other hand, in Cape Colony and Natal there are evidences of a folding of Post-Karoo age which is not represented in the Transvaal. If a comparison between regions so widely separated as the Southern Transvaal and the Cape be of any value, there seems more probability of the Rand Beds belonging to the Malmesbury Group than to any newer formation.

NOTICES OF MEMOIRS.

I.—The so-called Lode Formations of Hannans, and Telluride Deposits, in Western Australia.[1] By H. P. Woodward, Assoc. M. Inst. C.E., Memb. Inst. M. & M., F.G.S., etc.

HANNANS, as it was originally called, was named after the discoverer, Patrick Hannan, but its name has been recently changed by the Government officials to Kalgoorlie, the native name of a small hill that is situated close to the township. It is about 400 miles from Perth by railway, in the East Coolgardie Goldfield; this field is the smallest, but at the same time it produces the largest quantity of gold of any in the colony. A solid block of country has been taken up upon gold-mining leases, of about 10 miles in length and 2 miles in width, comprising over 700 leases, of which some ten produce almost the entire output of gold of the district.

The great discovery of the district was made at a point about 4 miles south of the township, where a group of mines is being worked which bids fair to equal the richest known mines in the world.

Geology.—The flat surface of the country is covered by a deposit of red loam, beneath which in some places a considerable thickness of blue clay is met with, whilst near the hills it is of only slight thickness. This clay rests directly upon the auriferous series, fragments of which, associated with ironstone and a little quartz, are strewn over the surface, and constitute the dry-blowing patches.

The low range of hills which extends from Kalgoorlie to the Boulder, consists of hard, fine-grained hornblendic schists, intersected by numerous diorite dykes, the whole being capped in many places by deposits of ferruginous claystone.

The rocks, like most of those occurring in Western Australia, do not appear to be of sedimentary origin, but most probably owe their stratified appearance to crystallization under pressure; and they have since been crumpled into a number of anticlinal and synclinal folds, the strike of the axial planes of which is a few degrees west of north.

Lodes.—The lodes or formations, as they are called, are decidedly peculiar, consisting, as they do near the surface, of an indurated mottled ferruginous claystone, which has proved in places to be extremely rich in gold; but, strange to state, where such was the

[1] From the Transactions of the Institution of Mining and Metallurgy, October 20, 1897.

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case, little or no gold upon the surface was discovered, clearly proving that no denudation has taken place since the gold-bearing portions of the lodes were uncovered. One of the characteristic features of the Western Australian goldfields is the almost total absence of alluvial deposits containing gold. Those surface patches which have been worked owed their origin entirely to atmospheric agencies, which have also often altered the rocks and lodes to a considerable depth from the surface. Another peculiarity of the Hannan's field is the scarcity of quartz and absence of well-defined quartz veins, thus proving conclusively that the surface gold, which shows no sign of water action, is derived from the weathering *in sitû* of belts of country rock traversed by small but rich veins.

The lodes, when opened up in the decomposed zone, do not exhibit the general characteristics of true fissure veins, since they rarely have defined walls or slicken-sides to prove that any sliding action has taken place, and when they have, such walls are of limited extent. Moreover, it does not follow that all the material which appears to be lode matter between such walls, or between the points at which the solid blue country is met with, is all ore.

The whole lode formation has a banded or schistose appearance and is mostly of a brownish colour, due to the presence of hydrated oxides of iron; and it is soft and greasy to the touch, owing to the fact that it consists largely of hydrated silicates of alumina and magnesia.

Small decomposed quartz veins, which are often ferruginous, intersect the lode mass, and it is where these are met with that the lode is found to be richest, all the coarsest gold being associated with the quartz. When these veins are entirely absent, little or no gold is met with; and when it does occur, it is in a very finely divided state disseminated throughout the entire mass.

At the surface, the lodes apparently run in a more or less north and south course; and since there is not a continuous outcrop, an individual lode cannot be traced with the slightest degree of certainty for any great distance. This is further rendered difficult by the fact that several of these lodes are often met with close together, and following apparently the same course, or nearly so, as the lode which it is desired to follow.

There appear to be few continuous lodes, most of them proving to be lenticular. These lenticular masses are found to lie one on another in splice fashion; therefore, when one pinches, if a cross-cut is driven east and west, one or more lodes are almost certain to be cut at no great distance from that which has pinched; but although such lode or lodes may, to all appearances, contain similar material, it does not follow that it will be as rich in gold. The rich ore appears to run in well-defined shoots, which dip to the south, varying in width from a few inches to several feet, and in length up to several hundred feet; the entire mass of which mostly goes from 3 to 4 ounces, whilst large portions are often as rich as from 10 to 20 ounces.

This decomposed zone in the lode varies in places from 50 feet

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to 300 feet from the surface; the greatest depths to which it has extended in many cases correspond with the richest portions of the lodes.

In the mineralized portions of the lode, a great change in its character is to be noticed, and it has, if anything, still less the appearance of a true lode than that nearer the surface; however, it continues to be equally as rich, but the gold, instead of being free, occurs in the form of a telluride. The ore is a bluish-green siliceous rock, often thickly studded with minute crystals of pyrites, and intersected by quartz veins, which are the richest portions of the lode; but here, as in the decomposed zone, the gold is found to extend often for a considerable distance into the mineralized rock upon either side of these veins.

Portions of this rock, taken from near the quartz veins, often contain large quantities of small crystals of telluride of gold, pyrites, calcite (which also occurs in veins and vughs), and probably serpentine, thus presenting an entirely different composition from the hornblende and felspar rocks which constitute the country rock, but into which it merges so gradually that it is impossible to say where one ends and the other begins.

The tellurides are met with as veins, splashes, and minute crystals disseminated throughout the entire mass. In the first of these forms, they appear to have been deposited subsequently to the quartz, for the veins intersect the latter, often filling right-angle cracks in them, which, when encountered, make a great show, since they may be seen in places all the way down the side of a shaft for 40 or 50 feet as veins several inches in width, but which upon being broken into only prove to be of slight thickness, with quartz behind them. Fortunately this is not invariably the case, for in many instances small solid veins of the tellurides, quite independent of the quartz, have been traced for a distance of 60 or 70 feet.

Origin of Lodes.—With regard to the origin of the lodes, the only explanation that is tenable is that advanced by Dr. Penrose in his Report upon the origin of the Cripple Creek lodes. This is, that a series of fissures has been formed without any yawning, gaping, or faulting, up which highly heated mineral solutions were forced which permeated the country rock on either side of these cracks, dissolving out certain of its constituents, and replacing them by others, thus altering the nature of the rock to a large extent near the fissure, and gradually less further and further from it until no alteration at all has taken place, and the country rock has remained in its original form.

When a number of these veins are met with, following the same general course, and at no great distance from each other, mineralization has taken place over a greater extent, thus presenting the appearance of a large lode, whilst when only one occurs, the zone of alteration is of course limited, and therefore the lode is said to be small or to pinch. It is almost needless to mention that the richest portions are almost invariably met with at the most highly mineralized points, and hence where the lodes are largest.

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The depth to which the zones of decomposition occur vary very greatly, even in a short distance, and bear no relation to the surface contour or to the water-level of the country. At the same time, when the matter is carefully examined, the reason is apparently clear.

The rocks of the district, except in the immediate vicinity of the lodes, have undergone very little change, since they often outcrop, forming bold rough hills, which are strewn with solid masses of rock. When such is the case, and a lode-cap is cut, upon sinking to, say, 50 feet from the surface in the solid ground, it is found to have undergone little or no alteration, which is clearly due to the protection it has received by the 50 feet of solid rock above it that may be said to have hermetically sealed it.

On the other hand, when large rich lodes outcrop, the oxidizing action has followed gradually down the same channels, up which the mineral matter found its way, and has altered it to a considerable depth; whilst in those portions which were poor, and not so highly mineralized, little or no change has taken place, even in the same lode and at the same levels.

The gold in the oxidized zone is clearly derived from the decomposition of the tellurides, since the gradual change from one into the other has been traced, whilst, further, the pyrites proves to contain little or no gold.

II.—Differentiation in Igneous Magmas as a Result of Progressive Crystallization.[1] By J. J. H. Teall, M.A., F.R.S.

CRYSTAL building in an originally homogeneous igneous magma necessarily produces differentiation into portions of different chemical composition, a fact the importance of which was first impressed upon the author sixteen years ago in studying the andesitic lavas and their associated quartz-porphyry dykes in the Cheviot district.

As is well known, Professor Rosenbusch has classified the common constituents of igneous rocks into (1) the ores and accessory constituents (including magnetite, etc.), (2) the ferro-magnesian constituents, (3) the felspathic constituents, (4) free silica; and has maintained that members of group (1) are the first to form in the process of crystallization, and that while there are irregularities of order between members of group (2) as compared with those of group (3), yet the members of these groups separate out *inter se* in the order of increasing acidity. This order of crystallization has been emphasized by many writers, though it has also been clearly recognized that the law is not constant in different magmas and under different conditions. The object of the present communication is to call attention to what is at least an important exception to this law.

Among an extensive series of rocks and fossils collected by the

[1] Abstract of a paper read at the British Association, Section C (Geology), Toronto Meeting, 1897.

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Jackson-Harmsworth expedition in Franz Josef Land, recently examined by the author and Mr. E. T. Newton, are many basalts essentially composed of labradorite, augite, and interstitial matter, in which labradorite formed first, then augite, and last of all the interstitial matter, either with or without further differentiation. The main interest of these rocks lies in the composition and relations of the interstitial matter. This is occasionally present as a deep brown glass, but more often is represented either by palagonite or by a turbid and more or less doubly refracting substance crowded with skeleton-crystals of magnetite. In many specimens it is only in this form that the magnetite occurs, the labradorite and augite being free from inclusions of this mineral. These facts prove that magnetite may belong to a very late stage of consolidation, and that progressive crystallization may lead to a concentration of iron-oxides in the mother liquor.

The palagonite appears to have been formed by the hydration of a deep-brown glass. An analysis was made of it with the following results :—

	I.		II.
Silica	35·48	...	42·88
Titanic acid	nil	...	—
Alumina	8·30	...	10·03
Ferric oxide	12·30	...	14·87
Ferrous oxide	14·60	...	17·65
Lime	1·04	...	1·26
Magnesia	7·10	...	8·58
Soda	3·92	...	4·73
Potash	trace	...	—
Loss on ignition	16·80	...	—
	99·54		100·00

In the second column the water is neglected, and the percentage composition of the remaining substances indicated. The analysis confirms the view that a great concentration of iron-oxide has taken place, and suggests the further conclusion that there has been a concentration of magnesia and a reduction of the lime, silica, and alumina, thus agreeing with the results of the microscopic examination.

Several observers are quoted by the author as having established the fact that magnetite is not always one of the earliest minerals to form, and in basalts of the Franz Josef Land type there is clear evidence that a basic magma may consolidate without any separation of this mineral, although the mother liquor may contain 30 per cent. of iron-oxides.

Brögger, Vogt, and others have observed a tendency in certain dykes for the molecular groups of which the first-formed minerals are built to migrate towards the cooling margins. The cases examined are mostly those of intermediate rocks, in which the basic minerals are the first to form, so that the margins are more basic than the central parts. But it appears probable that cases occur in which the opposite is true. If the magma of the Franz

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Josef Land basalts had cooled slowly in a fissure, we should expect to find the central portion of the dyke richer in iron-oxide than the margin. Professor Lawson has described two basic dykes from the Rainy Lake region, where this is actually the case, and a more striking illustration is seen in the Taberg iron-ore mass, described by Sjögren and Törnebohm, where the marginal portion of an eruptive mass about one square kilometre in area is formed of olivine-hyperite containing only small quantities of magnetite and olivine, and this passes inward by gradual stages into a magnetite-olivinite without plagioclase.

In conclusion, it is asked whether the metallic iron, which occurs as interstitial matter in some of the Greenland basalts, may not have been formed by the reduction, by included organic matter, of the iron-oxides previously concentrated by progressive crystallization.

III.—Drift Phenomena of Puget Sound and their Interpretation.[1]

By Bayley Willis.

THE area from which the facts for this discussion were collected is the Tacoma quadrangle of the United States topographical survey, comprising the district east and south of Seattle and Tacoma. The major topographic features are the channels of the Sound and the strictly homologous valleys now filled with alluvium. These divide, and in some instances surround, plateau-like elevations composed of stratified and unstratified drift that rise about 500 feet above the sea. On the slopes of the adjacent foot hills of the Cascade Range, drift deposits occur up to and beyond 1,700 feet above the sea. Various features of the Glacial-derived topography have been traced out in detail, including characteristic till surfaces, morainic zones, kames, and overwash plains. The distribution of these features indicates that at least the latest Glacial advance was along the valleys and channels of the Sound, and that glaciers rose above and overflowed the margins of the plateaus. The materials of the drift are to a large extent granite, and bear evidence of prolonged water transportation. A distinct variety of till, containing numerous erratics of Tertiary volcanic origin, was found in localities to which it was probably brought from the local centre of glaciation, Mount Rainier. The relation of these local Glacial deposits to the general drift indicates that the prevailing drift phenomena were due to glaciers which penetrated from the north as far south as the foot hills of Mount Rainier, thirty miles south-east of Tacoma.

The detailed examination of the various features of the drift suggests the hypothesis that the channels of the Sound are the hollows remaining after repeated Glacial occupation of a wide valley formerly diversified by the valleys and ridges of Pre-Glacial topography. In the course of repeated Glacial advance and retreat the earlier divides were built upon and transformed into plateau-like

[1] Abstract of paper read before the British Association, Section C (Geology), Toronto, 1897.

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eminences of Glacial drift, whereas the occupation of the valleys by Glacial ice, particularly in the stagnant stages of retreat, prevented their being permanently filled; with the final retreat of the ice the molds of glaciers remained as the channels of the Sound. This hypothesis is to be contrasted with that of erosion, due to repeated uplift and subsidence.

IV.—Life-Zones in the British Carboniferous Rocks.—Report of the Committee, consisting of Mr. J. E. Marr (Chairman), Mr. E. J. Garwood (Secretary), Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Dr. Wheelton Hind, Dr. G. J. Hinde, Mr. P. F. Kendall, Mr. R. Kidston. Mr. J. W. Kirkby, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. G. H. Morton, Professor H. A. Nicholson, Mr. B. N. Peach, Mr. A. Strahan, Dr. Traquair, and Dr. H. Woodward, appointed to study the Life-Zones in the British Carboniferous Rocks. (Drawn up by Mr. Garwood.)[1]

In consequence of the early date on which it is necessary to submit reports, little work has been done this year up to the present time, but it is hoped that during the summer months progress may be made with the work of the Committee, and collections may be obtained from localities of special importance.

At present a collector is engaged upon the fauna of the Millstone Grit at Eccup, five miles north of Leeds, where a fossiliferous black shale has been met with during the excavation of a puddle-trench for a reservoir, The bed occurs about the centre of the "Middle Grits" of the Yorkshire Millstone Grits.

The bed, which was discovered by Mr. Percy Kendall, some three years ago, contains a rich marine fauna, which has not yet, however, been properly worked out. The fauna includes species of *Nucula* and *Leda* in great abundance and in excellent preservation, also numerous individual specimens of *Lingula* and *Discina*. Gasteropods occur, and a few specimens of *Goniatites*, together with well-preserved specimens of *Conularia*. Several specimens of *Dithyrocaris* have been found, and a single specimen of a minute Trilobite, cf. *Brachymetopus Ouralicus*. Fish-remains referable to two genera have been identified.

The fauna appears to bear little resemblance to that of the Cayton Gill beds of Nidderdale, which lie at approximately the same horizon in the Millstone Grit. On the whole, the fauna appears to resemble in many points that of the Ridsdale Ironstone shale of the Bernician beds of South Northumberland. The Committee hope that the information obtained from this deposit will be of value, in consideration of the comparative neglect with which the fauna of the Millstone Grit has hitherto been treated.

Owing to the temporary nature of the exposure, the Committee considered it advisable to expend a considerable portion of the grant in obtaining the services of a competent collector, who has spent

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a fortnight in making as exhaustive a collection as possible from the locality, under the superintendence of Mr. Percy Kendall. The accounts have not yet, however, come in, and the Committee cannot therefore at present draw upon the grant generously placed at their disposal by the Association, but ask that the sum granted may be carried over to next year. They also ask that a similar sum may be granted for that year.

The Secretary has been in correspondence with the various members of the Committee as to the best methods of forwarding the objects of the Committee. From many of these he has received valuable suggestions; and it is hoped that reports will be furnished at an early date from each of the members for special districts, giving detailed sections of the rocks in their individual areas, and stating what reliable information has already been collected regarding their fossil contents, and what yet remains to be done in this connection.

REVIEWS.

I.—A Memoir of William Pengelly, of Torquay, F.R.S., Geologist; with a Selection from his Correspondence. Edited by his Daughter, Hester Pengelly, with a Summary of his Scientific Work, by the Rev. Professor Bonney, F.R.S., F.G.S., Honorary Canon of Manchester. 8vo; pp. xii and 342, with a Portrait and 10 plates. (London: John Murray, Albemarle Street, 1897. Price 18s.)

IF it be true that "there's a divinity that shapes our ends, rough-hew them how we will," it is also a trite observation that the physiography and geology of a man's birthplace and early home often exercise a most powerful influence upon his character and career in after life.

Take the case of Hugh Miller, born at Cromarty, with the sound of the sea for ever in his ears. His father, an owner of some small vessels employed in the coasting-trade, was drowned when the boy was only five years old. Subsequently Hugh was apprenticed to a mason. Who can doubt that the environments of the boy helped to form the thoughtful, self-reliant man and the geologist?

In like manner William Pengelly, the subject of the present volume, being born at the fishing village of East Looe, in Cornwall, went to sea with his father and followed for years the life of a sailor-boy. Here, too, as in Hugh Miller's case, the surroundings of his early days doubtless helped to impart that geological bias to his thoughts, that vigour and energy to his mind and body, for which he was subsequently distinguished.

For an agreeable and instructive "Life" of this eminent man of science, the well-known Torquay geologist, we are indebted to his younger daughter, Miss Hester Pengelly. The adventures of his hardy boyhood are of necessity autobiographical. For later years his wife's letters to her mother and her invalid sister in part supply

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