

## GEOLOGY OF AUSTRALIA

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**GEOLOGICAL OBSERVATIONS**  
**ON THE**  
**VOLCANIC ISLANDS,**  
VISITED DURING THE VOYAGE OF H. M. S. BEAGLE,  
TOGETHER WITH  
SOME BRIEF NOTICES ON THE GEOLOGY OF AUSTRALIA AND  
THE CAPE OF GOOD HOPE.

BEING THE SECOND PART OF  
THE GEOLOGY OF THE VOYAGE OF THE BEAGLE,  
UNDER THE COMMAND OF CAPT. FITZROY, R.N.  
DURING THE YEARS 1832 TO 1836.

BY

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THE EXPEDITION.

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## CHAPTER VII.

*New South Wales—Sandstone formation—Embedded pseudo-fragments of shale—Stratification—Current-cleavage—Great valleys.—Van Diemen's Land—Palæozoic formation—Newer formation with volcanic rocks—Travertin with leaves of extinct plants—Elevation of the land.—New Zealand—King George's Sound—Superficial ferruginous beds—Superficial calcareous deposits, with casts of branches—Their origin from drifted particles of shells and corals—Their extent.—Cape of Good Hope—Junction of the granite and clay-slate—Sandstone formation.*

THE *Beagle*, in her homeward voyage, touched at New Zealand, Australia, Van Diemen's Land, and the Cape of Good Hope. In order to confine the third Part of these Geological Observations to South America, I will here briefly describe all that I observed at these places, worthy of the attention of geologists.

*New South Wales.*—My opportunities of observation consisted of a ride of ninety geographical miles to Bathurst, in a W. N. W. direction from Sydney. The first thirty miles from the coast passes over a sandstone country, broken up in many places by trap-rocks, and separated by a bold escarpment overhanging the river Nepean, from the great sandstone platform of the Blue Mountains. This upper platform is 1000 feet high at the edge of the escarpment, and rises in a distance of 25 miles to between 3000 and 4000 feet above the level of the sea. At this distance, the road descends to a country rather less elevated, and composed in chief part of primary rocks. There is much granite, in one part passing into a red porphyry with octagonal

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crystals of quartz, and intersected in some places by trapdikes. Near the Downs of Bathurst, I passed over much pale-brown, glossy clay-slate, with the shattered laminæ running north and south: I mention this fact, because Captain King informs me, that in the country a hundred miles southward, near Lake George, the mica-slate ranges so invariably north and south, that the inhabitants take advantage of it in finding their way through the forests.

The sandstone of the Blue Mountains is at least 1,200 feet thick, and in some parts is apparently of greater thickness; it consists of small grains of quartz, cemented by white earthy matter, and it abounds with ferruginous veins. The lower beds sometimes alternate with shales and coal: at Wolgan I found in carbonaceous shale, leaves of the *Glossopteris Brownii*, a fern which so frequently accompanies the coal of Australia. The sandstone contains pebbles of quartz; and these generally increase in number and size (seldom, however, exceeding an inch or two in diameter) in the upper beds: I observed a similar circumstance in the grand sandstone formation at the Cape of Good Hope. On the South American coast, where tertiary and supra-tertiary beds have been extensively elevated, I repeatedly noticed that the uppermost beds were formed of coarser materials than the lower: this appears to indicate that, as the sea became shallower, the force of the waves or currents increased. On the lower platform,

however, between the Blue Mountains and the coast, I observed that the upper beds of the sandstone frequently passed into argillaceous shale,—the effect probably, of this lower space having been protected from strong currents during its elevation. The sandstone of the Blue Mountains evidently having been of mechanical origin, and not having suffered any metamorphic action, I was surprised at observing, that in some specimens nearly all the grains of quartz were so perfectly crystallized with brilliant facets, that they evidently had not in their *present* form been aggregated in any previously existing

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rock.\* It is difficult to imagine how these crystals could have been formed; one can hardly believe that they were separately precipitated in their present crystallized state. Is it possible, that rounded grains of quartz may have been acted on by a fluid corroding their surfaces, and depositing on them fresh silica? I may remark, that in the sandstone formation of the Cape of Good Hope, it is evident, that silica has been profusely deposited from aqueous solution.

In several parts of the sandstone, I noticed patches of shale, which might at the first glance have been mistaken for extraneous fragments; their horizontal laminæ, however, being parallel with those of the sandstone, showed that they were the remnants of thin, continuous beds. One such fragment (probably the section of a long narrow strip) seen in the face of a cliff, was of greater vertical thickness than breadth, which proves that this bed of shale must have been in some slight degree consolidated, after having been deposited, and before being worn away by the currents. Each patch of the shale shows, also, how slowly many of the successive layers of sandstone were deposited. These pseudo-fragments of shale will perhaps explain in some cases, the origin of apparently extraneous fragments in crystalline metamorphic rocks. I mention this, because I found near Rio de Janeiro a well-defined angular fragment, seven yards long by two yards in breadth, of gneiss containing garnets and mica in layers, enclosed in the ordinary, stratified, porphyritic gneiss of the country. The laminæ of the fragment and of the surrounding matrix, ran in exactly the same direction, but they dipped at different angles. I do not wish to affirm that this singular fragment (a solitary

\* I have lately seen, in a paper by Smith (the father of English geologists), in the Magazine of Natural History, that the grains of quartz in the mill-stone grit of England are often crystallized. Sir David Brewster, in a paper read before the British Association, 1840, states, that in old decomposed glass, the siliceous and metallic particles separate into concentric rings, and that the siliceous regains its crystalline structure, as is shown by its action on light.

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case, as far as I know) was originally deposited in a layer, like the shale in the Blue Mountains, between the strata of the porphyritic gneiss, before they were metamorphosed; but there is sufficient analogy between the two cases to render such an explanation possible.

*Stratification of the escarpment.*—The strata of the Blue Mountains appear to the eye horizontal; but they probably have a similar inclination with the surface of the

platform, which slopes from the west towards the escarpment over the Nepean, at an angle of one degree, or of one hundred feet in a mile.\* The strata of the escarpment dip almost conformably with its steeply inclined face, and with so much regularity, that they appear as if thrown into their present position; but on a more careful examination, they are seen to thicken and to thin out, and in the upper part to be succeeded and almost capped by horizontal beds. These appearances render it probable, that we here see an original escarpment, not formed by the sea having eaten back into the strata, but by the strata having originally extended only thus far. Those who have been in the habit of examining accurate charts of sea-coasts, where sediment is accumulating, will be aware, that the surfaces of the banks thus formed, generally slope from the coast very gently towards a certain line in the offing, beyond which the depth in most cases suddenly becomes great. I may instance the great banks of sediment within the West Indian Archipelago,† which terminate in submarine slopes, inclined at angles of between 30 and 40 degrees, and sometimes even at more than

\* This is stated on the authority of Sir T. Mitchell, in his Travels, vol. ii. p. 357.

† I have described these very curious banks in the Appendix (p. 196) to my volume on the structure of Coral Reefs. I have ascertained the inclination of the edges of the banks, from information given me by Captain B. Allen, one of the surveyors, and by carefully measuring the horizontal distances between the last sounding on the bank and the first in the deep water. Widely extended banks in all parts of the West Indies, have the same general form of surface.

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40 degrees: every one knows how steep such a slope would appear on the land. Banks of this nature, if uplifted, would probably have nearly the same external form as the platform of the Blue Mountains, where it abruptly terminates over the Nepean.

*Current cleavage.*—The strata of sandstone in the low coast country, and likewise on the Blue Mountains, are often divided by cross or current laminae, which dip in different directions, and frequently at an angle of forty-five degrees. Most authors have attributed these cross layers to successive small accumulations on an inclined surface; but from a careful examination in some parts of the New Red sandstone of England, I believe that such layers generally form parts of a series of curves, like gigantic tidal-ripples, the tops of which have since been cut off, either by nearly horizontal layers, or by another set of great ripples, the folds of which do not exactly coincide with those below them. It is well known to surveyors that mud and sand are disturbed during storms at considerable depths, at least from 300 to 450 feet,\* so that the nature of the bottom even becomes temporarily changed; the bottom, also, at a depth between 60 and 70 feet, has been observed† to be broadly rippled. One may, therefore, be allowed to suspect, from the appearances just mentioned in the New Red sandstone, that at greater depths, the bed of the ocean is heaped up during gales into great ripple-like furrows and depressions, which are afterwards cut off by the currents during more tranquil weather, and again furrowed during gales.

*Valleys in the sandstone platforms.*—The grand valleys, by which the Blue Mountains and the other sandstone platforms of this part of Australia are penetrated, and which long offered an insuperable obstacle to the attempts of the most enterprising colonist to reach the interior country, form the most striking feature in the geology of New South

\* See Martin White, on Soundings in the British Channel, pp. 4 and 166.

† M. Siau on the Action of Waves. Edin. New Phil. Journ. vol. xxxi. p. 245.

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Wales. They are of grand dimensions, and are bordered by continuous lines of lofty cliffs. It is not easy to conceive a more magnificent spectacle, than is presented to a person walking on the summit-plains, when without any notice he arrives at the brink of one of these cliffs, which are so perpendicular, that he can strike with a stone (as I have tried) the trees growing, at the depth of between 1000 and 1500 feet below him; on both hands he sees headland beyond headland of the receding line of cliff, and on the opposite side of the valley, often at the distance of several miles, he beholds another line rising up to the same height with that on which he stands, and formed of the same horizontal strata of pale sandstone. The bottom of these valleys are moderately level, and the fall of the rivers flowing in them, according to Sir T. Mitchell, is gentle. The main valleys often send into the platform great bay-like arms, which expand at their upper ends; and on the other hand, the platform often sends promontories into the valley, and even leaves in them great, almost insulated, masses. So continuous are the bounding lines of cliff, that to descend into some of these valleys, it is necessary to go round twenty miles; and into others, the surveyors have only lately penetrated, and the colonists have not yet been able to drive in their cattle. But the most remarkable point of structure in these valleys, is, that although several miles wide in their upper parts, they generally contract towards their mouths to such a degree, as to become impassable. The Surveyor-General, Sir T. Mitchell,\* in vain endeavoured, first on foot and then by crawling between the great fallen fragments of sandstone, to ascend through the gorge by which the river Grose joins the Nepean; yet the valley of the Grose in its upper part, as I saw, forms a magnificent basin some miles in width, and is on all sides surrounded by cliffs, the summits of which are believed to be nowhere less than 3000 feet above the level of the sea. When cattle are driven into the valley

\* Travels in Australia, vol. i. p. 154.—I must express my obligation to Sir T. Mitchell, for several interesting personal communications on the subject of these great valleys of New South Wales.

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of the Wolgan by a path (which I descended) partly cut by the colonists, they cannot escape; for this valley is in every other part surrounded by perpendicular cliffs, and eight miles lower down, it contracts, from an average width of half a mile, to a mere chasm impassable to man or beast. Sir T. Mitchell\* states, that the great valley of the Cox river with all its branches, contracts, where it unites with the Nepean, into a gorge 2200 yards wide, and about 1000 feet in depth. Other similar cases might have been added.

The first impression, from seeing the correspondence of the horizontal strata, on each side of these valleys and great amphitheatrical depressions, is that they have been in chief part hollowed out, like other valleys, by aqueous erosion; but when one reflects on the enormous amount of stone, which on this view must have been removed, in most of the above cases through mere gorges or chasms, one is led to ask whether these spaces may not have subsided. But considering the form of the irregularly

branching valleys, and of the narrow promontories, projecting into them from the platforms, we are compelled to abandon this notion. To attribute these hollows to alluvial action, would be preposterous; nor does the drainage from the summit-level always fall, as I remarked near the Weatherboard, into the head of these valleys, but into one side of their bay-like recesses. Some of the inhabitants remarked to me, that they never viewed one of these bay-like recesses, with the headlands receding on both hands, without being struck with their resemblance to a bold sea-coast. This is certainly the case; moreover, the numerous fine harbours, with their widely branching arms, on the present coast of New South Wales, which are generally connected with the sea by a narrow mouth, from one mile to a quarter of a mile in width, passing through the sandstone coast-cliffs, present a likeness, though on a miniature scale, to the great valleys of the interior. But then immediately occurs the startling difficulty, why has the sea worn out these great, though

\* Idem, vol. ii. p. 358.

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circumscribed, depressions on a wide platform, and left mere gorges, through which the whole vast amount of triturated matter must have been carried away? The only light I can throw on this enigma, is by showing that banks appear to be forming in some seas of the most irregular forms, and that the sides of such banks are so steep (as before stated) that a comparatively small amount of subsequent erosion would form them into cliffs: that the waves have power to form high and precipitous cliffs, even in landlocked harbours, I have observed in many parts of South America. In the Red Sea, banks with an extremely irregular outline and composed of sediment, are penetrated by the most singularly shaped creeks with narrow mouths: this is likewise the case, though on a larger scale, with the Bahama Banks. Such banks, I have been led to suppose,\* have been formed by currents heaping sediment on an irregular bottom. That in some cases, the sea, instead of spreading out sediment in a uniform sheet, heaps it round submarine rocks and islands, it is hardly possible to doubt, after having examined the charts of the West Indies. To apply these ideas to the sandstone platforms of New South Wales, I imagine that the strata might have been heaped on an irregular bottom by the action of strong currents, and of the undulations of an open sea; and that the valleylike spaces thus left unfilled might, during a slow elevation of the land, have had their steeply sloping flanks worn into cliffs; the worn-down sandstone being removed, either at the time when the narrow gorges were cut by the retreating sea, or subsequently by alluvial action.

\* See the Appendix (pp. 192 and 196) to the Part on Coral Reefs. The fact of the sea heaping up mud round a submarine nucleus, is worthy of the notice of geologists: for outlyers of the same composition with the coast-banks, are thus formed; and these, if upheaved and worn into cliffs, would naturally be thought to have been once connected together.

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##### *Van Diemen's Land.*

The southern part of this island is mainly formed of mountains of greenstone, which often assumes a syenitic character, and contains much hypersthene. These mountains, in their lower half, are generally encased by strata containing numerous small corals and some shells. These shells have been examined by Mr. G. B. Sowerby, and are

described in the Appendix; they consist of two species of *Producta*, and of six of *Spirifera*; two of these, namely, *P. rugata* and *S. rotundata*, resemble, as far as their imperfect condition allows of comparison, British mountain-limestone shells. Mr. Lonsdale has had the kindness to examine the corals; they consist of six undescribed species, belonging to three genera. Species of these genera occur in the Silurian, Devonian, and Carboniferous strata of Europe. Mr. Lonsdale remarks, that all these fossils have undoubtedly a Palæozoic character, and that probably they correspond in age to a division of the system, above the Silurian formations.

The strata containing these remains are singular from the extreme variability of their mineralogical composition. Every intermediate form is present, between flinty-slate, clay-slate passing into gray-wacke, pure limestone, sandstone, and porcellanic rock; and some of the beds can only be described, as composed of a siliceo-calcareo-clayslate. The formation, as far as I could judge, is at least a thousand feet in thickness: the upper few hundred feet usually consist of a siliceous sandstone, containing pebbles and no organic remains; the inferior strata, of which a pale flinty slate is perhaps the most abundant, are the most variable; and these chiefly abound with the remains. Between two beds of hard crystalline limestone, near Newtown, a layer of white soft calcareous matter is quarried, and is used for whitewashing houses. From information given to me by Mr. Frankland, the surveyor-general, it appears that this Palæozoic formation is found in different parts of the whole island;

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from the same authority, I may add that on the north-eastern coast, and in Bass' Straits primary rocks extensively occur.

The shores of Storm Bay are skirted, to the height of a few hundred feet, by strata of sandstone, containing pebbles of the formation just described, with its characteristic fossils, and therefore belonging to a subsequent age. These strata of sandstone often pass into shale, and alternate with layers of impure coal; they have in many places been violently disturbed. Near Hobart Town, I observed one dike, nearly a hundred yards in width, on one side of which the strata were tilted at an angle of 60°, and on the other they were in some parts vertical, and had been altered by the effects of the heat. On the west side of Storm Bay, I found these strata capped by streams of basaltic lava with olivine; and close by there was a mass of brecciated scoriæ, containing pebbles of lava, which probably marks the place of an ancient submarine crater. Two of these streams of basalt were separated from each other by a layer of argillaceous wacke, which could be traced passing into partially altered scoriæ. The wacke contained numerous rounded grains of a soft, grassgreen mineral, with a waxy lustre, and translucent on its edges: under the blowpipe it instantly blackened, and the points fused into a strongly magnetic, black enamel. In these characters, it resembles those masses of decomposed olivine, described at St. Jago in the Cape de Verde group; and I should have thought that it had thus originated, had I not found a similar substance, in cylindrical threads, within the cells of the vesicular basalt,—a state under which olivine never appears; this substance,\* I believe, would be classed as bole by mineralogists.

\* Chlorophæite, described by Dr. MacCulloch (Western Islands, vol. i. p. 504) as occurring in a basaltic amygdaloid, differs from this substance, in remaining unchanged before the blow-pipe, and in blackening from exposure to the air.

May we suppose that olivine, in undergoing the remarkable change described at St. Jago, passes through several states?

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*Travertin with extinct plants.*—Behind Hobart Town there is a small quarry of a hard travertin, the lower strata of which abound with distinct impressions of leaves. Mr. Robert Brown has had the kindness to look at my specimens; he informs me that there are four or five kinds, none of which he recognizes as belonging to existing species. The most remarkable leaf is palmate, like that of a fan-palm, and no plant having leaves of this structure has hitherto been discovered in Van Diemen's Land. The other leaves do not resemble the most usual form of the Eucalyptus, (of which tribe the existing forests are chiefly composed,) nor do they resemble that class of exceptions to the common form of the leaves of the Eucalyptus, which occur in this island. The travertin containing this remnant of a lost vegetation, is of pale yellow colour, hard, and in parts even crystalline; but not compact, and is everywhere penetrated by minute, tortuous, cylindrical pores. It contains a very few pebbles of quartz, and occasional layers of chalcedonic nodules, like those of chert in our Greensand. From the pureness of this calcareous rock, it has been searched for in other places, but has never been found. From this circumstance, and from the character of the deposit, it was probably formed by a calcareous spring entering a small pool or narrow creek. The strata have subsequently been tilted and fissured; and the surface has been covered by a singular mass, with which, also, a large fissure has been filled up, formed of balls of trap embedded in a mixture of wacke and a white, earthy, aluminocalcareous substance. Hence it would appear, as if a volcanic eruption had taken place on the borders of the pool, in which the calcareous matter was depositing, and had broken it up and drained it.

*Elevation of the land.*—Both the eastern and western shores of the Bay, in the neighbourhood of Hobart Town, are in most parts covered, to the height of thirty feet above the level of high-water mark, with broken shells, mingled with pebbles. The colonists attribute these shells to the aborigines having carried them up for food: undoubtedly, there

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are many large mounds, as was pointed out to me by Mr. Frankland, which have been thus formed; but I think from the numbers of the shells, from their frequent small size, from the manner in which they are thinly scattered, and from some appearances in the form of the land, that we must attribute the presence of the greater number to a small elevation of the land. On the shore of Ralph Bay (opening into Storm Bay) I observed a continuous beach about fifteen feet above high-water mark, clothed with vegetation, and by digging into it, pebbles encrusted with serpulæ were found: along the banks, also, of the river Derwent, I found a bed of broken sea-shells above the surface of the river, and at a point where the water is now much too fresh for sea-shells to live; but in both these cases, it is just possible, that before certain spits of sand and banks of mud in Storm Bay were accumulated, the tides might have risen to the height where we now find the shells.\*

Evidence more or less distinct of a change of level between the land and water, has been detected on almost all the land on this side of the globe. Capt. Grey, and other

travellers, have found in southern Australia upraised shells, belonging either to the recent, or to a late tertiary period. The French naturalists in Baudin's expedition, found shells similarly circumstanced on the S.W. coast of Australia. The Rev. W. B. Clarke† finds proofs of the elevation of the land, to the amount of 400 feet, at the Cape of Good Hope. In the neighbourhood of the Bay of Islands in New Zea-

\* It would appear that some changes are now in progress in Ralph Bay, for I was assured by an intelligent farmer, that oysters were formerly abundant in it, but that about the year 1834 they had, without any apparent cause, disappeared. In the Transactions of the Maryland Academy (vol. i. part i, p. 28) there is an account by Mr. Ducatel, of vast beds of oysters and clams having been destroyed by the gradual filling up of the shallow lagoons and channels, on the shores of the southern United States. At Chiloe, in South America, I heard of a similar loss, sustained by the inhabitants, in the disappearance from one part of the coast of an edible species of Ascidia.

† Proceedings of the Geological Society, vol. iii. p. 420.

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land,\* I observed that the shores were scattered to some height, as at Van Diemen's Land, with sea-shells, which the colonists attribute to the natives. Whatever may have been the origin of these shells, I cannot doubt, after having seen a section of the valley of the Thames River (37° S.), drawn by the Rev. W. Williams, that the land has been there elevated: on the opposite sides of this great valley, three step-like terraces, composed of an enormous accumulation of rounded pebbles, exactly correspond with each other: the escarpment of each terrace is about fifty feet in height. No one after having examined the terraces in the valleys on the western shores of South America, which are strewn with sea-shells, and have been formed during intervals of rest in the slow elevation of the land, could doubt that the New Zealand terraces have been similarly formed. I may add, that Dr. Dieffenbach, in his description of the Chatham Islands,† (S.W. of New Zealand) states that it is manifest " that the sea has left many places bare, which were once covered by its waters."

#### *King George's Sound.*

This settlement is situated at the south-western angle of the Australian continent: the whole country is granitic, with the

\* I will here give a catalogue of the rocks which I met with near the Bay of Islands, in New Zealand:—1st, Much basaltic lava, and scoriform rocks, forming distinct craters;—2nd, A castellated hill of horizontal strata of flesh-coloured limestone, showing when fractured distinct crystalline facets: the rain has acted on this rock in a remarkable manner, corroding its surface into a miniature model of an Alpine country: I observed here layers of chert and clay iron-stone; and in the bed of a stream, pebbles of clay-slate;—3rd, The shores of the Bay of Islands are formed of a feldspathic rock, of a blueish-gray colour, often much decomposed, with an angular fracture, and crossed by numerous ferruginous seams, but without any distinct stratification or cleavage. Some varieties are highly crystalline, and would at once be pronounced to be trap; others strikingly resembled clay-slate, slightly altered by heat: I was unable to form any decided opinion on this formation.

† Geographical Journal, vol. xi. pp. 202, 205.

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constituent minerals sometimes obscurely arranged in straight or curved laminae. In these cases, the rock would be called by Humboldt, gneiss-granite, and it is remarkable that the form of the bare conical hills, appearing to be composed of great folding layers, strikingly resembles, on a small scale, those composed of gneiss-granite at Rio de Janeiro, and those described by Humboldt at Venezuela. These plutonic rocks are, in many places, intersected by trappeandikes: in one place, I found

ten parallel dikes ranging in an E. and W. line; and not far off another set of eight dikes, composed of a different variety of trap, ranging at right angles to the former ones. I have observed in several primary districts, the occurrence of systems of dikes parallel and close to each other.

*Superficial ferruginous beds.*—The lower parts of the country are everywhere covered by a bed, following the inequalities of the surface, of a honeycombed sandstone, abounding with oxides of iron. Beds of nearly similar composition are common, I believe, along the whole western coast of Australia, and on many of the East Indian islands. At the Cape of Good Hope, at the base of the mountains formed of granite and capped with sandstone, the ground is everywhere coated either by a fine-grained, rubbly, ochraceous mass, like that at King George's Sound, or by a coarser sandstone with fragments of quartz, and rendered hard and heavy by an abundance of the hydrate of iron, which presents, when freshly broken, a metallic lustre. Both these varieties have a very irregular texture, including spaces either rounded or angular, full of loose sand; from this cause the surface is always honey-combed. The oxide of iron is most abundant on the edges of the cavities, where alone it affords a metallic fracture. In these formations, as well as in many true sedimentary deposits, it is evident that iron tends to become aggregated, either in the form of a shell, or of a network. The origin of these superficial beds, though sufficiently obscure, seems to be due to alluvial action on detritus abounding with iron.

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*Superficial calcareous deposit.*—A calcareous deposit on the summit of Bald Head, containing branched bodies, supposed by some authors to have been corals, has been celebrated by the descriptions of many distinguished voyagers.\* It folds round and conceals irregular hummocks of granite, at the height of 600 feet above the level of the sea. It varies much in thickness; where stratified, the beds are often inclined at high angles, even as much as at 30 degrees, and they dip in all directions. These beds are sometimes crossed by oblique and even-sided laminæ. The deposit consists either of a fine, white, calcareous powder, in which not a trace of structure can be discovered, or of exceedingly minute, rounded grains, of brown, yellowish, and purplish colours; both varieties being generally, but not always, mixed with small particles of quartz, and being cemented into a more or less perfect stone. The rounded calcareous grains, when heated in a slight degree, instantly lose their colours; in this and in every other respect, closely resembling those minute, equal-sized particles of shells and corals, which at St. Helena have been drifted up the sides of the mountains, and have thus been winnowed of all coarser fragments. I cannot doubt, that the coloured calcareous particles here have had a similar origin. The impalpable powder has probably been derived from the decay of the rounded particles; this certainly is possible, for on the coast of Peru, I have traced *large unbroken* shells gradually falling into a substance, as fine as powdered chalk. Both of the above-mentioned varieties of calcareous sandstone frequently alternate with, and blend into, thin layers of a hard sub-stalagmitic† rock, which, even when the stone on each side

\* I visited this hill, in company with Captain FitzRoy, and we came to a similar conclusion regarding these branching bodies.

† I adopt this term from Lieut. Nelson's excellent paper on the Bermuda Islands (Geolog. Trans. vol. v. p. 106), for the hard, compact, cream or brown-coloured stone, without any crystalline structure, which so often accompanies

superficial calcareous accumulations. I have observed such superficial beds, coated with sub-stalagmitic rock, at the Cape of Good Hope, in several parts of Chile, and over wide

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contains particles of quartz, is entirely free from them: hence we must suppose that these layers, as well as certain vein-like masses, have been formed by rain dissolving the calcareous matter and re-precipitating it, as has happened at St. Helena. Each layer probably marks a fresh surface, when the, now firmly cemented, particles existed as loose sand. These layers are sometimes brecciated and recemented, as if they had been broken by the slipping of the sand when soft. I did not find a single fragment of a sea-shell; but bleached shells of the *Helix melo*, an existing land species, abound in all the strata; and I likewise found another *Helix*, and the case of an *Oniscus*.

The branches are absolutely undistinguishable in shape, from the broken and upright stumps of a thicket; their roots are often uncovered, and are seen to diverge on all sides; here and there a branch lies prostrate. The branches generally consist of the sandstone, rather firmer than the surrounding matter, with the central parts filled, either with friable calcareous matter, or with a sub-stalagmitic variety; this central part is also frequently penetrated by linear crevices, sometimes, though rarely, containing a trace of

spaces in La Plata and Patagonia. Some of these beds have been formed from decayed shells, but the origin of the greater number is sufficiently obscure. The causes which determine water to dissolve lime, and then soon to redeposit it, are not, I think, known. The surface of the sub-stalagmitic layers appears always to be corroded by the rain-water. As all the above-mentioned countries have a long dry season, compared with the rainy one, I should have thought that the presence of the sub-stalagmite was connected with the climate, had not Lieut. Nelson found this substance forming under sea-water. Disintegrated shell seems to be extremely soluble; of which I found good evidence, in a curious rock at Coquimbo in Chile, which consisted of small, pellucid, empty husks, cemented together. A series of specimens clearly showed, that these husks had originally contained small rounded particles of shells, which had been enveloped and cemented together by calcareous matter, (as often happens on sea-beaches), and which subsequently had decayed, and been dissolved by water, that must have penetrated through the calcareous husks, without corroding them,—of which processes, every stage could be seen.

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woody matter. These calcareous, branching bodies, appear to have been formed, by fine calcareous matter being washed into the casts or cavities, left by the decay of branches and roots of thickets, buried under drifted sand. The whole surface of the hill is now undergoing disintegration, and hence the casts, which are compact and hard, are left projecting. In calcareous sand at the Cape of Good Hope, I found the casts, described by Abel, quite similar to these at Bald Head; but their centres are often filled with black carbonaceous matter, not yet removed. It is not surprising, that the woody matter should have been almost entirely removed from the casts on Bald Head; for it is certain, that many centuries must have elapsed since the thickets were buried; at present, owing to the form and height of the narrow promontory, no sand is drifted up, and the whole surface, as I have remarked, is wearing away. We must, therefore, look back to a period when the land stood lower, of which the French naturalists\* found evidence in upraised shells of recent species, for the drifting on Bald Head of the calcareous and quartzose sand, and the consequent embedment of the vegetable remains. There was only one appearance which at first made me doubt concerning the origin of the cast,—namely, that the finer roots from different stems sometimes

became united together into upright plates or veins; but when the manner is borne in mind, in which fine roots often fill up cracks in hard earth, and that these roots would decay and leave hollows, as well as the stems, there is no real difficulty in this case. Besides the calcareous branches from the Cape of Good Hope, I have seen casts, of exactly the same forms, from Madeira† and

\* See M. Péron's Voyage, tom. i. p. 204.

† Dr. J. Macaulay has fully described (Eding. New Phil. Journ. vol. xxix. p. 350) the casts from Madeira. He considers (differently from Mr. Smith of Jordan Hill) these bodies to be corals, and the calcareous deposit to be of subaqueous origin. His arguments chiefly rest (for his remarks on their structure are vague) on the great quantity of the calcareous matter, and on the casts containing animal matter, as

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from Bermuda; at this latter place, the surrounding calcareous rocks, judging from the specimens collected by Lieut. Nelson, are likewise similar, as is their subaërial formation. Reflecting on the stratification of the deposit on Bald Head,—on the irregularly alternating layers of sub-stalagmitic rock,—on the uniformly sized, and rounded particles, apparently of sea-shells and corals,—on the abundance of land-shells throughout the mass,—and finally, on the absolute resemblance of the calcareous casts, to the stumps, roots, and branches of that kind of vegetation, which would grow on sand-hillocks, I think there can be no reasonable doubt, notwithstanding the different opinion of some authors, that a true view of their origin has been here given.

Calcareous deposits, like these of King George's Sound, are of vast extent on the Australian shores. Dr. Fitton remarks, that "recent calcareous breccia (by which term all these deposits are included) was found during Baudin's voyage, over a space of no less than 25 degrees of latitude and an equal extent of longitude, on the southern, western, and north-western coasts."\* It appears also from M.

shown by their evolving ammonia. Had Dr. Macaulay seen the enormous masses of rolled particles of shells and corals on the beach of Ascension, and especially on coral-reefs; and had he reflected on the effects of long-continued, gentle winds, in drifting up the finer particles, he would hardly have advanced the argument of quantity, which is seldom trustworthy in geology. If the calcareous matter has originated from disintegrated shells and corals, the animal matter is what might have been expected. Mr. Anderson analyzed for Dr. Macaulay part of a cast, and he found it composed of—

Carbonate of lime . . . . .	73·15
Silica . . . . .	11·90
Phosphate of lime . . . . .	8·81
Animal matter . . . . .	4·25
Sulphate of lime . . . . .	a trace
	98·11

\* For ample details on this formation, consult Dr. Fitton's Appendix to Capt. King's Voyage. Dr. Fitton is inclined to attribute a concretionary origin to the branching bodies: I may remark, that I have

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Péron, with whose observations and opinions on the origin of the calcareous matter and branching casts, mine entirely accord, that the deposit is generally much more

continuous, than near King George's Sound. At Swan River, Archdeacon Scott\* states that in one part it extends ten miles inland. Captain Wickham, moreover, informs me that during his late survey of the western coast, the bottom of the sea, wherever the vessel anchored, was ascertained by crow-bars being let down, to consist of white calcareous matter. Hence it seems that along this coast, as at Bermuda and at Keeling Atoll, submarine and subaerial deposits are contemporaneously in process of formation, from the disintegration of marine organic bodies. The extent of these deposits, considering their origin, is very striking; and they can be compared in this respect, only with the great coral-reefs of the Indian and Pacific Oceans. In other parts of the world, for instance in South America, there are *superficial* calcareous deposits of great extent, in which not a trace of organic structure is discoverable; these observations would lead to the enquiry, whether such deposits may not, also, have been formed from disintegrated shells and corals.

seen in beds of sand in La Plata, cylindrical stems, which no doubt thus originated; but they differed much in appearance from these at Bald Head, and the other places above specified.

\* Proceedings of the Geolog. Soc. vol. i. p. 320.