[*Extracted from the* GEOLOGICAL MAGAZINE, Decade IV, Vol. VII, No. 434, p. 337, August, 1900.]

ON THE FAUNA OF THE UPPER CASSIAN ZONE IN FALZAREGO VALLEY, SOUTH TYROL.

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HAVING the opportunity of revisiting Munich, I have drawn up a list of the fossils which formed the basis of the "Upper Cassian Zone," erected by me in 1893. These fossils,[1] when I discovered them in Falzarego Valley in 1891, were then for the most part unknown. The tuffs and breccias in which they occur had been referred by Loretz to the fossiliferous Raibl horizon of the Schlern Plateau, and by Mojsisovics to the much lower horizon of Wengen strata. I found, by careful collection from strata in position, that the fauna, in addition to a fair proportion of St. Cassian types and a few Raibl types, comprised a number of types common both to Cassian and Raibl horizons and a still greater number of species which had not been found elsewhere (Q.J.G.S., 1893, pp. 31, 44, 46, 47).

Judging both from the transitional Cassian-Raibl character of the fauna and from the stratigraphical position of the fossiliferous series in the field, above a zone containing typical St. Cassian fauna, I concluded that this Falzarego Valley fauna represented a palæontological zone younger than the typical St. Cassian fauna as known at Stuores and Prelongei, and older than the lower Raibl fauna as known at Schlern Plateau and described by von Wöhrmann and Koken.[2] I therefore placed it as an independent palæontological zone, naming it Upper Cassian.[3] This determination of an Upper Cassian zone in South Tyrol practically demonstrated the same gradual faunistic transition from Cassian to Raibl zones in South Tyrol which had been demonstrated by von Wöhrmann[4] in the Cardita and Raibl strata of North Tyrol.

[1] My zonal collections from the Enneberg and Ampezzo Upper Trias are in the Palæontological Museum in Munich.

[2] von Wöhrmann und Koken: "Die Faunen der Raibler Schichten von Schlernplateau": Zeitschr. d. D. geol. Ges., 1892.

[3] Ogilvie: "On the Wengen and Cassian Strata in Southern Tyrol," Quart. Journ. Geol. Soc., 1893; "Coral in the Dolomites," GEOL. MAG., 1894.

[4] von Wöhrmann: "Die Fauna der sogenannten Cardita u. Raibler Schichten in den Nordtiroler u. bayerischen Alpen": Jahrb. der k.k. geol. Reichs., 1889.

After the publication of my paper in 1893, at Dr. Bittner's request I sent to him in Vienna my private collection of the Falzarego Valley fauna. I hoped that in Vienna, among the South Tyrol collections of the Austrian Geological Survey, a nearer identification of the material might be attained. Thus the fauna has had the advantage of Dr. Bittner's close examination and judgment, and I am now in a position to publish a list of the types named in accordance with the most recent advances in the literature of Alpine Trias.[1] The Lamellibranchs have for the most part been described and illustrated in Dr. Bittner's "Monograph." The Roman numerals and figures entered in the list refer to that work, and the bivalves are enumerated in the order adopted there.

LIST OF FOSSILS.

Abbreviations.—C* = occurrence in Stuores-Cassian zone; R* = occurrence in Raibl zones. S.Pl. after R = occurrence also in the Raibl beds of Sohlern Plateau.

	C	R
LAMELLIBRANCHIATA.		
Cuspidaria siliqua, Bittn. (i, 19, 20)	*	...
Gonodon (*Corbis*) *plana*, Mnst., sp.	*	...
Laubeia (*Megalodus*) *strigilata*, Klipst., sp. (ii, 13–18) ...	*	...
Astartopis Richthofeni, Stur	...	* S.Pl.
Myophoriopis lineata, Mnst., sp. (xiii, 1–6)	*	* (?)
Myophoria decussata, Mnst., sp. (xii, 1–8)	*	* S.Pl.
,, *fissidentata*, von Wöhrm.	...	* S.Pl.
Myophoria (?) *solitaria*, Bittn. (xxiv, 27)	...	...
Trigonodus Rablensis, Gredl., sp.	...	* S.Pl.
Cucullæa (*Macrodon*) *impressa*, Mnst., sp. (xv, 1, 2)	*	* S.Pl.
Pinna, sp. inn. (v, 15, 16)	...	...
Avicula Sturi (= pars *A. Gea*, D'Orb.), Bittn. (viii, 3, 4) ...	*	* S.Pl.
,, *Cassiana* (= pars *A. Gea*, D'Orb.), Bittn. (viii, 6) ...	*	...
,, *Cortinensis* (aff. *A. Gea*, D'Orb.), Bittn. (viii, 5) ...	...	...
,, *Tofanæ*, Bittn. (viii, 9–11)	...	...
Cassianella euglypha, Lbe. (vii, 1)	*	*
,, *decussata*, Mnst., sp. (vii, 6–15, 20)	*	* S.Pl.
,, *angusta*, Bittn. (v, 23–26)	...	*
,, *Ampezzana*, Bittn. (vi, 10, 11)	...	...
Hoernesia Johannis Austriæ, Klipst. (x, 10–15)	...	* S.Pl.
Gervillia angusta, Gdf. (ix, 13)	*	*
,, *angulata*, Mnst. (ix, 11–17)	*	* (?)
,, *Ogilviæ*, Bittn.	...	...
Pecten tubulifer, Mnst. (xix, 13–15)	*	...
,, cf. *auristriatus*, Mnst. (xix, 23–26)	*	...
,, aff. *Saecoi*, Par. (xix, 22)	...	*
,, aff. *subdemissus*, Bittn. (xix, 29)	*	...
,, *Landranus*, Bittn. (xix, 21)	...	...

[1] Bittner: "Die Brachiopoden der Alpinen Trias," Abhandl. der k.k. geol. Reichsanstalt, Wien, 1890; "Die Lamellibranchiaten der Alpinen Trias," Theil i, "Revision der Lamellibranchiaten von St. Cassian," Wien, 1895. Kittl: "Die Gastropoden der Schichten von St. Cassian der Süd-Alpinen Trias," Annalen des k.k. naturhist. Hofmuseums, Wien, 1891; "Die triadischen Gastropoden der Marmolata u. verwandt. Fundstetten in den weissen Riffkalken Südtirols," Jahrb. k.k. geol. Reichs., 1894; "Die Gastropoden der Esinokalke nebst einer Revision der Gastropoden der Marmolatakalk," Annalen des k.k. naturhist. Hofmuseums, Wien, 1899. Salomon u. Böhm: "Fauna der Marmolatakalk," Palæontographica, 1895.

	C	R
Lima angulata, Mnst. (var. *opulenta*, Bittn.)	•	...
,, (*Plagiostoma*) *subpunctata*, D'Orb. (xxi, 19, 20) ...	•	...
,, (*Mysidioptera* ?) *spinigera*, Bittn. (xx, 32)	...	...
Mysidioptera aff. *vixcostata*, Stopp. (xx, 30)	...	...
,, cf. *tenella*, Bittn. (xxi, 1)	...	...
Plicatula solea, Lbe.	•	...
,, *Ogilviæ*, Bittn. (xxiii, 20, 21)	...	...
Placunopsis, sp. indet. (xxiii, 16)	...	...
Solen, *Mytilus*, *Anaplophora*, and *Myacites* (in poor specimens).		
GASTEROPODA.		
Dentalium simile, Mnst.	•	...
Acmæa (*Patella*) *campanæformis*, Klipst., sp. ...	•	...
Patella capulina, Braun (? *granulata*, Lbe.) ...	•	...
Neritopsis decussata, Mnst., sp.	•	• S.Pl.
,, *armata*, Mnst., sp.	•	• S.Pl.
Neritina imitans, Kittl	•	...
Eucycloscala (*Scalaria*) *ornata*, Mnst., sp. ...	•	...
Collonia cincta, Mnst., sp.	•	...
Delphinulopsis, sp. indet.	...	...
Naticopsis neritacea, Mnst., sp.	•	...
,, *expansa*, Lbe., sp.	•	...
,, aff. *Cassiana*, Wissm., sp.	•	...
Ptychostoma pleurotomoides, Wissm., sp. ...	•	•
Ptychostoma, n.sp., aff. *Trochei*, Kittl	...	...
Hologyra Ogilviæ, Böhm	...	...
Loxon ma, sp.	...	...
Goniogyra, n.sp.	...	...
Natica plicatilis, Klipst.	•	...
Spirostylus subcolumnaris, Mnst., sp.	•	...
,, *columnaris*, Mnst., sp.	•	...
Euthystylus hastile, J. Böhm (*Orthostylus* cf. *Fuchsi*, Kittl)	...	...
Hypsipleura subnodosa, Klipst., sp.	•	...
Cœlostylina crassa, Mnst., sp.	•	...
,, sp., cf. *i frastriata*, Kittl	...	...
Promathildia (*Turritella*) *subornata*, Mnst., sp.	•	...
,, sp. ?	...	...
Pseudomelania (*Turritella*) cf. *similis*, Mnst., sp.	•	•
CEPHALOPODA.		
Aulacoceras inducens, Mojs.	•	• S.Pl.
Orthoceras elegans, Mnst.	•	...
Nautilus, sp. indet.	...	...
Lobites (*Clydonites*) *nautilinus*, Mnst., sp.	•	...
Trachyceras Aon, Mnst., sp.	•	
Pinacoceras Philopater, Lbe.	•	
BRACHIOPODA.		
Cyrtina Buchii, Klipst., sp.	•	...
Amphiclina scitula, Bittn.	...	•
Thecospira tenuistriata, Bittn. (aff. *T. Gümbeli*)	•	• (?)
Rhynchonella cf. *tricostata*, Mnst., sp.	•	...
Terebratula, n.sp., aff. *Cassiana*, Bittn. ...	...	
Waldheimia, n.sp.	...	
ECHINODERMATA.		
Cidaris parasta ifera, Schafh. ...	•	•
,, *dorsata*, Braun	•	• S.Pl.
,, *alata*, Ag.	•	• S.Pl.

	C	R
Cidaris Hausmanni, Wissm.	*	*
,, *decorata*, Mnst.	*	...
,, *Braunii*, Desor	*	*
,, *flexuosa*, Mnst.	*	...
,, *Liagora*, Mnst.	*	...
Entrochus (*Encrinus*) *Cassianus*, Lbe., sp.	*	* S.Pl.
,, ,, *granulosus*, Mnst., sp. ...	*	*
,, ,, *varians*, Mnst., sp. ...	*	...
,, (*Pentacrinus*) *Tirolensis*, Lbe., sp.	*	*
,, ,, *propinquus*, Mnst., sp. ...	*	*
CŒLENTERATA.		
Cladophyllia sublævis, Mnst., sp.	*	
Isastræa Gümbeli, Lbe.	*	
Thamnastræa Zitteli, von Wöhrm.	*	
Toechastræa Oppeli, Volz.	*	
Stylina, n.sp., and several *Thecosmilia*, sp. ind.		

Reckoning the percentages from the Lamellibranchs as a sure standard, the result yields 34 per cent. new species not yet known in any of the Cassian or Raibl zones of Alpine Trias; 25 per cent. species present in the Stuores-Cassian fauna but not in Raibl horizons; 25 per cent. species common both to Stuores-Cassian and to Raibl faunas; and 16 per cent. species present in Raibl horizons but not in the Stuores-Cassian fauna. The thick-shelled larger habitus of the bivalves at once marks a difference from the Stuores-Cassian fauna, and presents a striking resemblance to the character of recognized Raibl faunas in this district, e.g. the Travernanzes Raibl fauna at the higher horizons in Falzarego Valley and the Schlern Plateau Raibl fauna farther west. This faunistic transition in the bivalves is undoubtedly attributable to renewed local accumulations of tuff and volcanic dust, to strong current action, and the frequent reconstitution of littoral molluscan colonies at one place or another as the eruptive invasions permitted. The same transition seems to have taken place simultaneously in the neighbouring localities of Rimbianco, Misurina, and Seeland Alpe (Q.J.G.S., 1893, pp. 24, 33, 36).

While the list shows clearly the close affinities of this fossiliferous zone with the older Stuores-Cassian fauna, a few observations may be made regarding the affinities with the younger Raibl fauna.

The most commonly occurring genera among the bivalves are *Avicula* and *Cassianella*. According to Dr. Bittner's terminology, two species, *A. Sturi* and *A. Cassiana*, represent the older name of *A. Gea*, while *A. Cortinensis* has close affinity with these species. On the actual ground it was *A. Sturi* which distinguished itself by the number of its representatives. On the other hand, *Avicula Tofanæ* is a more distinctive local type. *A. Sturi* occurs in North Tyrol at a high horizon of the Cardita strata, and continues in the upper (Torer) Raibl fossiliferous series. *Hoernesia Johannis Austriæ* and *Gervillia angusta* likewise continue, both in North and South

Tyrol, in the Upper Raibl zone (von Wöhrmann, loc. cit., N. Tyrol, 1889, p. 250).

Cassianella decussata and *Cucullæa impressa* are present in the Schlern Plateau strata, which von Wöhrmann regards as contemporaneous with the 'Upper Cardita' or 'Lower Raibl' series in North Tyrol.[1] Opinions differ regarding the absolute identity of the two species *Myophoria decussata* and *Myophoriopis lineata*, in the Falzarego fauna, with the types described by von Wöhrmann at Schlern Plateau, but the affinity is certainly close. *Myophoria* (?) *solitaria* has, according to Dr. Bittner, nearest resemblance to a Raibl form, *M.*, sp. *Tommasi*. The *Gervillias* and *Pectens* are genera which are relatively exceedingly rare in the Stuores-Cassian zone, but here, as in Raibl strata, they are of common occurrence and comprise a few species identical with, or closely related to, Raibl species.

Thus, the close examination which the Cortina Lamellibranchs have now undergone has served to prove that the evidence which I gave in 1893 of an Upper Cassian or Cassian-Raibl transition zone was well-founded. Previously to 1893 the only intermediate Lamellibranch fauna known in South Tyrol between the Stuores-Cassian zone and the typical Torer Raibl zone was the Schlern Plateau fauna, but a palæontological gap existed between it and the Stuores-Cassian zone.

With regard to the Gastropods in the foregoing list of the Upper Cassian fossils in Falzarego Valley, the majority of the species are identical with Cassian species. This is natural, since the Stuores-Cassian fauna is characterized by the extraordinary number of small Gastropod species and individuals, whereas the Raibl fauna is characterized by a greater number of Lamellibranchs in proportion to the number of Gastropod species. As a local feature it may be noted that certain species, e.g. *Neritina imitans* and *Scalaria ornata*, are present in relatively far greater number of individuals in the Falzarego area than in the Stuores Meadowland. More important as a sign of transition is the occurrence in large number of individuals of two species, *Neritopsis decussata* and *armata*, which are common both to the Stuores-Cassian zone (in small number) and to the Schlern Plateau and other Raibl faunas. *Ptychostoma pleurotomoides*[2] is a species numerously represented in the Upper Cassian zone in Falzarego Valley and at Heilig-Kreuz, and is one which continues in Raibl horizons.

Another interesting feature in connection with the Gastropods is, that several species are identical with species found in the Marmolata-Kalk or calcareo-dolomitic facies south of this area, and that the beds of dolomitic limestone which immediately overlie the Falzarego tuffs are locally full of Gastropod fossils. The transitional Cassian-Raibl relations of the other groups call for less remark. Amongst the Brachiopods, *Amphiclina scitula*, amongst

[1] von Wöhrmann, "Die Raibler Schichten," m. Uebersichtstabelle: Jahrb. k.k. Reichs., 1893, p. 768.

[2] See Kittl, "Die Gastropoden der Schichten von St. Cassian der Süd-Alpinen Trias": loc. cit., pp. 157–8.

the Echinoderms, *Pentacrinus Tirolensis* and *Cidaris parastadifera*, continue in the highest Raibl horizons. In all groups the revised list is found to fulfil the requirements of a palæontological bridge between the Stuores-Cassian and the Schlern Plateau (or Upper Cardita) strata, and therefore to merit the place I assigned to the fauna in the percentage table and accompanying remarks of my earlier paper (Q.J.G.S., 1893, p. 44; also GEOL. MAG., 1894, p. 10 seq.).

I now submit the complete series of Upper Triassic zones in Falzarego Valley.

PALÆONTOLOGICAL AND STRATIGRAPHICAL SERIES.

	Locality: Schlern. Comparative extract from von Wöhrmann's "Die Raibler Schichten": Uebersichtstabelle, 1893.	Locality: Falzarego Valley and Travenanzes. (Cf. Ogilvie, 1893–4.)
Upper Raibl Series.	Horizon *d* (von Wöhr.). Dolomite banks with species of *Megalodus*. Dolomite with coral growths, etc.	Dolomite bands and variegated marls. Numerous *Megalodus* fossils: *Megalodus triqueter*; *Megalodus* cf. *compressus*. Thin band of dolomite weathered as terrace. '*Ostræa* marls' and limestones: leading type, *Ostræa montis caprilis*. Thick-bedded limestones, full of imperfect Pectenfossils: *Pecten Hallensis*, etc. 'Cipit Limestone' bed with coral and echinoderm remains. Soft, flaky limestone, with ammonite and nautiloid sp. Gypsum, red marls, dolomitic flagstones, rauchwackes. Hard arenaceous limestones, poor in fossils.
Lower Raibl Series.	Horizon *e* (von Wöhr.). Red Schlern Plateau fossiliferous strata with *Myophoria fissidentata* and *Keferʃteinii*, *Pachycardia Haueri*, *Trigonodus Rablensis*, *Hoernesia Johannis Austriæ*, *Patella J. Boehmi*, *Tretospira multistriata*, *Joannites cymbiformis*, etc. (Sphærocodien, coral growths, plants, etc.) Horizon *b* (von Wöhr.). Stratified dolomite.	Brown sandstones, the chief horizon of *Myophoria Keferʃteinii* & *M. Whateleyæ*; *Myophoria fissidentata*, *Myophoricardium lineatum*, *Physocardia Ogilviæ*, *Trigonodus Rablensis*, *Hoernesia Johannis Austriæ*; *Pecten*, sp.; *Turbo*, n.sp.; plant stems; numerous coaly fragments, and specks of various mineral ores; 'Cipit Limestones' interbedded with sandstones. Thin band of dolomite weathered as terrace. Red nodular marls of tufaceous character. Quartziferous sandstones with *Trigonodus Rablensis*, *Myophoria fissidentata*, etc., passing into upper horizons of Cliff of stratified dolomite, and finely interlayered volcanic sand; locally developed as dolomitic limestone, with many Gastropods; in lower horizons interbedded with

Lower Raibl Series (= Cardita Strata, North Tyrol).	Horizon *a* (von Wöhr.).	Upper Cassian Series.	'Cipit limestones' and volcanic tuffs; tufaceous marls, impure limestones, lignite, and aragonite. *Spirostylus subcolumnaris, Ptychostoma pleurotomoides, Neritopsis decussata, armata, Astartopis Richthofeni*, and crowded fragments of species of *Solen, Plicatula, Placunopsis, Avicula*, etc.
	Augite porphyry and tuffs.		Pale-greenish tufaceous shales, reddish-brown tufaceous breccias with quartz grains, glassy and metalliferous ore inclusions, limestones with uneven bedding surfaces. These are the chief horizons of Upper Cassian bivalves: *Avicula Cortinensis, Tofanæ, Sturi, Cassiana*; *Cassianella decussata*; *Gervillia Ogilviæ, angulata*; *Myophoria decussata*; *Hoernesia Johannis Austriæ*; *Lima angulata*; *Pecten Landranus, tubulifer*; *Trigonodus Rablensis*; etc.
		Lower or Stuores-Cassian Series.	Irregular crags and blocks of 'Cipit Limestones' in tuffs.
			Dark tufaceous earth and marls; thin-bedded shales and limestones containing rich fauna of small forms, in typical 'Stuores' character: *Cardita crenata, Koninckina Leonhardti, Trachyceras Aon, Nucula lineata, strigilata, Schizogonium subcostatum*, etc.
			Gypsiferous marls, aragonite, tufaceous grits and shales with 'Cipit limestones'; sponges, corals, echinoderms, *Posidonomya Wengensis*, etc.
		Wengen Series.	Ashy and felsitic series, black tufaceous earth, occasional dark bituminous limestones: *Halobia Lommeli, Posidonomya Wengensis*, plants, etc. (for Stuores-Cassian and Wengen Series, cf. aut., 1893, p. 16).

The Lower and Middle Cassian horizons, distinguished by me in 1893, are here combined as one palæontological zone, the Lower or Stuores-Cassian zone; since, although the subdivision is useful in field survey, the horizons are not palæontologically independent.

The stratigraphy of the Upper Cassian zone in Enneberg and Ampezzo is more difficult than the palæontology, since the lower Raibl fossiliferous sandstones are replaced by various local facies, wholly dolomitic (as at Lagazuoi), or developed as a series of dolomitic limestones and irregular banks of dolomite, interbedded with marls and sandstones (as at Roces Alpe).

In Falzarego Valley the Upper Cassian tufaceous series rests conformably upon Cassian strata containing the typical Stuores fauna, and is succeeded by a bed of dolomite of varying thickness, in some places fossiliferous, with Gastropod colonies, coral banks, algæ, etc., in others unfossiliferous and interlayered with volcanic sand

and nodular iron ore. Sometimes the sandy material occurs in patches, sometimes in layers a few inches thick, sometimes in layers as fine as the finest dust. The chemical decomposition of the calcareous and the volcanic material and the weathering-out of the finely and coarsely interlayered sands and tuffs from the rock largely account for the frequent occurrence of toothed and fantastic erosion forms at this horizon of the Schlern Dolomite.

The relations of these dolomitic and sandy layers are such as are presented to us in recent descriptions of volcanic and organic muds in the vicinity of oceanic islands, or more generally of 'Red Clay' and pelagic 'Oozes.' I have always held that the deposits of Raibl age represented the actual sediments in South Tyrol in which a dolomitic character may be regarded as original ("Coral in the Dolomites," 1894, pp. 11–13, 20–22), and that it was there associated with chemical decomposition going on contemporaneously with sedimentation. My specimens from this horizon are under examination in Prof. Armstrong's laboratory at South Kensington.

The chemist is confronted in the dolomites with the same possibilities of chemical decomposition and interchange, both in the past submarine and in the present subaerial conditions, which were clearly set forth by Sir John Murray in his Presidential Address to the Geographical Section, British Association, 1899, from which I quote the following passages: "The inorganic constituents of the Pelagic Deposits are for the most part derived from the attrition of floating pumice, from the disintegration of water-logged pumice, from showers of volcanic ashes, and from the débris ejected from submarine volcanoes, together with the products of their decomposition. . . . . If the whole of the carbonate of lime shells be removed by dilute acid from a typical sample of Globigerina Ooze, the inorganic residue left behind is quite similar in composition to a typical Red Clay. . . . . The volcanic materials in a Red Clay having, because of the slow accumulation, been for a long time exposed to the action of sea-water, have been profoundly altered. The massive manganese-iron nodules and zeolitic crystals present in the deposit are secondary products arising from the decomposition of these volcanic materials."

The development of organic and inorganic muds, with all possible variations in the alternative bedding, is the normal character of the Schlern Dolomite within Enneberg and Ampezzo. And, as I previously pointed out, the contemporaneity of this dolomitic series, in whole or in part, "*with fossiliferous Raibl strata elsewhere* (e.g. *the Schlern Plateau strata*) *would in nowise afford evidence of the Coral Reef Theory, but only of the familiar fact of Raibl heteropism.*" ("Coral in the Dolomites," 1894, p. 13.)

The dolomite cliff and marls in Falzarego Valley, Roces Alpe, and Travenanzes are succeeded by a well-defined group of sandstones, shales, and shaly limestones, in which a typical Raibl fauna occurs. The fossils enumerated at this horizon, in the above table of Upper Trias, were all personally collected from a number of places along this high mountain terrace above the valley. Strange

to say, I never found *Pachycardia Haueri*, which is such a numerously represented type in the Schlern Plateau strata. The limited colonial aspect of local faunas seems to have been the leading palæontological feature of the Cassian-Raibl period.

Whilst the age of the intervening calcareo-dolomitic and sandy series is quite securely fixed by the presence of the *Myophoria* and *Ostræa* fossil zones above, and the *Avicula Tofanæ* and *Cortinensis* fossil zones below, I have always referred to it in previous papers as "Schlern Dolomite," following the original intention of von Richthofen, who applied this term to any dolomitic facies of Upper Triassic tufaceous series in the district. The fossiliferous Upper Cassian tuffs are present at Pec di Palu, south of the Falzarego road, and may be followed over Valparola, Pordsi, and Sella Pass to the south of Langkofl and Mahlknecht. Remnants of the series occur at Cra di Mont, Crap di Sella, Freina Meadow, and elsewhere farther north.

I already showed, in 1893–4, that throughout Enneberg and Ampezzo the *horizons of Raibl time were those which displayed the most extreme and complex facies relations.* All Raibl zones pass now at one place, now at another, into local massive developments of Schlern Dolomite (e.g. Lagazuoi, Dürrenstein, etc.). The Upper Cassian zone also presents varying local facies relations *within* Enneberg and Ampezzo, but the Wengen and Stuores-Cassian zones underlie the dolomitic deposits in Enneberg and in all parts of Ampezzo which I have examined. Thus, the identification of successive palæontological zones proves that the tufaceous invasions overspread the floor of the Enneberg and Ampezzo areas more generally in the earlier periods of the Upper Trias epoch in South Tyrol. And the passage-limit between the tufaceous material and the ordinary sediments was at that time locally situated within that wide 'Buchenstein-Mahlknecht' series of lavas and tuffs which represents one of the chief local areas of contemporaneous eruptive fracture-planes. These are the heteropic conditions which I have depicted in a series of diagrams, showing the successive stages in the accumulation of deposits, and the intermixture from time to time of volcanic material during the Wengen, Cassian, and Raibl periods ("Coral in the Dolomites," 1894, GEOL. MAG., Pl. II).

In the second part of the same paper (in the GEOL. MAG.), Sasso Pitschi (a small mountain that occurs in the Buchenstein-Mahlknecht passage-area of facies) was selected as an example of the tendency displayed by later differential movements to coincide with the original passage-areas between different lithological groups of strata, whether these areas occurred in the horizontal extension of different rock facies, as at Sasso Pitschi, or in the ordinary geological succession. My publication[1] in 1899 rests on the same standpoint.

[1] "Torsion-Structure of the Dolomites": Quart. Journ. Geol. Soc., 1899. Attention may be directed here to a printer's slip that unfortunately evaded me in the proofs, and which causes some confusion: see p. 580, under '5,' near the bottom of the page: "A and C to be moved counterclockwise, B and D clockwise," should read "A and C to be moved clockwise, B and D counterclockwise."

Subordinate movements have readily taken place at the planes where the more rigid and the more plastic rock-groups have been next one another. Thus local conditions have produced local modification of the more general movements due to compression and cross-compression of this district in subsequent epochs of Alpine upheaval.

In addition to its use in the solution of the stratigraphy, the value of an Upper Cassian fauna is in the link it adds to the Upper Trias chain of faunas in South Tyrol. Its discovery and its identification by me in 1893 as a transitional Cassian-Raibl zone established, for the first time in South Tyrol, a closely connected series of palæontological zones traceable through Wengen-Cassian-Raibl periods. The Upper Cassian zone has therefore given important evidence of the impracticability of placing a palæontological limit between Middle and Upper Alpine Trias anywhere within that series. The transition from Raibl horizons to Dachstein Dolomite in Enneberg and Ampezzo also takes place quite gradually, as evidenced by species of the genus *Megalodus*. Hence the only subdivision between Middle and Upper Trias which seems natural in the 'Dolomites' is between the Upper Muschelkalk (Buchenstein strata of some authors) and the Wengen series, that is, at the horizon of Triassic time, when eruptive material began to be incorporated with the local sediments of that area. (Cf. von Wöhrmann, "Die Raibler Schichten," 1893; Rothpletz, "Querschnitt," 1894; Salomon, "Palæontographica," 1895; von Zittel, "Zeitschrift," 1899.)

A farther confirmation of the presence of a transitional Cassian-Raibl fauna in the 'Dolomites' has been given by the fauna in the '*Pachycardia* Tuffs' of the Seiser-Alpe. Geheimrath von Zittel, who made the discovery, during a geological excursion with his students, that these tuffs contained a large number of Raibl forms in addition to Cassian forms, has since published a short account of the faunal characteristics of these tufaceous horizons at the Seiser-Alpe (von Zittel, "Zeitschrift," 1899; also Rothpletz, "Zeitschrift," 1899). The preliminary notes on the stratigraphy given by Prof. Rothpletz show that these tuffs at the Seiser Alpe rest conformably upon strata containing a Stuores-Cassian fauna, so that in this important feature their position at the Seiser-Alpe agrees with that which I determined at Falzarego Valley and other localities. The 'Cipit Limestones' also occur, as blocks or irregular banks, at various horizons, in the way that I described for other localities along the Buchenstein-Mahlknecht area of eruptive invasions. "Along the hem of this volcanic girdle communities of Corals and Echinoderms settled and formed a series of small barrier reefs (Cipit Limestones), frequently interrupted in their growth by fresh lavas" (aut., l.c., 1894).

But, compared with the Falzarego Valley fauna, the '*Pachycardia*-tuff' fauna bears a distinct local impress. For example, just as I never found *Pachycardia Haueri* in the higher Raibl horizons of Falzarego Valley, so I never found *Pachycardia rugosa*, the leading fossil of the *Pachycardia* tuffs, in the Upper Cassian zone of Falzarego Valley. Both may be there, as my personal collection

oan only represent a small part of the fauna, but they at least cannot be common.

A similar impression of narrow spacial limitation is given by each of the local developments of a fossiliferous Upper Cassian zone, at Heilig Kreuz, Seeland Alpe, Misurina, and Rimbianco. This horizon of Upper Triassio time is characterized, therefore, not only by marked differences in the local lithological facies, but also by marked local speoializations in the aspect of contemporaneous faunas inhabiting neighbouring seas and lagoons. Many of the fossils have affinity with Cassian or Raibl species, yet oan neither be identified with, nor olearly distinguished from these. Hence, we may regard it as probable that those speoialized Upper Cassian faunas included, amongst the species peculiar to themselves, certain types due to strong adaptation or to retrogression. And we may learn from the faunas of the Upper Cassian zone, no less than from those of the higher Raibl zones, that there are biological questions in South Tyrol whioh concern the occurrence of pelagio and of littoral faunas as local colonies in a neighbourhood of very unequal depth and subject to volcanio interruptions in the form of lavas, tuffs, and fine voloanio sand. These questions are one with the consideration of lithological facies in the same district.

The following table of Upper Trias strata in South Tyrol represents the zonal sucoession and local ocourrence of faoies as desoribed in former papers (of. Geol. Mag., 1894, Pl. II, and Q.J.G.S., 1893, p. 16).

	Fassa-Schlern, south of the Buchenstein-Mahlknecht eruptive fractures.	*Within* Enneberg and Ampezzo, north of the Buchenstein-Mahlknecht eruptive fractures.
Upper Trias (South Tyrol).	Dachstein Dolomite.	
	Raibl series.	or Upper Raibl series (von Wöhrmann), with *Ostræa* and *Megalodus* beds.
	Schlern Dolomite.	Schlern Dolomite: or Lower Raibl series (von Wöhrmann), equivalent to Upper Cardita series in North Tyrol, represented by "red Schlern Plateau fossiliferous series" or by a varying thickness of stratified dolomite in South Tyrol.
		or Upper Cassian tufaceous series (Ogilvie), with *Avicula* beds.
		Cassian series in 'Stuores' development.
		Wengen series, with *Halobia Lommeli*.
	Upper Zone of Muschelkalk or Middle Trias.	

As, however, Baron von Wöhrmann, in his comparative work on "The Raibl Strata," found the palæontological transition quite gradual throughout the Cardita and Raibl zones in South Tyrol, he included the whole series from the *Halobia Lommeli* to the *Ostræa* beds as Raibl strata in wider sense (cf. "Uebersichtstabelle d.

Raibler Schichten": Jahrb., 1893). Hence, to continue to call the 'Red Schlern Plateau' series 'Lower Raibl' would undoubtedly cause confusion. The distinction of Upper, Middle, and Lower Zones in a series of 'Raibl strata' (using the term in the now wider sense given by von Wöhrmann), might be locally possible, but at the present time it is more important to arrive at a clear presentation of the complete series of palæontological zones in each Alpine locality. Thus in South Tyrol we have:

LEADING FOSSIL-TYPES

in the Wengen-Cassian-Raibl series ('Raibler-Sch.' in wider sense, von Wöhrmann).

All pass into the Calcareo-dolomitic facies in South Tyrol; von Richthofen's 'Schlern Dolomite.'

'Torer'-Raibl Zone: *Ostræa montis caprilis*, *Megalodus triqueter*, etc. (diverse local developments of volcanic marls and sand, limestone, gypsum, dolomite).
'Red Schlern Plateau' Raibl Zone: *Pachycardia Haueri*, *Myophoria Kefersteinii*, *Myophoricardium lineatum*, etc. (diverse local developments of volcanic sand and calcareo-dolomitic facies; molluscan faunas contain almost exclusively Raibl species).
Upper Cassian or Transitional Tuff Zone: *Avicula Sturi*, *Tofanæ*, and *Cortinensis*, *Pecten Landranus*, etc. (diverse local facies of Upper Cassian series, containing a mixed fauna of Cassian and Raibl species).
Stuores-Cassian Zone: *Koninckina Leonhardi*, *Cardita crenata*, *Nucula strigilata* (tufaceous, marly, and calcareous series, containing almost exclusively Cassian species).
Wengen Zone: *Halobia Lommeli*, *Monophyllites Wengensis*, *Trachyceras Archelaus*, *Posidonomya Wengensis*, etc.; series of shales and limestones, grits, tuffs, and lavas.

Summary.

(1) Conformably above strata containing the typical or Stuores-Cassian fauna as known before my paper of 1893, and below any palæontologically well-defined Raibl horizon, so regarded before von Wöhrmann's paper of 1893, I found in Falzarego Valley in 1891 a series of tufaceous breccias, shales, and quartziferous sandstones, containing a transitional Cassian-Raibl fauna, and passing upward into interstratified dolomite, dolomitic limestone, and volcanic sand and marl, or into a wholly dolomitic group of strata. The latter I termed 'Schlern Dolomite,' stating it to be the time-equivalent in part, or wholly, of the 'red Schlern Plateau fossiliferous strata' which von Wöhrmann had in 1892 called a Lower Raibl zone in South Tyrol. Revised identifications of my Falzarego Valley material, carried out in accordance with the recent special monographs on Alpine Molluscan faunas by Dr. Bittner, Dr. Kittl, Dr. J. Böhm, and others, have fully corroborated the palæontological position which I gave to the fauna in 1893–4 as a local 'tuff' facies

of part of the Schlern Dolomite, comprising a gradual transition from a typical Stuores-Cassian fauna to the 'Travenanzes' Raibl fauna of the Falzarego district.

(2) The Wengen and Stuores-Cassian fossiliferous tufaceous series are present throughout the district of Enneberg and Ampezzo in complete zonal development. These palæontological zones are therefore *not*, as has been said, the tufaceous facies of the dolomitic rock composing the massives in these areas. On the other hand, the Upper Cassian zone and the higher Raibl zones are developed in varying degree *within* Enneberg and Ampezzo as local facies of local dolomitic sediments. 'Cipit Limestones' (the true coral-reefs of the district) occur both in the tufaceous and in the dolomitic facies at all horizons as occasional local beds of comparatively small thickness (loc. cit., GEOL. MAG., 1894).

(3) The Wengen and Stuores-Cassian tufaceous and calcareous series of Enneberg and Ampezzo represent time-equivalents of part of the calcareo-dolomitic series south of the Buchenstein-Mahlknecht passage-area of facies, that area having been one of the chief localities of contemporaneous eruptive fracture-planes.

(4) In many cases the passage-areas between facies of different lithological character, as well as the passage-bands between subjacent rock-groups of different lithological character, have been the seat of subsequent differential movement or distortion. So that the complex local developments of passage-areas and passage-bands in the Upper Trias of South Tyrol have induced many local effects of cross-movement which now complicate the stratigraphy of that district.

(5) The more general movements associated with Cretaceous-Tertiary upheaval in the Eastern Alps have called forth an east-west strike, which must be regarded as fundamental in the district, and also a cross-compression from east and west or slightly oblique directions. The complex resultant system of folds, faults, and overthrusts has been cut by subsequent faults associated with local subsidences.

Stephen Austin and Sons, Printers, Hertford.