

V.—ON THE AGE AND ORIGIN OF THE GRANITE OF DARTMOOR,
AND ITS RELATIONS TO THE ADJOINING STRATA.

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THE object of this paper is an attempt to furnish proof of what has been a growing conviction in the mind of the writer, that the true age of the Dartmoor granite, and probably its associated line of bosses running south-westwards into Cornwall, might be referable to an interval or period of geological time between the Lower and the Upper Culm, or Carboniferous system.

Up to the present time, as geologists are doubtless well aware, these granite bosses have been considered Post-Carboniferous and Pre-Triassic as to age, and the evidences for this so ably advanced by De la Beche and others have been almost universally accepted. Up to Lower Culm, or Carboniferous times, the nature of the proofs have been of so decisive and convincing a kind as to place the question beyond doubt to the minds of most observers. There are, however, grave doubts and difficulties with regard to the Permian age of the granite. There are no clear proofs that it even belongs to an early portion of that formation; or that it can in any way be connected with the highly basic lavas of the adjoining Permian strata; indeed, the evidences for the very reverse of this is the case.

In support of this contention the writer would draw attention to a point which has never before been urged, which appears to him to very materially affect the question as to the true age, not only of the granite of Dartmoor, but also of the other bosses of the same rock already referred to.

In the history of the Culm rocks of South Devon there is what he considers to be a striking gap or break in the sequence between the Lower and the Upper Culm, which without doubt would indicate a prolonged interval of time between these two members of the system, as will immediately appear.

In making use of the term Upper Culm he would refer more especially to certain conglomerates, grits, and sandstones, which seem only to have a very local development in South Devon. They occur as mere isolated or semi-detached deposits confined to a very limited area in the neighbourhood around Newton Abbot as a centre. The most conspicuous of these deposits are certain conglomerates—coarse, medium, and fine—associated with which are grits and sandstones. These conglomerates are not met with in any of the other extensive general sections where the Lower Culm beds occur, as in the direction of Exeter and the Teign Valley. Neither are they known to occur in the North of Devon. In point of fact these conglomerates show every indication of belonging to a much higher series of beds than any that are elsewhere developed in other portions of the county.

There is a striking lithological contrast presented between this conglomerate series and all the other older members of the Culm in their relations to the granite. The older members are everywhere affected by great earth-movements, bent and plicated sometimes to an

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extraordinary degree. There is likewise a cleavage structure more or less developed throughout these rocks. With regard to the conglomerate series, the very reverse of all this is the case, and as a rule they repose at low angles and seem to have suffered little disturbance in comparison with the older members of the Culm.

The Lower Culm system has lately received close attention from Messrs. Hinde & Fox in their valuable memoir recently published in the *Quart. Journ. Geol. Soc.*¹ The Radiolarian cherts and associated beds there described are conclusively shown to have been deposited in a sea of great depth, far removed from the detrital washings of the land; yet there is the clearest of evidence that this deep-sea bottom was elevated by earth-crust-movements, and even ultimately eroded and wasted, to supply the materials which abundantly occur in the conglomerates just referred to. These conglomerates, in all the various localities where they occur, contain abundant fragments of the Radiolarian cherts, besides those of the other associated rocks of the Lower Culm series.

It has been suggested that the fragments of the Radiolarian cherts may have been brought up to the surface by volcanic explosions. These fragments, however, are as a rule well rounded and water-worn, and they are not accompanied by any true tuff-like matter in the conglomerates. The only intelligible explanation of the fragments of the cherts in the contents of the conglomerates is the long interval separating the former from the latter; the granting of sufficient time to account for the phenomena of elevation, waste, and reconstruction.

It is most interesting at this point, to note that during the formation and elevation of the Lower Culm there are the clearest proofs of contemporaneous volcanic action. Belonging strictly to this period, there are in the immediate localities concerned numerous examples of eruptive, explosive, and effusive volcanic products, which might have extended over a long period previous to the formation of the conglomerate series. These volcanic outbursts had apparently entirely ceased long before the formation of the conglomerates began to be deposited. It is to the latter portion of this interval—sufficiently long—that the writer would refer the eruption of the Dartmoor granite.

On studying with attention the geological map of the area, it will be perceived that during the early or Lower Culm period the central area of Dartmoor had been long weakened by the extensive volcanic action previously referred to. Volcanic rocks, principally eruptives, are thickly clustered together on each side of what is now the granite—as at Tavistock on the west and in the Teign Valley district on the east side,—running along a line of old pre-granitic fissures. All these volcanic rocks are decidedly Lower Culm in age, but older than the associated granite, as the latter truncates and indurates them.

The central portion of the area of Dartmoor, now occupied by the granite, was clearly a previous centre of volcanic activity

¹ Vol. li (1895), p. 609.

both in Devonian and in Lower Culm times. In the vicinity of the other granitic bosses volcanic action was also active throughout Devonian times, and continued for long periods in these and other parts of the counties of Cornwall and Devon to produce highly basic products; culminating during the Lower Culm period in Devonshire in those very extensive basic products extending in a line through what is now Central Dartmoor.

These long-continued, highly basic products, however, at length came to a close, possibly from sheer exhaustion, and seem to have been followed by the highly acid products which now form the granites of Dartmoor and Cornwall.

Some of the views suggested in this paper occurred to the writer when in Central France, sitting on the basic products of the Puy de Parion, gazing at the trachyte mass of the Puy de Dôme. That enormous mountain of domite, as it is termed, with others in the same chain of puy, together with masses of trachyte elsewhere, if one could exactly explain their history, might throw much light on the granite bosses of Dartmoor. In the case of the Puy de Dôme and other trachyte puy, there are good reasons for regarding these acid protrusions as later than the basic ones, as there are also for the acid magma which now forms our own Dartmoor granite. The Dartmoor granite, though now essentially a portion of a once deeply-seated core, was doubtless formerly represented in its upper and outer portions by a variety of materials—necessarily arising from loss of heat, pressure, and more rapid cooling—of a more trachytic nature. The boss of granite as it now remains has had stripped from it its more external parts. This even seems true of the Puy de Dôme itself, and other trachyte masses like those of the Rhine district, which certainly have suffered a considerable amount of denudation within the very limited period since their formation.

The question might now be asked—Is the interval between the Lower Culm and the overlying conglomerates, with the included fragments of the former, sufficiently great to allow for the formation or protrusion of the granite? The author is firmly convinced that it is, for the reasons already given. Messrs. Hinde & Fox, in their paper already referred to, say: "It is hardly probable that the Radiolarian beds are directly succeeded by beds of coarse clastic materials, i.e. the Ugbrooke Park conglomerates." The author's own personal observation of these conglomerates impresses him with the fact of their being widely separated in time from the chert series. In addition to the reasons already mentioned, the conglomerate series never seem to occur in direct succession above the lower members of the Culm. They rather seem to rest on their denuded and disturbed surfaces, and many appearances would indicate that the conglomerate series overlap, or are unconformable on the Lower Culm. Indeed, the conglomerate series sometimes rest directly on the Devonian limestones, clearly proving that great denudation of the Lower Culm, and even of the Devonian itself, had occurred previous to the formation of the conglomerates. These unconformabilities were long ago distinctly noted by Godwin-Austen

and De la Beche,¹ as was also the fact of the conglomerates containing fragments of the cherts and other Lower Culm rocks. As to the age of these conglomerates, the author thinks they might, for good reasons, be referred to the Pennant Grit series of the South Wales and Bristol Coalfields, both of which, curiously enough, contain boulders or pebbles of coal and anthracite from the lower measures, indicating similar conditions to what existed in South Devon.

The question of the time required during this interval or break in the sequence between the Lower and Upper Culm deposits, for the protrusion of the granite, is now sufficiently well disposed of. So also is the question of the protrusion of the granite following the old and weakened line of former Culm basic products. There is, moreover, much good reason to suppose that the acid magma of the granite, and its perhaps more trachyte-like external portions, followed very hard after the great basic masses already mentioned.

The most important question of all, however, remains to be answered — Do the contents of the conglomerates contain any materials such as might be derived from the waste of granitic or trachyte-like rocks? To the eye, and with the aid of a lens, these conglomerates, besides the chert fragments, contain much arkose materials, such as quartz, feldspars, etc.; and mica in large flakes are most abundant in them. These granitic and trachyte-like materials are present in such large quantities as would make it very difficult to find their source of origin from the wear and tear of any other of the ordinary Devonian or Lower Culm rocks. The feldspar crystals and particles are so abundant, so large, and so distinct that the author deemed it quite unnecessary to have specimens submitted for microscopical examination. Fragments of a variety of granite are also present.

With regard to the alleged fragments of the Dartmoor granite said to have been found in the adjoining Permian breccias by the late Mr. Pengelly² and others, the writer would remark that if this be really so it would accord very much better with the inter- or late Culm age of that rock than with its Permian or Pre-Triassic age, as formerly held.

In the breccias referred to the author has been able to detect many examples and varieties of a kind of quartz-porphry. These latter might in some way or other be connected with the outer granite mass of Dartmoor, as also might be the large and numerous crystals of Murchisonite found in the breccias, which seem to have no connection with the subsequent basic flows in that formation.

It is rather unfortunate that none of these Upper Culm rocks or conglomerates are found in connection with the other bosses of granite running into Cornwall, whereby we might better test their age; but many reasons combine to show that they all belong to the same period of protrusion.

There are many other points, such as the denudation of the Devonian

¹ Trans. Geol. Soc., ser. II, vol. vi, p. 457; Geol. Rep. of Cornwall, Devon, etc., p. 111.

² Rep. Brit. Assoc., 1861, p. 127.

and Lower Culm strata from portions of the granitic areas in question, but these must be dealt with subsequently. There is, however, one important point to which the writer desires to draw attention—that is, the almost certain fact that the Devonian and Lower Culm strata had been previously disturbed and folded by great earth-crust-movements before the protrusion of the granite. The arrangement and disposition of the strata in relation to the granite certainly favour this conclusion. The great plications and the cleavage of the strata had at least in greater part, if not in whole, been completed before the eruption of the granite had taken place, and also before the conglomerate series of South Devon had been deposited, which latter occurrence, however, the author believes was subsequent to the eruption of the granite. It is extremely probable that these highly acid cores which now represent the granite never were the stumps or roots of great volcanic cones, in the correct sense of the term, as suggested by the late Mr. R. N. Worth,¹ from which proceeded highly basic lavas, but rather that they were the feeders or more central portions of extrusions, parts of which came to the surface as trachyte, forming great dome-like masses after the manner of the Puy de Dôme, near Clermont Ferrand, in Central France.

In conclusion, the author is aware that the evidences here brought forward to sustain his views as to the age and origin of the granite of Dartmoor are not absolutely conclusive; but when compared with the opinions already held they seem at all events worthy of consideration and discussion.

NOTICES OF MEMOIRS.

I.—NEUE BEITRÄGE ZUR KENNTNISS DER FOSSILEN RADIOLARIEN AUS GESTEINEN DES JURA UND DER KREIDE, VON DR. RÜST. Palæontographica, Band xlv (1898). 4to; pp. 67, pls. i-xix.

NEW CONTRIBUTIONS TO THE KNOWLEDGE OF THE FOSSIL RADIOLARIA FROM THE JURASSIC AND CRETACEOUS ROCKS. By Dr. Rüst.

SINCE the completion of his important work on the Palæozoic Radiolaria, Dr. Rüst has been revising his earlier monographs on those from the Jurassic and Cretaceous strata. Struck by the close resemblance of the forms in the Upper Jurassic *Aptychus*-beds of Cittiglio, near Laveno, from which 79 new species were described and figured by Professor Parona² some years since, to those which he himself³ had described from the Lower Neocomian beds at Gardenazza near St. Cassian, the *Aptychus* shales near Urschlu, and from Kren, and the Tithonian jaspers of the Tyrol and West Switzerland, Dr. Rüst prepared some hundreds of microscopic sections of the nodules of siliceous limestone from Cittiglio, and in these he has discovered no fewer than 212 new species, which, with

¹ Quart. Journ. Geol. Soc., vol. xlv, p. 398, etc.

² Bollettino della Soc. geol. italiana, vol. ix, fasc. 1 (1890).

³ Palæontographica, Bd. xxxi (1885); Bd. xxxiv (1887-8).