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Outlines of Tasmanian Geology

SECTION 13 (Continued) UNDERGROUND WATER.

Before we discuss the forms of land surface that can be moulded through the action of rivers, we must mention briefly the great factor controlling the continual flow of a river. A certain amount of the water runs off the landscape after falls of rain and finds its way down the lowest valley; but rainfall is not necessarily regular, and most large rivers flow with relatively little alteration through the driest summer. Most of this water has not run directly off the sides of the valley, but has come as soakage or springs from below the surface.

Most of the rain that falls on the surface soaks down through the soil and rocks. Beneath the surface, at varying depths, the rocks are more or less saturated. If a well is sunk into this zone it will be filled with water up to the level of the top of the saturated zone. The top of this belt is called the water table, and it conforms roughly with the configuration of the surface. Its position depends largely on rainfall, and also on the nature of the country and slope of the strata, while some compact rocks are so dense that they absorb little or no water at all. Our diabase (or blue metal) is of this nature.

Travels of Water Underground.

Water percolates through the substance of previous rocks, such as gravels and such loosely compacted rocks and sandstones, and other soft rocks. It finds its way in cracks and pores of harder rocks. Some very compact rocks, such as granite, have few cracks at any distance from the surface, and others, such as clay, are formed of fine particles which fit very closely together. These types of rocks form an absolute bar to the travels of water underground. But with the exception, perhaps, of clay, there are usually cracks, joints, strata planes, and crushed zones even in the hardest rock through which water can penetrate, and any large bed of clay usually has many inclusions of pervious sands.

Through these pervious rocks water descends from the surface, and if the surface supply is sufficient the bed of rock will eventually become saturated (that is, will contain as much water as it can hold). When this occurs the water table will gradually rise. If the particular bed of rock is surrounded by impervious strata the water will rise, perhaps, to the surface, or at any rate until it reaches the broken surface zone of some neighboring rock; and it will then pass along the top of the impervious bed. But it usually happens that beds of porous rock are more or less connected. Water in that case passes from one to another, and the water table maintains an approximate level below the surface throughout a district, just as the level of inter-connected lakes remains much the same.

The Water Table.

Therefore, unless the rock is absolutely impervious, at some distance below the surface water will be struck. The quantity and depth depend on—(1) Precipitation; (2) relative amount of space in rock for storage (which depends largely on the nature of the rock); and (3) the possibility of getaway for the water underground. The level the water table stands at is known as the ground water level. Naturally, in regions of heavy rainfall, this is near the surface, and in deserts it is at a considerable depth. In relatively pervious rocks, such as sandstone, the water table is constant throughout the bed, and a well sunk to it anywhere will yield water. In other rocks, such as diabase, it will exist only in more porous pockets. This ground water level follows roughly the contour of the surface, and hence water may be found on the tops of ridges as in the bottom of valleys. In Tasmania, on the wet West Coast, water can be struck in all but the very solid rocks at a very shallow depth. At Catamaran pits sunk for six feet soon fill with water and remain with water within a few feet of the surface throughout the year. On the button grass plains, which are usually underlain at some depth or other by clay, water can be struck within a few feet of the surface, and this even on the top of steep hills. Further east the ground water level sinks, but there are few places wherein gravel or standstones water will not be struck before the fifty feet level is reached. Thus all mines have to be kept open by pumping

Springs.

When a stream cuts its channel down below the ground water level it taps this underground reservoir just as a well does, and water oozes out of the soil at favorable places in the form of springs. In some places streams will have only cut down to the level to which the water table rises in winter. In these cases the springs will only function in winter, and in summer, as the water table drops lower, they will cease to flow. In other cases the streams have cut down below the lowest summer level. In eastern Tasmania the variation between summer and winter level is considerable. It is these springs which give the streams their regular flow. If the water table drops below the stream's bed in summer the main source of supply is cut off, and the stream ceases to flow until further rainfall replenishes the supply. Only those streams which are sufficiently large to have cut below the summer level are perennial. The streams with steep-sided, deep gorges have more chance of tapping this supply than those with wide, open valleys, as in the latter case the water table tends to conform with the contour, and is not cut by the stream.

Besides this water underground travels along the dip of the strata. In doing this it may find a natural outlet as on the side of a mountain or may accumulate against an impervious rock mass until the level rises to the surface at a particular spot which is lower than the main source of supply.

Artesian Basins.

In continental areas a pervious rock mass may cover many thousands of square miles. If the passage of water downwards is prevented by an impervious layer the water may accumulate in a great underground reservoir, and be tapped by wells or bores. If a considerable area is higher than the place where a bore is sunk the pressure of water there will force water out of the bore with often great force as is often the case on the mainland, where the rainfall caught on the plateaux of the Dividing Range soaks underground to the plains to water the dry paddocks when released by bore holes.

In other areas the water is present, but there is no pressure to cause it to rise. If a well is put down water can be pumped out. Such a place is termed a sub-artesian basin. Many of these exist throughout the midlands and south-eastern Tasmania. Here the requisite conditions are a bed of Ross sandstones overlying a bed of hard permo-carboniferous silicious mudstone, as we shall see later a very usual occurrence. The water acumulates in the sandstone and cannot escape through the underlying mudstone. A borehole or well sunk into the sandstone will yield water, only pumping for ten to fifty feet being required to ensure a steady supply.

Caves.

Water travelling underground soon wears for itself well defined channels which in time develop into caves. This is especially the case in limestone country where the mechanical action of the flowing water is greatly reinforced by the chemical action, mainly the effect of carbon compounds picked up from decaying vegetation on the surface dissolving out calcium from the limestone. Where the limestone beds are very massive and of great antiquity wonderful caverns may be hollowed out. In the case of limestone caves these are beautified by deposits of calcite until they present sites of most surpassing wonder. Drips of water from the roof, carrying a large load of lime, deposit some of this on reaching air. More is deposited when they drop to the floor and dry. Thus are formed stalactites (growing down from the roof) and stalagmites (growing up from the floor). As the volume of water, the lime content and the form of deposition vary from drip to drip a wondrous variety of forms grow in the cave. Smooth, untapering glass-like tubes, candles, pillars, are common forms. Often water flowing over the surface make knobs of fantastic shapes, often tiny drips drying at different points on the tip of a tube give it a twisting form; sometimes water exudes from a crack and forms a shawl or screen of transparent white lime rock. Again, differences in content give a "bacon"-like appearance. In fact, each stalictite must be described to include all forms. These limestone caves are one of the greatest wonders of nature. They are common in Tasmania wherever we have beds of very ancient limestone. The best known are at Mole Creek, Chudleigh, Ulverstone, Junee, Florentine Valley, Hastings and Ida Bay.

Water at Beaconsfield.

To give but one example of the travels of underground water, the Tasmania mine at Beaconefield, our largest gold mine, had to close down on account of the volume of water that it made. A million gallons a day had to be pumped out. Chemicals placed in water in the Chudleigh caves 60 miles away were traced to the mine. And there is the old legend—unhappily untrue, but widely believed even yet—of the dog that wandered into the Chudleigh Caves and appeared in the mine at Beaconsfield.

Section 15.

THE DEPOSITION OF SEDIMENTS.

We have already seen that various agencies are at work continuously reducing the surface of the land. As little material leaves the globe, the vast quantities of soil and rock waste removed from their original site are merely redistributed. Ultimately, rivers are the great transporters of the particles torn from the parent rocks, and the river mouths and adjacent coasts are the great repositories of the material carried from the land surface. The size of these particles of the land surface so carried to sea varies with the power of the river to transport weights, but in all cases the finest grains greatly preponderate. When given a chance, this material settles and hence is called a sediment. The usual land detritus settling close to the shore is called a littoral deposit.

Other types of deposit are met with. Those which are moved from their original site by wind and are piled up elsewhere on the landscape are termed terrestrial deposits, and the same name is applied to dust deposited by a volcanic eruption. Rivers may drop sediments in lakes, when they are called lacustrine deposits, or along their own banks, when they are called fluvatitile deposits. Then, besides rivers, glaciers also carry a considerable amount of rock waste. This is dropped where the ice melts and is termed a glacial deposit. Finally enormous depths of "ooze" accumulate on the floors of the great ocean deeps from the remains of animal organisms, and from chemical precipitation. These are called deep sea deposits. Each type has its special peculiarities resulting from the manner of its deposition. It is necessary to know these, because they are preserved throughout the subsequent history of the sediment as a rock, and after many changes always give an unmistakable indication of the state of the locality where they were first deposited. This forms, as we will see later, the basis of geological history.

Littoral Deposits.

By far the greater quantity of material worn from the land finds its way by storm water channels to streams, and thence by rivers to the sea. As explained before, the river's ability to carry a sediment load depends on the force of the current. A river's current cannot make its power felt against the sea, which soon brings it to a standstill. Where this happens, most of the sediment load is deposited. When the current begins to feel the drag of the tidal waters of the river's mouth, the heaviest portions of the river's load, the big boulders which it can just push along its bed, no longer have sufficient pressure behind them to be moved, and stay in the place where they were left when this pressure was reduced below the minimum required to move them. Gradually as the force of the current becomes less and less, finer and finer particles are left behind. This is referred to as the sorting of the sediment load—the heaviest materials being dropped first, and the sediments shading thence to finer and finer grains as the shore is left behind, until within 100 miles of the shore little or no sediment from the land remains in the waters of the ocean.

To these sediments are added those worn by waves and tides from the coast and particles blown from the land into the sea, all of which commingle, but the river and stream sediments always greatly preponderate. The ocean currents function much as rivers and move sediments along the coasts, distributing them over the continental shelf, but sooner or later these sediments come to rest in the deeper and quieter waters, and accumulate until some change of conditions brings about a cessation of the supply of sediments, and alteration of currents a difference in relative positions of land and sea or a change in depth.

At its bottom such a deposit of sediments must rest on the older sea floor.

If this is close inshore, it will be broken by the waves and boulders of this rock, and will become included in the lower level of the newer sediments. Besides this, the sediments near the shore will be in general course, and gradually fining out with distance until at no great distance only the finest mud will be found.

The remains of animals, such as shell-fish, will drop to the bottom and become incorporated in the sediments. Sometimes these remains form the bulk of such sediments; for example, at Maria Island there is a bed of limestone a thousand feet thick composed entirely of remains of ancient shells. Coral also accumulates to a great depth. Also plant remains may form a large proportion of the mass of sediment deposits in certain places, as enclosed lagoons on low coasts, mangrove swamps and seaweed beds.

From all the various types of rocks into which these different natures of sediments are ultimately turned, and which will be discussed later, an idea can be formed how far from the coast the spot where the rocks now are, was when the original sediments were deposited. These simple rules of deposition are unalterable physical laws, and their evidence is incontrovertible.

Terrestrial Deposits.

Over great continent masses there is a constant resorting of rock particles. Higher elevations are denuded by frost, wind and rain, and the waste is distributed over the lower basins. On the mainland, most of the great Murray-Darling basin is built up to a depth of up to a thousand feet of sediments actually deposited where they are now seen, on dry land. In desert regions, this is even more pronounced, and everybody knows of the shifting sand hills of central Australia. Wind is a most active agent in the deposit of these sediments. They present many differences from marine deposits, which will be discussed in our chapter on Petrology. In Tasmania this form of sediment is represented chiefly by sand dunes, composed of fine particles of rock worn by the waves from the coast or of portion of the sedimentary load of a littoral current, left at high water for breezes and winds to blow inland during low water. These dunes spread far inland, and cover a great area to a good depth in some places, especially on the West Coast.

Lacustrine Deposits.

Rivers drop their sedimentary load when their flow is checked by a lake in much the same way in which they do when they enter the sea. Deposits in a lake closely resemble those in the sea, and the two forms are difficult to distinguish if the lake is large. Absence of marine organisms is a test. Also, especially if the lake is small, a river may in time of flood extend its current much beyond ordinary limits, thus giving a greater irregularity in matter of size to these deposits, and the sorting and distributing effects of tide and currents is absent.

Fluviatile Deposits.

Rivers, in many portions of their courses, have quiet reaches. Here they often deposit a bed of sediment. In flood time, when the current, which is swift and powerful in its course, overflows surrounding plains, it there tends to bear resemblance to a lake, and any sediments that find their way into that part are usually left there. Thus large beds of sediment are often built up in the flat portion of the valleys overflowed by the river during flood time. These are termed flood plains. They and the smaller fluviatile deposits formed in bends and on low banks of rivers are distinguishable by their small area, quick variations in nature, and because they are usually less sorted than sediments dropped in lakes and in the sea. Very often they give a level effect to the river valley. It is common for rivers to be cutting out their valley in their upper reaches and depositing a flood plain over it in the lower reaches

Glacial Deposits.

Water can never stop suddenly, and it always has a certain amount of sorting action. A glacier or ice sheet melts at a given point. Here everything that is being carried drops. There can therefore be no sorting. Every stone, from boulders the size of houses to clay grains, are to be seen piled on each other in one huge rubble heap. If the glacier is melting in one place for a long while a mound—often resembling a high railway embankment—will be built up. If the ice is gradually extending its field or retreating—the usual case—this material will be strewn without arrangement, and generally in irregular heaps and lines over the glacial

The striking difference between a sorted deposit and an unsorted one is the first indication of past glacial action. These deposits are usually termed "moraines," although strictly speaking a moraine is the debris actually being carried by the ice. Various distinctions, such as terminal moraines (the debris dropped off the end of a melting glacier), lateral and medial moraines (that carried on the sides and in the middle of the glacier), kames and esker ridges (deposits in englacial streams) are indistinguishable in Tasmania, and probably everywhere where these deposits have been exposed to rain and weather for a considerable time. Often glaciers drop single boulders—known as "erratics," or perched blocks: this cannot be done by water.

Deep-sea Deposits.

Sediments from the land do not reach the great ocean depths. Still, these are covered with many thousand of feet of deposits, which present special characteristics. In the first place their structure is very massive. The layers are of great depth, as conditions do not change quickly. There are none of those quick alterations of strata common in inshore deposits. Currents, wind, floods, and changes of position of neighboring land have little effect.

The second great difference is in the materials. Sand, lime, terrestrial and coastline, plant and animal, remains are not carried out into the ocean. Their place is taken by "ooze," composed of fine volcanic and wind-blown dust in small quantities, with the bulk of the deposit consisting of remains of microscopic sea animals, and chemically deposited minerals dropped by precipitation

Tasmanian Examples.

Examples of these deposits are too numerous to mention in detail. Most of our rocks are formed from one or the other. The common mudstones and limestones were once littoral deposits. Terrestrial deposits are represented by the sand dunes common round our coast, and probably by many of our sandstones. Coal measures give us examples of lacustrine deposits. Many of the clay beds come also under this heading, especially those of Launceston, Cornelian Bay, and Kingston. Fluviatile deposits abound along every valley. A walk along the Derwent or Esk or Mersey Rivers, to mention only three, show these deposits at every step. The west coast and the higher mountain ranges are covered in many places with glacial deposits, and the limestones of Railton, Mole Creek, Ulverstone, Ida Bay, and the Gordon River are probably deep-sea deposits. These will all be referred to in more detail later.

Section 16.

THE LIFE HISTORY OF A LANDSCAPE.

A Young Drainage System.

When a given region has been recently uplifted, the courses of streams and the topography of their valleys and the divides between them present features showing that the effects of water erosion have only been left for a very short period. The time factor is unimportant. A stream working in soil or very soft rock will complete the maximum erosion in its power very much more quickly than one running over country composed of a very hard rock. Similarly one with a large and continuous supply of water, or with more power given by greater height, will reduce the features ordinarily characteristic of a short period of operation much quicker than a small, intermittent stream or one unfavorably situated in regard to slope, or possessing barriers to its erosion. A young drainage system, therefore, implies not so much a system that has commenced eroding the given landscape recently, as a system possessing the characteristics of one that has not had time to effect much erosion, even though it has been at work far longer than a more mature system, which has in these ways had an easier task, and has completed it in a shorter time.

This early stage in river erosion is marked by many small and often parallel streams—the water taking the easiest line of slope. The streams have considerable power owing to the slope and as they cut the bottom of their channels quickest, they run in deep, steep-sided gullies. Between these are wide and often level divides. The whole power of the stream being concentrated on its bed, there is little deposition, except, perhaps, where it reaches flat country with its mouth. There are few barriers to make it bend, and these are soon cut away; therefore it is generally faifrly straight coursed. If the uplift is quick, the river's bed will be steep, and rapids will result; in extreme cases inland cliffs will be developed and result in al waterfall. A basin will fill with water as a lake or swamp. Given time, a stream will cut away a rapid or waterfall, as here it has greater power and will fill a lake with sediment. Hence rapids, waterfalls, and lakes are a sign of youth. Tributaries will be mere drainage from the valley sides, running straight to the river at the bottom of the valley, and so will tend to enter the main river more or less at right angles. These rivers, being in general above the ground level and fed mainly by rainfall, and having small catchment areas, will tend to vary greatly in their volume. Any of these characters show that a given drainage system has been eroding the landscape for a relatively short space of time.

The Adolescent Stage.

As the orderly process of river erosion proceeds, those portions of the bed with the greatest slope will be worn away first. Thus waterfalls and then rapids soon disappear, and lakes are removed. Then as rivers erode their valleys chiefly at the head—that is, where the slope is greatest—the high land separating the heads of systems will be reduced, and the tributaries, each doing similar work, will reduce the divides, until ultimately the former level plateau will be reduced to a line divide, and valleys of various river systems will occupy the whole landscape.

Detailed characters for this stage cannot be given. The general straight line profiles have become rounded. The rivers flow in valleys and not canyons. The divides resemble ridges rather than plateaus, and in general the topography can be spoken of rather as a series of river valleys separated by high divides than as a plateau cut by gorges. However, the boundary lines between youth and adolescence an dadolescence and maturity are vague The stage termed adolescence can best be described as a stage in which the characters of youth have been removed by the long-continued process of erosion, but those of maturity have not yet had time to develop.

The drainage of a region is said to be in the nature stage when the streams have just completed all the erosion they are capable of in the existing circumstances. As a river erodes the landscape by cutting down its bed with sediment carried along and by thus giving its tributaries a level to which to erode their beds, it follows that a point must be reached eventually at which the river has no longer sufficient slope to give it power to carry a sediment load. A river system obviously cannot plane the landscape level. Some slope must remain, and the altitude at the head of a long system will be considerable. Water requires a drop of about 4 feet a mile as the minimum slope to enable it to flow. A river would probably cease to erode when the level had been reduced below 10 feet per mile, and in most cases would not have power to do much erosion long before this limit is reached. Similarly the divides between systems could not be completely removed.

The general aspect of a landscape with mature drainage is that of wide rolling plains unbroken by sharp features or steep slopes. The original plateau is all gone, and only a succession of river basins remain. This type of landscape is termed a peneplain—almost a plain—the nearest approach to level to which river erosion can reduce it.

Drainage Systems in Old Age.

If no alteration of strand level occurs and the mature system persists for a long period, the drainage passes into the stage of old age. Although in normal times the rivers cannot cut lower, periods of flood occur occasionally during which the bed is cut lower than the stream can in normal times transport its sediment load. This is then deposited over the broad valley when the river's power is normal. Even a further stage is reached when the river cannot carry any sediment load over a great portion of its course as the slope is too gentle to give it the power. It then builds a wide flood plain over its valley. The force of the river having gone, the water meanders, often in a series of bows, through this plain. Floods cause frequent changes of course. The tendency to bend is aided by the slightly increased power given to the outward side portion of the current on the turn. Often the stream cuts across the base of one of its bends or cuts into the points where the bends commence until they meet and leave a straight path for the stream. The old course in the bend then becomes a lagoon or billabong. A glance at a map or aerial photo of the Murray or Darling will show these features in every stage. A caution must be given here. In a newly uplifted area the drainage is still indeterminate. Rivers flow everywhere. None has yet developed predominance. The general level is not broken and lakes abound. In some respects this resembles a system of old age, but the lakes, swamps, and haphazard arrangements of the river courses show that it is not so. This type is known as plateau drainage.

Rejuvenated Drainage Systems.

Beyond old age a river cannot go. In the great stable centres of the continents the systems have long ago reached this stage, and now merely pile more and more sediment over their plains and meander through these deposits. The best known example to us is the Murray-Darling system, which around Mildura, for example, flows over its own flood plain six hundred feet thick. This has been piled up to such an extent that, although distributed until it is unnoticeable to the naked eye, the streams of the Wimmera and Mallee cannot flow uphill to meet the Murray and vanish in salt swamps behind the flood plain. Many of our features have not yet been established, and there is at present a great controversy as to whether the landscape of our central plateau and east and southern districts is due to diabasic uplift followed by a long period of erosion chiefly influenced by differential resistance of various beds, or whether, as the writer is inclined to think, it is due rather to block faulting in the recent past. Until this is established we cannot be quite certain as to the development of our landscape.

River Piracy.

In this process of development from youth to maturity one of the striking features is the way in which certain main rivers take the place of many small streams, and these large rivers are fed by a network of tributaries, resembling in plan the branches of a tree, which system takes the place of a large number of small, independent streams flowing roughly parallel to each other—one of the characteristics of a youthful drainage system.

Of two or more parallel rivers, it usually occurs that one or more are more favorably situated than the others, by reason of greater initial catchment area, greater slope or softer rock beds, all of which factors tend to allow them to outpace neighboring streams in the work of erosion. These rivers erode their sides of the divide, thus widening their valleys at the expense of those of their neighbors. At the same time they also push their heads further into the plateau mass. The result is greater catchment area, and hence greater water supply for erosion. This, added to any other advantages, often enables these streams to cut deeper channels than their neighbors. This greater depth gives greater power to tributaries. If one of these tributaries by headward erosion cuts right through the divide into the valley of the next stream, it will eventually be flowing at a lower level than that stream and will tap all the water flowing in at that point, diverting the whole system above to its own course. In this way, one large stream will capture the headwaters of many smaller ones, and eventually enlarge its catchment area to include a great proportion of the hinterland, and leave the many original streams represented only by short trickles on the coastal slope. A river which has had its headwaters so captured is said to be "beheaded." This process naturally increases with every additional capture.

The great inland drainage systems of old established continental areas are largely due to this cause. The drainage has been captured by one or more master systems, which have extended tributaries over much of the interior of the area, draining all except the actual slope to the sea, and continually pushing the divide between their system and that slope nearer to the coast. A marked right-angled, or hairpin, bend in the general direction of a big river, is very often a sign of such a capture, the original course of the upper portion having been diverted to the general course of the lower.

These processes take place during the change from youth to maturity. They may be seen in every stage in most systems, but not until they are more or less complete does the adolescent stage pass into the stage of maturity.

Firstly, as to rise and fall of the land, we see, as explained before, that at no great distance in the past the effects of river action were felt at a lower level than now, as evidenced by the many waterworn valleys now flooded by the sea in the form of the estuaries at the mouth of most of our rivers. This rise of the strand level has been followed by a slight sinking. Today we see most of our rivers ,notably on the Derwent between Macquarie Plains and Bridgewater, and on the Mersey above Latrobe, beds of river conglomerates, portions of old flood plains, now high above any possible flood level, indicating that in response to rise of the level of the land or sinking of the sea level, the rivers are cutting into their old flood plain.

One possible reason for this is common, and must be watched for as it is not connected with rise or fall of the land. If a river flows over a bed of hard rock near its mouth, and this bed is not very thick and rests on beds of softer rock, the river will not be able to cut quickly through the hard rock and the level of this will represent the base level for the valley above it. The river may succeed in reducing the topography of its valley above the bar of hard rock to maturity. Then it may cut through the bar and deepen its course quickly in the soft beds below. The result will be a rejuvenation of its course in the higher levels.

Although this occurs in stable continental regions, these are few, and a system in most parts of the world seldom reaches even maturity. A new strand level is produced by earth movements after the cycle has proceeded a certain distance. If the landscape has reached a stage when the drainage is mature and is then elevated these streams will be given new power by the increased slope to the sea. The same happens if the level of the sea drops. They are said to be rejuvenated. At first they cut deep young channels into their old valley, and then the cycle of erosion commences again, its course depending largely on the amount and rate of uplift. This young valley cut into the mature one is termed "a valley within a valley landscape." If the old river has been meandering, it probably will be unable to move out of its old course and will cut a gorge following its former bed. This is termed a river with "entrenched meanders." When the re-elevated peneplain is again reduced to a stage approaching maturity, hills will stand out the remnants of the old peneplain, and these will have tops relatively level and at approximately the same elevation, all that is left of the old sand surface. These are termed "peneplainal residuals."

Having discussed the various processes by which a given landscape is formed and moulded, we must turn to an examination of the characters which tell us how long these processes have been at work, and the relative order of their occurrence. A landscape may be newly uplifted, or may have not felt the influence of earth movements for an infinite length of time. The river system may have been at work eroding the surface during all this time, or it may have been interrupted. It is the various features of the landscape which give us an indication of these happenings that we must now study. This is sometimes called the cycle of erosion, but this title is confusing, as only one particular phase can be seen in one place and one given locality, seldom even in the whole course of geological time completes the cycle, the movement being often as much backward as forward. Also different phases can only be seen over large areas, although small variations in the phase of erosion may occur from place to place.

Effects of Rise or Fall of the Land.

A given tract of land is more often slowly rising or falling in response to earth movements explained previously than it is stationary. As has been explained, streams, in order to erode their valleys, require velocity, and this is imparted by slope. Also for an increase of one in velocity their eroding power is increased 27 times. As a stream can only erode in its bed, and an uplift gives it such a great increase in power, it immediately starts to entrench its bed, to cut a narrow, steep-sided gorge in the bottom of its valley. Tributaries conform and in turn cut deep valleys, where they join the main stream.

On the other hand, if the land is sinking, the transporting power of the rivers is being reduced. They must deposit sediment loads which they were once able to carry out to sea. Thus alluvial plains are the rule, and valleys tend to become shallow and flat-bottomed as they are filled with sediment deposits. Thus we get the first indicating mark of the immediate past history of our landscape.

If the rivers have been eroding their valleys evenly for a long time, the land is probably stationary. If, within their old valleys, they have recently commenced to cut deep, narrow channels, the land is rising. And if they are now depositing sediments in valleys they previously cut out of the surrounding landscape, the land is probably sinking. This rising and sinking of the land is the first matter to be determined in deciphering the history of a landscape. It is so usual that it upsets the regular work of erosion many times in one cycle, and is often the true explanation of many features elaborately explained away by involved theories of river erosion. It must also be remembered that the sea is also rising and falling in response to melting or otherwise of polar ice sheets, formation of ocean deeps, etc., and it is often impossible to be certain whether it is the sea or the land that is moving. To avoid this difficulty, we usually speak not of the rise or fall of land or sea, but of strand level, that is, the place where land and sea meet, as the phenomena on land are the same whichever cause operates.

Effect of Alteration of Strand Level on Coast Line.

It is at the sea coast that the records of rise and fall of strand levels are especially recognisable, and as the determination of these movements is so important, it is necessary to look at the coast line before endeavoring to interpret the history of our landscape.

In the first place, a straight coast line, or a coast line formed of series of straight-fronted segments jointed to each other, is generally a mark of uplift. The lengthy work of streams and the action of the waves and the weather tend to produce inlets where streams wear out valleys, leaving headlands and terminating the inter-stream divides, and these and the other agencies tend to cut out the softer portion of the coast, leaving the more durable portions as capes. Again, cliffs show a recent uplift, as these cannot long endure the effects of the weather and streamlets, especially when the great increase in eroding power given by such a slope is borne in mind. It must, however, be borne in mind that a sudden downward faulting of the segment under the sea bordering on the present land will give the same results, as the unfaulted land then presents a straight face to the flooded portion, which has now subsided.

Conversely a ragged coast line, with intricately etched front, indicates a sinking land, as the sea flooding over the subsiding landscape covers the country following a given contour round the many gullies and valleys worn by small and large watercourses. The waves in general wear the shore in a fairly regular line. Very many small inlets and capes indicate that some agency other than waves has produced the form of coast line. This generally can only have been done by submergence of a topography, already moulded by water action.

Therefore in examining a coast line for rise or fall of land, the first questions an observer must ask himself are whether the features he now sees could have long resisted the attack of weather, waves, and streams in their present form, and whether waves and existing streams and rain-water channels could have produced the features he now sees where they now exist.

More detailed evidence may be available when these questions are determined. For example, the existence of soft, recently-laid marine sediments on what is now dry land—a feature termed a coastal plain—is sure indication of a recent uplift. So also are raised beaches—shell mounds and other typical beach formations high above the present level of the waves, wave terraces cut in places well above present high-water mark, cliffs obviously wave-cut, now seen well inland, and wave-cut caves far beyond the present reach of the sea.

On the other hand, drowned valleys—estuaries that must have been cut by rivers, but now occupied by the sea in such a way as to prevent erosion by the rivers that enter them—are sure indications of a sinking landscape. So also are islands in groups off the coast, which are obviously the tops of submerged hills, and could not have been formed by more resistant cores of hard rock left standing beyond the general front of the eroded coast line.

It must be borne in mind that these phenomena do not necessarily show present elevation or depression. They only show that these movements occurred at a time so recently past that the traces have not yet been obliterated. The movements may have stopped for some time, and a contrary movement may now be in progress. The general condition of coast lines is that of continual oscillation with, however, either an upward or downward movement predominating.

Recent Rise and Fall of Tasmanian Coasts.

Our coast line in general shows all round the island a general sinking, which movement, after being very pronounced until recent geological times, has now changed to one of general rising. Our great estuaries, the Derwent, Huon, Tamar, Mersey, and others all show signs of having been worn by rivers. Since this they have become flooded by a general rise of strand level. Our numerous harbors have been formed in this way. But it must be remembered that in recent geological time the level of the ocean has risen about 150ft. through the liberation of water formerly locked up in the great ice sheets of Pleistocene times.

The straight lines of the east, south-west, and southern coasts, and the numerous lines of high cliffs there, indicate a recent dropping away of the sea level to a slight degree are shown by the numerous raised beaches common round our coast, and standing up to 25ft. above sea level in the south-east, and several hundred feet in the north-west. A very marked shore platform runs round the base of the cliffs of south-eastern Tasmania, and is continued up the Derwent estuary at Bellerive, Bedlam Walls, etc. On the north-west coast a small coastal plain is very marked. The railway from Don to Wynyard runs along this, and the old line of cliffs is clearly seen in the line of steep hills rising immediately behind, especially at Wyvenhoe and Burnie. Altogether the tendency at present appears to be a general rising level of the land, this being more marked along the Bass Strait coast, especially in the north-west and least marked, but still decided, in the south coast.

The Cycle of Glacian Erosion.

Glaciated landscapes show a similar development from youth, through adolescence to maturity and old age. The characteristics naturally are different as a glaciated landscape differs so materially in general aspect from a waterworn one. As so much of Tasmania shows the imprint of recent ice-erosion passing mention must be made to these types of landscape. These characters depend chiefly on the length of time during which they have been exposed to ice action. Slope has relatively little bearing, but its place it taken by quantity of ice which in turn depends on precipitation.

When a glacial period commences naturally the higher elevations are the first affected. As far as Tasmania is concerned these are the only regions to be seriously considered. The manner of the development of cirques and other glacial features has already been considered. As it is by cirques that ice chiefly models the landscape these are the features to be considered in studying the cycle ot glacial erosion. Ice caps will be discussed separately later.

The Youthful Channelled Upland.

The first effects of glaciation are the appearance of the summer snow bank, "dug in" by its own erosive work in a hollow of its own making. This hollow ultimately develops into the cirque The earliest stage in glacial erosion is seen when the upland is grooved by numbers of cirques at the head of U-shaped glacial valleys. The form of the original upland still persists and the cirques are obviously cut out of it. Broad plateaux remain between them and at the head of a group of radiating glacial valleys much of the original plateau can still be seen. The cirque is the distinguishing feature of this stage.

The Fretted Upland or Adolescence Stage.

As erosion proceeds, the sides and head of the cirques are enlarged by the intense frost action along the invation zone and by the plucking action of the glacier as previously explained. Cirques, which first were regular troughs, become "nail-headed," and then multiple, this latter stage being reached when the glacier really grows from a number of cirques separated by rock buttresses. The cirques and U valleys enlarge sideways until eventually they meet. They first join not right at their heads, but some distance down at the broadest portion of the cirques. By this time the original plateau is reduced to a series of ridges, very little of the original surface being left. These ridges present knife edges, often with a very sharp contour, markedly different from the rolling contours of water divides. In time the ice in the cirques eats right into the ridges. Not along their whole length as a rule, but in spots at often regular intervals. Here the ice removes the original surface and leaves the rock between standing as a series of pinnacles. These ridges have been termed "comb ridges," and are the typical features of this stage. The process has been compared by Professor W. H. Hobbs, the leading worker in this branch of physiography, to the process of cutting biscuits from a sheet of dough with a biscuit cutting mould. When the maximum number of biscuits have been cut from the dough, thin strips are left between the portions so cut out. A glaciated landscape in this stage of erosion resembles the sheet of dough when the maximum number of biscuits have been cut out.

The Glacial Horn of Maturity.

As the process continues the ridges are gradually reduced. At first these are somewhat at the same height as that of the original plateau. These connecting ridges in a glaciated topography are termed cols. Early maturity is represented by high cols. Gradually these are lowered, and in a later stage become low cols. In the course of time they disappear, or almost so. Then all that is left is the original col of the plateau, or that portion which stood at the head of a group of glaciers. This now stands out as an isolated mountain peak, termed a glacial horn. The Matterhorn is the type of this feature par excellence.

The Monumental Upland.

Beyond this stage glacial erosion seldom proceeds, but Professor Hobbs has discerned a further stage in Glacier National Park, U.S.A., and another class has to be made. When the Glacial Horn is subjected to still further prolonged erosion it gradually disappears. Then the whole interior of the original plateau has been reduced to a level. But the point at which the erosion by this agency is least felt is at the edges of the plateau, at the ends of the cirques. Thus after the interior horns have disappeared rock masses still stand out at what was originally the lower ends of the cirques. These are termed monuments, and when they alone are left the landscape is said to have reached the old age of glacial erosion. These monuments naturally stand in pairs, one on either side of the original cirque. Continued ice erosion then takes the form of ice cap erosion, and not glacial erosion, and an ice cap, beyond a general levelling effect, does little work in reducing the level of the landscape.

It must finally be noted that there is not in glaciated landscapes the orderly progress from youth to old age seen in water-worn landscapes. One stage does not follow after the previous one is completed, but each of the more manure exists with the mere juvenile stage, but in an embryonic form. Thus in the early fretted upland the portion which will ultimately form the glacial horn is to be seen standing well above the general level, and the future monuments are also beginning to appear. As the erosion proceeds from stage to stage, the later forms, always noticeable, become more pronounced.

Of course, a glaciated landscape cannot be studied until the ice has disappeared, or almost so.

A. N. Lewis.

Some Notes on the "Wattle" or "Acacia"

(Continued.)

I have here some statistics for the year ending June 30, 1923. Wattle bark exported from Tasmania was 53,222cwt., valued at £25,474, of which £16,659 was from Hobart the remainder from Launceston. Quite lately a shipment was sent direct from Bridport, 12 miles from Scottsdale, to the mainland, the first to be shipped direct. There is about £600 worth of wattle bark used in this State for tanning purposes every year, which, in addition to exports, it will be seen that it is very valuable.

Mr. Mitchell, on East Coast, had a plantation of black wattle harvested once in seven years gave the largest percentage of tanning under cultivation.

The black wattle contains 38 degrees tanning, the silver wattle 24 degrees, approximately.

Imports of Wattle Bark Into Australia, 1922-23.

Importing States.	Quantity. cwt.	Value. £
New South Wales	35,745	14,632
Victoria	54,463	21,076
Western Australia	3,458	1,593
Total	93,666	37,301

Note.—With the exception of 6cwt of Australian bark re-imported, all of the above imports were received from South African Union.

Imports of Wattle Bark Extract, 1922-23.

Country of Origin.	Value. £
United Kingdom	64
South African Union	2,878
United States of America	25
Importing States.	
New South Wales	1,626
Victoria	608
Western Australia	733
Total	2,967

Exports of Tanning Bark (So Described) from Australia, Produce of Australia. 1922-23.

Country to Which Exported.	Quantity. cwt.	Value. £
United Kingdom	12	3
Mauritius	309	194
New Zealand	11,034	7,604
China	2,478	1,385
Japan	2,003	826
Netherlands, East Indies	9	9
Total	15,845	10,021

Commonwealth Bureau of Census and Statistics, Melbourne, May 19, 1924.

Note.—In addition to above exports, 1,684cwt., valued at £695, of tanning bark produced in other countries were exported from Australia during 1922-23.

I would point out at this stage that

South Africa Got the Seed

of this wattle from Australia, and now is exporting wattle bark in the quantities just named to Australia. Australians should try and grow enough wattle to supply all their needs, and also to export more. Returns from the South African Union show that in one year over £975,000 of black wattle bark had beem grown, shipped and sold.

Blackwood timber exported from Tasmania for the year ending June 30, 1923 (dressed and undress and log) totalled 3,610,000 super, feet, valued at £59,500. These figures, taken with what was used in Tasmania, show that it is a very valuable asset to our country, and should be conserved in every way; and by growing young wattle for stripping and getting blackwood seed, and raising seedlings and planting them to help re-build the forests.

Wattles grow very readily on almost any part of Tasmania. It only requires, as stated before, for a fire to go over the grass for the seed to be ready to germinate, and Tasmanians would do well to see that this is done wherever possible, so that Australia will not have to import bark, etc., from countries thousands of miles away, as is done at the present time.

I have tried to show that Australia's national emblem is not only a very beautiful plant and tree, but also that it is a very valuable and useful one as well, and it is something for Australia to be very proud of. Any emblem worth notice at all should be a

Real and Living Expression

of something precious to its people, and a source of inspiration as well. Think of this unique flower, complex, and yet so simple, bending in "golden rain," swaying in mystic plumes, twisted in "golden wreath," glowing in a million fluffy spikes, easy to grow, eager to bloom, both in lowly shrub and stately forest tree, greatful for good soil, content with very poor or almost none, fragrant, friendly, beautiful! Have we not something to live up to here?

Some of the Tasmanian varieties of acacias are:—

Acacia riceana, which is found only in Tasmania. It is of the very prickly varieties, the leaves are phyllodes; it has its leaves in two and sometimes threes, and the flowers are in sprays of 2 to 2½ inches long, with about a dozen balls of flowers. It is sometimes called weeping wattle on account of its habit of drooping with the weight of flowers.

Acacia verticillata is about the most prickly, sometimes called "prickly watter" or "prickly Moses." The leaves (phyllodes) grow in verticills or rings round the stem, the flowers are made up of very many small flowers and form a spike about one inch long and about ½ to 5-8 inches thick. The variety will grow from 20 to 30 feet high.

Acacia diffusa, another prickly one, grows only to a small shrub and sprawls about chiefly, hence its name. The leaves are phyllodes, the flowers are round balls containing numerous flowers and come along the stem.

Acacia myrtifolia is, as its name suggests; the leaves also phyllodes are the shape or similar to myrtle leaves. It only grows to two or three feet high. The flowers are in small spikes of several balls, the leaves are dark green, and have a gland near the stem on one of their edges.

Acacia discolor is one that has true leaves, but they are not divided nearly as much as the silver and black wattles. The flowers are paler in color, and they branch a good deal and flower about Easter time. It is sometimes called river wattle.

Acacia sophorae, boobyalla wattle, grows near the sea beaches, and has a spreading habit. Flowers in spring, leaves or phyllodes have several midribs, but look almost as if they had none, flowers in spikes about 2 inches long. Makes a good shelter tree.

Acacia melanoxylon, "blackwood," previously mentioned. Flowers in spring. The flowers appear on branch-like stems and make a very pretty picture, leaves or phyllodes have four or five midribs or nerves, and when young the tree shows the divided true leaves as well as phyllodes.

Acacia dealbata, or silver wattle, is known by most people. It flowers in early spring, and is mentioned earlier. It has true leaves.

Acacia deacurrens, also previously mentioned, flowers in December. The leaves are much darker than silver wattle.

Acacia stricta is one with a narrow leaf or phyllode, about two to three inches long, with one midrib. Only grows about 4ft. high, flowers in spring. Flowers appear chiefly near the leaf stalks. Has a dull colored leaf.

Acacia verniciflua is similar to the last-named, but its leaves or phyllodes have two midribs, and have a varnished appearance. The flowers are similar to the last-named, and it grows up to nearly 30ft. high.

Acacia suavcolens. This one is similar to stricta, but grows larger. Has leaves, or phyllodes, up to nearly 6 inches in length. Has a single midrib, is dull in color and very narrow, and has ridges along the stems, especially near a branch or leaf, giving a triangular appearance. It flowers in the autumn, and they appear at the base of the leaf in very pretty buds of a brownish color, which open into a fine spike of florets or balls up to 2½ inches long.

Acacia vomeriformis has leaves something like the nose of man, and is named for its similarity to the shape of the bone in the nose called the "vomer." It only grows up to about one foot high, the leaves or phyllodes are up to half an inch long, and pretty balls af flowers at intervals along the stem. Flowers in spring.

J. C. Breaden.

Some Tasmanian Naturalists.

(1) Cook, Anderson, Nelson.

Introduction.

Tasmania was discovered early in the fifth decade of the 17th century, and not until the opening years of the last century did actual settlement take place. In the time intervening between discovery and settlement, a number of expeditions of British and French nationalities visited the shores of the island. Attached to most of these expeditions were men who had distinguished themselvs in their pursuit of scientific knowledge. With the sailors who navigated their small ships into these uncharted waters these men endured hardships which are today inconceivable. After long and perilous voyages they set foot on a strange shore and labored unstintingly in the cause of knowledge. They have left on record much valuable groundwork, which has been the source of inspiration and information for those who have come after. With the establishment of settlement

A New Era Commenced.

but the tradition of the workers before 1803 has never been lost. Occasionally eminent men of science from overseas have visited the island and investigated some aspect of our natural phenomena. The hard and frequently unrewarded labor of such researches has mostly fallen upon the shoulders of a few Tasmanians. They have undergone perils and hardships not incomparable with those of the earlier period. Readers of Robert Mackenzie Johnston's description of his geological expedition to the South and West Coast in 1874, can, to a certain extent, appreciate the difficulties which these workers had to encounter. Far from the stimulating influence of seats of learning, through dense beech and bauera forests, over sharp ridges and across precipitous ravines these pioneers fought their way. In spite of hardship and difficulty the scientific workers in Tasmania have made valuable contributions to the store of knowledge.

Dutch Expedition, 1642.

The main object of the Dutch expedition which discovered Tasmania and New Zealand in 1642 was the extension of commerce. No doubt the authorities at Batavia and the Council of Seventeen, who directed the policy of the Dutch East India Company, also wished to add to their knowledge of the seas to the south and east of Cape Leeuwin. In case the expedition failed to find new Indies, it might at least discover a new and safer route for their wealth-laden ships sailing to Holland. Immediate material gain was uppermost in the minds of the men who sent Tasman on his voyage of 1642. From the commercial aspect the expedition was a failure. So much so that the opulent councilors never again voted for the expenditure of so much as

A Single Guilder

to further the cause of South Sea exploration. Nevertheless the expedition made an extremely important contribution to pure knowledge. Geography particularly benefited by the discovery of land lying between 140 and 180 longitude lower than 40 latitude. Definite land must be now recorded on maps in place of fabulous representations of the southern continent.

Unfortunately the expedition did not count amongst its company an experienced observer of natural phenomena. Tasman and Visscher (a contempory Dutch geographical authority) was not in a position to make scientific observations. It cannot be reasonably expected that the commander of two small ships sailing for months in unknown seas,

(B) JAQUES JULIEN LABILLARDIERE.

The excitement of the revolution in no way abated the interest of the French nation in the disappearance of their illustrious navigator, La Perouse. The years 1789 and 1790 passed away, but nothing was heard of his expedition, which had left Sydney for a Pacific cruise in 1788.

At last in 1791 the French Government despatched Admiral Bruny D'Entrecasteaux with two ships, La Recherche and L'Esperance, to the Pacific to solve the mystery of the sea. A small scientific staff was attached to the expedition, the chief naturalist being Jaques Julien Labillardiere. He was assisted by three other observers, Deschamps, Perin, and La Haye. An astronomer namer Bertrand also accompanied the expedition, but it seems that he remained at the Cape of Good Hope. We know little of Labillardiere, but that he was a scientist of no mean order is clearly seen by his accomplishments. Probably he was one of the enthusiasts who worked with such men as Buffon or Jussieu. The expedition arrived off the south of Tasmania in April, 1792, and by a memorable error discovered the long passage of water between Bruny Island and the mainland. Over a month of exploration work was carried on by means of boat expeditions, which extended as far as the present Risdon cove on the east Derwent.

As the boat expeditions were making entirely new discoveries, Labillardiere and his fellow naturalists were given unique opportunitie sto perform original work. David Nelson and Surgeon Anderson, o Cook's third voyage, were limited to the shores of Adventure Bay, but these men were able to examine the flora and fauna for nearly 100 miles of hitherto unknown coast line.

The members of expeditious came into contact with the aboriginal inhabitants who had their middins in the bays and beaches of shores of D'Entrecasteaux Channel. Labilliardiere gives several highly interesting descriptions of his meetings and intercourse with the natives. It is pleasing to record that the French preserved the friendliest relations with these primitive people. It is impossible to give in detail Labillardiere's account in such an outline, but several incidents be describes as worth relating. He was very surprised that he found the utmost difficulty in persuading one native to exchange a kangaroo skin for some articles of European clothing. Of a group of four native girls he interviewed, he says:—"No doubt we lost much by not understanding the language of these natives, for one of the girls said a good deal to us; she talked a long time with extraordinary volubility, though she must have perceived we could not understand her meaning; no matter, she must talk. The others attempted more than once to charm us by songs, with the modulation of such I was singularly struck, from great analogy of the tunes to those of the Arabs of Asia Minor."

Labillardiere very fortunately gives us a great deal of detail concerning the aborigines. He saw more of them in their natural state than any other observer, and we have every reason to believe that in the record of his observations he maintained a high degree of accuracy. In the collection and describing of the flora he met we find Labillardiere doing his best work.

Among the many Tasmanian species that he first described are some of our best known bush plants. Blue gum (E. globulus), peppermint gum (E. amygdalina), white gum (E. viminalis), sheoke (Casuarina quadrivalris), lancewood (Eriostemon squameus), laurel (Anopterus glandulus), purple heather (Tetratheca glandulosa), and the white flag (Dipharrhena moroea).

It is impossible for students of botany not to envy Labillardiere for the opportunity he had of viewing the forests on the banks of the Huon in their natural state. The expedition failed to find the missing navigator, but the scientific work done by its members in Tasmania was very considerable. Labillardiere's observations and studies of the aboriginal peoples have been, and still are, of value to students of anthropology. His botanical work prepared the way for the great British botalist, Robert Brown, who was to visit the islands a few years later. He also described a number of the animals and fish. A brief extract from the journal of the voyage gives us an idea of the labors of Labillardiere and his fellow scientists.

"The naturalists have made precious harvests in every department. Several new plants, unknown fish, birds never before described, and others, which, without different as to species from those of neighborong countries, are, however, of very curious varieties, have enriched their collection, which seems to have been more abundant in this southern part of New Holland than was that made by Mr. Anderson in Adventure Bay."