porphyritic mass subsequently to its consolidation;* then followed the period of denudation; but all this was anterior to the commencement of the conglomerate era, since pebbles of each kind of granite occur in the Haldon beds, which belong to the base of the red rocks of Devonshire.

Should it be objected that the granites, though requiring great pressure, were not necessarily formed beneath an accumulation of *rocky* matter, but possibly under an equivalent depth of sea, it does not appear that this can greatly affect the chronology of the question, at least by way of abridgment. Passing by all other considerations, we should require a lapse of time sufficiently great to carry down the area of, at least, central Devon, from the relatively high level at which the culmiferous beds were certainly deposited, to an ocean depth of enormous profundity; and time enough, too, after the plutonic masses had, at this depth, been called into existence, to bring it up again within the influence of the waves, so that they might detach samples of each kind of granite, to be transported to where the conglomerate was being formed.

Take what view of the case we may, an enormous period between the culm and conglomerate series appears inevitable; a period during which great changes were effected within, and on, the crust of the earth—changes which, from their nature, could not have been contemporary, but must have followed each other in a definite and ascertained order, and the greater part of which at least convulsion or catastrophe must have been powerless to produce or hasten.

Unless we assume that a great chronological interval elapsed between the Carboniferous and Permian periods,—and to this palæontology appears to give no sanction,†—the facts of the case before us seem to require the belief:—

1st. That the granites of Dartmoor are not older, at most, than the close of the Carboniferous period.

2nd. That they had been stripped bare by denudation when the materials of the red conglomerates were being brought together.

3rd. That the red conglomerates and sandstones are not of higher antiquity than the Lower Trias.

4th. That the Permian period was of great duration.

ON THE MODE OF FORMATION OF LIMESTONE BANDS.

BY REV. J. D. LA TOUCHE, *Stokesay, Salop.*

With a Note by J. W. SALTER, F.G.S., A.L.S.

The existence of layers of limestone at various intervals among the rocks, while in the intermediate strata there is a remarkable defi-

* Trans. Geol. Soc., 2nd series, vol. vi. part ii. p. 477.

† Page's 'Past and Present Life of the Globe,' p. 114.

ciency of that substance, is a fact which I have not seen hitherto satisfactorily accounted for, but of which we may hope to find some rational explanation.

The surface of the country in Shropshire, where these rocks abound, may be roughly described as consisting of ridges of hills, of which one flank is steep, the other shelving; the crest of the ridge being composed of a band of limestone, which, by its hardness, has evidently resisted the action of the denuding forces which have worn away the softer strata, and thus have formed the valleys.

I. Now, while the proportion of lime to earthy matter is immensely great in these comparatively thin bands which form the crests of these hills, it is as remarkably deficient in the rest of the strata; in the one case, the fossils, and their bed also, are often found to be a mass of carbonate of lime, while, in the other, not only the substance in which the fossils are deposited is deficient in that substance, but the fossils themselves have frequently lost the lime which once, beyond all doubt, entered into their composition.

II. Besides these remarkable and extensive layers of limestone, we meet occasionally with minor bands of more limited extent, and in some places with *nodules* of limestone varying from an inch or two to eighty feet in diameter.

Such, briefly, are the facts of the case, and attempts have been made to account for them in the following manner:—1st. It has been supposed that occasionally, during the deposition of the strata, a sudden but transitory development of carbonate of lime took place in the waters of the primæval seas—an hypothesis which seems to be at once refuted by the existence of the nodules I have alluded to: and, 2ndly, a more plausible theory, that these bands have been formed in a manner analogous to coral reefs; that the animals of which the fossils are the remains, secreted vast quantities of lime; that an accumulation of that substance took place around them, and so ultimately a layer of limestone was formed.

The last hypothesis seems to me also unsatisfactory, for while it may account for those cases where fossils are enormously abundant, as in some parts of the Wenlock limestone, it seems to fail in those where they are absent; and such instances are frequent. We find large masses where fossils are rare, and yet that they have not been destroyed or absorbed in any way is proved by the existence of occasional specimens in a very perfect state. Witness such fossils as the *Illænus Barriensis*; the *Euomphalus*, and other shells at Woolhope, preserved perfectly in the midst of an enormous bed of limestone. And does this hypothesis give any satisfactory account of the nodular masses? Can they be supposed to be formed in the same way as coral reefs?

Altogether, the facts above mentioned seem to me to point to some kind of aggregation of particles, like to like, probably *after* the deposition of these strata. While they were in the transition state between mud and rock, the limestone particles which had been equably distributed throughout them arranged themselves in definite

layers to form strata, or round certain centres to form nodules, in a manner analogous to that in which metals crystallize themselves from their vast dispersion throughout the substance of the globe. It is quite true, we know but little of the effects of such forces, exerted incessantly during countless ages, but we have good reason to believe that they have acted; and may we not, with some probability, refer to them such phenomena as I have described?

Let it be remembered, that two distinct facts demand explanation:—1st, the preponderance of lime in certain comparatively thin strata; and, 2ndly, the not less remarkable absence of lime in strata enormously thick. Are not these facts correlative? Is it not probable that the lime which once composed part of the fossils in the earthy strata has been agglomerated in these bands and nodules, by a process on a large scale analogous to that which takes place in the formation of flints, and, in some degree, like the aggregation of the metals?

Dear Sir,—I enclose the above suggestive note by my friend the Rev. J. La Touche, a working geologist, trained in the the Ludlow school.

I cannot say I agree with him in his larger generalization, for there is no doubt whatever of the actual deposit of these beds of limestone, again and again, over the same area, with interruptions marked by the deposit of shale. Nay, strange as it may seem, the beds of limestone, crammed with fossils, often alternate closely with beds of shale, in which one can hardly detect a fragment of a fossil. In these, and in most cases, I believe, a band of limestone means—a period of “rest.”

The shale beds are signs of a more turbid action of the water.

But then, his observation is a good one for a great many cases. No one who has studied the old limestones can believe they were deposited quite as we now find them—full of strange lenticular shapes, now crowding out the shale beds, now completely enveloped in them. Such cases as the following are not at all uncommon.

Fig. 1.—Nodules of Limestone in Shale.

We may be well assured of two things:—1. There *was* a bed of limestone, for the nodules lie in horizontal planes, and are made up of fossils in many cases. 2. The subsequent action has increased the size of the limestone band, and given it a nodular form by attraction round central points.

The old proverb, “He that hath shall have more,” is, I believe, strictly applicable in such cases. The band, comparatively rich in

lime, has served as a point of attraction for neighbouring small quantities of lime, precisely as my friend suggests. And, really, the analogy with flints, and not remotely so with metals, is much to the point.

I had lately before my eye a thick series of nodular limestones in that little-known formation, the carboniferous slate. A rough drawing of it might be thus given:—

Fig. 2.

Here were thick beds, 28 feet and 25 feet respectively, of nodular limestone among shale, separated by a thick band of shale, *b c*, without limestone, or, rather, with only a uniform distribution in small proportion to the mass; and a flat bed of lime in the middle, *c*.

But the nodules were extremely regular—the projection of one fitting opposite the recess of another, and the shale between following these sinuosities. These could never have been the lines of original deposition. Moreover fossils, though plentiful enough, did not form the mass of the limestones *a*. Here segregation is evident enough.

It is the commonest of all phenomena to meet with beds of lime-stone in which the lenticular form prevails, and to find such beds crowded with fossils. Here we have the result of the two causes—plain deposition and subsequent segregation. The base

Fig. 3.

of the mountain limestone group gives excellent examples of both. The beds are one mass of shells and encrinites, and in them, disposed in every fanciful form, and yet in layers on the whole, are nodules of chert.

Some of the prettiest instances of the change of dimensions (I think it was Sorby who applied the term) in limestones occur when the rocks containing them are cleaved. In such cases, where cleavage is well-developed, the limestone nodules will often form along the cleavage, *i. e.* the line of least resistance. In cases where great pressure has been exerted, the bed of limestone is often violently crumpled up, while the shale has quietly submitted to be squeezed, and “made no sign,” though every layer of it must have undergone the same process. I have, in my sketch-book, a Devonian limestone bed, near Ilfracombe. Here are two lines of original deposit; *a* and *b* were limestone bands, and are full of encrinites, but the thickness of neither *a* nor *b* can be determined except by calculation; the bed

is squeezed into nothing in one part, thickened out to thrice its original diameter in another. The mass has changed its dimensions; and a limestone band could not have done this without a rearrange-

Fig. 4.

ment of its particles. This is, in part, what Mr. Latouche means. However, we must combine the two ideas: original deposit, as bands of limestone, of which we have abundant instances—the whole mountain-limestone to wit—with that of a very frequent, nay, I am inclined to believe, all but universal—alteration, and segregation afterwards. In this way we may account for nearly all the vagaries of limestone—and they are neither few nor small. The arrangement of the shale itself in layers parallel to these concretions, nodules, and irregular layers, is yet more difficult of explanation. Yet it is certain. It is foliation on a small scale. Are the rocks never at rest?

J. W. SALTER.

ON THE GEOLOGICAL EVIDENCES OF HORSES IN THE NEW WORLD.

BY CHARLES CARTER BLAKE, Esq.,

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Before attempting to deduce any general conclusions respecting the geological evidences of the genus *Equus* in the New World, it is necessary to have clear ideas respecting the geographical distribution of its members. In the first place, therefore, I give a sketch of the classification and range of the existing species.*

* Much information may be derived from the works of Owen, Gervais, Gay, Gray, Hamilton Smith, Crawford, Darwin, Leidy, Lubbock, Pictet, Bronn, Falconer, Sclater, Bartlett, Nott, Gliddon, Blyth, Laird, Sykes, Youatt, Schreber, Wagner, and others, and at the end of this series I shall give a list of the authors to which I have referred.

In the geographical distribution of animals into provinces, I follow the philosophical arrangement proposed by Dr. P. L. Sclater, who has applied the classification to ornithological arrangement with so much success.