Huronian, there are not wanting portions of its more schistose strata which have a resemblance to certain Montalban rocks. Hence it was that at an early period in the writer's studies he attempted to group Montalban and Taconian under the name (soon after abandoned) of Terranovan. For a detailed account of the whole Taconic controversy, see the author's *Mineral Physiology and Physiography*, and for a more concise statement, but with more new light, "The Taconic Question Restated" in the *American Naturalist* for 1887.

13. The name of Taconian was given to the Lower Taconic of Emmons to distinguish it from his Upper Taconic, which is essentially uncrystalline, and, as shown by its trilobitic fauna, and recognized by Emmons himself, is clearly Cambrian, and is in some regions directly overlaid by Ordovician strata. Beneath the recognized Cambrian, in parts of the North American continent, is a great body of uncrystalline sediments, which I have designated Keweenawian. While newer than the Taconian, their relation to the unconformably overlying Cambrian is as yet uncertain.

It is not claimed that the above indicated division of the great pre-Palæozoic or Archæan succession is complete. Further study will probably show that there are other groups, and furnish grounds for subdividing those here proposed. They are, with small help from without, chiefly from the generalizations of a single observer during a period of forty years, and as such are offered as a first attempt at a classification of the stratified crenitic rocks, and as illustrations of the process of mineralogical evolution. It must be remembered that for reasons already assigned (§ 2), none of these groups save the fundamental granite can be supposed to possess the characters of uniformity and universality.

IV.—ON SOME BRECCIATED ROCK IN THE ARCHÆAN OF MALVERN.

By T. MCKENNY HUGHES, M.A., F.G.S.,
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THE question of the origin of the Archæan rocks is one of such great interest that it will not be thought unimportant on the one hand to record any facts that may bear upon it, and on the other to examine somewhat severely all the evidence that may be from time to time brought forward on the subject. Among the facts which may be adduced in support of the view that the Archæan rocks are altered sedimentary strata, the occurrence of breccias and conglomerates may well claim a foremost place; and a vast amount of superincumbent theory must rest on a very shaky foundation if there be any doubt whether some of those ancient fragmental beds be true conglomerates or not. The manner of occurrence, the mode of formation, and the character of pseudo-breccias and pseudo-conglomerates become therefore questions of first importance.

What one would be at first inclined to accept as evidence of the conglomeratic character of a bed would be that the included fragments were rounded, and that they were of a different character from the mass in which they were imbedded. I have on a former

occasion¹ discussed this point, and given examples of rocks made up of fragments differing more or less in character from the surrounding matrix in cases in which I was able to offer abundant evidence that these rocks owed their fragmental character to brecciation in place. I explained the pebble-like form of the fragments by the rounding off of the corners which usually accompanies infiltration from the joint surfaces, and further pointed out how the apparent matrix was derived from the alteration of the more finely comminuted portions of the brecciated mass, and from the decomposition of the outside portion of the larger fragments.

I am now able, as the result of observations made at various times on the Archæan rocks of the Malvern Hills, to supplement and extend these remarks.

It might be argued that the modification induced by chemical change within the mass would be likely to affect equally adjoining fragments of the same size, composition, etc., and therefore, that, if the apparently included fragments were of different nature, not only from the matrix but also from one another, this must be accepted as evidence that the mass was made up of bits transported from different rocks and various localities, especially if the pieces could be matched among the members of the underlying series.

It would be pointed out that a volcanic brecciated conglomerate often seems made up of fragments of rock belonging to the very series in which the agglomerate occurs.

In the Archæan rock which rises abruptly from the level of the New Red west of Malvern Link, near the quarries, there are some bands of rock (Fig. A B) answering these conditions, which might easily be taken for a brecciated conglomerate. The included fragments are of various kinds, different from the matrix, and also unlike one another. Some are coarse light-coloured crystalline syenite, others close-grained pink felsitic rock. The matrix is a claret-coloured earthy, homogeneous, felspathic paste, with here and there a coarser or crystalline structure, or a few imperfect felspar crystals and grains of quartz. The fragments are often quite rounded, like shore pebbles. Following the band along its trend we find variations in the size of the fragments, and in the proportion of the different kinds, but otherwise its general character prevails as far as it is exposed.

If, however, we trace this fragmental mass across its trend into the adjoining part of the rock, we find that the fragments cease to be round, and their sides are bounded by the continuation of the joints which affect the whole rock. The claret-coloured matrix disappears, being represented first by thin bands along the outside of the angular fragments, then by mere lines of colour along the joints. The pink felsitic fragments run together, and are at last seen united in a vein (C D) of compact pink felspar-rock, such as is so common in the Malvern Archæan. Where the vein has got much broken up and displaced, we find sometimes, on the margin and at

¹ *Geol. Mag.* Vol. X. 1883, p. 306, "On the Brecciated Bed in the Dimetian of St. Davids."

the sharper folds, even a commingling of fragments of the vein and surrounding rock.

When, moreover, such fragmental beds are observed to coincide with the trend of the ridges, and with the larger divisions of the series which are supposed to represent original differences in the succession, this may be urged as an argument in favour of the conglomeratic character. But in any folded rock the chief crush is apt to run along and be confined to the central portions of the folds, so that the bands of breccia caused by it must necessarily coincide in direction with the trend of the ridge and the strike of the succession of rocks of which the mass is made up, and any rock having a different texture in successive portions, whether original or superinduced, will, during earth-movements, behave just like a sedimentary rock in which there is a succession of beds of different powers of resistance.

In the Malvern Hills, as so often elsewhere, the axes of folding of the older rocks run slightly oblique to the trend of the ridge.

Diagram sketch of part of band of pseudo-agglomerate in the Archæan rocks of Malvern.

A.B.—Band of brecciated rock. *C.D.*—Vein of pink felsite.

The margin against which the New Red abuts on the east of the Malvern Hills was probably determined by pre-existing lines of weakness, due to faults and crushes in the Archæan, but the now more important but originally less intense movements which took place after the deposition of the New Red have determined the existing boundary of that series. But the principal divisional planes and sequences indicating the direction of the great folds in the Archæan rock run into the hill obliquely to the margin in the locality to which these observations chiefly refer, namely, the quarries west of Malvern Link. Along these axes, and therefore coinciding with what looks most like strike in the Archæan, run the bands of fragmental rock, and thus, if it had not been that we were able to examine the surrounding rock sufficiently to satisfy ourselves that the conglomeratic character was deceptive, and to see that the breccia passed into jointed rock, we might easily have taken this band as an ancient shingle or agglomerate, to the great confusion of the evidence already sufficiently difficult to unravel.

Thus it is clear that we may in certain cases have a conglomerate-

tic-looking mass composed of rounded pieces of rock differing in lithological character both from the matrix and from one another, occurring along what looks like the strike of the rocks, and yet may be able to make out that it is entirely a superinduced structure due to brecciation in place and subsequent decomposition of the broken rock.

From these observations we may also learn another lesson, viz. that crushing may take place without producing any effects analogous to metamorphism properly defined, and may act in aid of true metamorphism or other chemical change, chiefly by comminuting and preparing the rock for chemical reaction.

V.—ARCHÆAN ROCKS.

By G. H. KINAHAN, M.R.I.A., etc.

(Read before the British Association, Manchester, 1887.)

AT the present time the American geologists, both those of the United States and the Dominion of Canada, are at variance as to the groups the Archæan should be divided into; it is however unnecessary to enter into this controversy, as the strata may be conveniently grouped, as in Selwyn's map (1884), into *Norians* or *Labradorians*, excessively coarse gneiss or other granitic rocks; *Laurentians*, gneiss and granite; and *Huronians*, schists with subordinate gneiss.

Some of the authorities both in the States and the Dominion would have us believe that the Archæans originally accumulated as crystalline foliated rocks; that is, the minerals were deposited by chemical action from solution. Others, however, hold that at one time they were ordinary sedimentary rocks, which during one or more successive periods of metamorphic action were changed into their present conditions. The present school of English Archæan geologists seems from their writings to coincide with the Americans, who believe in originally crystalline accumulations.

The facts in favour of the first theory seem to be obscure; we are indeed told that "chemistry forbids" an ordinary sedimentary rock changing into a schist, gneiss or granitic rock; yet in the field we can walk along beds that change from unaltered rocks through schist into gneiss, and thence into metamorphic granite. Such a change may be quite contrary to the chemical laws laid down by such Archæan geologists for their own guidance, but they are patent facts effected by the GREAT CHEMIST, and to be ocularly learnt by any ordinary observer who carefully works out any large tract of metamorphic rocks.

In connection with this subject the value of lithological characteristics may first be mentioned. It is now generally well known that any rocks, no matter to what period they belong, from the newest Tertiaries to the Archæan, if they have been subjected to sufficient metamorphic action, will be changed into schist and gneiss; that is, that foliation will be developed in them, although originally they may have been ordinary sedimentary rocks, volcanic