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ON THE CAVES PERFORATING MARBLE
DEPOSITS, LIMESTONE CREEK.

By JAMES STIRLING, F.L.S.

PRICE ONE SHILLING.

ON THE CAVES PERFORATING MARBLE DEPOSITS, LIMESTONE CREEK.

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DURING a recent examination of some marble deposits at the head of the Murray River (Limestone Creek), it occurred to me that a few measurements and observations on the interior of the caves by which these deposits are perforated might prove interesting. The following descriptions and diagrams are the result of such examination:—

TOPOGRAPHY OF LIMESTONE CREEK VALLEY.

Forming the most southern source affluent of the Murray, the Limestone Creek presents many important physiological features. The southern and eastern watershed line is formed by the Great Dividing Range, culminating on the east in the rugged Cobboras mountains, 6025 feet above sea-level; while the western watershed line is formed by a high lateral range at a mean elevation of 4500 feet above sea-level. The general direction of the course of the Limestone Creek, from its source in the Dividing Range to its confluence with the Indi or Hume River, is north north-easterly, and the area of its catchment basin about 240 square miles.

Most of the small tributary streams have their source runnels in fine grassy upland flats, on the crests of the ranges forming the watershed lines, but as they near the parent stream traverse deeply eroded gorges in the mountain flanks, frequently forming cataracts and waterfalls of great beauty. This is more particularly the case with the eastern affluents, which are much shorter than the western.

The view obtained when descending the valley from the west, on the main route from Omeo to Maneroo, N.S.W., is very grand and impressive. Away to the north, just discernible in the distant horizon, looms the snow-capped peaks of the culminating ranges of the Australian Alps, Mount Kosciusko, and the Bugong Ranges, over 7000 feet above sea-level; in the middle distance rises the coned peak

of Mount Pilot, 6020 feet; to the east tower the serrated rocky ridges of the Cobboras mountains, 6025 feet; while intervening and winding amid bold, wooded ranges lies the gorge formed by the Limestone Creek valley. Along the course of the stream are a series of richly grassed open flats, backed in many places by low bluffy spurs, giving in their undulating contour and other appearances unmistakable evidences of calcareous deposits *in situ*.

GEOLOGICAL STRUCTURE.

The eastern watershed (with the exception of the locality hereinafter mentioned as Stony Creek) is composed of masses of porphyries, fragmental and compact, the former from grains as fine as sand to blocks weighing many tons; while the western watershed is made up principally of slates, and interbedded bands of whitish marble and dense blue limestone. The slates merging on the western watershed line into a class of schistose rocks, bearing a strong resemblance to the metamorphic schists of the Omeo District.* Although the Limestone Creek may generally be said to have eroded its course along the contact of the sedimentary rocks with the porphyries, yet the latter, in the lower part of the stream, have been cut through, leaving precipitous banks on either side.

In order that the stratigraphical relation of the porphyries to the sedimentary rocks may be better understood, the following sectional notes and diagrams are given. The section was determined from personal observation, and crosses the Limestone Creek valley at right angles to the course of the stream.

Starting from the level of Marengo Creek (an eastern affluent of the Mitta Mitta), and proceeding easterly, we have, first, a mass of granitiform rock exposed on the bed of Marengo Creek; ascending Mount Pendergast coarse metamorphic schists, gneissic in character, are seen, showing apparently a vertical dip. As the crest of the range is reached these rocks become more micaceous, full of thin quartz seams, and corrugated along the line of strike, which is here seen to be N. 20° W. Descending towards the Limestone Creek some upland alluvial flats are passed over, with

* "The Diorites and Granites of Swift's Creek, and Their Contact Zones." By A. W. Howitt, F.G.S. *Royal Society of Victoria*, pp. 9 to 15.

Yellow sandstone

50 feet

thick bedded sandstone
large sandstone

DK. Grey fine grained sandstone
11 feet to bed of Creek

Bed of Creek

Bed of Creek

Section of Hill exposed at creek bed
Creek near Gannon

Nº 1.
 (Great dividing range)
 MT COBBERAS 6025

Nº 1.

MT. PENDERCAST 4600
 (Main divide between
 MITTA MITTA & INDI RIVERS)

HEAD OF MARENGO Ck (2900)

TOP FLATS

LIMESTONE Ck (3000)

STONY Ck

COBBERAS Ck

GEOLOGICAL SKETCH SECTION
 FROM
 MARENGO Ck TO MT. COBBERAS

- GRANITE
- METAMORPHIC
- SLATE
- DIORITE
- MARBLE
- PORPHYRY

James H. King del.
 1/16 SE

here and there, on the crests of the dividing ridges, contorted schistose rocks protruding. These are both argillaceous and silicious in character, and generally finely laminated, showing a dip of from 70° W. to vertical at N.N.W. At lower levels a mass of diorite is met with, presenting in the weathering rounded boulders traces of its igneous origin. The soil formed by the disintegration of the latter is shown to be very fertile by the rich carpeting of grasses at this place. So far as I could judge from the altered indurated appearance of the rocks at contact, this mass has been protruded, or rather intruded, from deep-seated sources along the line of section, and not, as might be suggested, either interbedded with the sedimentary rocks, or the remnant of a once larger mass intruded elsewhere. The rock appears to be a mixture of felspar and hornblende principally. On the spurs descending the valley of the Limestone Creek the normal Silurian slates are seen, inclined at high angles, generally $70'$ to W., and vary in colour from yellow to bluish grey—soft, yellowish sandstone, and micaceous-argillaceous slate, thin bedded or finely laminated. On the creek flats are deposits of tertiary gravels, frequently auriferous, and which may hereafter be profitably sluiced for gold. Several of the western tributaries of the Limestone Creek are also auriferous, and one, Slaty Creek, contains titaniferous iron sand with cassiterite.* On the east bank of the creek is a bluffy outcrop of what appears to be thin-bedded blue limestone, the beds varying from a few inches to as many feet thick, and inclined at an angle of $70'$ to W., with strike to N.N.W., in fact, parallel with the slates with which they are interbedded. These apparent blue limestones, however, when broken, exhibit a crystalline, somewhat saccharoidal texture, and vary in colour from milky white to shades of light grey, and are found to be more or less full of thin yellow seams parallel to the bedding planes. The quality of this marble, on an analysis of hand specimens, seems good, yielding a small percentage of earthy matter, and a large percentage of carbonate of lime; yet even where the beds are thickest these seams would probably deteriorate from the commercial value of the deposit. Whether these seams are in any way due to the percolation of surface waters holding colouring matter, such as one of the oxides of

* *Geological Survey of Victoria*, Vol. IV., p. 189.

iron, limonite, $H_6 Fe_2 O_9$, in solution; or represent thin seams laid down during the deposition of the calcareous sediments, and which have not been obliterated during the processes of consolidation by which it is probable these beds were metamorphosed from marine limestones into crystalline marbles, I am unable to decide; although, from the evident regularity and parallelism of the seams and their continuousness, together with the facts noticed when examining the structure of the marble in the interior of the caves, it is probable that the latter is the more correct explanation of their origin. The apparent thickness of this marble bed when crossed by the line of section does not exceed 250 feet. To the east the slates again appear, but, at contact with the marbles, very much contorted along the line of strike. Crossing an eastern affluent of the Limestone Creek (Painter's Creek), the porphyries are first seen, and the change is marked both in regard to the character of the soil and the vegetation.

On examination the rock is found to have a somewhat granular felspathic base, in which are scattered numerous irregularly-shaped patches of felspar, the dimensions of which may generally be about a quarter of an inch by an eighth of an inch in width. On ascending the hill side similar rocks are to be found, nearly to the first summit, but in places becoming more compact.* On descending towards Stony Creek similar rocks are met with, until at lower levels the slates again appear, presenting the same strike and dip, and without any more than the normal state of alteration as seen generally on the eastern watershed near the marble deposits. On a small spur abutting on Stony Creek are seen the deposits of fossiliferous blue limestone from which specimen No. 1 was taken.

At lower levels a tributary of Stony Creek—Round Mountain Creek—has laid bare another narrow band of finely laminated slates, which are succeeded by the Stony Creek marbles, consisting of rather amorphous or thick-bedded masses of whitish, greyish, pinkish, and variegated marbles, as seen in specimens Nos. 2, 3, 4, and 5.

In one place a ridge of undenuded porphyry remains overlying the marble deposits, as shown in sketch; while on

* *Progress Report, Geological Survey of Victoria*, 1876, p. 196. A. W. Howitt, F.G.S.

No. 2.

DIAGRAM
SECTION A TO B

PLAN OF
PENDERGAST'S CAVE
N^o 1.

— INTERIOR OF CAVE —
— at D —

— INTERIOR OF CAVE —
— at C. —

the eastern bank of the creek the marble beds are capped by blue unaltered limestones containing fossils (molluscs).

In ascending the steep and rugged ranges to the east, the porphyries become more compact and silicious, having a greyish or reddish felsitic base, with small translucent quartz-crystals, patches of pink-coloured felspar and fragments of other rocks, the whole forming a breccia-like mass, as seen in specimen No. 6. On the summit of Mount Cobboras, and on the rocky-crested ridges near it, the rock masses weather into vertical layers with a northerly strike. Descending the eastern slopes of Mount Cobboras, the porphyries previously described give place to salmon-coloured quartz-porphyries, almost granitic in structure and weather in rounded masses.

EXAMINATION OF CAVES.

CAVE NO. 1.—PENDERGAST'S CAVE.

The first examined is that perforating a marble deposit near the Limestone Hut (an out-station of Mr. James Pendergast, of Mount Leinster). For reference this may be called Pendergast's Cave. In examining the ground plan of this cave (Diagram 3), it will be seen that it traverses generally the line of strike of the strata. This is the case with most of the caves examined, and would appear to indicate their origin to be by percolation of water from the adjoining creeks. What I mean by this is that the present water channel of the Limestone Creek, although in some cases at a lower level than the orifices forming the entrances to the caves, originally stood at a much higher level, and washed the bases of the limestone bluffs; then, percolating along the lines of strike, gradually eroded a channel to a lower level; and, owing to the calcareous mass being traversed by joints and lines of shrinkage, the water charged with carbonic acid gradually decomposed the hard crystalline masses, and by the further mechanical action of silt and small stones eroded a larger passage. The action of rain water from above, acting similarly by its carbonic acid, derived from the decomposing vegetable matter covering the calcareous deposits, would probably form many of the curiously-shaped holes and crevices seen on the surface.*

* *Vide* Boyd Dawkins' *Cave Hunting*, p. 53.

The entrance to this cave is fully twenty feet above the level of the Limestone Creek, and is exceedingly narrow. The difficulty encountered on entering is, however, amply recompensed for by the pleasure experienced when the interior beauties are brought into view—pendent crystalline stalactites of innumerable forms of beauty stud the ceiling, while the floors and sides, in addition to numerous stalagmital pillars, are here and there fretted with a rich deposit of glittering calcitic crystals. The rough sketch is a faint endeavour to portray the characteristic cave scenery.

In many places the floor is made up of thick deposits of silt, covered by a thin stalagmital coating; while in others the original silt has been removed, leaving a thin floor of stalagmite.

In many places where fissures exist to the surface from the uppermost cavern, the sides of the latter are covered with a mass of soft, milky-white substance, fully three inches thick, which I cannot describe better than by calling it calcareous froth. The substance hardens upon exposure to the external air, and is most abundant after a heavy rainfall, when the interior of the cave is in a moist condition. The marble, where examined on the sides and roof of the cave, although the bedding was more obscure and apparently of greater thickness than seen on the weathered surface, yet still retained the objectionable yellow seams discernible at the surface. The only fossils obtained in the vicinity of this cave were impressions of encrinites, too obscure for palæontological identification. A section through the caves, and the deposit in which they are situated, gives the features shown in Diagram No. 4, and in following the deposit along the line of strike the beds are seen to be flexured to a considerable extent, and narrow at their extremities to thin bands of corrugated calcareous shale, as in Diagram 4.

CAVE No. 2.—SHEEAN'S CAVE.

This is, perhaps, the largest cave in the series, and is situate at the base of an extensive bluff of marble on the western side of Limestone Creek, about half-a-mile below Pendergast's Cave (see sketch). The general direction of the cave conforms to the existing drainage system of the Limestone Creek, and is nearly parallel with the strike of the beds themselves. Where the ramifications are rectangular to the general direction, they are, I think, produced by the

N^o 4

DIAGRAM SECTION ACROSS LIMESTONE CR.
AT PENDERGASTS CAVE

S. SLATE A. ALLUVIUM & TERTIARY GRAVELS. M. MARBLE. C. CAVES.

M. MARBLE. S. SLATE. C.S. CALCAREOUS SHALE.

DIAGRAM
SECTION A TO B
THROUGH
SHEEAN'S CAVE.

SECTION across Cave at X.Y.
To shew mud conglomerates
and Original Cave

Plan of
SHEEANS CAVE

No 2.
Scale 20 Ft

percolation of acid-laden waters from the interior—i.e., as the main channels became choked up by the accumulation of débris, silt, and gravels, etc., the rushing waters caused by an annual flood would endeavour to find a passage along the lines of joint or shrinkage. At present the water traverses from A to B (see plan), and from B finds its way through narrow or flattened orifices to lower levels, re-entering the Limestone Creek about 200 yards below the entrance to the cave. The roof of the entrance, and for some distance inward (about 20 feet), consists of a mass of whitish marble beautifully scalloped by the action of running water. The entrance is very nearly on a level with the Limestone Creek, from which it is distant about 70 feet, and separated by the alluvium and an accumulation of débris (see plan). After the first 33 feet are traversed the narrow entrance passage gives place to a large chamber, from which start various ramifying passages. Those through which the water runs are narrower than that which I have shown traverse lines. The floors of 2 to 3, 4 to 5, and 7 to 8 are simply masses of soft and hardening silt with, in some places, stalagmital covering. These present many favourable spots for fossil hunting, but owing to the limited time at my disposal I could not undertake any examination. However, the plans and sections submitted may prove useful as a basis for further examination by any one disposed to undertake such interesting work. Many of the roof fissures extend almost up to the surface of the deposits, quite 60 feet in some places, and their sides are frequently covered with stalactical drapery of every conceivable shape and of very beautiful appearance. The rate of accumulation of these stalactites depends, apparently, on two principal causes—viz., the quantity of percolating water holding carbonate of lime in solution, and the rate of evaporation of the carbonic acid from the surface of each drop of water, the latter depending upon the temperature, accessibility of the air, and other conditions. During my last visit to Pendergast's Cave, No. 1 (there had previously been a rather heavy rainfall), the stalactites were covered at their extremities with bright, clear drops of water, some indeed were dripping, and there was also a visible increase in the quantity of matter I have denominated calcareous froth. It is probable, therefore, that the rate of stalactital growth depends largely on the seasons, a wet season being most favourable. The lines of bedding are well seen in the interior of the cave,

although frequently covered with reddish and yellow earthy sediment. Throughout this cave, at about 6 feet above the present bottom and water-level, are masses of mud conglomerates, with waterworn pebbles and boulders from $\frac{1}{2}$ -inch to 3 inches in diameter, and made up of the porphyries and slates which exist *in situ* on the surrounding hills. These mud conglomerates evidently are the undenuded remnants of what was for a long time the original deposit forming the floor of the ancient cave, and may yet be found to contain fossils of scientific value. I have indicated their position on Diagram No. 5. The beds, where visible within the cave, seem to be much thicker than on the weathered surface, and are still full of the parallel earthy seams before referred to.

TEMPERATURE OF THE CAVES.

During two visits I made some observations on the temperature of the caves examined. On the first occasion, in August, 1882, when the surrounding hills were covered with snow, the thermometer at the entrance to caves Nos. 1 and 2 stood at 50° Fahr.; at a distance of 100 feet within the caves it rose to 58° Fahr. During November of same year the thermometer at entrances registered 62°, and at the same place as before, within the caves, it fell to 54°, thus giving a difference of 8° between the external and internal air in each case. This seems to agree with the result of observations recorded elsewhere, "that the air in caves is generally of the same mean temperature as that of the district in which they occur, and consequently cool in summer and warm in winter."* For instance, during August, the minimum degree of cold registered during a severe frost at the Limestone Creek was 20°, or 12° below freezing point, while in November the maximum registered was 80°. Taking the mean of these observations as an approximate mean annual temperature, we have 50°, which I anticipate is about that of the regular mean temperature of the caves, and also that of the Limestone Creek valley in which they are situated. Of course this determination is not to be taken as strictly correct, as a more extended series of observations are required to ascertain the mean temperature of the place, and it is probable that the maximum and minimum heat is greater and less

* Boyd Dawkins' *Cave Hunting*, p. 71.

than that recorded, but from the altitude and latitude of the place it is not improbable that this approximate determination may be found to be correct within reasonable limits, the latitude of the caves being about $37^{\circ} 7'$, and the altitude 3000 feet above sea-level.

CAVE NO. 3.—DRY CAVE.

This is situated close to No. 2, in the same bluff, and is probably connected with it by narrow orifices. The interior caverns are more lofty, and the stalagmital floors quite dry, the scenery being similar to No. 2 Cave, and the general direction parallel to the strike of the beds it perforates. The entrance is very flat, and at a higher level than No. 2.

STONY CREEK CAVES.

These are, so far as I could examine them, unimportant; flat, low-roofed orifices, through which the flood-waters of Stony Creek find their way, and are of limited extent, being apparently younger than the Limestone Creek caves. And in regard to the latter, it is probable that they are not greater than Pliocene age, and have been hollowed since the partial denudation of the once superincumbent porphyries, for, as previously stated, the mud conglomerates within the caves are made up of rounded waterworn fragments of the rocks found *in situ*. I was unable to find anywhere in the whole series of calcareous deposits evidences of cavities which might have existed and have been filled up by mineral constituents during any consolidation of the mass prior to the deposition of the porphyries. There are certainly numerous small veins of calc spar, but no break in the general continuity of the beds. The greater hollowing out of the caves on the Limestone Creek are, I think, to be accounted for by the more lengthened periods of exposure to subaërial influences and the percolation of acid-laden waters; the Stony Creek calcareous deposit having been more recently laid bare by denudation of the porphyries. So far as a superficial examination would enable me to judge, I think the marbles at this place will prove of considerable commercial value, the texture and colour being excellent, and the beds more homogeneous than at the Limestone Creek. However, this is a matter for determination by commercial enterprise, and outside the objects of this paper.

In concluding this sketchy article on the caves, a few remarks on the beds they perforate may be interesting. It has been shown with reference to the Limestone Creek marble beds that the surface outcrops, and also those within the caves, are intersected with thin yellow seams parallel to the bedding planes, and it is conjectured that these seams can hardly be due to the percolation of surface waters holding colouring matter in solution, because of their regularity and parallelism. Whether the intense subterranean heat, which it is probable caused the metamorphism of the calcareous sediments into crystalline marbles, has obliterated all traces of bedding at a depth, and so produced a homogeneous mass of saccharoidal marble, I am unable to suggest; but in regard to the origin of the marbles the evidences are, I think, in favour of their having assumed their crystalline form during shrinkages in the earth's crust at the close of the Silurian or at the beginning of the Devonian periods, when the whole series of sedimentary rocks were inclined at high angles—i.e., folded and bedded together by the dynamic and metamorphic agencies of nature—and, after long-continued periods of subaërial or subaqueous denudation, were again submitted to the influence of plutonic forces, during which the fragmental porphyries which at present rest on the upturned edges of the sediments were deposited. That the latter are the results of either subaërial ash, or subaqueous tuff, grouped round such probable volcanic centres as Wombargo and Cobboras mountains,* is, I think, evident enough from their lithological character and their stratigraphical position. It is hardly probable that the deposition of the porphyries over the palæozoic sediments would cause such extensive metamorphism of the calcareous beds; in fact, the proof that such is improbable is seen at Stony Creek, for here the unaltered fossiliferous beds are in direct contact with the overlying porphyries, while the crystallisation of the rock masses appears to increase with the depth below the surface.

In my examinations of the Stony Creek marble beds I was fortunate in finding some fossils, which Professor M'Coy has been good enough to examine, and has identified one shell, *spirigina reticularis*, which he states is one of the few

* Vide A. W. Howitt in *Progress Report, Geological Survey of Victoria*, 1876, p. 200.

fossils common to the Devonian and Silurian systems. He also states that some crinoidal stems—which are very abundant in the Stony Creek beds—are apparently “*Actinocrinus*,” and that there is a small undescribed species of *Atrypa* and a species of *Beyrichia*. He also remarks that the evidence points to these specimens being either Upper Silurian or Lower Devonian, the geological interval between these two being very small. Among many highly scientific problems arising out of an examination of the rock masses in this rugged portion of our Australian Alps, that which relates to the metamorphism of the sedimentary rocks into crystalline schists is, perhaps, one of the most important. Of the relations between the palæozoic sediments of the Limestone Creek and the regional metamorphic schists of the Mitta Mitta source basin, I shall, I hope, have more to say when dealing with the geological structure of the Indi River and the Mitta Mitta source basin. The facts elicited in this paper may pave the way for more extended observations and determinations in that respect.

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