

distinguishable. A few experiments on these two substances might, therefore, throw some light on the question as to what is the cause of the odour of clay. This odour, by-the-bye, I find is very perceptible on the oyster-shell, although there is no trace of clay about it, and the specimen was imbedded in a fine whitish sand, stained with a little oxide of iron. For other details on this point I would refer you to a paper on the Plasticity and Odour of Clay, by Mr. Tomlinson, contained in No. 8 of our Proceedings, where an experiment is made in which this odour is referred to the presence of sesquioxide of iron.

The other mineralogical fact is that the mottled clay has a considerable proportion of gelatinous or soluble silica, that is, silica which can be dissolved in alkaline solutions without the application of heat. Since, then, it actually exists in this form in the Tertiaries, it is possible that it may have existed in this form in the Cretaceous period. Indeed it occurs in beds older than the Chalk, namely, in the Lias, and in beds between the Gault and the Chalk. This note scarcely belongs to my subject, but I have mentioned it because, on the hypothesis of the existence of the gelatinous silica during the deposition of the Chalk, we may perhaps understand how shells can have become imbedded in flint. Several excellent examples of such shells were shown to the excursionists. Many other subjects occupied the attention of the party, and the success of the excursion was mainly attributable to the exertions and hospitality of Mr. Ilott.

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*Ordinary Meeting, November 1st, 1864.*

Professor Tennant, F.G.S., Vice-President, in the Chair.

The following papers were read:—

1st. "On Metamorphism in certain Strata at Bendigo, Australia."  
By Mr. R. Lechmere Guppy.

Among the many remarkable phenomena met with in the gold-fields of Australia, and which have scarcely yet received the attention they seem to deserve, there is one of which I shall attempt to give a short description.

At the south-eastern corner of the great gold-field of Bendigo in Victoria, there is a remarkable range of auriferous hills, known as

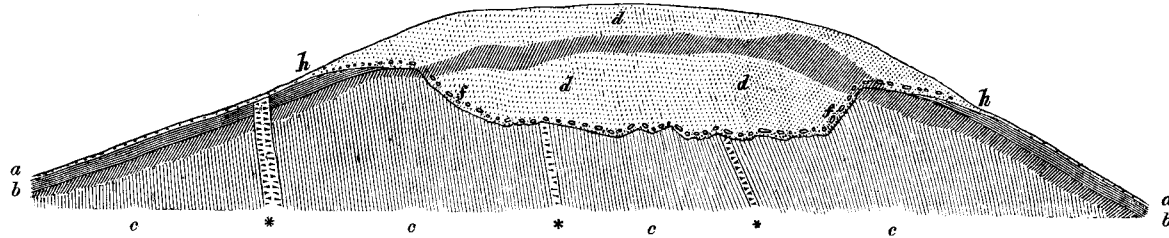
the "White Hills." These hills are numbered respectively from first to seventh, though there is a small hill at the commencement of the series which is not taken into account in this enumeration. The gold-bearing deposit runs through these hills without interruption; for every portion of ground within the limits of the auriferous band, whether the deposit yielding the metal exhibits itself superficially on the hill-sides, or at some depth in the gullies and the upper portions of the hills, has been profitably worked.

I shall now describe the ideal section which I have constructed for the elucidation of the phenomena; I say *ideal*, because it is not drawn from actual admeasurement, nor to any particular scale; but it may be taken as a pretty fair representation of the conditions of the deposits forming the White Hills.

The lowest stratum represented in the drawing at p. 411 is a pipe-clay, (c) usually white and pure, but in some places red and yellow, and in others sandy. It is, in general, finely laminated, and it is intersected by veins or dykes of quartz, in a direction parallel to its lamination. Upon the pipe-clay, which is called the "*bottom*," is superimposed the gold-bearing stratum of quartz gravel. This stratum is distinguished in the middle or upper portions of the hill by large, sometimes immense, quartz boulders and pieces of sandstone and pipe-clay. This auriferous layer is thickest towards the "*dips*," as at *f* in the drawing. It is usually not more than a foot in thickness, sometimes even not more than two inches, but in the *dips* it sometimes exceeds twelve feet. It only differs from the other layers of gravel (*d*) above it in that the latter are composed chiefly of smaller pebbles, and have little or none of the pipe-clay. The gravel is deposited in layers of varying degrees of coarseness up to the surface, where there is a slight mixture of vegetable earth.

But an irregular layer or mass of indurated gravel is invariably met with in sinking shafts in the White Hills. This mass, represented in the drawing by the oblique shading, does not differ, except as to hardness, from the other portions of the gravel-beds, and bears no relation to the stratification. When we follow this indurated gravel to the margins of the hill, where the *bottom* comes near to the surface, we lose it, and we find that the pipe-clay

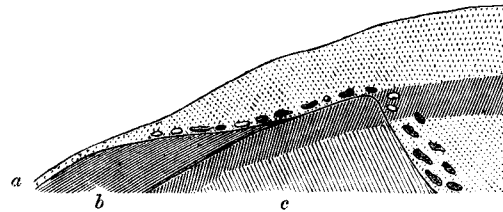
FIG. 1. DIAGRAM-SECTION OF A "WHITE HILL," BENDIGO, VICTORIA.



*a* Surface-soil, auriferous; the quartz usually angular. *b* Red, yellow, and mottled clays. *c* White pipe-clay. *d* Quartz-pebbles and sand. \* Quartz-veins or Reefs. The indurated portions are expressed by oblique shading, thus



FIG. 2. ENLARGED SECTION at *h* in No. 1.



becomes indurated; and that first, as we proceed in a direction away from the middle of the hill, we find that the gold-bearing gravel, superimposed upon the indurated pipe-clay, is also indurated; then we find a gradual interposition of softer white and mottled clays, between the auriferous gravel and the indurated pipe-clay, until they are some feet apart. Upon the softer clay, which now becomes the *bottom*, we find softer red and mottled clayey gravels for our "*washing-stuff*," as the auriferous stratum is termed. At the point marked in the diagram by the letter *h* we find the *bottom* to be red clays, descending into yellow and mottled clays, the gold-bearing stratum being angular quartz gravel, mixed with humus, but rarely having large boulders of quartz. I should remark that the gravel above the "*cement*," as the indurated gravel is locally termed, is usually more or less clayey and red.

Having given a brief description of the section, I will now proceed to suggest an explanation of part of the phenomena. It will be noticed, that the quartz-reef on the left of the section is represented as coming up through the indurated pipe-clay, and through the red and mottled clays. The surface-deposit of auriferous gravel rests upon the edge of the quartz-dyke in the same manner as upon the red clays, where the latter constitute the *bottom*. It is evident therefore, that if the quartz-dyke belongs to the same formation as the pipe-clay, that the red and mottled clays also belong to the same formation; in fact, that they are a part of the same deposit. Now, it is evident, from the fact that induration passes through all the layers alike of clay or gravel that have come within the sphere of its action, that that state was induced subsequently to the deposition of all the strata; yet we find no red clay below the indurated gravel. Now, I think it follows that the red clay must have been deposited prior to the induration; and if so, it was probably in the state of white pipe-clay. It, therefore, appears that some action must have taken place in all those parts of the deposit of originally white pipe-clay which were not covered by the *cement*, and that this action must have been most intense at the surface, in such a manner as to cause the upper part of the pipe-clay to have become of a deep red colour, gradually lightening downwards into pink, mottled, and yellow,

and finally white clays, which lie directly on the indurated pipe-clay. What the nature of the action was that caused the induration I cannot conjecture; nor why it should have happened that a complete cover at the depth of six or eight feet below the surface all over these hills has been formed of the indurated materials, whether pipe-clay or conglomerate. As I have shown that it is quite irrespective of the nature of the stratum it has taken place in, it would be impossible to suppose that there had been two or more deposits of gold—one prior to, for instance, and others subsequent to the induration; for in such a case we should find gold all along above the surface of the indurated material, whereas we only find it on the *bottom*, be that soft pipe-clay, indurated pipe-clay, or red clay. In any case the phenomena are so remarkable as to deserve in a high degree the attention of geologists and mineralogists.

There are two points worthy of investigation. First, the cause which led to the induration of the masses in so remarkable a manner; and, second, the causes of the change from white pipe-clay to red clay.

As far as my observations have extended, they have not thrown any light upon these causes. I have only been able to arrive at the conclusion that the causes were irrespective of the deposition of the strata, and that that which led to their induration operated at a depth of a few feet only below the surface. The sequence of events was in this wise. After the deposition and solidification of the pipe-clay, a large quantity of gravel was deposited above it, probably by fresh-water action. Subsequently to this there occurred an action of induration, taking place at a depth of several feet below the surface, leaving untouched the superficial portions of the deposits. Then there occurred a metamorphism of the pipe-clay, and perhaps a corresponding change, but in a less marked degree, in the gravels resting on the portions wherein induration had taken place. This metamorphic action reduced the part of the pipe-clay affected by it to a state of red and mottled clays, less compact than the original material.

I do not, however, overlook the possibility that these two actions might have been synchronous, and may, in fact, have been one the cause of the other. It is possible that the draining-out of certain

constituents of the superficial portions into those immediately beneath them may have caused the metamorphism of the superficial and the induration of the inferior portions.

I do not know of the existence of organic remains in any of the strata, with the exception of the anomalous worm-burrowings in the red and mottled clays, which were described by me in a paper read to the Geologists' Association, and which will be found in vol. 1 of the Proceedings, p. 161.

2nd. "On the Uneven Surface of the Chalk when covered by Boulder-clays and Gravel." By Mr. A. Bott, F.G.S.

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*Ordinary Meeting, December 6th, 1864.*

E. Cresy, Esq., President, in the Chair.

A Paper was read by Mr. C. Tomlinson, F.C.S., entitled 'Two Days on the Chesil Bank,' in which he described a visit to that remarkable bank of shingle, the most extensive in Europe, extending, as it does, from Burton Cliff, near Bridport, to the Isle of Portland, a distance of nearly nineteen miles. Mr. Tomlinson did what few visitors to this part of our coast care to do: he walked the whole length of the Bank, which in the last ten miles has no other path than the loose shingle. He also collected (and exhibited) pebbles from different parts of the Bank, not only to illustrate their species, but also the remarkable and gradual increase in size, from blown sand, at Burton Cliff, to pebbles of the size of turnips, at the village of Chesil. Among the pebbles, those of rolled flint or of translucent quartz are most abundant: there were also pebbles of black fullers' earth, black Devonian Limestone, Old Red Sandstone, Porphyry with green and red spots, Lias with lines of carbonate of lime, forest-marble, and jasper. Parts of the Bank are broken into gulleys by the infiltration of water, and the subsequent hydrostatic pressure during heavy seas. A large map of the locality, and diagrams showing the dimensions of the Bank, as determined by Mr. Cooke, the Engineer of the Portland Breakwater, were exhibited. The questions then discussed by Mr. Tomlinson were—1. Where do the pebbles come from? 2. What