

20. *The GEOLOGY of MONTE CHABERTON.* By A. M. DAVIES, Esq., B.Sc., F.G.S., and J. W. GREGORY, D.Sc., F.G.S. (Read May 9th, 1894.)

IN the study of the geology of the Cottian Alps the problem that has given rise to most difference of opinion is the age of the beds of serpentine and 'pietre verdi' which occur so abundantly among the schists of this district. Most geologists now admit them to be altered igneous rocks, though the theory of their being bedded sediments still lingers in Italy. As to their age, however, there is much greater uncertainty, so that in spite of all the work that had been done in the Cottians, when the subject was considered in 1890 in the description of the Variolitic Rocks of Mont Genève, it was only possible to conclude that "we must in fairness merely style them Post-Carboniferous until further evidence is forthcoming."¹ The locality that offered the best prospect of the solution of this question seemed to be on the flanks of Monte Chaberton, the great dolomite mass on the north side of the well-known pass of Mont Genève. Here a typical series of the intrusive rocks is associated with stratified beds containing three distinct sets of fossils, namely, those of the radiolarian phthanites of Cesana, the *Gyroporella* and other Triassic organisms of Clavières,² and those hitherto known only from some fallen boulders on the eastern talus-slopes of Chaberton. The age of the first and last of these was uncertain, and it was necessary to determine that of the last before any great advance could be made.

The fossils in the boulders had been found on two occasions; a few were collected by the members of the Société géologique de France, during its excursion to the mountain in 1861³; a larger and better series was obtained by Michelotti and is now in the Pisa Museum. These were described by him in 1877, and determined as of Silurian age⁴; the schists of the district were therefore assigned to the pre-Palæozoic. Neumayr re-examined Michelotti's specimens and identified them as Cretaceous.⁵ The fossils, however, had never been found *in situ*, and the bearing of this change of view on the age of the main dolomite series was therefore very uncertain, nor could any positive objection be urged against either the views of Lory,⁶ who included all the dolomite in his Liassic 'Calcaire du

¹ Cole & Gregory, Quart. Journ. Geol. Soc. vol. xlv. (1890) p. 323.

² K. Diener, 'Der Gebirgsbau der Westalpen,' 1891, p. 18.

³ 'Réunion extraordinaire à St. Jean de Maurienne,' Bull. Soc. géol. France, ser. 2, vol. xviii. (1861) p. 779.

⁴ B. Gastaldi, 'Sui fossili del calcare dolomitico del Chaberton (Alpi Cozie) studiati da G. Michelotti,' Atti R. Accad. Linc. ser. 2, vol. iii. Mem. (1876) pp. 114-121, pls. i.-ii.

⁵ A. Bittner, M. Neumayr, & Fr. Teller, 'Ueberblick über die geologischen Verhältnisse eines Theiles der ägäischen Küstenländer,' pt. iii. Denkschr. d. k. Akad. Wissensch. Wien, vol. xl. (1880) pp. 404-405.

⁶ 'Stratigraphie des Alpes Graies et Cottiennes,' Bull. Soc. géol. France, ser. 3, vol. i. (1873) p. 278; and 'Description géologique du Dauphiné,' §§ 256 & 286, Bull. Soc. Stat. Isère, ser. 2, vol. vii. (1864) pp. 14 & 72.

Briançonnais'; those of Zaccagna and Mattiolo,¹ who included them in the Permian and Trias; those of Gastaldi,² who regarded the Calcaire du Briançonnais as made up of Lias, Trias, and Carboniferous; or those of Kilian,³ who regards this as composed of Trias and Lower, Middle, and Upper Jurassic.

One of us having failed on a previous occasion to find any trace of the limestones on the pass of Mont Genève, we commenced our search on the eastern cliffs of the mountain. We struck up the Grand Vallon, which cuts into the eastern face of Monte Chaberton; we climbed Mont Sisnières and thence up the north-eastern crest to the 2620-metre stone man. About this point we found numerous fossiliferous boulders, some of which also occur near the entrance to the Grand Vallon; the beds from which we thought it probable that these had fallen were inaccessible on this side. We therefore moved to Bourg Mont Genève and thence climbed Chaberton up the valley of the Gr. Baisses. We could find only Triassic limestones on the western slopes, but succeeded in discovering the coralline and shelly limestones *in situ* on the north side of the valley of R. Clos des Morts, just above a ruined sheepfold east of the Col de Chaberton. (See Map, p. 309.)

Figs. 1 & 2 illustrate the mode of occurrence of these limestones; they are much contorted, and have been let down by faults into the Triassic dolomites which are not especially crumpled. In places, as shown in fig. 2, the shelly limestones are much contorted, and overlie the uncontorted dolomites. There is therefore no doubt that the fossils do not belong to the dolomite series, but to one of later date, and that they have been preserved owing to their having been faulted down into, or across on to, the Trias. As some name for these beds is desirable, we propose to call them the 'Clos des Morts' Limestones.

We made a considerable collection of the shelly limestones, but the fossils are so fragmentary that Mr. R. B. Newton, F.G.S., of the Geological Department of the British Museum, is unable to determine any of them. We are none the less obliged to him for the care with which he has examined the specimens.

The corals, however, are more satisfactory: they all seem to belong to one species, which we regard as the same as that found by Michelotti in the Valle della Vermanagna, on the northern side of the Col di Tenda. This was identified as a *Cyathophylthum*.⁴ Neumayr has pointed out the erroneous nature of this determination, and sections made from specimens collected by us show that it is one of the *Astræida* and belongs to the genus *Calamophyllia*. As one of us has had recent occasion (in connexion with the Indian

¹ 'Sulla geologia delle Alpi occidentali,' Boll. R. Comit. geol. Ital. vol. xviii. (1887) pl. xi.

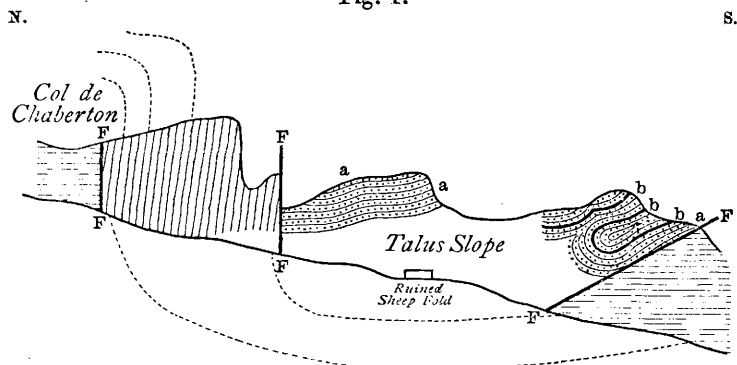
² 'Sui rilevamenti geologici fatti nelle Alpi piemontesi durante la campagna del 1877,' Atti R. Accad. Lincei, ser. 3, vol. ii. Mem. (1878) pt. ii. p. 959.

³ 'Structure géologique des Chaînes alpines,' Bull. Soc. géol. France, ser. 3, vol. xix. (1891) p. 615.

⁴ B. Gastaldi, 'Su alcuni fossili paleozoici delle Alpi marittime e dell' Appennino ligure studiati da G. Michelotti,' Atti R. Accad. Lincei, ser. 3, vol. i. Mem. (1877) pt. i. pp. 122-123 & pl. i.

Jurassic Corals) to revise the European *Calamophyllia*, we have the less hesitation in referring the specimens to *Calamophyllia fenestrata*, Reuss.¹ The specimens agree in mode of growth, the thickness of the walls, the number of the septa, and the coarseness of the dentation. The prominence of the collerettes is well shown in one of

Fig. 1.

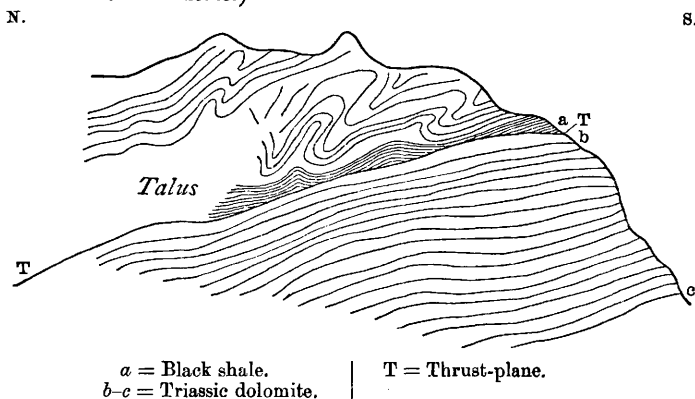


NORTH SIDE OF THE VALLEY OF R. CLOS DES MORTS.

Trias.
 Cretaceous, a...Shelly Limestone. } Clos des Morts
 b...Coral Reef. } Limestones.
 F...Faults.

[This shows the Clos des Morts Limestones faulted into the Triassic dolomites. The direction of the lines in the dolomites indicates bedding.]

Fig. 2.—Crumpled Clos des Morts Limestones carried by a thrust-plane on to uncontorted dolomite. (North side of the valley of R. Clos des Morts.)



a = Black shale.
 b-c = Triassic dolomite.

T = Thrust-plane.

¹ A. E. von Reuss, 'Beiträge zur Charakteristik der Kreideschichten in den Ostalpen, besonders im Gosauthale und am Wolfgangsee,' Denkschr. d. k. Akad. Wissensch. Wien, vol. vii. (1854) p. 105, pl. v. figs. 20, 21.

Michelotti's figures (*op. jam cit.* pl. i. fig. 2), and the septa in a weathered specimen collected by us (Brit. Mus. No. R. 2374) in the valley of the Clos des Morts.

Calamophyllia fenestrata, Reuss, is the typical species of the Gosau Beds, and it is therefore interesting to find that we are driven to the same conclusion by the study of the coral as that which Neumayr reached from the examination of Michelotti's gasteropoda. We are quite conscious that to maintain the existence of Cretaceous deposits in the Western Alps is a reactionary step, especially in view of Kilian's¹ recent refusal to admit any of the Monte Chaberton limestones as later than Jurassic, and Dr. Diener's² apparent retraction of this view in a recent letter; he had previously accepted it, and claimed that the fact "was the most remarkable phenomenon in the geological structure of the Western Alps."³ Our profound faith in the late Melchior Neumayr's soundness of judgment and especial qualifications for expressing an opinion on this subject had been somewhat shaken by Kilian's doubts. The field evidence, however, has clearly shown that the coralline and shelly limestones are certainly post-Triassic; whereas Kilian's view seems to be based on the correlation of these beds with those near Oulx, which have yielded the *Myophoria* described by Portis.⁴ The latter horizon is unquestionably rightly assigned by Portis to the Trias: the *Diplopora* (Schafh., non Young, *i.e.* alga, non bryozoon) associated with the *Myophoria* settle that point; but this bed is the representative of the *Gyroporella*-limestone at the base of the Chaberton series, and not of the limestones faulted down into the dolomites.

The question then arises, is this band of limestone the only representative of the Cretaceous in the Cottians? We think not, for the Vermanagna limestones must belong to the same horizon as those at Chaberton. A third representative is more doubtful, but judging from Kilian's⁵ description of some limestones from Dorgentil, south of Moutiers, we should not be surprised if they also have gained their association with Jurassic deposits only by later dislocations.

We had thus determined the first of the two problems for which we had visited Monte Chaberton, for by proving that the coralline and shelly limestones are not part of the dolomite series, and are probably of Cretaceous age, a fairly complete time-scale has been established.

Let us next consider the relations of the associated igneous rocks to the various divisions of this time-scale.

The views held as to the nature and ages of these rocks are very varied. Those who regard them as metamorphosed sediments

¹ W. Kilian, 'Notes sur l'histoire et la structure géologique des Chaînes alpines de la Maurienne, du Briançonnais et des Régions adjacentes,' Bull. Soc. géol. France, ser. 3, vol. xix. (1891) pp. 618-620.

² Quoted by Kilian, *ibid.* p. 620.

³ K. Diener, 'Der Gebirgsbau der Westalpen,' p. 19.

⁴ A. Portis, 'Nuove località fossilifere in Val di Susa,' Boll. R. Com. geol. Ital. vol. xx. (1889) p. 175.

⁵ W. Kilian, 'Sur le Lias de la Savoie,' Bull. Soc. géol. France, ser. 3, vol. xix. (1890), Opt. Rd. Séances, p. xxvi.

naturally class them as of the age of the rocks among which they occur; they therefore regard most of them as pre-Palæozoic, while the older Italian geologists, such as Gastaldi, and Gervais and Sterry Hunt, claimed them all as of this age. A later and smaller part of the series has been generally considered Tertiary, but Prof. Sacco's detailed work gives reason for showing that this later series may be Cretaceous. Those who regard these rocks as intrusive are less pronounced in their judgment as to the age, and though generally accepting the division into an ancient and recent series, they have even sometimes called this into question (Cole and Gregory, *op. cit.*).

The first point to be settled was whether the mass of serpentine cut through by the road at Clavières occurred in the calc-schists, in the dolomite, or between the two (as in Prof. Bonney's section¹). The slopes at Clavières are too much covered by talus, and too near the Italian forts, to tempt one in that direction, so we struck round the Bois de Chaberton, hoping to find the same bed exposed in the Grand Vallon. (See Map, p. 309.) We soon came upon the serpentine, and determined two points about it:—

(1) That some tufas in the base of the Triassic limestones contain many fragments of the serpentine. Both the field evidence and examination of thin sections showed that the rock containing these is a true tufa and not a fault-breccia. This settles the pre-Triassic age of the serpentine;

(2) That the serpentine is intrusive into the calc-schists, as it here occurs in them, as it cuts across the strike of the schists, and as there is fairly well-marked contact-alteration on each side of the serpentine.

Elsewhere, however, on the mountain the Triassic dolomites are cut through by some sheets of schistose 'pietre verdi'; these may be seen in two places in the valley leading northward from the pass of Mont Genève to the Col des Trois Frères-Mineurs. The first is by a crag above and to the west of Gr. Baisses; the relations of the 'greenstone' to the basal quartzite of the Triassic series here is unquestionably that of an intrusive igneous rock. The second is beside the path leading to the Col de Chaberton, a little to the north of the 2145-metre point; here the evidence of intrusion is not so plain. Two other similar masses of the 'pietre verdi' occur on the northern arête of Chaberton between the summit and the Col de Chaberton. This is indisputable evidence that some of the igneous intrusions are post-Triassic.

It is advisable, therefore, to examine these rocks somewhat closely, in order to see whether it is possible to gain from them any guidance in determining the age of the intrusive rocks of the 'pietre verdi' series elsewhere in the Cottians. At Chaberton there are two main types: the serpentine which we now know to be pre-Triassic, but later than the 'schistes lustrés,' has been previously described²; but the later igneous rocks are so crushed as to be at present unrecognizable.

¹ 'Two Traverses, etc.,' Quart. Journ. Geol. Soc. vol. xlv. (1889) p. 80.

² Cole & Gregory, *ibid.* vol. xlv. (1890) p. 306.

We have examined microscopically three specimens, two from the greenstone-schists a little to the north of the summit of Chaberton, and one from the dyke by the bed of a stream north of Gr. Baisses. The former consist mainly of lines of chlorite separated by bands of quartz, with a little authigenous white mica and some fragments of plagioclase; in one of the specimens there is an enormous amount of secondary quartz. The dyke by the stream consists also of much chlorite and quartz, with patches of a quartz-zoisite-calcite aggregate; there is, moreover, a good deal of titanoferrite passing into leucoxene. These rocks belong to the series which includes the appeninite, besimaudite, ovardite, etc., of some writers on the district. They are doubtless altered basic igneous rocks, probably crushed epidiorites. The only name, however, which we feel justified in attaching to them at present is that of quartz-chlorite schists or greenstone-schists.

We hope to consider the correlation of these two sets—the older Clavières serpentine and later chlorite-schists—with the ‘*pietre verdi*’ of other localities in the Cottians, in a more detailed account of these rocks and their distribution. But it may be worth mentioning here the probability that there is a third group of basic igneous rocks in the Cottians, which are of still later age. The gabbros, diabases, and porphyrites of Mont Genève, and of Rocciavré (north of the pass of Fenestrelle), may belong to this age; there is evidence suggesting that the gabbros of the former locality are intrusive through the serpentines at Punta Rascia.

The Earth-movements of Monte Chaberton.

No description of this mountain would be complete that omitted reference to the folds, faults, and thrust-planes that have combined to render its geology so complex and interesting. We should have wished to possess a large-scale map, and carefully work out the whole of its numerous faults. But the prolonged involuntary residence in the country that might have resulted from this detailed mapping would have been so inconvenient to both of us that we thought it advisable to forbear. A more precise survey must be left to an Italian geologist, until such a time as the nations of the Continent shall beat their bayonets into hammers; the numerous forts in the district will then afford superior accommodation to any that can now be got in the inns.

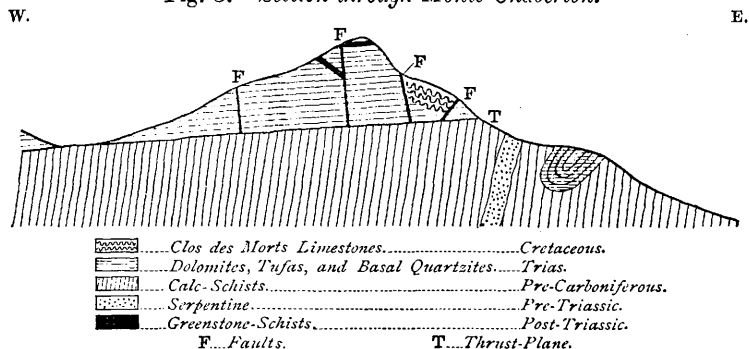
The movements may be divided into four main sets:

- (1) A thrust-plane that has carried the Trias on to the calc-schists.
- (2) A series of north-and-south faults that has troughed the Cretaceous limestones into the dolomites.
- (3) Some east-and-west faults, to one of which the Col de Chaberton is due.
- (4) A fold that has inverted the calc-schists on the eastern slope, and there caused an infold of the Trias.

The accompanying map and the section (fig. 3, p. 310) illustrate the general arrangement of these movements, but the exact order of

their succession is doubtful. Numerous minor faults that do not affect the relations of the different beds to one another are omitted.

Fig. 3.—Section through Monte Chaberton.



In conclusion we may summarize the results of the present paper as follows:—

(1) In the Cottian Alps there have been three distinct series of intrusions of basic rocks, the first pre-Triassic and post-schistes *lustrés*, the second post-Triassic and pre-Cretaceous, the third probably Lower Tertiary or Cretaceous.

(2) That the 'Calcaire du Briançonnais' consists of three distinct rocks:—the *cargneules* and dolomites of the Trias, the limestones of the Jurassic (which contain representatives, according to Kilian, of the lower, middle, and upper divisions of that system), and thirdly the shelly and coralline limestones which we call the Clos des Morts Limestones of the Cretaceous (possibly Turonian).

(3) That, in spite of the many doubts thrown upon the presence of Cretaceous beds in the Western Alps, representatives of such beds are known in at least two places in the Cottians.

(4) The identification of the common Gosau coral (*Calamophyllia fenestrata*, Reuss) in the Cottians.

DISCUSSION.

Prof. COLE congratulated the Authors upon their survey of a difficult mountain-area. To him the most interesting rocks were the schistose dykes near the summit of Monte Chaberton, showing how much metamorphism might have taken place in the 'pietre verdi' generally since Triassic, and probably since Eocene times. He believed that the metamorphism produced in the Alps by Cainozoic earth-movements equalled anything that had gone on in earlier eras.

Dr. J. W. GREGORY also spoke.

Mr. A. M. DAVIES, in reply, pointed out that the remarkable way in which the variolitic rocks of Mont Genève had escaped crushing was one of the facts that pointed to their very recent date.