NOTICES OF MEMOIRS.

I.—The Geological Aspects of South African Scenery. Presidential Address delivered to the Geological Society of South Africa by Dr. Geo. S. Corstorphine, B.Sc., F.G.S.[1]

NO country affords readier facility for the observation of the geological causes of scenery, though we may regret the fact that the facility owes its existence largely to the deplorable destruction of a former vegetation.

South African scenery is striking in its very monotony. Over hundreds, or rather thousands, of square miles there is a sameness which becomes oppressive, and a want of variety of feature which exceeds all imagining. There is nothing stimulating in the landscape but its immensity, yet, owing to the limited horizon, that immensity is not a characteristic immediately appreciated. The fascination of the veld is subtle and elusive, probably because, more there than anywhere else, is the charm due to conditions of sunshine and atmosphere, factors as essential to the final effect of a landscape as the configuration of the earth's surface.

The geological constitution and structure are the fundamental conditions on which the scenery of a country depends, and the resulting landscape is the outcome of the work done by the agents of denudation, which are themselves mainly due to the prevailing climatic conditions. Denudation working on the original structure, finding out the weak spots and gradually carving away even the hardest rocks, is the great factor in the evolution of a landscape. Whether that denudation is of one type or another, whether its weapons are rain, running water, snow and ice, or whether extremes of temperature aided by torrential tropical rains are the main modifying influences, depends on the climatic conditions. Similar geological conditions in regions enjoying different climates are subjected to different denuding forces, with the result that varied types of scenery are produced.

In a region such as South Africa, where the same geological formations extend from the Atlantic to the Indian Ocean, and from Agulhas to the retreating boundary of 'Darkest Africa,' the resemblances in the scenery are produced by the prevailing geological uniformity, and the differences are due to the variations in the climate.

It is to the action of long-continued subaerial denudation that South African scenery owes most of its characteristic features. Geological investigation reveals the fact that long ages have elapsed since the main stratigraphical structures originated, and that even the present land surface has an antiquity for which any possible equivalent in years would convey no meaning to the human understanding, for since the upper beds of the Karroo System were deposited only a small portion of the coastal region has undergone submergence.

[1] Annual General Meeting, 28th January, 1907 (Proceedings of the Geological Society of South Africa, 1907, pp. xix–xxvii).

The present surface, here as elsewhere, is the last expression of the interaction of various geological forces, some of which are as active to-day as they probably ever were, while others have in these days no share in the sculpturing of this landscape. Changes of temperature, wind and rain, surface and underground water, are probably not much less active in South Africa to-day than in past ages; whereas extreme glacial conditions have played no part in modifying the surface since the beginning of the Karroo Age, nor have volcanic agencies been at work since the eruption of the rocks of the Drakensbergen and the Lebombo Range.

The record of the South African strata tells us that before the present conditions began there were five periods during which a land surface existed. The earliest of these, and yet not the first, was formed by the complex mass of old rocks, now largely metamorphic in character, which we group together as the Swaziland System. To-day again these rocks play a large part in the constitution of the region, but whether any portion has remained continuously a land area cannot be determined. Certainly the northern granite and schist regions were dry land while the central and southern areas were gradually covered by the sea in which the Witwatersrand Beds were laid down. These beds in turn were added to the land surface, and in the process of upheaval they underwent considerable folding and contortion. Having been again submerged, portions of the granite area, and probably the whole Witwatersrand System, formed the floor for the heterogeneous Ventersdorp System, with its succession of sediments and volcanic rocks, which in turn formed the third land surface that plays a part in the present one. When the next submergence ensued, the Black Reef, the Dolomite, and the Pretoria Series were deposited in the northern areas, which we know as the Transvaal, Bechuanaland, and Northern Cape Colony, though whether land conditions prevailed southward, or whether these beds were also deposited there, but were subsequently denuded, is again a matter of conjecture. At any rate, the evidence now available points to little deposition having occurred in the south during that period.

In the land surface next formed, the Swaziland, the Witwatersrand, the Ventersdorp, and the Potchefstroom or Transvaal Systems all played some part, there being a gradual increase in complexity from the north southward.

During the next submergence there was deposited the Cape System, consisting of the Table Mountain, the Bokkeveld, and the Witteberg Series, so predominant throughout Western and Southern Cape Colony, but represented in Natal by the Table Mountain Series only, and in the Transvaal most probably by the Waterberg sandstones and conglomerates.

When this period of deposition ended, the present terrestrial conditions began to prevail, for the characteristic Karroo System was not due to marine action, but, as is universally recognised, was formed mainly on the floor of an inland lake, while in the north land ice caused the extensive morainic deposit of the Ecca Glacial Conglomerate. This inland lake must have covered the greater portion of the region, and its shores certainly extended considerably south of the

Karroo, for we find its deposits in the Breede River Valley, south of the Langebergen. It seems likely that the lacustrine conditions prevailed longest in the east, north-east, and north, for it is only there that the Stormberg Beds, the youngest division of the Karroo System, are found, and we have no reason to believe that their absence in the south and west is due to denudation.

The disappearance of the Karroo Lake was probably accompanied by, if not actually due to, the upheaval of the only true mountain chains which characterise South African scenery, and it was doubtless during the same period of disturbance that the enormous volcanic activity now represented by the lavas of the Drakensbergen had its origin. The fossil evidence shows that this final upheaval most probably occurred in Jurassic times.

The submergences which occurred later affected only the coastal belt of the country, and are represented by the relatively small patches of Cretaceous rocks occurring in Cape Colony, Natal, and Zululand, and the strip of Tertiary beds on the coast of the last-named province. Throughout the greater extent of Secondary and Tertiary times the larger part of South Africa has been a land surface, and it is no wonder that its landscape should, to such an extent, show features due to denudation.

The present scenery has originated from the accretion of remnants of successive formations, each to a large extent formed by the disintegration of such portions of its predecessors as could be affected by the complex agents of denudation, while the sum-total as presented by the land of to-day is undergoing continuous modification by the denuding agents now at work.

For the present purpose South Africa may be regarded as falling into three zones—the Coastal Zone, the Mountain Belt, and the Interior Plateau.

The Mountain Belt.—The Mountain Belt is well developed in the west and south, and, as it is the essential feature in the structure of South Africa, I shall deal with it first. It embraces all the mountains which trend north and south on the western border of the Karroo and the various ranges which run east from Hex River Pass to the vicinity of Algoa Bay. This extended area consists of a series of true mountain chains, showing as much intricacy of structure as the Alps of Central Europe. The most conspicuous geological component is the Table Mountain Series, but the two higher members of the Cape System also play a part, while on the internal boundary of this zone the lower beds of the Karroo System are included in the mountain folds. Sections showing true mountain structure are to be seen in such places as Mitchell's Pass, Hex River Pass, and in the various passes and river gorges which cut the mountain chains from north to south, such as the Montagu and Prince Alfred's Pass over the Langebergen and the Gamka River Poort and the Zwartberg Pass through the Zwartebergen. Mountain scenery of the wildest and grandest type is to be seen among the Zwartebergen, the Langebergen, and the intervening ranges. Denudation has played a large part in the production of the present scenery, for the summits of all these ranges consist of Table Mountain quartzites, the geologically higher

Bokkeveld Beds being confined to the flanks of the mountain chains, or even to the valleys, while the more quartzitic Witteberg Beds may form subsidiary ridges. On the south-western coast of Cape Colony, and at intervals eastward to Algoa Bay, the mountain belt virtually reaches the coast: the Cape Peninsula itself is an outlying remnant, having been cut off by denudation from the hills on the western shores of False Bay.

The South Africa of to-day has lost a considerable portion of the mountain belt beneath the waves of the Indian Ocean, for from Algoa Bay northward through Natal we have no longer the same marked mountain scenery. Where the Table Mountain Beds appear in Natal they are lying for the most part horizontally, and though they form what are locally termed mountains, these, like the Cape Peninsula, are on the outskirts of the region of extreme pressure, which in eastern South Africa probably lies beneath the ocean.

Between such portions of the mountain belt as still exist in Natal and the more typical Langebergen and Zwartebergen of Cape Colony the contrast is very marked. In Natal the valleys are not structural valleys, but have been produced by the cutting out of great masses of the strata. The mountain tops are plateaux, formed of horizontal beds, whose edges form the sides of the deep-cut valleys.

The mountain belt being composed essentially of quartzites, those portions of it in the more arid districts of Cape Colony yield a very stern, bare landscape. In the east of Cape Colony and in Natal, however, the moister climate renders vegetation abundant, and we find the rocks of the mountain belt covered by bush, and even forest.

The Coastal Zone.—The Coastal Zone varies considerably in character, and, as has been already stated, it is in places actually cut out by the encroachment of the mountain belt. On the west coast it is perhaps most typical, consisting there of the old slates and schists of the Namaqualand Series, with bosses of intrusive granite. It presents a low undulating landscape, broken by hills of granite, which in places, as at Paarl and Robertson, are conspicuous features.

Along the west and south coasts, bare sand dunes are abundant, and some of the older of these have solidified into coherent masses, which are again being cut into by the sea. On the north shore of False Bay, and near Struys Bay, Cape Colony, there are cliffs 20 to 25 feet high, formed of these old sand dunes.

Where the mountain zone has encroached on the coast, as on the shore of False Bay, and many places eastward, the Table Mountain quartzites form steep sea cliffs.

The eastern coast of Cape Colony and of a considerable portion of Natal is formed by the rocks of the Karroo, which, however, are much covered by recent coastal deposits. The lagoon landscape is particularly well developed along the Natal coast, owing to the heavy banking up of sand bars at the river mouths, while the Zululand coast is for the most part a low-lying belt.

The variation in the scenery produced by differences of climate acting on the same geological formations is again well illustrated in the coastal zone. The granitic and schistose rocks of the north-west, being exposed almost to desert conditions, show a bare and uninteresting

scenery—low undulating hills with a marked absence of river valleys. From the district of George eastward, and northward into Natal, the more generous rainfall renders forest vegetation possible; the granite tors and barren schist areas of the west are unknown, and numerous rivers flow seaward in deep-cut valleys. On the Natal coast the vegetation is still more abundant, and much of that area has an almost tropical character, though the geological formations are identical with those of the barren west coast.

The Interior Plateau.—The third area—the Interior Plateau—is the most extensive and also most varied in South Africa, showing the greatest diversity both of scenery and of geological constitution.

In the Cape Colony it consists of the Karroo, with its desert conditions, which disappear as one passes north-eastward into the Orange River Colony and the Southern Transvaal, though the same geological horizons prevail throughout these areas. Northward, the High Veld of the Transvaal consists, in addition to the Karroo Beds, of an extensive area where the older rocks, down to the oldest formation of all, have been laid bare. To discuss briefly the scenery of this vast interior plateau, it will be advantageous to deal first with the Karroo proper, and then the other areas built up of the rocks of the Karroo System.

The great Karroo is one of the most characteristic features of South Africa, and though its scenery may not be inviting, we may remember that it was the Karroo fossils sent home by Andrew Geddes Bain which first excited keen geological interest in South Africa, an interest which was stimulated on other sides by the controversy over the marvellous basal glacial conglomerate, while it was with the discovery of the Karroo diamonds that South Africa's importance to the modern world began.

The Karroo is built up of sandstones and shales which, except in the extreme south and west, where the lowest members of the series have been involved in the folding of the mountain belt, lie horizontally. Basic igneous intrusions, belonging to a late period in the geological history of the region, are everywhere abundant throughout the Karroo rocks. The Karroo scenery is a true denudation landscape. The hills which abound are remnants carved out from a surface once much higher. The flat-topped hills are in the earlier stages, the pointed ones in the later stages, of disintegration. The interbedding of harder sandstones with soft shales gives the alternate cliffs and slopes on the hillsides, while sheets of dolerite make the more marked escarpments, or krantzes.

Along the south of the Karroo, and well seen between Touws River and Matjesfontein, the slab-like weathering of the Glacial Conglomerate gives the hillsides a peculiar appearance.

The change of scenery which occurs from about the centre of the Orange River Colony northward into the central Transvaal coincides with the predominance of softer, more felspathic, sandstones, and the practically unbroken aspect of this portion of the High Veld is due to the more regular and homogeneous weathering which there occurs. There is not the same alternation of hard and soft rocks as in the Karroo proper, and the less arid climate enables the veld grass to protect the soil.

The whole of the central plateau, where the Karroo sandstones and shales form the surface, shows numerous ridges, scarcely to be called hills, which mark the site of basic igneous intrusions, which can often be traced for miles across the country. The west and south-west of the Orange River Colony often presents what may, on a small scale, be termed quite a rugged landscape, owing to the abundant presence of dykes and small irregular bosses of dolerite and allied rocks, which, even when forming no great elevation above the general level, stand out conspicuously from the grassy veld by reason of their dark colour and their growth of sparse bush.

The central Transvaal has been largely stripped of its covering of Karroo rocks, and the old rocks appear as mountain ridges, which are in every case a reappearance of a part of one of the older land surfaces. In this portion of the country, whether the rocks belong to the Witwatersrand System or the Potchefstroom System, the resulting scenery is practically identical—low, but abrupt, escarpments of quartzites, with dip slopes inclining north or south, and forming one side of a valley which has been carved out of the softer slates or shales. The Gatsrand, the Witwatersrand, the Witwatersberg, and the Magaliesberg are all instances of this type of scenery—east and west ridges with their escarpments facing north or south according as the beds dip south or north respectively. Each intervening valley has on one side a gentle declivity and on the other a steep precipitous wall.

In contrast to the long lines of sedimentary escarpments, which make many of the hills in the southern Transvaal, are the irregular masses of Ventersdorp amygdaloid, forming the Klipriversberg and the hills south-east of Heidelberg, while north of the Witwatersrand there is the undulating landscape due to the presence at the surface of a large extent of the old granite.

Beyond the Magaliesberg, where the great Bushveld massif of igneous rocks appears at the surface, the landscape opens out again into the broadly undulating type. The more basic of the rocks often form hills, such as the Pyramids or Zwartkopjes north of Pretoria, but the granitic rocks give a scenery differing in no wise from that of the old granite, or, in fact, of any non-mountainous granite area. These rocks form a large part of the Bushveld proper, which in many places, with its grassy surface and irregularly dotted trees, has a close resemblance to the scenery of an English park.

Where the Waterberg formation appears resting unconformably on the Bushveld igneous rocks, or on the old granite of the north, there is a return to the escarpment and dip valley type of landscape, which is well seen in the hills north of the Premier Mine, the Waterberg itself, and the Zoutpansberg still further north. In all these hills the reddish-brown colour of most of the Waterberg conglomerates and quartzites is always a conspicuous feature.

By far the larger portion of the northern Transvaal is a granite landscape, presenting over thousands of square miles a gently undulating surface, with occasional bare tors rising like inverted bowls above the surrounding country. It is, except in rare seasons, a dry country covered by straggling thorn trees, above which rise the grotesque limbs of the fantastic baóbab.

The same type of country extends northward into Rhodesia, and westward into Bechuanaland. In the former territory schist and slate ridges often form conspicuous escarpment hills, as along the Mazoe Valley, but it is the exception to find the granite rising into elevations which might rightly be styled hills. In the Transvaal, however, east of Louis Trichardt in the Letaba Basin, there are some conspicuous granite peaks, while the Matopos and the hills of the Lomagundi district, in Rhodesia, are other instances. All these, however, differ from such mountains as the Central Alps, in being due to the denudation of the surrounding country, and they can in no sense be regarded as true mountains of elevation.

The whole of the central plateau is a poorly watered country. The Karroo, in Cape Colony, has not a single perennial stream, and the rivers of the Orange River Colony are little better. Even the Vaal and Orange Rivers are, for the greater part of each year, only a series of standing pools over a large part of their upper, and often over their lower, courses. The best-watered regions are where the dolomitic limestone of the Potchefstroom System prevails, either in the southern or in the eastern Transvaal.

Few of the other rivers present much of the nature of river scenery as known in European countries. Those of the Karroo have broad shallow courses, covered with the boulders brought down in the rare times of flood. In the Orange River Colony many of the rivers have cut deep channels through the soil and soft surface deposits, but rocky gorges are not common, though good instances may be seen on the Caledon River on the Basutoland border.

The edge of the central plateau in eastern South Africa makes a marked physical feature, especially where it forms the great escarpment of the Drakensberg. But everywhere there is a more or less sudden drop from the High Veld down to the low country of the eastern coastal belt, whether over the basal granite, as in the Letaba Valley and at Waterval Boven, on the Delagoa Railway, or over the uppermost beds of the Karroo System, as in Natal and the Transkei.

The passage of the rivers from the central plateau to the coast zone presents considerable variation. In Cape Colony they have cut deep gorges through the Zwartebergen, Langebergen, and intervening ranges, but in Natal and the eastern Transvaal lofty waterfalls over the edge of the plateau are the common feature.

South Africa is absolutely devoid of lakes—such bodies of water as are often designated lakes being lagoons along the coastal belt, as in the George and Knysna districts, Cape Colony, and in the case of Lake St. Lucia, Zululand; or, like Lake Chrissie, in the eastern Transvaal, they are shallow depressions filled by rain-water in the wet years—in fact, simply enlarged pans.

Many interesting observations are readily possible as to the modifications now taking place of the scenery whose geological basis I have thus briefly sketched. Over a large tract of country rock-masses break up by alternate expansion and contraction due to the wide daily variation of temperature from noon to midnight throughout a large part of the year, and whether we look at the crumbling shales

of the Karroo kopjes or the massive granites of the Matopos, the same destruction is visible.

Even more obvious is the result of the torrential rains over the central plateau: we see channels cut or deepened before our eyes, and the soil of the country is carried seaward in vast quantities during every rainy season. The general surface, especially when the rain has been aided by wind, shows sometimes coverings of sand, sometimes fine gravel, decomposed from the surrounding rocks, and there are many places where this material has been accumulated to such an extent that it is often assumed to be due to an ancient river.

The intensity of these processes to-day is largely due to the scantiness of the vegetation, which is not always natural, but has been caused by the ruinous custom, almost universally observed, of burning off the grass at the end of each Summer season. Instead of such senseless destruction of Nature's own protective covering, we might hope that it would now be realised that we need to add to, and not diminish, the vegetation of this part of the earth's surface. As geologists, we should willingly sacrifice our interest in observing the rapid action of denudation, when the first of each season's rains beat down on, and wash away, the soil laid bare through the destruction of grass or bush, for the knowledge that the land was not being wantonly impoverished year by year. We should even be glad to see many of these surface features, which are now so easily referable to their underlying geological features, hidden from us by a kindly growth of vegetation, and we should welcome a wise system of afforestation throughout the entire land.

In conclusion, gentlemen, I think you will agree with me that the natural and the political South Africa present some striking contrasts: geologically this part of the world has reached a maturity which no human system can hope to attain, politically the entire country is in an embryonic stage; geologically the region is the one throughout, but politically we have dismembered it. It appears almost as if Nature's plan had been too vast; her scheme too grand for poor humanity. Certainly, if the character of the people who have their home in South Africa develops in accord with the natural environment, pettiness of view or paltriness of aim will not be national traits—a country whose foundations are so wide cannot be the home of other than a broad-minded, large-hearted race, bound to play no mean part in the history of the world.

II.—General Report of the Geological Survey of India for the year 1906. By T. H. Holland, F.R.S., Director. (Reprint from Records, Geol. Surv. India, vol. xxxv, part 1, April, 1907.)

In the Introduction to his Report Mr. Holland states that "The great development of interest in Indian mineral deposits, as shown by the remarkable increase in the applications for concessions reported by the Local Governments, has had an effect also on the office work of this Department, and the duty of answering enquiries, instead of being a mere addition to the work of the officers at head-quarters, as was formerly the case, now consumes the largest fraction of our time."

It is satisfactory to learn that the Rt. Hon. the Secretary of State has sanctioned an increase in the graded list of gazetted officers, and the creation of a special post of chemist. The temporary posts for Mining Specialists have been abolished, in order to permit the appointments of permanent officers with a knowledge of mining. In order to assist in the development of the mineral resources of India, Mr. Holland visited during the year certain metallurgical and chemical works in England and Ireland.

Attention is drawn to the occurrence in India of highly aluminous laterites or bauxites that may prove to be valuable as a source of aluminium. Various other ore-deposits and economic products are referred to.

Investigations have been commenced with the view of supplying data on the problem of denudation, by determining the amounts of silt and dissolved salts carried into the sea by the larger rivers of India, and observations with this object were made on the Indus river.

Mr. E. Vredenburg, who was last year appointed Palæontologist to the Indian Geological Survey, has devoted attention to the fossils of the Lower Tertiary formations; Mr. F. R. Cowper Reed has completed an examination of the Devonian fossils collected in the Northern Shan States; and Professor Carl Diener has dealt with the collections of Muschelkalk fossils.

In Petrology assistance has been given by a former member of the staff, Dr. T. L. Walker, now Professor of Mineralogy and Petrology in the Toronto University.

Field-work was carried on in the Andaman and Nicobar Islands, in Baluchistan, Burma, Central India, and Kashmir, and the results of many interesting and important observations are summarized.

REVIEWS.

I.—The Scenery and Geology of Devonshire.

The History of Devonshire Scenery: An Essay in Geographical Evolution. By Arthur W. Clayden, M.A., Principal of the Royal Albert Memorial College, Exeter. 8vo; pp. viii, 202, with 43 illustrations. (Exeter, J. G. Commin; and London, Chatto & Windus, 1906. Price, 10*s.* 6*d.* nett.)

The Geology of Devonshire. By W. A. E. Ussher, F.G.S. Victoria History of the Counties of England. Devonshire, vol. i, pp. 48. (London: Archibald Constable & Co., 1906.)

The Hills and Valleys of Torquay: A study in Valley-Development and an Explanation of Local Scenery. By A. J. Jukes-Browne, B.A., F.G.S. 8vo; pp. viii, 104, with 7 plates (pictorial views), and 12 maps and diagrams. (Torquay: published by the Author, Floriston, Torquay, 1907. Price 3*s.* 6*d.*)

To those who have been accustomed to wield the hammer, there can be little doubt of the popularity and attraction of that branch of geology which deals with the sculpture of the earth's surface. The