west to Misurina and the Seeland Alpe in the east.

(2) That in the west only the lower and less fossiliferous horizons

of St. Cassian strata are present; the typical Stuores or Middle St. Cassian zone is first completely developed in Enneberg, while above it there succeeds, at Cortina, Misurina, and the Seeland Alpe, a fossiliferous Upper St. Cassian zone.

In the wide district north of Falzarego and Ampezzo Valleys, where St. Cassian strata are not exposed, their non-occurrence is due to tectonic relations.

The fossiliferous horizons of Raibl strata exposed in Enneberg and Ampezzo represent the *Myophoria*-beds and the slightly higher *Ostræa montis-caprilis* horizon of the typical species of Raibl strata near Raibl. The unfossiliferous variegated marls, the thin-bedded dolomitic flags, the beds of gypsum and dolomite, and the rauchwackes which succeed the fossiliferous Raibl Beds in Enneberg and Ampezzo, represent at least in part the 'Torer' or highest horizon of the 'Raibl' succession.

On several of the dolomite-*massifs* (Gardenazza, Sella, etc.) the rock immediately underlying the *Myophoria*-horizon is dolomitic, but is not the characteristic drusy Schlern Dolomite. This variable thickness of dolomitic shaly flagstone or sandy rock is of Lower Raibl age. At Schlern the unique development of fossiliferous 'Schlern Plateau' Beds has been proved by the recent work of Wöhrmann and Koken (see footnote, p. 42) to be of Lower Raibl age. I found no exactly corresponding fauna in the districts of Enneberg and Ampezzo.

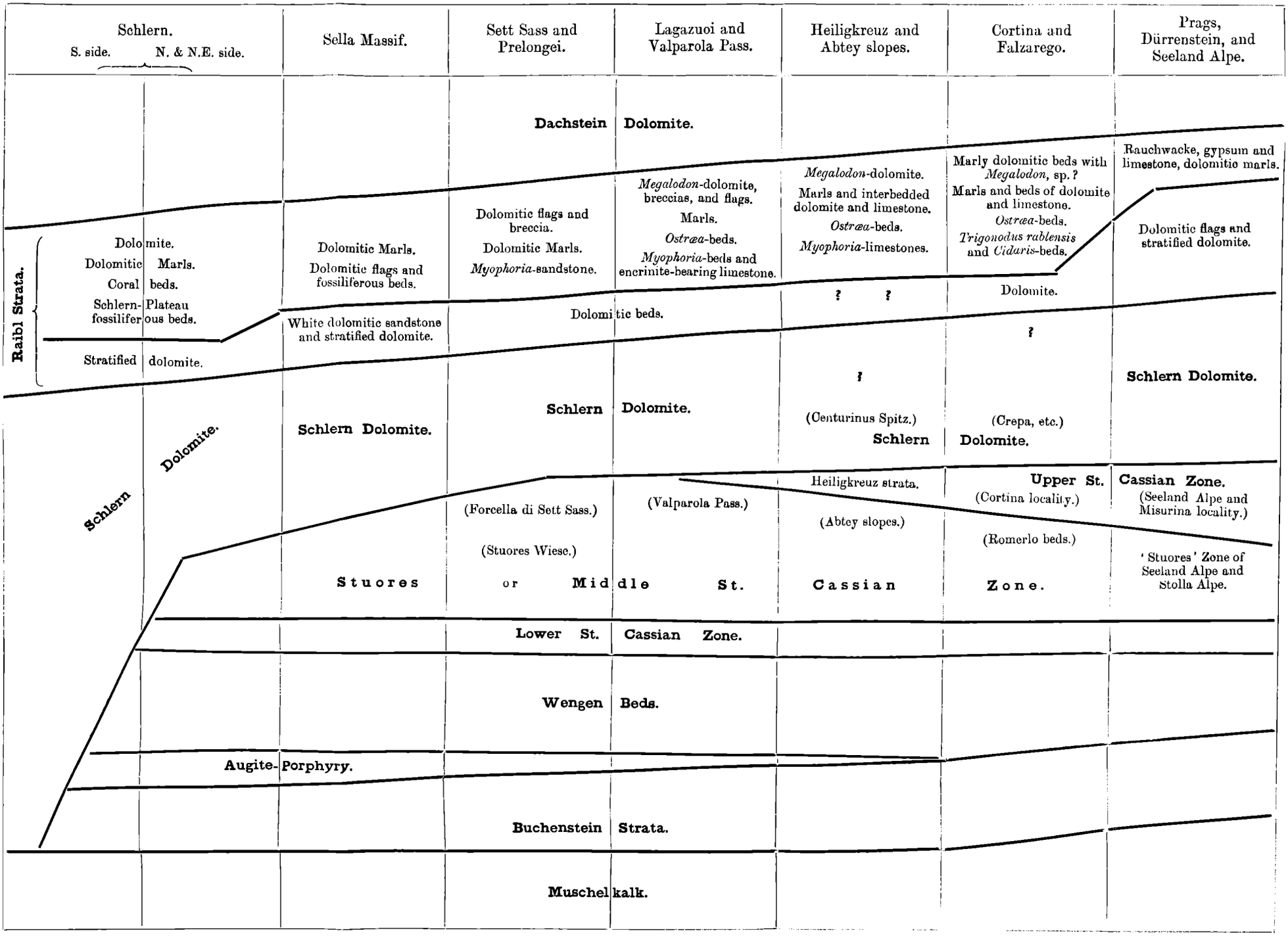
Thus, in the Raibl period also, the occurrence of rock-facies is recognizable in the district from Schlern to the Dürrenstein, while the dolomitic or flaggy development of Lower Raibl beds extends higher in the Dürrenstein district than in Enneberg or Falzarego. In the Raibl strata on Plätz Wiese (Dürrenstein district) no *Myophoria* or *Ostræa montis-caprilis* beds are present, but the highest marls-and-rauchwacke horizon succeeds a continuously dolomitic development.

Inequalities of thickness are remarked in the rocks of all horizons from the Muschelkalk to the Dachstein Dolomite; these inequalities are correlated with the frequent occurrence of ashy beds and of augitic volcanic rock during the Buchenstein, Wengen, and St. Cassian periods, and with the highly magnesian and ferruginous contents of the sea-water during the Schlern-Dolomite and Raibl periods.

The accompanying diagram illustrates the general stratigraphical relations in the districts examined.

The fossils found in the various localities are enumerated in the appended list. I must express my thanks to Herr von Suttner, of Munich, for having kindly identified the ammonites; and to Herr Söhle, who was good enough to identify the fossils found on Stuores during the second season of my field-work.

Diagram of Upper Triassic Strata in Enneberg and Ampezzo.



List of Fossils found by the Writer[1] in various Localities of Southern Tyrol (Enneberg and Ampezzo).

Note.—The numbers in the tenth column of the following table denote the occurrence of similar species in corresponding strata of other districts:—

1. St. Cassian (Partnach) strata of Northern Tyrol.
2. Lower Raibl or *Cardita*-strata of Northern Tyrol.
3. Upper Raibl or 'Torer' strata of Northern Tyrol.
4. Fischschiefer (Lower Raibl), Carinthia.
5. *Myophoria*-beds (Lower Raibl), Carinthia.
6. Torer Beds (Upper Raibl), Carinthia.
7. Raibl strata, Friaul.
8. Raibl strata, Lombardy.
9. Lower Schlern-plateau Beds, Southern Tyrol.

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abley slopes.	Romerlo.	Sett Sass (Forcella).	St. Cassian. Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alpe.	Occurrence elsewhere.
SPONGIDA.[2]										
Eudea polymorpha, Klpst. sp.	...	...	*							
—— *Manon*, Mnst. sp.	...	...	*	...	...	*	...	...	*	
Colospongia dubia, Mnst. sp.	...	...	...	...	...	...	...	...	*	2.
Verrucospongia armata, Klpst. sp.	...	*	...	...	...	...	...	...	*	Spong. indet. 9
Cryptocœlia Zitteli, Steinm.	...	...	...	...	...	...	...	...	*	2, 7.
Peronella Loretzi, Zittel	...	...	*	...	...	...	...	...	*	2, 7.
——, sp.?	...	...	*							
Corynella gracilis, Mnst. sp.	...	...	*							
—— *astroites*, Mnst. sp.	...	...	*	...	...	...	...	...	*	
——, sp.?	...	...	*							
Stellispongia variabilis, Mnst. sp.	...	...	*	...	...	...	...	...	*	
—— *stellaris*, Klpst. sp.	...	...	*							
—— *rotularis*, Mnst. sp.	...	...	*	...	...	...	...	...	*	
—— *Manon*, Mnst. sp.	...	...	*							
——, n. sp.	...	...	...	...	...	...	...	...	*	
Spongia, n. gen.	...	...	...	...	...	...	...	...	*	
Sestrostomella robusta, Zitt.	...	...	...	...	...	...	...	...	*	
? *Amorphofungia granulosa*, Lbe.	...	*	*	...	...	*				

[1] Several fossils have been kindly given me by Freiherr Dr. von Wöhrmann from Seisser Alpe, Stuores, and Forcella di Sett Sass.

[2] Besides the sponges in the above list, many species are as yet unidentified; some (among which are 10 specimens of *Pharetrones*) are in the hands of Dr. Rauff, of Bonn, others are in the Munich collection. Species were found at Cortina, and more especially at Romerlo, which are the same as some of the figures given by Laube, but identification, according to more recent work on sponges, has not yet been accomplished.

LIST OF FOSSILS (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romerlo.	Sett Sass (Forcella).	St. Cassian. Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alps.	Occurrence elsewhere.
SPONGIDA (*continued*).										
Leiospongia rugosa, Mnst. sp.									*	
—— *radiciformis*, Mnst. sp.			*						*	
—— *verrucosa*, Lbe.									*	
—— *reticularis*, Mnst. sp.						*			*	
CŒLENTERATA.										
Calamophyllia cassiana, Lbe.		*	*		*	*			*	
Cladophyllia subdichotoma, Lbe.		*	*			*				
—— *sublævis*, Mnst. sp.			*		*	*		*		
—— *gracilis*, Mnst. sp.						*			*	
——, n. sp.					*					
Rhabdophyllia recondita, Lbe.			*			*				
Thecosmilia neglecta, Lbe.					*	*				
—— *Hoernesi*, Lbe.			*						*	
—— *rugosa*, Lbe.			*		*				*	
—— *granulata*, Klpst.			*			*				
—— *irregularis*, Lbe.			*		*					
—— *confluens*, Mnst. sp.						*			*	
—— *Zieteni*, Klpst. sp.						*				
——, n. sp. 1 & 2			*						*	
——, n. sp. 3 & 4									*	
——, n. sp. 5								*	*	
Montlivaltia tirolensis, Wöhrm.						*				2.
—— *cæspitosa*, Mnst.						*				
—— *capitata*, Mnst.			*		*	*				
—— *crenata*, Mnst.						*			*	
—— *radiciformis*, Mnst.			*							
—— *obliqua*, Mnst.			*							
—— *rugosa*, Mnst.			*							
—— *perlongata*, Mnst.			*							
—— *recurvata*, Lbe.									*	
—— *granulata*, Mnst.						*			*	
—— *acaulis*, Mnst.						*			*	
——, n. sp. 1 & 2									*	
——, n. sp. 3			*						*	
Axosmilia alpina, Loretz									*	
Omphalophyllia gracilis, Mnst. sp.						*			*	
—— *cyclolitiformis*, Lbe.			*		*		*		*	
—— *pygmæa*, Mnst. sp.									*	
—— *boletiformis*, Mnst. sp.						*	*		*	2.

List of Fossils (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romerlo.	Sett Sass (Forcella).	St. Cassian. Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alps.	Occurrence elsewhere.
Cœlenterata (*continued*).										
Omphalophyllia, n. sp.	...	...	...	...	...	*				
Elysastræa Fischeri, Lbe.	...	...	...	...	...	*				
Phyllocœnia decipiens, Lbe.	...	...	...	...	...	*				
——, n. sp.	...	...	...	...	...	...	...	...	*	
Astrocœnia Oppeli, Lbe.	...	...	*	...	...	...	...	...	*	
Isastræa Gümbeli, Lbe.	...	*	*	...	...	...	...	*	*	
—— *Haueri*, Lbe.	...	...	*	...	...	...	...	*	*	
Latimæandra Bronni, Klpst. sp.	...	...	...	...	*	...	...	*	*	
—— *plana*, Lbe.	...	...	...	...	...	...	...	...	*	
——, cf. *labyrinthica*, Klpst.	...	...	...	...	...	...	...	*		
Thamnastræa Zitteli, Wöhrm.	...	*	*	...	*	...	...	*	*	2.
Dimorphastræa, n. sp. 1 & 2	...	...	...	...	...	...	...	...	*	
Stylina, n. sp.	...	...	...	...	...	...	...	*		
Echinodermata.										
Encrinus cassianus, Lbe.	...	*	*	*	*	*	...	*	...	1, 2, 3, 6, 7, 8, 9.
—— *varians*, Mnst.	...	*	*	*	*	*	...	*		
—— *granulosus*, Mnst.	...	...	*	...	*	*	...	*	*	1, 2.
Pentacrinus propinquus, Mnst.	...	*	*	*	*	*	...	*	*	1, 2, 3.
—— *tirolensis*, Lbe.	...	...	*	...	*	...	...	...	*	3, 6.
—— *subcrenatus*, Mnst.	...	...	*	...	*					
—— *lævigatus*, Mnst.	...	*	*	...	*	*	*			
Cidaris dorsata, Braun	*	*	*	*	*	*	...	*	*	1, 2, 3, 7, 9 (?).
—— ——, n. var.	...	...	...	...	...	...	...	...	*	
—— *Hausmanni*, Wissm.	...	*	*	...	*	*	...	*	*	1.
—— *Braunii*, Desor	...	*	*	*	*	*	...	*	*	1, 2, 3, 6.
—— *semicostata*, Mnst.	...	...	*	...	*	*	...	*		
—— *alata*, Agas.	...	...	*	*	...	*	...	...	...	1 (?), 9.
—— *Roemeri*, Wissm.	*	*	*	*	...	*	...	...	...	9.
—— *linearis*, Mnst.	...	...	*	*	...	*	*	...	*	
—— *Liagora*, Mnst.	...	...	*	...	...	*	...	*		
—— *triserrata*, Lbe.	...	...	*	...	...	...	...	...	...	7.
—— *flexuosa*, Mnst.	...	...	*	...	*	...	*	*	...	1.
—— *decorata*, Mnst.	...	...	*	...	*	*	...	*		
—— *trigona*, Mnst.	...	...	...	...	...	*				
—— *subsimilis*, Mnst.	...	...	...	...	...	*				
—— *fasciculata*, Klpst.	...	...	...	*						
—— *Klipsteinii*, Desor	...	...	...	...	...	...	...	...	*	
—— *spinosa*, Agas.	...	...	...	...	...	...	...	...	*	

LIST OF FOSSILS (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romerlo.	Sett Sass (Forcella).	Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alpe.	Occurrence elsewhere.
ECHINODERMATA (*continued*).										
Cidaris parastadifera, Schafh.	...	...	...	...	...	...	...	*	...	2, 3.
—— *subnobilis*, Mnst.	...	...	*							
—— *Buchii*, Mnst.	...	...	*							
—— *biformis*, Mnst.	...	...	*	...	...	...	...	...	...	1.
—— *scrobiculata*, Braun	...	...	*							
Rhabdocidaris subcoronata, Mnst. sp.	...	...	*	...	...	...	...	*		
POLYZOA.[1]										
Ceriopora, sp. divers.	...	...	...	...	...	...	...	...	...	2 (*C. enemidium*).
BRACHIOPODA.										
Waldheimia Münsteri, d'Orb. sp.	...	...	...	...	...	*				
—— *Eudora*, Lbe. sp.	...	...	*							
—— *subangusta*, Mnst. sp.	...	...	*	...	...	*				
—— *carinthiaca*, Rothpl.	...	...	*	...	...	...	...	...	...	5, 7.
Rhynchonella tricostata, Mnst. sp.	...	...	*	...	...	*	...	...	*	
—— *semicostata*, Mnst. sp.	...	...	*							
—— *subacuta*, Mnst. sp.	...	...	*	...	...	...	...	...	*	1.
—— *linguligera*, Bittn.	...	...	*	...	...	...	...	...	...	1.
—— *quadriplecta*, Mnst. sp.	...	...	*	...	...	...	...	...	*	
—— *subacuta*, var. *coralliophila*, Bittn.	...	...	...	...	...	...	...	...	*	
Amphioclina Suessi, Lbe.	...	...	...	...	...	*				
—— *amœna*, Bittn.	...	...	...	...	...	...	...	...	*	
—— *scitula*, Bittn.	...	...	...	...	...	...	...	*		
Koninckina Leonhardti, Wissm., sp.	...	...	*	*	...	...	...	...	...	1.
——, n. sp.	...	...	...	*						
Koninckella triadica, Bittn.	...	...	*	...	...	...	...	...	...	1.
Spirigera Wissmanni, Mnst. sp.	...	...	*	...	*	*	...	...	*	1.
—— *indistincta*, Beyr. sp.	...	...	*	...	*	*	...	*	*	1.
—— *subcurvata*, Mnst. sp.	...	...	...	...	...	...	...	...	*	
—— *quadriplecta*, Mnst. sp.	...	...	*	...	...	*				
—— —— (var. *euplecta*, Bittn.)	...	...	...	...	*					
—— *Schloenbachii*, Lbe. sp.	...	...	*							
—— *flexuosa*, Mnst. sp.	...	...	*	...	...	*				
—— *contraplecta*, Mnst. sp.	...	...	*							

[1] Several species of polyzoa were found in all the above localities, but they have not yet been identified.

List of Fossils (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romerlo.	Sett Sass (Forcella).	St. Cassian. Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alps.	Occurrence elsewhere.
Brachiopoda (*continued*).										
Retzia Klipsteinii (nov. nom. Klipst. sp.), Bittn.	...	...	*							
—— *distoria*, Bittn.	...	...	...	...	...	...	...	...	*	
——, n. sp.	...	...	...	...	*	...	...	...		
Cyrtina Zitteli, Klipst. sp.	...	...	...	...	...	*	...	...		
Spiriferina Frechii, Bittn.	...	...	...	...	...	...	...	...	*	
——, sp. indet.	...	...	...	...	...	*	...	...		
Crania Calymene, Klipst.	...	...	*	...	...	...	...	...	...	
Discina (*Orbicula*) *discoidea*, Mnst. sp.	...	*	...	...	...	...	...	...	...	
Lamellibranchiata.										
Lima subpunctata, d'Orb.	...	...	...	...	...	...	...	*	...	8.
——, n. sp.	...	...	...	...	...	...	...	*		
Placunopsis, sp. indet.	...	...	...	...	...	...	...	*		
——, sp. n. aff. *fissistriata*, Winkler	...	...	...	...	...	...	...	*		
Hinnites obliquus, Lbe.	...	...	*	...	...	...	...	...	...	
Pecten Nerei, Mnst.	...	...	*	...	...	...	...	...	...	
—— *subalternans*, d'Orb.	...	...	*	...	...	...	...	...	...	2, 3, 6, 7.
—— *tubulifer*, Mnst.	...	...	...	...	...	*	...	...	...	
—— *subdemissus*, Mnst.	...	...	*	...	...	*	...	...	...	
——, cf. *Schlosseri*, Wöhrm.	...	...	...	...	...	...	...	*	...	3, 6.
——, n. sp.	...	...	...	...	...	...	...	*		
Gryphæa arcta, Braun	...	...	...	...	...	*	...	...	...	
—— *avicularis*, Mnst.	...	...	*	...	...	...	...	...	...	
Avicula arcuata, Mnst.	...	...	*	...	...	*	...	...	...	7.
—— *depressa*, Wissm.	...	...	*	...	...	...	*	...	...	
—— *Gea*, d'Orb.	...	...	*	...	...	*	*	...	...	2, 6, 7, 8.
——, n. sp. aff. *Gea*, d'Orb.	...	...	...	...	...	...	...	*	...	
Cassianella decussata, Mnst. sp.	...	...	*	...	*	*	...	...	...	2, 8, 9.
—— *grypheata*, Mnst. sp.	...	...	*	...	...	*	*	*	...	8.
—— *tenuistriata*, Mnst.	...	...	*	...	...	...	...	...	...	
—— *euglypha*, Lbe.	...	...	*	...	...	*	...	...	...	
Halobia Richthofeni, Mojs.	...	...	*	*	...	...	...	...	...	1.
—— *Lommeli*, Wissm.	*	*	...	...	...	...	...	...	...	1, 2, 4 (?).
—— *rugosa*, Gümbel	...	...	...	...	...	...	*	...	...	1, 2, 8.
Posidonomya wengensis, Wissm.	*	*	*	*	*	...	...	*	...	2, 8.
——, n. sp. 1	*	*	*	*	...	...	...	...	...	
——, n. sp. 2	...	...	*	...	...	...	...	...	...	
Gervillia angulata, Mnst.	...	...	*	...	*	...	*	*	*	
—— *angusta*, Goldf.	...	...	*	*	...	*	*	*	...	3, 6.
Nucula lineata, Goldf.	...	*	*	*	...	...	*	...	...	

LIST OF FOSSILS (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romer'o.	Sett Sass (Porcella).	St. Cassian. Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alpe.	Occurrence elsewhere.
LAMELLIBRANCHIATA (*continued*).										
Nucula subcuneata, Goldf.	...	...	*	*						
—— *strigilata*, Goldf.	...	...	*	*	...	*	...	...	...	6, 8.
—— *inflata*, Wissm.	...	...	...	...	...	...	*			
—— *subtrigona*, Mnst.	...	...	...	...	...	...	*			
—— *cordata*, Mnst.	...	...	*							
—— *subobliqua*, d'Orb.	...	...	...	...	...	*	...	...	...	7(?).
—— *expansa*, Wissm.	...	...	...	...	...	*				
Cucullæa impressa, Mnst.	...	...	*	...	...	...	...	*	...	7 (?).
Macrodon strigilatus, Mnst. sp.	...	...	...	...	...	*	...	...	...	2, 3, 6, 7, 8, 9.
Leda elliptica, Goldf.	...	...	*							
—— *præacuta*, Klipst.	...	...	*	...	...	...	...	...	...	7 (?).
—— *tirolensis*, Wöhrm.	...	...	...	...	...	...	*	...	...	2, 3, 7, 8.
Myophoria Whateleyæ, Buch, sp. (=*Myophoria chenopus*, Lbe.)	...	...	*	...	...	*	*	...	...	2, 3, 5, 6, 7, 8, 9.
—— *harpa*, Mnst. sp.	...	...	...	...	...	*				
Grünwaldia (*Myophoria*) *decussata*, Mnst. sp.	...	...	*	...	...	...	...	*	*	2, 3, 7.
Myophoriopis lineata, Mnst. sp.	...	...	*	..	...	...	*	*	...	2, 7.
Anoplophora Münsteri, Wissm.	...	...	...	...	...	*	*	...	...	5, 7, 8.
—— *recta*, Gümb. sp.	...	...	...	...	...	*	...	...	...	3.
Cardita crenata, Goldf.	...	...	*	...	...	*				
—— ——, var. *Gümbeli*, Pichl.	...	...	...	...	...	...	...	...	*	2, 3, 7.
——, n. sp.	...	...	...	...	...	...	...	...	*	
Pachyrisma rimosum, Mnst. sp.	...	...	...	...	...	...	...	*	...	7, 8.
—— *rostratum*, Mnst. sp.	...	...	*							
——, n. sp.	...	...	...	...	...	...	...	*		
Trigonodus rablensis, Gredler	...	...	...	...	...	...	...	?	...	7, 8, 9.
Modiola, cf. *obtusa*, Eichw.	...	...	...	...	...	...	...	*	...	9.
—— *gracilis*, Klpst.	...	...	...	...	...	...	*	...	...	7, 8, 9.
Mytilus Münsteri, Klpst.	...	...	*	*	...	*	*	...	...	1.
——, n. sp.	...	...	...	...	...	...	...	*		
Lucina anceps, Lbe.	...	...	...	...	...	...	*	...	...	8, 9.
Fimbria (*Corbis*) *astartiformis*, Mnst. sp.	...	...	*	...	...	...	...	...	...	2, 8, 9.
Pinna, n. sp.	...	...	...	...	...	...	...	*		
GASTEROPODA.										
Dentalium decoratum, Mnst.	...	...	...	...	...	...	...	*		
—— *undulatum*, Mnst.	...	...	*	...	...	...	...	...	...	3.
Patella granulata, Mnst.	...	...	*							
Emarginula Münsteri, Pictet	...	...	*	...	...	...	...	...	*	
Zygites delphinula, Klpst. sp.	...	...	*							

List of Fossils (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romerlo.	Sett Sass (Forcella).	St. Cassian. Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alps.	Occurrence elsewhere.
Gasteropoda (*continued*).										
Raphistomella radians, Wissm. sp.	...	...	*	...	*					
Kokenella costata, Mnst. sp.	...	...	*							
Temnotropis fallax, Kittl	...	...	*							
—— *bicarinata*, Lbe.	...	...	...	...	...	...	...	*		
Pleurotomaria, n. sp. aff. *nodosa*, Mnst.	...	...	...	...	...	...	...	...	*	
Worthenia (*Pleurotomaria*) *coronata*, Mnst. sp.	...	...	*	...	...	*				
—— (——) *cirriformis*, Lbe. sp.	...	...	*							
—— (——) *subcostata*, Mnst. sp.	...	...	*							
—— (——) *canalifera*, Mnst. sp.	...	...	*	...	...	*	...	...	...	9.
—— (——) *subgranulata*, Lbe. sp.	...	...	*							
—— (——) *Münsteri*, Klpst. sp.	...	...	*							
—— (——) *spuria*, Mnst. sp.	...	...	*							
—— (——) *coralliophila*, Kittl	...	...	...	...	...	...	...	...	*	
—— (——) *turriculata*, Kittl	...	...	...	...	*	...	...	...	*	
—— (——) *Joh.-Austriæ*, Klpst.	...	...	*	...	*					
—— (——) *rarissima*, Kittl	...	...	...	...	*					
—— (——) *cassiana*, Kittl	...	...	*							
Chilotoma Blumi, Mnst. sp.	...	...	*	*	...	*				
Laubella, n. sp.	...	...	...	...	*					
Euomphalus (=*Schizostoma*, Kittl) *dentatus*, Mnst.	...	...	*							
—— *spiralis*, Mnst. [em.) (=*Margarita lævigata*, Mnst. sp., Kittl	...	...	*	...	...	*	...	*	*	
—— *lineatus*, Klpst. sp.	...	...	...	...	...	*				
Cœlocentrus Pichleri, Lbe. sp.	...	...	*	...	*	*				
Schizogonium scalare, Mnst. sp.	...	...	*	...	*	*				
—— *serratum*, Mnst. sp.	...	...	*	...	...	*				
—— *Laubei*, Klpst. n. sp.	...	...	...	...	*					
Turbo vixcarinatus, Mnst.	...	...	...	...	*	...	...	...	*	
—— *subcarinatus*, Mnst.	...	...	*	...	...	...	...	...	*	
——, n. sp.	...	...	...	...	...	...	...	...	*	
Umbonium helicoides, Mnst. sp.	...	...	*							
Pachypoma Damon, Lbe.	...	...	...	...	...	*				
—— *calcar*, Mnst. sp.	...	...	*	...	*					
Trochus subglaber, Mnst.	...	...	*	...	...	...	...	...	*	
—— *nudus*, Mnst.	...	...	*							
—— *sub-bisertus*, d'Orb.	...	...	*							
—— *subconcavus*, Mnst.	...	...	*							
—— *lissochilus*, Kittl	...	...	*							
—— *bistriatus*, Mnst.	...	...	*							
—— *glandulus*, Lbe.	...	...	...	...	*					

LIST OF FOSSILS (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romerlo.	Sett Sass (Forcella).	Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alpe.	Occurrence elsewhere.
GASTEROPODA (*continued*).										
Ziziphinus (*Trochus*) *semipunctatus*, Braun sp.	...	...	*	...	...	*	...	...	*	
Colonia cincta, Mnst. sp.	...	...	...	...	*	...	...	*		
Eunemopsis dolomitica, Kittl	...	...	*							
—— *Epaphus*, Lbe. sp.	...	...	*	...	...	*				
Delphinula lævigata, Mnst.	...	...	...	...	...	...	...	...	*	
Clanculus (*Monodonta*) *cassianus*, Wissm. sp.	...	...	*	...	*	*	...	...	*	
—— (——) *nodosus*, Mnst. sp.	...	...	*	...	...	*				
Neritopsis ornata, Mnst. sp.	...	...	...	...	...	*				
—— *armata*, Mnst. sp.	...	...	*	...	...	...	...	...	*	9.
—— *armata*, var. *plicata*, Kittl	...	...	...	...	...	...	...	...	*	
—— *decussata*, Mnst. sp.	...	...	*	...	*	...	...	...	...	9, & in 2, *N. pauciornat.*
——, n. sp.	...	...	...	...	...	...	...	*		
Scalaria triadica, Kittl	...	...	...	...	...	...	...	...	*	
—— *ornata*, Mnst. sp.	...	...	...	...	...	...	...	...	*	
—— *Damesi*, Kittl	...	...	...	...	...	...	...	...	*	
—— *venusta*, Mnst. sp.	...	...	...	...	...	*				
—— *binodosa*, Mnst. sp.	...	...	*							
—— *biserta*, Mnst. sp.	...	...	*							
—— *elegans*, Mnst. sp.	...	...	*							
—— *supranodosa*, Klpst. sp.	...	...	*							
Palæonarica constricta, Kittl	...	...	*							
—— *concentrica*, Mnst. sp. (Cf. *pseudofossarum*, Koken.)	...	...	*	*	*	...	...	...	*	9.
Oncochilus globulosus, Klpst. sp.	...	...	*	...	...	*				
Naticella concentrica, Mnst.	...	...	...	...	...	*				
—— aff. *sublineata*, Mnst. sp.	...	...	*	...	...	...	...	...	*	
Naticopsis neritacea, Mnst. sp.	...	...	...	...	...	...	*	*	*	
—— *impressa*, Mnst. sp.	...	...	*	...	...	*	...	*	*	
—— *ornata*, Mnst. sp.	...	...	*	...	...	...	...	*	*	
—— *expansa*, Lbe. sp.	...	...	*	...	...	...	...	*		
—— *elongata*, d'Orb. sp.	...	...	*	...	...	...	...	...	*	
——, cf. *cassiana*, Wissm. sp.	...	...	...	...	...	...	...	*		
——, sp. indet.	...	...	...	...	...	...	...	*		
*Natica Mandelsloh*i, Klpst.	...	...	*	...	*					
—— *neritina*, Mnst.	...	...	*							
—— *sublineata*, Mnst.	...	...	...	...	...	*				
Amauropsis paludinaris, Mnst. sp.	...	...	*	...	...	...	...	...	*	
——, sp. indet.	...	...	...	...	...	...	...	*		
Ptychostoma pleurotomoides, Wissm. sp.	...	...	*	...	*	*	*	*		
—— *Wähneri*, Kittl	...	...	*							
——, sp. indet.	...	...	...	...	...	...	...	*		

List of Fossils (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romerlo.	Sett Sass (Forcella).	St. Cassian. Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alpe.	Occurrence elsewhere.
Gasteropoda (*continued*).										
Lacuna Karreri, Kittl	...	...	*							
Delphinulopsis binodosa, Mnst. sp.	...	...	*	...	...	...	...	*	*	
—— *Laubei*, Kittl	...	...	*							
——, sp. indet.	...	...	...	...	...	...	...	...	*	
Turritella subtilestriata, Klipst.	...	...	...	...	...	*	...	...	*	
—— (*Undularia*, Koken) *carinata*, Mnst.	...	...	*	...	...	...	...	...	*	9.
——, n. sp.	...	...	...	...	...	...	...	...	*	
Loxonema subornatum, Mnst.	...	...	...	...	...	*	...	...	*	
—— *tenue*, Mnst. sp.	...	...	*	...	...	...	...	...	*	
—— *obliquecostatum*, Bronn	...	...	...	...	...	...	...	...	*	8, 9.
—— *arctecostatum*, Mnst. sp.	...	...	*	...	...	...	...	...	...	9.
(For the preceding two, cf. *Zygopleura*, Koken)										
—— *acutecostatum*, Mnst. sp.	...	...	*							
—— *Haueri*, Klpst. sp.	...	...	*							
—— *hybridum*, Mnst. sp.	...	...	*							
——, n. sp. (cf. *Hypsipleura* ?)	...	...	...	...	...	...	...	*		
——, n. sp.	...	...	...	...	...	...	...	...	*	
Chemnitzia gracilis, Mnst. sp.	...	...	*	...	...	*				
—— *longissima*, Mnst. sp.	...	...	*							
—— *supraplecta*, Mnst.	...	..	*							
—— *subcolumnaris*, Mnst.	...	...	*	...	...	*				
—— *subscalaris*, Lbe.	...	...	*	...	...	...	...	...	*	
—— *turritellaris*, Mnst. sp.	...	...	*	...	...	...	...	...	*	
—— *reflexa*, Mnst.	...	...	...	...	...	*				
—— *Dunkeri*, Klpst.	...	...	...	...	...	*				
Cerithium fenestratum, Lbe.	...	...	*	...	...	*				
—— *Koninckianum*, Lbe.	...	...	*							
—— *nodoso-plicatum*, Mnst.	...	...	...	...	*					
—— *bisertum*, Mnst.	...	...	*							
——, sp. indet.	...	...	...	...	...	...	...	*		
Holopella Lommeli, Mnst. sp.	...	...	*							
Niso conica, Klpst. sp.	...	...	*							
Neritaria, cf. *plicatilis* ?, Klpst.	...	...	...	...	...	...	...	*		
Katosira, cf. *fragilis* ?, Koken	...	...	...	...	...	...	...	...	*	9.
——, cf. *Zygopleura spinosa*, Koken	...	...	...	...	...	...	...	...	*	9.
Hypsipleura, n. sp. 1 & 2	...	...	...	...	...	...	...	...	*	
Cephalopoda.										
Aulacoceras inducens, Mojs.	...	...	*	...	...	...	*	*	...	9.
Orthoceras elegans, Mnst.	...	...	*	...	...	...	...	*		

LIST OF FOSSILS (*continued*).

	Wengen Beds.	Lower St. Cassian.	St. Cassian. Middle or 'Stuores' Zone. Stuores.	Abtey slopes.	Romerlo.	Setti Sass (Forcella).	St. Cassian. Upper Zone. Heiligkreuz Strata.	Cortina.	Seeland Alpe.	Occurrence elsewhere.
CEPHALOPODA (*continued*).										
Orthoceras, aff. *subellipticum*, Mojs			*							
Nautilus granulosostriatus, Klipst.			*							
——, cf. *linearis*, Mnst.								*		
Arcestes bicarinatus, Mnst.			*			*				
——, aff. *Gaytani*, Klipst.			*							
——, sp. indet.						*				
Joannites cymbiformis, Wissm.	*		*	*						2, 9.
Lobites pisum, Wissm. (acc. to Mojs. = *nautilinus*, Lbe.)			*	*						
Celtites, aff. *Buchi*, Lbe.			*							1.
—— *epolensis*		*								
Klipsteinia Boetus, Wissm.			*							
—— *irregularis*, Mnst.		*								
Trachyceras Aon (forma—typical *Aon*), Wissm.		*	*	*						1, 4.
—— —— (forma *Münsteri*), Wissm.			*							
—— —— (forma *Brotheus*), Wissm.			*							
—— *furcatum*, Mnst.	*									4.
—— *Basileus*, Wissm. (= *Busiris*, Lbe.)			*							4.
—— *Zeuschneri*, Klipst.			*							
—— *sulciferum*, Mnst. (= *Saulus*, Lbe.)			*							
—— *Gredleri*, Mojs.	*									
——, cf. *Archelous*, but an evolute form; see also Parona, 'Fauna Raibliana di Lombardia.'								*		8 (?).
Badiotites Eryx, Mnst.			*							
Megaphyllites Jarbas, Mnst.			*							
Lecanites glaucus, Mnst.			*							

NOTE.—Besides the well-known plant-fauna occurring in the Wengen Beds near Corvara, badly-preserved remains of plants were found both in the St. Cassian and Raibl Beds, but the identification of these is impossible.

The fossils occurring in the Wengen Beds at Prags have been so fully quoted by Hoernes and by Loretz that it is unnecessary for the present writer to mention the specimens found by her.

VIII. The Tectonic Relations.

(*See General Tectonic Map, facing* p. 70.)

Before entering into a detailed consideration of the geological maps, it is perhaps advisable to refer to the general tectonic relations of the northern district of the Dolomites; the three separate districts which I have specially studied will thus be more clearly brought before the reader. My own knowledge of this wider region is based on a study of the literature, as well as on personal observations in several places.

A glance at a geological map of the Dolomites shows that the pre-Triassic rocks are exposed in the Pusterthal, and are succeeded in the south by younger strata. In the neighbourhood of Prags, west of Toblach, we meet Werfen and Muschelkalk beds; these continue westward in the Hoch Alpe towards St. Vigil and Wengen, and cross the Enneberg Valley north of Pedratsches. Here they bifurcate, the northerly branch passing off in the Villnös direction, the southerly over the valley of Campil to that of Gröden. From the Gröden Valley it turns southward, and, leaving Schlern on the east, is exposed in the Tiers Valley and farther south. The same strata strike along the base of the Rosengarten *massif* and the Fassa Valley, eastward over the Pordoi Pass into the Buchenstein Valley; from Buchenstein they strike south-west towards Caprile, where they are in great measure lost sight of, owing to an east-and-west fault-line, but may be partly traced as far as St. Vito in the Boita Valley. Within these limits the older Triassic strata are nowhere exposed, with the exception of a small band from the Upper Gröden Valley, over the Gröden Pass to Colfuschg and St. Cassian. The younger Triassic strata attain, on the other hand, an extended outcrop, so that in a merely general sense we may regard this as a synclinal area, in which at one part (Gröden Pass—Langs-da-für—St. Cassian) the older beds form a broken anticline. This folding of the beds, although indicated on a broad scale, has been modified and sometimes entirely destroyed by a number of faults.

Not many miles distant from the outer zone of older Triassic strata there rises abruptly a great complex of Dachstein Dolomite, succeeded in many places by Jurassic and Cretaceous rocks. This Dachstein-Dolomite complex embraces Hohe Gaisl, Seekofl, Heiligkreuz Kofl, La Varella, Tofana, Monte Cristallo, and one may add Gardenazza in the west. Numerous faults have let down this whole region of Dachstein rock, and it is perhaps better to speak of it as a subsided area than as a syncline. In many of the sections given by Mojsisovics ('Dolomit-Riffe,' pp. 209, 213, 288, 289, etc.) the lines of disturbance and faulting are shown.

The relations in the outer zone of older Trias vary. At many places (*e. g.* the Dürrenstein, Wengen district, Puflatsch) the older Triassic strata are let down by step-faults, whereas in the neighbourhood of Pedratsches they are folded.

Of more importance are the faults which have brought down the younger Triassic against this zone of older Triassic rocks.

These faults have an east-and-west course, and extend along the whole region north of the sunken area. If, now, the strata on the southern or downthrow side be brought down to the level of the Mendola Dolomite on the other side of the fault, we have from the Lower Muschelkalk a continuous outcrop of dolomite up to the Raibl strata.

Loretz has previously explained this as in part the result of such east-and-west faults. Mojsisovics, on the other hand, has explained it as an unbroken dolomitic rock, part of which is a 'heteropic' development of dolomite corresponding in age to the marls, tuffs, etc. of the St. Cassian, Wengen, and Buchenstein periods.

In several cases I found that the younger strata were brought down by faults against different horizons of older strata; naturally, in the particular case of two dolomitic horizons being faulted against one another, the line of fault, or even its presence, is extremely difficult to prove, not only from the lithological similarity of the two rocks, but also from their poverty in fossils.

One of the main fault-lines recognized by Mojsisovics (in co-operation with the survey of Hoernes) is the Villnös fault, which, he says, may be traced through the Villnös Valley, over Campil, then across the Enneberg Valley, through Fanis, south-east to Peutelstein and towards Tre Croci. I could not convince myself that this was one and the same fault-line; for instance, Mojsisovics says (*op. cit.* p. 293):—"West of the Wengen Valley, the northern wing of the fault-line is the downthrow; east of the Wengen Valley, on the contrary, it is the southern wing which is the downthrow."

So far as my own observations go, the Villnös fault, from the Upper Villnös Valley up to near Campil, belongs to the set of step-faults already mentioned, which have thrown down the older Triassic strata to the north. That part of the Villnös fault which is found west of the Enneberg Valley is one of a set of parallel faults with a repeated downthrow to the south occurring within the sunken district of Dachstein Dolomite.

The system of older Triassic rocks faulted up both east and west of the Gröden Pass meets farther west the outer zone of Werfen Beds, Muschelkalk, etc. West of the Tschisler Alpe and Wolkenstein, therefore, we find no outcrop of Dachstein Dolomite and younger Triassic rocks, the Gardenazza *massif* and Puez forming the western limit of the sunken area. Hence it is, also, that the relations of the strata are so much simpler towards Puflatsch and Schlern.

Two of the districts mapped lie in the southern portion of the wide area just discussed. That of Prelongei (Map A) is precisely on the boundary-limit where, in the Buchenstein Valley, the southern wing of the broad syncline of older Trias bends up; that of Cortina (Map B) lies just south of the area of subsidence, below the Dachstein *massif* of Tofana. But the map of the Dürrenstein (Map C) lies partly in the outer zone of older Trias, and shows interesting transitional features from this zone to the Dachstein Dolomite.

(i.) *The District of Prelongei and Sett Sass.*
(See Map A, facing p. 18.)

At the north-eastern corner of the Prelongei map lies Centurinus Spitz, a peak of Dachstein Dolomite. Southward, towards Sore Bach, this Dachstein Dolomite is in contact with the Schlern Dolomite, and below the Schlern Dolomite are the St. Cassian Beds. Very little farther south the St. Cassian Beds form the slopes below Lagazuoi, and above them follows the complete succession, *i. e.* Schlern Dolomite, Raibl Beds, and Dachstein rocks.

The Raibl Beds and part of the Schlern Dolomite have disappeared at Centurinus Spitz, owing to an east-and-west fault. The Lagazuoi *massif* is south of the fault-line, while the Centurinus Spitz, north of it, is on the downthrow side, Dachstein Dolomite having been faulted down against Schlern Dolomite. This fault-line bends round towards the north, and may be followed along the eastern side of the Enneberg Valley. The rocks east of it are everywhere let down against older strata. I shall have occasion to refer again to this fault in connexion with the Heiligkreuz section.

The Falzarego fault-line, observed by Mojsisovics in the Falzarego or Cortina Valley, is further continued over the Tra i Sassi Pass and Valparola in a south-east and north-west direction, and cuts off the Lagazuoi *massif* from Sett Sass. The relations at this western end of the fault remain the same as those already proved in the Falzarego Valley, *i. e.* the rocks south of the fault-line are in all cases thrown down.

In the Falzarego Valley Raibl strata and Schlern Dolomite are faulted against St. Cassian strata; at Valparola, within the district of my map, Raibl strata and Dachstein Dolomite are faulted against St. Cassian strata and Schlern Dolomite. The throw is greater in the west than in the east, where Schlern Dolomite is present above the St. Cassian Beds south of the fault-line. According to the explanation of Mojsisovics, the Raibl strata rest at Valparola conformably upon St. Cassian strata, as a natural consequence of the thinning-out of the Schlern Dolomite of Sett Sass. As may be seen in Map A and in fig. 3 (p. 21), there is clear evidence of the already mentioned fault north of Sett Sass, bringing at first Raibl Beds and then Dachstein Dolomite down to the horizon of the St. Cassian strata.

Moreover, I have proved that south of Sett Sass the higher Middle St. Cassian horizons are separated by an east-and-west fault from the Wengen Beds of Monte Sief, while towards the west the Schlern Dolomite, Raibl Beds, and Dachstein Dolomite are cut off from the St. Cassian strata of Prelongei and Stuores by a north-and-south fault-line of considerable throw.

The Sett Sass Berg has a horseshoe shape, steep cliffs rise all round the outer convex side, but the rocks descend more gently towards the inner side. In this way the woods and Alpe of Valparola lie in a rocky hollow. The strata have a general east-and-west strike, and a northerly dip.

The southern wall of Sett Sass is Schlern Dolomite, succeeded

towards Tra i Sassi (on the eastern limb of the horseshoe) by Raibl and Dachstein strata. On the southern wall itself these rocks have been eroded, but are seen lying conformably upon the Schlern Dolomite in the Valparola hollow; here the dip of the beds is steeper than the angle of incline of the mountain (see fig. 3, p. 21). On the western limb of the horseshoe the Raibl and Dachstein rocks have a wider outcrop than on the eastern limb, and are brought against the Schlern Dolomite and the Raibl strata at Valparola by means of a south-west and north-east fault-line.

The fault is seen again at the south-western corner of Sett Sass, between Raibl strata and Schlern Dolomite. It is, however, merely of minor importance, branching from the north-and-south fault which extends between the whole of the western limb and the Stuores Wiese. Both transverse faults are then cut off by the main longitudinal east-and-west Valparola fault, this triangular break having thrown the western limb farther down than the rest of Sett Sass. Towards Prelongei, long lines of Raibl and Dachstein blocks and débris occur in the course of the fault below Sett Sass and above Stuores wood.

The system of Monte Sief and Col di Lana belongs to the previously-mentioned anticlinal outcrop of older Triassic strata. In the valley between Andraz and Pieve the Werfen Beds strike east-and-west; above them Muschelkalk, Buchenstein Beds, and augite-porphyry follow in symmetrical succession, both southward towards Marmolata and northward towards Sett Sass. This valley was not included in my detailed study, although in the map I have for convenience indicated the general relation of the older Trias to the strata exposed on Prelongei.

On the northern side of the valley the Buchenstein limestones and the augite-porphyry and sedimentary tuffs have an unusually thick development on the Col di Lana hill. The strata dip northward, and are bent up towards the south as an anticlinal arch, which may be very clearly observed in the north-east and north-west of Monte Sief—in the north-east, where the stream running to Castello takes its source; in the north-west, where the slopes of Monte Sief descend steeply to Montagna della Corte. Here the bed-surface is often almost parallel with the slope of the hill, and in many places, where the Wengen Beds have been eroded, augite-porphyry reappears suddenly, sometimes with a fairly large outcrop.

The strike of the older Triassic rocks continues west over Cherz and Varda to Arabba. They dip northward, and are here also conformably succeeded by Wengen Beds. A complication is caused by an east-and-west fault above Varda, throwing down the southern wing, and cutting off the exposure of Werfen Beds on the northern wing. I found, however, Werfen Beds (which I identified by the fossils occurring in them) on the right hand of the ascent to Campolungo Pass. These strike north-east and south-west, dip 30°–40° S.E., and are succeeded by Muschelkalk and Buchenstein Beds. This small outcrop of older Trias is then faulted from the Buchenstein Beds and

volcanic agglomerates exposed higher on the Pass. The whole system on the Pass belongs to the northern wing of the Varda fault; augite-porphyry forms the southern wing, and is present below the exposure of Werfen Beds in the stream which flows towards Arabba. The Buchenstein anticline is therefore broken north of Arabba by an east-and-west fault of reversed hade. I did not follow the eastward continuation of this Varda fault, but at Cherz I observed that the succession from the Werfen to the Wengen Beds was conformable. The latter are exposed on a wide hilly upland between Cherz and the Incisa Bach; again, descending along the Incisa Bach towards Corvara, they are found in complete succession, resting upon the augite-porphyry near Corvara (see fig. 1, p. 17). This whole system meets (along the transverse fault west of Campolungo) the system of Wengen and St. Cassian strata which underlie Sella. Close under the rocky wall of the Sella *massif* several small faults occur; Dachstein Dolomite and Raibl strata are faulted down against St. Cassian strata; sometimes, again, the Schlern Dolomite remains in considerable thickness above the St. Cassian Beds.

North of Monte Cherz the Prelongei succession is exposed (see fig. 2, p. 19); in this the St. Cassian strata are predominant. A fault of small throw runs from the north-west at the Incisa Bach towards the south-east. Although this fault can be easily traced towards Corvara, it is difficult to follow it through the meadows of the Selvaza Bach, partly owing to the presence of slipped débris, and partly because its course here is only through different horizons of Wengen Beds. It apparently meets the (east-and-west) Monte Sief fault near Cherz, and the Prelongei succession north of it is slightly let down.

That succession, which occupies the central portion of Map A, is cut off eastward towards Sett Sass by the north-and-south fault against the Dachstein Dolomite; southward by the Monte Sief-Cherz fault and the Cherz-Incisa Bach fault against the Wengen Beds; north-westward and northward by the fault from the Gröden Pass. Another fault runs parallel with the Gröden Pass-and-Prelongei fault, and north of it; between them, on Langs-da-für, the older strata, from the Werfen to the Wengen Beds, are exposed. This is the southern wing of the Gröden Pass anticlinal fold; the northern wing is cut out here, but is exposed farther west and faulted against the Gardenazza *massif* at Sass Songe, north of Colfuschg.

The main strike of the Langs-da-für system is south-west and north-east, and the strata dip south-east. On the northern slope (towards the confluence of the Grosser Bach and the Sore Bach) the Langs-da-für system is faulted against Wengen Beds, which form part of the system of Wengen and St. Cassian Beds exposed on both sides of the Gader Bach (see fig. 4, p. 26).

Near St. Cassian the Werfen Beds and the Muschelkalk are again cut off against younger strata by a minor east-and-west fault. Augite-porphyry and bedded tuffs are the rocks chiefly exposed in

the lower part of the Freiner Bach, along with a great many blocks of Buchenstein limestone; but the strata are largely hidden by all kinds of débris. They strike in an east-and-west direction across the valley at St. Cassian. Immediately north of St. Cassian is a thick mass of augite-porphyry, and above it follow the Wengen shales containing *Halobia Lommeli*. The higher Wengen horizons and the St. Cassian strata form the Ru and Peravuda slopes on the north. At St. Cassian, therefore, a small outcrop of augite-porphyry and *Halobia*-shales is cut off on all sides, except Langs-da-für, against younger strata, the outcrop being essentially a continuation of the Langs-da-für anticline, only slightly disjointed.

To return now to the central Prelongei succession, we may consider it as a shallow synclinal exposure of Wengen and St. Cassian strata. Southward (Selvaza or Buchenstein Alpe) the series of beds dip at a small angle, 15° to 20° north, whereas on Stuores Wiese, wherever a sure reading of the beds in their true position is obtainable, they are found to dip at a still smaller angle (5° to 10°) south. The most fossiliferous St. Cassian horizons are found on the ridge of Prelongei, and, as I have already said, are repeated in Ruones Muren (see fig. 1, p. 17). For, towards Corvara, the strata on Prelongei are twice let down by small step-faults. A large district in the north-west, known as 'Siadu,' is also faulted down from the Prelongei succession, so that the St. Cassian strata, which are in position between Sorega and the Piccol Bach, have a quite different strike-system from the strata between the latter stream and the Stuores Bach. Numerous blocks and an unusual thickness of dolomitic débris cover the St. Cassian Beds of Siadu, and indicate the presence at a former period of a continuous bank of Schlern Dolomite in that locality.

The palæontological difficulties introduced by the landslips on the Stuores Wiesen have already been touched upon (p. 18). The constant sliding down of younger strata upon older strata, and of a whole piece of meadow into a secondary and quite irrelevant position, may be observed at every part of the northern slopes of Prelongei. The soft marls, shales, and ashy Wengen Beds become saturated with water, and give way under the St. Cassian marls, with their numerous interstratified beds of hard Cipit Limestone. Slips then occur in the St. Cassian strata on a more or less grand scale, and one finds remnants of thick St. Cassian limestone at varying heights, looking at first sight like tongues of limestone thinning out in the fossiliferous marls, and only with difficulty recognized as the broken and slipped fragments of originally continuous beds.

Naturally the slips occur more readily on Prelongei than in cases where Schlern Dolomite rock still remains as a protection upon the St. Cassian strata. The mossy hollows and high meadows of Prelongei form an extensive eroded surface exposed to the action of heavy rains, melting snow, and swollen streams, and the down-wash of centuries is spread as a loose soil upon the outcrop of older beds.

(ii.) *The Upper Enneberg.*

Although no map of the Abtey portion of Enneberg is presented in this paper, I made very careful observations of the tectonic relations, and they are best considered in conjunction with the Prelongei district. The Wengen and St. Cassian strata are in place on both sides of the Enneberg Valley; they dip on the Gardenazza side westward, and on the Heiligkreuz side eastward. The succession in the northern part of the Gardenazza *massif* is complete from the Wengen Beds to the Dachstein Dolomite; but southward, between Varda and Colfuschg, the succession is broken by the Gröden Pass faults, and the Schlern Dolomite is found abutting against various horizons, *e.g.* at Sass Songe, against augite-porphyry and Wengen tuffs. In the central portion of the *massif* Jurassic and Cretaceous strata are faulted down, the relations within Gardenazza showing a general similarity to those in the large 'Dachstein' area farther east.

The relations of the strata exposed below Heiligkreuz Kofl and La Varella are more complicated.

As I have already said, in describing fig. 4 (pp. 25–27, 40), the Raibl Beds appear to succeed St. Cassian strata. The exposures of acknowledged Raibl Beds containing *Ostræa montis-caprilis*, *Corbis Mellingi*, etc., lie north of the Heiligkreuz Kirche. They strike N. 15° W., dip slightly east, and are succeeded on the steep slopes below Kreuz Kofl conformably by a series of marls, breccias, beds of dolomitic limestone, and dolomite interstratified with thinly-bedded dolomite-flags. The 'Heiligkreuz Schichten' behind the Kirche, which contain St. Cassian fossils, strike north-and-south, and, if followed northward along their strike, would continue in part directly into the fossiliferous Raibl Beds, while above them are strata belonging to a higher horizon of the Raibl Series than the *Ostræa*-limestones. A slight cross-fault cuts, therefore, the succession of Raibl Beds just north of the Kirche from the 'Heiligkreuz strata.'

Going southward, the Raibl Beds, now with a different strike (N. 15° E., dip 45° E.), crop out all along the road and strike against different horizons of the same system of St. Cassian strata as that to which the exposures at the Kirche belong. A north-and-south fault is thus proved between the Raibl and St. Cassian Beds here. In the system north of the cross-fault, owing to large slips and to the thick surface-covering of fallen blocks, it is impossible to follow this north-and-south fault, but better evidence of its presence is found farther south. Again, on the Medis Wiese, the whole system is cut by a cross-fault; and, as before, the St. Cassian strata are faulted up on the southern side.

On a mountain Alp, above the woods of Peravuda, there are steep exposures of the grey limestone-shales ('Heiligkreuz Schichten') and, below them, St. Cassian limestones full of fossils (*Halobia Richthofeni*, *Mytilus Münsteri*, corals, etc.). Still farther south a ridge may be seen running out towards Ru. I did not myself examine it, but Dr. Rothpletz has kindly communicated to me

the result of observations he had previously made here. The marls and limestones on the ridge are St. Cassian strata, above which Schlern Dolomite follows conformably. The dolomite has, however, only a thickness of 80–100 feet, and is then faulted against the Dachstein Dolomite of La Varella. Very little farther north Dr. Rothpletz had seen the succession of Raibl Beds in full sequence. The outcrop of the Raibl Beds is therefore cut off on this ridge by a north-and-south fault. As I have already mentioned, the Schlern Dolomite is also faulted against the Dachstein Dolomite on the southern wall of Centurinus Spitz (see Map A, facing p. 18).

Considering now the relations on the northern side of Kreuz Kofl, we find the high Alpe of Armentara, on which Wengen tuffs are in place; only a small outcrop of St. Cassian strata occurs close to the mass of débris from the Kofl. Dachstein Dolomite then rises at once as a precipitous crag, faulted from the strata on the Alpe.

These facts—namely, that different horizons of Raibl strata meet St. Cassian strata, and that Dachstein Dolomite is brought down to the level of Schlern Dolomite and of St. Cassian rocks—prove that an important fault-line, whose general direction is north and south, occurs along the western limit of Kreuz Kofl and La Varella. This conclusion need not surprise us when we consider that these mountains are included within the sunken area of Dachstein Dolomite. The Gardenazza *massif*, together with the whole system of strata in the Enneberg Valley, is less deeply sunk than Kreuz Kofl, and, further, the downthrow of the Gardenazza *massif* is locally minimized by the anticlinal folding of the strata in the Enneberg Valley.

I must say a few words in explanation of Section 5 (p. 28). At that section the St. Cassian strata strike east-and-west, and dip gently below the northern wall of Gardenazza, whereas in Section 4 (p. 26, across the Enneberg Valley) the same beds strike north-and-south. The strata therefore bend round, as is also the case north of Kreuz Kofl, towards the Armentara Alpe. At the lowest point of the pass between Enneberg and Campil, Wengen strata are exposed; these may be followed westward and are seen to crop out on the Campil Alpe a little south of the saw-mills. This outcrop is farther north than the position of the same strata on the pass, and although, owing to the rich vegetation, there are few points at which a dip-and-strike reading can be obtained with certainty, it may be concluded from their direction of outcrop that the Wengen Beds dip steeply northward. The succeeding strata form outstanding features, and are more easily studied. Augite-porphyry, Buchenstein, and Muschelkalk strata appear northward from the pass in the usual succession, but their strike is east-and-west, and they dip steeply towards the north. Again, below the two saw-mills, on the Campil Alpe, the beds occur in the same way, and the Werfen Beds are also exposed. This inverted succession of older Trias must be separated from the St. Cassian Beds below Gardenazza by a fault-line. Farther north the same beds form a normal succession, as anticline and syncline, the latter extending north to the pre-Triassic schists.

I have also drawn a parallel section in the Gader Valley below the pass. As the fault which separates the inverted system from that of Gardenazza does not strike exactly perpendicular (*i. e.* east and west) to the plane of the section, but W.S.W. and N.N.E., the St. Cassian and Wengen Beds of the Gardenazza system exposed in the Abtey Muren extend farther north than in the Pass section.

Recapitulating briefly the tectonic relations in the Upper Enneberg :—

(1) We have in Abtey, west of Kreuz Kofl, a region of less sinking, where Wengen and St. Cassian Beds possess an extended outcrop. The same result is attained in Prelongei, and the St. Cassian strata are still more favourably exposed by the folding of the whole series into the form of a flat syncline. Towards the Buchenstein Valley the Prelongei syncline passes into an anticline, and, erosion having removed the higher beds, the older Triassic strata are there fully exposed.

The system of older Trias which comes over the Gröden Pass separates the Wengen and St. Cassian strata in Abtey from those of Prelongei; and the strike of the two systems is different: in Abtey the strike is north and south, on Prelongei it is east and west.

(2) St. Cassian strata lie conformably below Schlern Dolomite on the southern side of Sett Sass, at various parts of Sella, Gardenazza, and Zwischenkofl, at one part of La Varella, at Centurinus Spitz, Lagazuoi, and Tra i Sassi. In all other places the Schlern Dolomite has either been removed by erosion (Prelongei and Abtey), or it has been faulted down.

(3) At Heiligkreuz Kirche, on the western side of Sett Sass, and at Valparola, the Raibl strata do not lie conformably upon St. Cassian beds, but *beside* them, separated by faults.

(iii.) *The District of Cortina and Falzarego.*

The Cortina map (B, facing p. 28) forms the easterly continuation of the Sett Sass district and embraces the high-lying valley of Falzarego between the Tofana and Nuvolau *massifs*, and the western portion of the Cortina hollow. Over an extent of ground measuring 12 miles as the crow flies, from Falzarego northward to Schwalben Kofl, one meets no other rocks than Dachstein Dolomite, Jurassic, and Cretaceous strata.

The road from St. Cassian to Ospizio in Falzarego leads over Valparola and Tra i Sassi. As was shown in discussing the Prelongei map (see pp. 20, 60), the fault separating the Valparola and Lagazuoi system from Sett Sass passes eastward towards Falzarego, while the north-and-south Heiligkreuz fault bends round north of the Sore Bach, and is continued eastward over Monte Cavallo.

These relations may be thus shortly represented :—

North.	North.
Centurinus Spitz	Sunk.
* * Fault * *	*
Lagazuoi and Valparola	Raised.
* * Fault * *	*
Sett Sass.....	Sunk.
(Gradual passage to the anticlinal fold of older Trias.)	
South.	South.

The Lagazuoi system consists of Dachstein Dolomite forming Fanis Spitz, then a band of Raibl strata, resting conformably upon the Schlern Dolomite rock of Lagazuoi, and lastly, below the Schlern Dolomite, the St. Cassian strata exposed west of Ospizio; south of these we meet again Raibl strata on Nuvolau. Whereas the St. Cassian strata below Lagazuoi dip only slightly northward, the Raibl Beds on Nuvolau dip very steeply in the same direction, and the Schlern Dolomite below them is exposed on the high ridge of Nuvolau. Farther south (on the slopes of Nuvolau towards Andraz and Buchenstein), St. Cassian, Wengen, and older Triassic strata follow in regular succession below the Schlern Dolomite.

These strata on Nuvolau form the continuation in part of the anticlinal fold of Wengen and older Triassic strata on Monte Sief and in the Buchenstein Valley, while the continuation of the east-and-west fault from Sett Sass throws down the Nuvolau system against the St. Cassian strata, west of Ospizio in Falzarego.

Before I follow the Falzarego fault farther east, I would like to refer to certain observations of Hoernes which seem to indicate the eastward continuation of the fault between Centurinus Spitz and Lagazuoi (see Mojsisovics' 'Dolomit-Riffe,' p. 291). According to Hoernes, the southern peak of Tofana Secunda is formed by Dachstein Dolomite and Lias, the northern peak by Jurassic rocks alone; a fault separates the two peaks, and the strata to the north of it have sunk. It seems probable that the fault-line which I observed at Centurinus Spitz coincides with this one observed on Tofana Secunda, in which case relations analogous to those farther west at Valparola and Sett Sass exist here:—

North.	North.
Monte Casale (northern peak of Tofana Secunda)...	Sunk.
* * Fault * *	*
Tofana Secunda (southern peak)	Raised.
* * Fault * *	*
Nuvolau	Sunk.
(With passage to the anticlinal fold of older strata.)	
South.	South.

Looking up from the Falzarego road at the dolomite-cliff of Lagazuoi, nothing can be seen either of the Raibl strata or of the Dachstein Dolomite. They lie at a height of more than 1000 feet above the road, and their outcrop is some little distance north of it.

East of Ospizio in Falzarego, the Raibl strata are seen on Col dei Bos at a relatively low level, and above them the Dachstein Dolomite forms the imposing wall of Tofana Prima. Associated with this unexpected geological feature, a change in the mere terrain makes itself felt (see fig. 6, p. 29).

Lagazuoi descends southward with steep walls close to the Falzarego road, and eastward it descends towards a good stretch of meadow, the Roces Alp. Some little distance back from the road, Tofana rises above the meadow, and between Lagazuoi and Tofana a narrow ravine leads up from the Roces Alp to the Travernanzes Pass. In this ravine there is a north-and-south fault-line cutting Lagazuoi completely off from the Roces Alp and from Tofana Prima.

The Tofana system east of the fault has been thrown down; hence it is that Raibl strata are in contact with the Schlern Dolomite of Lagazuoi, and blocks of Schlern Dolomite cover the greater part of the Roces Alp near Lagazuoi. The continuation of this fault-line is followed across the Costeana Bach, where it passes between fossiliferous Raibl beds (mentioned in the stratigraphical part of the present paper) on the western or upthrow side of the fault, and unfossiliferous variegated marls on the eastern or downthrow side.

The general strike of the Tofana Prima *massif* at the Roces Alp is east-and-west, and the dip north; but on the eastern slopes of Tofana Secunda the strata strike north-and-south, and dip west. (This bending round of the strata is similar to that which was observed in the Enneberg Valley, north of Gardenazza and Kreuz Kofl, and again at Centurinus Spitz; the strata always dip towards the central area of Dachstein Dolomite.)

This bending round has been accompanied in the neighbourhood of Cortina by several radial faults. I cannot enter into the minute details of these. Figs. 7 and 8 (pp. 29, 30), together with a glance at Map B, show that the radial faults are again broken by faults parallel with the main direction of the mountain *massif*. The higher strata are faulted down, and are always brought to different horizons, until, at Col Druscie, Dachstein Dolomite and Raibl strata extend down to the Boita Valley.

The Schlern Dolomite is seen only at two places within the system of radial faults. One of these is near the Verviers or Federale chalets; the other is on the Majorera slope, just north-east of the Lago di Majorera. A downthrow of Raibl Beds occurs immediately below the Schlern Dolomite on Majorera, and these are again faulted in a north-and-south direction against St. Cassian strata.

At the Roces Alp a triangular arrangement of faults has raised the St. Cassian Beds; in the south they come in contact with Raibl strata (the 'Falzarego fault'), in the west with different horizons of the Col dei Bos system, and in the east they reach quite close up to the sharp angle where the Dachstein Dolomite is faulted so far forward, and forms the prominent Verviers (or Federale) ridge. Near Cortina the outcrop of the St. Cassian Beds forms a wide undulating meadow, in many parts entirely covered by a superficial mass of slipped débris and broken masses from the steep Tofana slopes. Extensive slips have occurred in the neighbourhood of the Romerlo chalets, where the red Raibl marls and the lower fossiliferous beds have slipped eastward.

The Schlern Dolomite crag of Crepa rises abruptly from the midst of these Cortina meadows. South of Crepa, a small stream has cut its way through a rocky gorge in the dolomite; and immediately south of that, St. Cassian and Wengen strata are seen in place. Exposures of these strata are, however, better seen in the Costeana stream and near Pec di Palu. Crepa is faulted on all sides, and is a part of the overlying rock let down in the midst of the St. Cassian and Wengen strata.

The observations detailed above, so far as they go, show that:—

(1) The Cortina district has, in its western part, the closest tectonic connexion with the Valparola district.

(2) The strata of Tofana Secunda bend round near Cortina by means of radial faults.

(3) There follows in this neighbourhood, south of the sunken area of Tofana, a raised system of strata in which St. Cassian Beds now form the surface-outcrop.

(4) Within the raised system, Crepa occurs as a faulted-down block of younger beds.

(5) St. Cassian strata conformably underlie Schlern Dolomite in the neighbourhood of Ospizio in Falzarego; in the other parts of the map the St. Cassian Beds are faulted, and come into contact with the Schlern Dolomite, the Raibl Beds, and the Dachstein Dolomite.

(iv.) *The District of the Dürrenstein and the Sarl Alp.*

(See Map C, facing p. 32.)

As already mentioned, the district of the Dürrenstein is intermediate between the outer zone of older Trias forming the low hills south of the Pusterthal, and the sunken 'Dachstein' district represented here by the great dolomite-*massifs* of Croda Rossa, Cristallo, etc.

The Werfen Beds and the Muschelkalk are exposed north-east of Alt-Prags. The Muschelkalk is repeated three times, at Lung Kofl, at Mesner Kofl, and at Sarl Köfele; the strike is always east-and-west, and the dip southerly. Faults parallel with the strike of the beds separate the three systems from one another; these faults must be regarded as one system of step-faults, throwing down the strata to the north and repeating them to the south. I referred, in the general remarks on the tectonic relations (p. 58), to such step-faulting as being of frequent occurrence in the outer zone of older Triassic rocks.

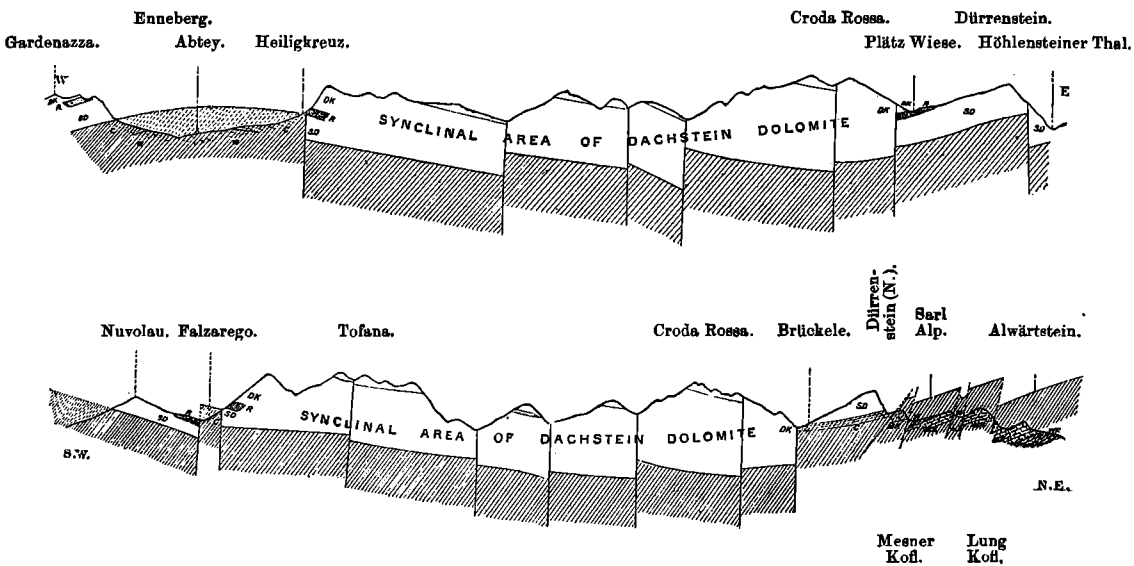
The Werfen Beds are exposed north of Badmeister Kofl and Alwärtstein, and pass over Puez Alp, Sueskopf, and Troger Alp, eastward to the Toblach Valley. At Badmeister Kofl and Alwärtstein, Lower Muschelkalk, Mendola Dolomite, Upper Muschelkalk, Buchenstein strata, and Wengen Beds succeed the Werfen Beds regularly, the lower strata dipping at a very high angle southward, the higher strata not so steeply (strike W.N.W. and E.S.E.).

The Wengen Beds form the Kameriod Wiesen and extend southward towards Heimwald Kofl. Heimwald Kofl is a steep cliff of Mendola Dolomite rock, succeeded on Schafriedl by highly-contorted beds of Buchenstein, Wengen, and St. Cassian age. The general strike of this system is north-eastward, the dip south-easterly. A fault therefore separates the systems of Heimwald Kofl and Schafriedl from the Kameriod Wiesen.

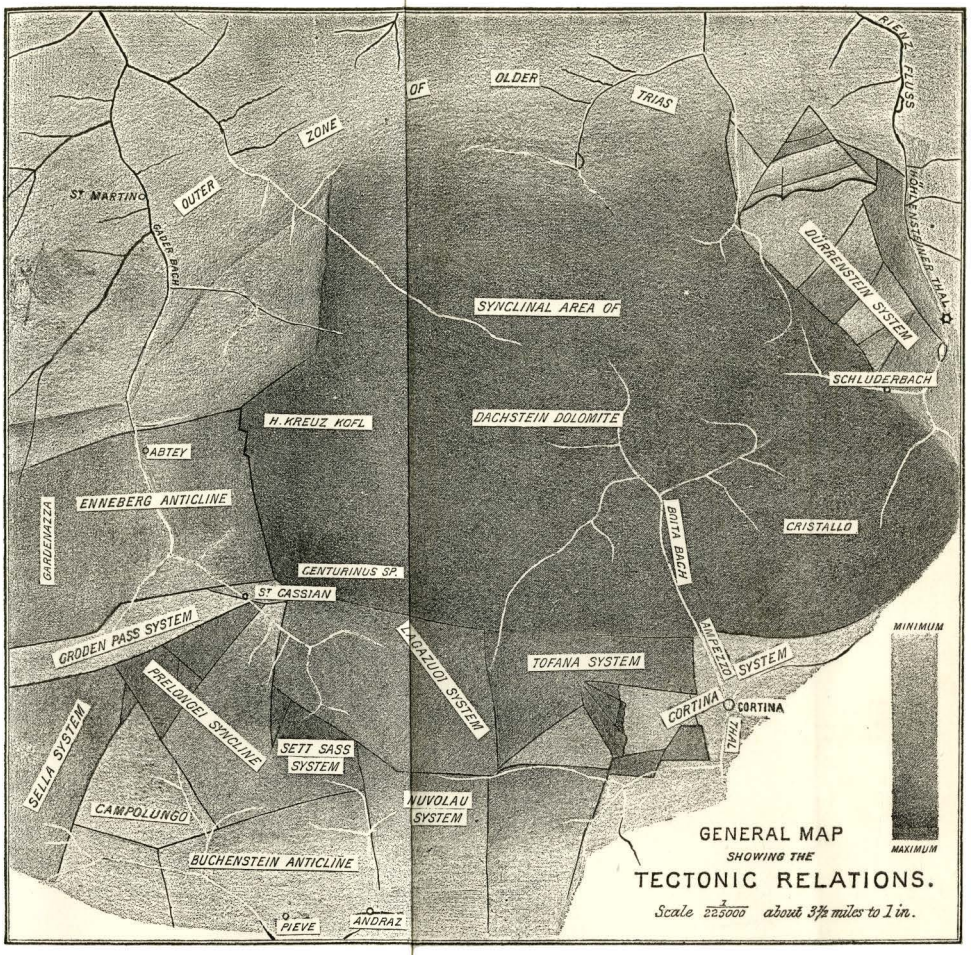
The Mendola Dolomite of Lung Kofl meets in the Lung Valley the Buchenstein and Wengen strata of the outer system. Again, in the ravine between Lung Kofl and Mesner Kofl, Buchenstein and Wengen strata occur. Here they have a very high dip and are much

General Sections through the 'Dachstein' Area.

(Enneberg, Falzarego, and the Dürrenstein from personal observations.)



[Scale: $\frac{1}{225000}$ = ·281 inch to the mile.]



Note.—The above Map shows the main faults and the depressed areas, the greater amount of depression being indicated by deeper shading. For details, see Maps A, B, and C (facing pp. 18, 28, 32). The term 'system' is here, and in the text of the accompanying paper, used to denote an area surrounded by faults. Such faulted areas are termed *Schollen* by German geologists, and the English equivalent of that expression would appear to be 'fault-block;' see J. S. Diller, 'Notes on the Geology of Northern California,' Bull. U. S. Geol. Survey, vol. v. (1887) no. 33, p. 15 (379).

crushed and folded between fault-lines both north and south. The Lung Valley outcrop is less disturbed, the Mendola Dolomite of Lung Kofl being merely the continuation of the Alwärtstein system thrust forward.

On the southern side of Mesner Kofl the Buchenstein and Wengen Beds on the Sarl Alp are again faulted down below Sarl Köfele. The strata of all three systems, Lung Kofl, Mesner Kofl, and Sarl Köfele, have a north-easterly strike and dip to the south-east. The same transverse fault which is observed in the Lungthal may be followed southward between the Kameriod Wiesen on the downthrow side and the Sarl Alp and Mesner Kofl succession on the upthrow.

From Lung Kofl the outcrop of Mendola Dolomite and Lower Muschelkalk is continued eastward over Sarl Kofl and Sarl Brand to the Toblach Valley. On both sides of the Ampezzo road, from Lake Toblach to Schluderbach, dolomite is present, nowhere interrupted by marly strata. The dolomite-rock of Sarl Kofl and Sarl Brand strikes north-east and dips south-east; this changes, however, south of the Sarl Bach, for the Mendola Dolomite which forms the lower part of Nockboden strikes north-west and dips south-west.

Lastly, wedged in between Sarl Kofl, Sarl Brand, Nockboden, Kasamütz, and Mesner Kofl, we find Buchenstein and Wengen strata on the Sarl Alp, and they have much the same tectonic relations to the Mendola Dolomite around them as the outcrop between Lung Kofl and Mesner Kofl. Here, however, the strata are thrown down by a triangular break.

Summarizing these observations, we find therefore the system of older beds from Prags to the Toblach Valley broken up into three main sub-systems by two transverse faults:—

a.	*b.*	*c.*
Alwärtstein.	Lung Kofl.	Sarl Kofl.
Kameriod Wiesen.	Mesner Kofl.	Sarl Brand.
	Sarl Köfele—Sarl Alp.	Nockboden.

Sarl Brand is somewhat sunk from Sarl Kofl towards the Toblach Valley; the fault may be followed farther north in the Werfen Beds exposed in the Troger Bach.

Looking southward from the Sarl Alp beyond the low dolomite escarpment which extends (although in some places more or less eroded) from Sarl Köfele to Nockboden, the view is entirely shut in by the Dürrenstein *massif*. This *massif* is of Schlern Dolomite rock and lies conformably upon the St. Cassian strata exposed on the Flodiger Wiese. The St. Cassian strata of the Flodiger Wiese rest apparently conformably upon the dolomite-rock of Sarl Köfele and of Kasamütz. Regarding the dolomite here as Mendola Dolomite, the following section is obtained (in descending order):—

Schlern Dolomite of the Dürrenstein.
St. Cassian strata of the Flodiger Wiese.
Mendola Dolomite of Sarl Köfele and Kasamütz.

At Nockboden, where St. Cassian strata are no longer present, the section, according to the same reading, would give:—

{ Schlern Dolomite.
{ Mendola Dolomite.

This is, so far as mere succession of beds goes, a case exactly analogous to the succession in the Tiers Valley, the Rosengarten, and other *massifs* of the western region. It has been proved in that district that the strata which in many other places intervene between the Mendola Dolomite and the Schlern Dolomite thin out gradually in a continuous development of dolomite. And this very natural explanation has also been applied to the district north of the Dürrenstein. The evidence which previous authors have found in the latter district is largely based on the appearances at Mesner Kofl and at Sarl Köfele; these are regarded as dolomitic masses belonging to Wengen or St. Cassian time and thinning out in the marls or shales of the Sarl Alp and of the Kameriod Wiesen, a conformable succession being thus presented from the Dürrenstein to Lung Kofl (in descending order):—

Dürrenstein	.....	Dolomite (by some regarded as St. Cassian Dolomite).
Flodiger Wiese	.....	St. Cassian strata (non-dolomitic).
Sarl Köfele	.....	St. Cassian or Wengen Dolomite.
Sarl Alp Mesner Kofl	....	Wengen strata (non-dolomitic), with contemporaneous Reef-dolomite.
Intervening Valley	... .	Wengen and Buchenstein strata (non-dolomitic).
Lung Kofl	.....	Mendola Dolomite.

According to the same view, the non-dolomitic strata are represented above the Toblach Valley by a dolomitic facies continuously developed during all the periods that elapsed between the laying down of the Mendola Dolomite and of the Raibl strata.

The dolomite-rock of Mesner Kofl is, according to the succession quoted, a *Wengen* Dolomite, and not *Mendola* Dolomite. As yet no fossils have been found in it, but in the districts east and west *Gyroporella pauciforata*, a Muschelkalk form, occurs frequently in a dolomitic rock which has also been assigned to the Wengen period.

With respect to the dolomite of Mesner Kofl I can only bring forward stratigraphical evidence. As I have already said, and as may be seen in my map, the Buchenstein and Wengen Beds which are exposed in the valley between Lung Kofl and Mesner Kofl are strongly crushed and sheared. The Wengen Beds come in contact with the dolomite-rock of Lung Kofl on the ridge, while lower down on the western slope the Buchenstein Beds are in contact with that of Mesner Kofl. Farther east, on the eastern slope of the Sarl Alp, the Buchenstein and Wengen Beds are cut off against the dolomite of Mesner Kofl, and have a different strike from it and from the outcrop of the same beds on the western slopes.

South of Mesner Kofl large blocks of the characteristic Buchenstein limestones with siliceous secretions are found on the grassy slope, and on the Sarl Alp Wengen Beds are in place. Nowhere is it possible to see the thinning-out of the Mesner Kofl dolomite-rock in the series of Buchenstein and Wengen strata, and we are confronted therefore by two stratigraphical possibilities:—

(1) The dolomite of Mesner Kofl may be a reef-dolomite thinning out in Buchenstein and Wengen strata, although, owing to later faulting, the relations of dolomitic and non-dolomitic beds have been obscured.

(2) The dolomite of Mesner Kofl may be Mendola Dolomite brought into its present position as the axis of a small anticlinal fold embracing the whole system between Sarl Köfele in the south and Lung Kofl in the north. This anticlinal fold is the result of crush, and is broken in several places by fault-planes.

The same conclusions are applicable with slight differences to the case of the Heimwald Kofl dolomite-rock and its relations with the Kameriod Wiesen system of non-dolomitic rocks.

The dolomite of Sarl Köfele (below the St. Cassian strata) and of Kasamütz (also underlying Cipit Limestones probably of St. Cassian age) forms a no less debatable point. Thinning-out of the dolomite in bedded limestones and shales is said to occur between these two prominent rocks. But the limestones and shales which are exposed do not occur in the same direct east-and-west line with the dolomite, and their exposure might be explained as the result of erosion. Leaving this for the present, we find that below Kasamütz the whole of the Sarl Alp system of strata is cut off against the dolomite. This system is also cut off north and south above the rocky ravine of Sarl Bach, so that nowhere is thinning-out of the Sarl Alp non-dolomitic strata directly observable.

The St. Cassian strata above Kasamütz are still very thick, nor are they observed to thin out gradually in the dolomite of Nockboden. In short, the disappearance of the Buchenstein and Wengen strata on the Alpe below and of the St. Cassian strata on Kasamütz is not gradual, but sharp, and takes place exactly in the same north-and-south line. This is a north-and-south fault-plane separating the central or Sarl Alp system (general strike E.–W.) from the eastern or Toblach Valley system (general strike N.N.W.–S.S.E.). It may be said that in this case, as at Mesner Kofl, the actual thinning-out of the strata has been faulted out of sight, and this is very possible. It is at the same time striking that there should be a perfectly normal thickness and perfectly characteristic development of non-dolomitic St. Cassian strata on Kasamütz, so close to the dolomitic facies of Nockboden.

Following the dolomitic rock exposed on Sarl Köfele westward, it is seen to strike across to Kirchenschroffen. Here it meets the Schafriedl system of non-dolomitic beds, with which it has no possible relation of thinning-out. A further complication is introduced by the Dürrenstein system, and the beds at Kirchenschroffen

are thrown into a series of large folds, which prove the presence at one time of important strain between the two large systems—that of the older Trias of Prags and the Sarl Alp, and that of the younger Trias of the Dürrenstein *massif*. The Sarl Köfele Dolomite disappears finally in Kirchenschroffen, and the Wengen and St. Cassian strata of the Schafriedl system come in contact, very little north of Brückele, with the Wengen and St. Cassian strata of the Dürrenstein system.

If now both Kirchenschroffen and Heimwald Kofl are Wengen Dolomite, we have (according to the view which accepts for this district a gradual transition of non-dolomitic into dolomitic strata) again the following conformable succession between the Dürrenstein and the Kameriod Wiesen :—

Locality.	*Nature of Rock.*	*Probable age.*
Dürrenstein.	Dolomitic.	St. Cassian.
	Non-dolomitic.	
Kirchenschroffen.	Dolomitic.	Wengen.
Schafriedl.	Non-dolomitic.	
Heimwald Kofl.	Dolomitic.	
Kameriod Wiesen.	Non-dolomitic.	
Buchenstein and older Trias.		

But below Kirchenschroffen the non-dolomitic strata are St. Cassian with beds of Cipit Limestone, and they are the same beds as those which apparently follow conformably above the dolomite of Sarl Köfele and below the dolomite of the Dürrenstein; hence, even if we accept the view of facies-developments, we must rather consider the Kirchenschroffen and Sarl Köfele Dolomite as a dolomite-bed in the St. Cassian marls, such as we have at the Richthofen Riff, in marls of the same age below Sett Sass.

From the already-mentioned tectonic features and the marked disturbance and folding of the strata on Schafriedl, I find it much harder to explain the dolomite-rock of Kirchenschroffen and Sarl Köfele as 'St. Cassian Dolomite' than the Richthofen Riff; the latter is a bed of dolomite which is seen to thin out gradually and regularly in St. Cassian marls and limestones. Again, the non-dolomitic strata above the Heimwald Kofl are present in normal thickness; on the Sarl Alp the succession of non-dolomitic rock ends with Wengen Beds, but the surface here has been deeply eroded.

So many difficulties having suggested themselves to me in accepting the facies-development as a complete explanation of the facts which I observed, another view may be stated as a possible explanation.

When examining the dolomite-rock at Nockboden I found that *Gyroporella pauciforata*, the typical fossil of the Mendola Dolomite

(Muschelkalk), occurred at a considerable height above the Toblach Valley in the Sarl Bach ravine; it also occurs in the dolomite on both sides of the valley nearly as far south as the bridge below the Flodiger Wiese. On the other hand, the ascent to that Wiese cuts through a dolomite which is unquestionably Schlern Dolomite, often possessing the oolitic structure characteristic also of the Wetterstein Kalk in Northern Tyrol. I concluded that Schlern Dolomite rests on Mendola Dolomite at Nockboden, although an exact limiting-line can naturally not be drawn.

Assuming that the Sarl Köfele and Kasamütz dolomite-rock is Mendola Dolomite, the St. Cassian Beds of the Flodiger Wiese rest on the last-named horizon. They dip below the Schlern Dolomite of the Dürrenstein, and on the western slopes of that mountain, towards Stolla, rest conformably upon Wengen strata. We have, between the Flodiger Wiese and the Dürrenstein, a fault-plane hading gently to the south, on which a system of Upper Trias has been thrust down upon a system of Lower Trias. A thrust of that kind explains the apparent unconformity of the St. Cassian Beds and the Schlern Dolomite upon the Mendola Dolomite.

The north-and-south vertical fault, which separates the system of strata exposed on the Sarl Alp and Kasamütz from that of the Toblach Valley, is of later date, and cuts through the thrust-plane. This fault lets down the Schlern Dolomite and Mendola Dolomite which form the Nockboden system. On the western side the thrust-plane system is cut off at Kirchenschroffen by the continuation of the north-and-south fault between Lung Kofl and the Kameriod Wiesen. It may be that there is a farther extension east and west of this thrust-plane, and in the subsequent changes brought about by vertical faulting we may have an explanation of the various anomalies in the neighbouring regions.

In the four sections 10–13 (pp. 34, 35) I have shown the result of my observations at the Dürrenstein, and can only regret that time did not allow of my continuing the study of the geology farther west. With the same inclination and throw of the thrust, Dachstein Dolomite and Raibl strata of the upper system would rest on Schlern Dolomite of the lower; but I need not enter into considerations which do not immediately concern the district mapped. I have already indicated, in my preliminary remarks (p. 60) on the district between the northern outer zone and the Falzarego Valley, the general tectonic features, as I should interpret them after detailed study of some portions.

The tectonic relations of the Dürrenstein *massif* are simple. It is separated from the 'Dachstein' region by a main north-and-south line of fault, continued also across the Ampezzo Valley at Schluderbach.

The road between Alt Prags and Schluderbach bends eastward at Brückele, and winds round the base of the Dachstein *massif* of Rauhe Gaisl on the right. Wengen and St. Cassian strata are in place on the left, with an east-and-west strike and a slight southerly

dip. The St. Cassian strata are the same as those which dip below the Dürrenstein along its northern face, and here also the Schlern Dolomite follows conformably above them. Several south-west and north-east faults of small throw let down the Schlern Dolomite and the underlying strata at this northern corner. The St. Cassian and Wengen strata which form the base of the valley are faulted against the Dachstein Dolomite on the west.

Farther up the valley, towards the Plätz Wiese, the road passes through Schlern Dolomite, but towards the summit the Raibl strata form steep slopes below the road, cut by stream-gullies and slipped in various directions.

On the Plätz Wiese Raibl strata are exposed in conformable succession upon the dolomite descending from the highest ridge of the Dürrenstein. The beds strike north-west and south-east, and dip south-west. On the steep wooded slope between Stolla and the road, the dolomite and the St. Cassian strata of the first system strike against the slipped Raibl Beds which form part of a second system. This fault passes then through the dolomite itself in a general north-east and south-west direction, and although it cannot be followed in the dolomite, the strike of the two systems differs as mentioned.

The Raibl Beds above Stolla do not properly belong to the strike-system of the Plätz Wiese and the Wällsche Boden farther south, but are plainly the remains of a big slip at some former period from the rocks of the Dürrenstein above the Wiese.

Dachstein Dolomite follows conformably above the Raibl strata on the Wällsche Boden (see pp. 41, 42, and fig. 14), and the whole Plätz Wiese system is, like the first system, faulted against the Dachstein Dolomite to the west.

The road continues southward on beds of dolomitic flags, which underlie the red Raibl marls on the meadow, and only very gradually descends towards the new fort. Here a rocky ridge running west from the Hellthaler Schlechten spans the Plätz Wiese and slopes steeply south towards the Seeland Valley. The dolomite-flags and Raibl marls bend up on the northern slope towards Knollenkopf. On the ascent to Knollenkopf from the Plätz Wiese they are succeeded conformably by rauchwackes and Dachstein Dolomite, but on the Seeland Valley face of the ridge the beds of the Lower Raibl horizon meet the north-and-south fault from the Wällsche Boden and are cut off against Dachstein Dolomite. Again, as at Stolla, the 'Plätz Wiese system' is let down by a fault running east-and-west and continuing into the Schlern Dolomite of the Dürrenstein. On the southern side of this fault, an upthrow of St. Cassian strata forms the base of the Seeland Valley and is succeeded eastward by Schlern Dolomite on Strudelkopf. This southerly system of the Dürrenstein strikes N.N.W., and dips with varying angle to N.E.; it is separated by the continuation of the north-and-south fault from the Dachstein Dolomite of Knollenkopf on the west (see fig. 9, p. 32). The 'Strudelkopf system' is broken by several small cross-faults which bring down the

St. Cassian strata and overlying dolomite repeatedly to the south, so that, although a comparatively small thickness of St. Cassian strata is exposed on the Alpe, their outcrop continues very nearly as far as Schluderbach. Then, however, the north-and-south fault has on the western or downthrow side Dachstein Dolomite, and on the eastern or upthrow side the Schlern Dolomite of Strudelkopf and of Monte Pian farther south.

The most important tectonic relation is that brought out by the north-west and south-east fault which separates the Dürrenstein *massif* from the 'Dachstein Dolomite region' of Rauhe Gaisl, Schlecht Gaisl, and Hohe Gaisl (Croda Rossa). These form part of the sunken area west of the Dürrenstein. The Knollenkopf is a mass of Dachstein rock, let down between two branches of this main fault, the westerly branch passing through the Knappenfuss Valley.

Downthrow of the strata has taken place also on the eastern side of the Dürrenstein. The Sarl Brand, as already mentioned, is sunk from the Sarl Kofl, and the Muschelkalk faulted down; the Nockboden is sunk from Kasamütz and the Sarl Alp; and towards Landro the eastern part of the Dürrenstein is sunk from the main ridge. By this north-and-south fault through the Dürrenstein, an apparently much greater thickness of Schlern Dolomite is seen above the Toblach Valley than on the northern or western sides. No part of this thickness is due to Mendola Dolomite, as, for instance, is the case south of Schlern; in the Dürrenstein *massif*, the only place where Mendola Dolomite underlies Schlern Dolomite is at Nockboden.

We have, therefore, sunken *massifs* both west and east of the Dürrenstein; that mountain itself remains at a higher level between the two, and may be called a 'Horst' in the sense originally applied by Suess.[1] At the same time the 'Dürrenstein Horst' borders on the 'Dachstein' region, and this nearness to the important fault finds expression, especially on the western side, in a number of smaller faults.

In the Plätz Wiese system, the strata are sunk much lower in the south-western portion near the 'Dachstein' region than in the eastern or Dürrenstein-ridge portion, and in the Strudelkopf system we find repeated sinking of the strata southward, towards the Dachstein Dolomite *massif* of Monte Cristallo.

Discussion.

Mr. J. W. Gregory remarked on the many questions of interest which this paper affected. The Authoress's work had destroyed faith in the most famous fossil atoll, doubts as to which had been previously suggested by palæontological and stratigraphical considerations. Careful zonal collecting in these beds was greatly needed, as in the three principal collections (Vienna, Munich, and London) the fossils are simply localized as St. Cassian. The fauna, with its

[1] 'Antlitz der Erde.' 1st ed. 1885, vol. i. p. 167.

abnormal forms such as *Tiarechinus*, suggested an unfavourable environment, and the speaker hoped that Miss Ogilvie's work would demonstrate whether these were due to deep-sea or lagoon conditions.

Mr. VAUGHAN JENNINGS said that any geologist who knew the country of the Schlern, the Lung Kofl, and the Sella Joch would welcome new evidence on the stratigraphy of the district. If the area of discussion were widened, as it had been by previous speakers, to include the Western Alps, it should also include the Southern. In the Ligurian region, which he had recently been able to examine, there was a sudden thinning-out of dolomite-reefs similar to that of the Tyrol—for instance, Monte del Gazo near Genoa. Here, careful examination and mapping precluded the idea of simple faulting; at any rate, later than the Eocene. If it were a system of faults which here caused the thinning-out of the dolomite, it was a very ancient series of earth-movements, not a recent one.

Mr. TOPLEY remarked that whilst one important result obtained by Miss Ogilvie was to fix the position of the Schlern Dolomite between the St. Cassian and Raibl strata, her observations at the same time showed that masses of dolomite occurred at other horizons; for instance, the Cipit Limestone lies in the Lower St. Cassian Beds, whilst the Richthofen Riff is a lenticular mass of dolomite in the Middle St. Cassian.

The Rev. J. F. BLAKE also spoke.