The surface zones of the globe : a handbook to accompany a physical chart / by Keith Johnston.

THE SURFACE ZONES OF THE GLOBE

BY

KEITH JOHNSTON, F.R.G.S.

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Geographical Works

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3 Asia	9 Ireland	14 Australia
4 Africa	10 Central Europe	15 New Zealand
5 North America	11 India	16 Palestine
6 South America		

THE SURFACE ZONES OF THE GLOBE.

A HAND-BOOK

TO ACCOMPANY

A PHYSICAL CHART.

BY

KEITH JOHNSTON, F.R.G.S.

WITH TWO MAPS AND SIX ILLUSTRATIONS.

W. & A. K. JOHNSTON,

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CONTENTS.

		Page
1.	THE SURFACE ZONES IN GENERAL, AND THEIR CAUSES	5
2.	THE EQUATORIAL FORESTS	14
3.	THE TROPICAL PASTORAL LANDS	17
4.	THE DESERTS	21
5.	THE TEMPERATE PASTORAL LANDS	47
6.	THE TEMPERATE FOREST REGIONS	59
7.	THE TUNDRA REGIONS	70
8.	THE ICY POLAR REGIONS	73

Illustrations.

1.	DIAGRAM OF THE SURFACE ZONES, TO FACE PAGE	11
2.	DIAGRAM OF THE SURFACE ZONES ON THE SUPPOSITION OF A CHANGE OF 90° IN THE POSITION OF THE EARTH	11
3.	PRIMEVAL FOREST OF THE AMAZONS	16
4.	TROPICAL PASTORAL LANDS OF SOUTH AFRICA	20
5.	THE SAHARA DESERT	24
6.	TEMPERATE PASTORAL LANDS, THE AMERICAN PRAIRIES	50
7.	NORTHERN FORESTS—VIEW IN CANADA	62
8.	VIEW IN THE ARCTIC REGIONS	76

THE SURFACE ZONES.

We are accustomed to associate different countries of the world with broadly characteristic landscapes—North America with 'backwoods' and 'prairies;' Asia with 'steppes' and Siberian forests; Africa with sandy deserts; and South America with rich tropical vegetation. These landscapes appear in great belts, more or less regular in form, surrounding the globe from the equator to the icy poles. Without considering the particular species of plants, or the more minute details of the forms of natural life which occur in these belts, and which may differ in one continent from another, there is a resemblance in character throughout the whole extent of each zone, whether of forest, or pasture, or desert, which cannot be mistaken. Any one, unskilled in botany and zoology, if blindfolded and set down in a tropical forest, would not be able to tell whether he was in the Amazons valley, or in Central Africa, or in an island of the East Indies; or, in the pastoral zone, he could not distinguish from the landscape alone, whether he stood in the midst of an Asiatic steppe or an American prairie.

In the large diagram of the world, which this Hand-book is intended to accompany, the regions occupied by each of these characteristic landscapes have been marked out in tints approaching those which may be considered to represent their broad natural colouring, if seen from a great height above

them. For the lands in which deciduous forests are the general covering a dark green has been chosen, for the deserts a hot yellow brown, and for tropical vegetation a bright green, while the grass-covered belts between these are shown in paler green. It is not to be understood, in looking at this diagram, that in every case the particular kind of surface which is indicated is limited precisely to the outline of the colour which represents it, for in general these features merge gradually one into the other: the trees of the forest lands become smaller and more scattered as the steppes are approached, and the grass again becomes stunted and dry on the borders of the sandy waste; but, on the other hand, in many parts of the limits of these different regions, a hard and fast line has been set by nature, beyond which neither form of covering may pass to encroach on the other.

Here we hope to show that these surface zones are compelled, in their shape and appearance, by the unequal distribution of heat and moisture over the globe alone: that their distribution results from that great process of circulation which is constantly going on between sea and land, in which the vapours drawn up by the sun's heat from the ocean are carried by the winds over the continents, to be distilled there in rain, and to return again to the sea by the rivers; combined with the heating power of the sun, as influenced and modified by latitude and elevation, and by the currents of air and sea. With such punctuality do these forces work together, that every region of the globe, it is believed, receives very nearly the same average (greater or less) amount of heat, and the same amount of moisture from year to year, and hence it is, that the limits of each surface belt are so clearly defined. Thus also, when meteorology shall have accumulated a greater store of facts from a much greater number of points than at present, it may

be possible to predicate with certainty, that within given limits of annual and daily temperature, and deposition of moisture, a certain nature of surface will present itself.*

Wherever great moisture and great heat are found together throughout the year, there luxuriant vegetation appears. In the tropical regions of the globe, to which the great equatorial currents of the sea, and the trade winds blowing constantly from the east, carry the vapours drawn up by the vertical sun from the ocean, the forests of the East Indies, of Central Africa, and of South America appear. This is the great central landscape zone. Those occurring on each side of it appear in duplicate, and are found in corresponding positions in both hemispheres.

Wherever great drought prevails, and the deposition of moisture throughout the year is reduced to little or nothing, there the deserts appear. Generally these are found on the borders of the tropics, where the sun in its apparent movement north and south during the year, remains longest in a vertical position over the earth, and where, in consequence, the heat is greatest of all; but deserts are also found beyond this general belt, as in Central Asia and North America, where they are produced by dryness alone. Corresponding to the great representative deserts of the Sahara and of Arabia in the northern hemisphere, are the dry regions of Australia, of South Africa, and of South America, on the borders of the southern tropical line.†

* The chart was constructed and printed some considerable time before the news of Livingstone's great discoveries in Central Africa, westward of Tanganyika, arrived in this country. In consideration of its probable meteorology, the whole space of the unknown region of Central Africa, between Tanganyika and the west coast, had been coloured as tropical forest. The reports (quoted at p. 15) abundantly prove the accuracy of this generalization.

† In the descriptions given of the desert lands of the globe, nothing is more frequent than to have these compared to former sea-beds; or, going

Where the great westerly currents of the sea and of the air, the 'anti-trade' winds, begin to prevail in both hemispheres, carrying great volumes of moisture over the lands which occur in the directions towards which they move, forests again appear, but these are now of a different character, hardier and less luxuriant in their growth, since, in these latitudes, the sun's rays are weaker, and the average temperature is less. The great forests of North America and of Siberia, represent this belt in the northern hemisphere. The southern hemisphere has only a small proportion of land extending into the climate in which temperate forests occur; but wherever there is such land in the southern half of the globe, there again are forests similar in character and aspect to those of the northern belt; in the extreme point of South America, in Tasmania and New Zealand, and just touching upon the Cape of Good Hope.

Between these great primary belts, in the regions of transition from the moist climates of the equatorial and temperate forests, to the excessive drought of the deserts, the natural grass lands of the globe appear in double belts, one on each side of the deserts in each hemisphere.

Beyond the temperate forests nearer the poles, where, though moisture is not absent, the heating power of the sun's slanting rays becomes very small, there is not sufficient warmth

further, to find the opinion stated, that these regions have, in recent geological times, been beneath the ocean. The salinity, also, of many parts of their surface is frequently ascribed to this, and is given as the cause of their barrenness. But no explanation of their origin could be more erroneous, since, in every part of the desert zone where moisture is introduced, either naturally by rivers or artificially by canals, there luxuriant vegetation springs up, showing clearly that dryness alone is the cause of the desert; and it is probable that every salt-encrusted portion of the true desert surface throughout the world can be shown to be the dried up bed of some continental lake, fed by fresh streams.

for tree growth, the soil is permanently frozen to a great depth, and a sprinkling of mosses and lichens is the only covering of the land. These are the 'tundras' of Siberia, and the barren regions of North America, which would doubtless be represented in the southern hemisphere also, if any land existed there in the latitudes of their climate. Approaching the poles in both hemispheres, where cold reigns supreme, ice covers the sea and glaciers stretch over the land.

Since the temperature of the air decreases as we ascend from the level of the coast line (in the proportion of about 1° Fahrenheit for each 300 feet of rise), it follows that at certain elevations the average temperature limits of each of the great surface zones may be reached, and the nature of the covering of a mountain between certain heights may be expected to correspond with that of the land to poleward of its position, between certain latitudes. Thus, in ascending a mountain near the equator, when that height has been reached, the climate of which corresponds to that of the temperate forest zone, the covering of the mountain should be of similar character to that of the northern belt. To a great extent this proves true, and there are mountains in which each landscape zone is represented, from the rich vegetation of the tropics at the base, to the snow and glaciers of polar regions at the summit. It is to be remembered, however, that a mountain in the region of tropical forests must remain throughout its elevation in a zone of great moisture, so that only those forms of covering which are produced between the extremes of heat and cold and of moisture, not of drought, can appear on its slopes. The volcano of Agua (13,200 feet high), in Guatemala, for example, is clothed with forest from base to summit, tropical forest beneath and noble pine trees above. Again, a mountain in the desert zone might be expected to continue bare, and with-

out any form of vegetation, to its summit; but another cause here frequently comes into operation. The deserts occur in regions towards which the winds blow from a moister to a drier, or from a colder to a hotter region; the vapours which the winds carry, tend consequently to expand as they advance; but a mountain rising out of the desert belt and intercepting their current, would cause exactly the opposite effect, and the air driven up its slopes into the higher, cooler, atmosphere, would condense and give out that moisture which the lower general level of the region allowed to pass. Hence it is that elevations in the midst of the desert region, causing a rainfall for themselves, are often covered with vegetation in all parts which rise above the general level of the country. Of such mountains the Sahara region presents several examples.

If then it can be shown that wherever certain meteorological conditions are at work on the land of the globe, there certain characteristic forms of surface appear, we are justified in assuming that the landscape belts are completely dependent upon these conditions, and that any change in the method of distribution of heat and moisture over the land would bring about a change in the aspect and covering of its different parts. It may be useful in order to fix the relations of these causes and effects in the mind, to suppose a complete alteration in the bearing of the present meteorological phenomena of the globe upon the existing land. In this we may be doing no more than conceiving the actual relations of these causes and effects at a former period in the history of the globe, since geology teaches that in the course of time vast changes have taken place in the condition of every part of the earth's surface. The presence of coal in the Arctic regions, where only ice and snow now appear, points to a time when these regions must have been covered with luxuriant forest, and the change which we shall suppose restores precisely this state.

DIAGRAM Nº 1.

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DIAGRAM OF THE SURFACE ZONES.

DIAGRAM Nº 2.

Plate II

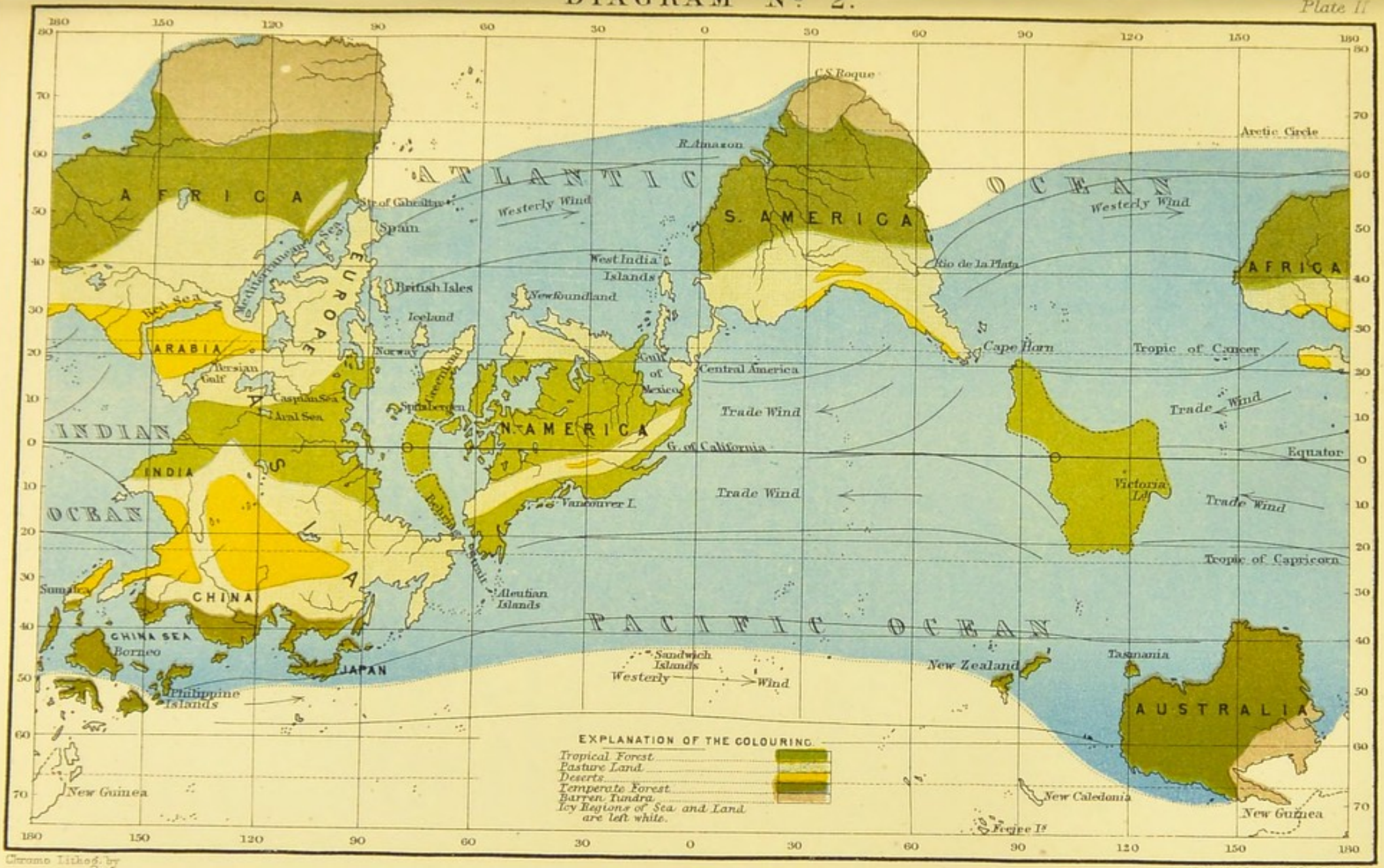

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DIAGRAM OF THE SURFACE ZONES ON THE SUPPOSITION OF A CHANGE OF 90° IN THE POSITION OF THE EARTH.

The first diagram on the preceding page is a rough reduction of the larger chart, and shows the surface belts in the position they at present occupy on the land of the world. In the second diagram the earth is supposed to have turned ninety degrees from its present position, the axis of rotation remaining in exactly the same position relative to the sun, all other conditions of land and sea and atmosphere being the same. Points upon the present equator (in 20° W. and 160° E. of Greenwich) have been chosen to represent the new poles; the actual polar regions therefore fall in the supposed equator of the globe.* In both diagrams the ocean is coloured as far as the line in each hemisphere beyond which no sea ice passes.

Conceiving this change to have progressed very gradually over long periods of time, each belt would have crept southward and northward (turning upon two antipodal points on the equator, in long. 110° W. and 70° E., which do not move), slowly gaining on that side on which the climatic conditions became more favourable, and dying out on the side upon which moisture or temperature failed.

The trade winds would have then taken up some such positions as those indicated in the diagram, blowing from southern Asia towards the Antarctic lands, and thence to North

* This diagram is in every way as correct, or as incorrect, a representation of the globe as the ordinary charts on Mercator's projection or its modifications, and it may serve a number of useful purposes, besides that for which it has been specially drawn. Chiefly it serves to correct the distorted idea of the forms of the continents and their relative positions, conveyed by the projections of the sphere on a flat surface, with which long use has made us familiar, by giving a view, equally distorted, but in precisely opposite directions, showing the regions which are ordinarily expanded to far beyond their true limits, in truer proportions, while those countries which we are accustomed to see fairly represented, are in their turn exaggerated. The relation of the two polar regions to the other parts of the globe, and to each other, are shown here more distinctly than in any other form of map.

America; belts of westerly winds also would blow from Europe to the north coast of South America, and between the estuary of the Plata and South Africa, in the one hemisphere; and between Eastern Asia and Australia in the other; winds of a monsoonal character would blow periodically over Northern Asia and the Arctic basin. We may conceive the Arctic and Antarctic lands to have moved gradually out from beneath their coverings of ice, and to have passed successively through each stage of landscape till they reached the other extreme, entering the moist equatorial region, and becoming covered with tropical vegetation. Tropical forests would, under these new conditions, be transferred to North America, and from Africa and India to a belt of Central Asia. The greatest deserts would probably be found in Eastern Asia and in Arabia, and on the coast-land of East Africa, for upon these the polar currents of air which feed the trade winds would descend, becoming drier as they advanced; temperate forests would have spread outward from the corners they at present occupy to cover Africa and South America in the northern hemisphere; whilst Australia, in a higher latitude in the southern hemisphere than at present, would have become the great representative land of the forests there. The great mountain ranges of the world also, turned now to a position nearly parallel with the greater movements of the atmosphere, not opposed to these as at present, would have lost much of the disturbing power they exert upon the zones in which they occur.

We shall now go on to examine the existing surface zones a little more closely in the order in which they are set out in the following comparative table.

NORTHERN HEMISPHERE. SOUTHERN HEMISPHERE.

(1). The Equatorial Forest Region.

The tropical forests of Central America, of Florida and the West Indies ; the 'Selvas' of the Amazon basin and of Guiana, the forests of Central Africa, of Ceylon, and Southern India ; of Further India, the East India Islands, and of Northern Australia.

(2). The Tropical Pasture Lands.

The 'Llanos' of the Orinoco in South America, the pasture lands east and west of Lake Chad in North Africa, and the Ganges basin in India.

The pasture lands of the Upper Parana and Paraguay river basins in South America, the grassy plains of the Zambezi in Africa, the 'Plains of Promise' in North Australia.

(3). The Deserts.

The 'great basin' of the salt lake in North America and the 'American desert;' the Sahara of North Africa ; the deserts of Arabia and Persia ; the 'Gobi' and the 'Thur' deserts in Asia.

The deserts of the 'Gran Chaco' and the 'Salinas' of the Argentine Republic in South America ; the Kalahari desert in South Africa, and the great interior desert of Australia.

(4). The Temperate Pasture Lands.

The treeless 'Prairies' of North America, the 'Steppes' of South Russia and of Central Asia, and the pasture lands on the borders of Mongolia.

The 'Pampas' of Patagonia, the Argentine Republic, and Buenos Ayres ; the grassy uplands of the north-east of Africa ; the 'downs' of Australia.

(5). The Temperate Forests.

Forests of British North America, from Aliaska to Canada and Labrador ; the woods of Sweden, Norway, and Russia, and the forests of Siberia.

The forests of South-Western Patagonia and of Tierra del Fuego, of Tasmania and New Zealand.

(6). The Barren Tundra Regions.

The 'barren grounds' and 'sterile regions' of North America, of Iceland, and the 'Tundras' of Siberia.

Kerguelen Island, in the South Indian Ocean, sterile and moss-covered.

(7). The Icy Polar Regions.

The Arctic region.

The Antarctic region.

I. THE EQUATORIAL FORESTS.

THE 'selvas,' or vast unbroken forests of the Amazons valley, in the northern part of the South American continent, form the main representative area of this region, and the causes to which this zone is due, and which support this enormous growth, are here most completely developed. The whole basin of the Amazon is a plain, one of the most extensive on the globe, crossed by the equator, and its natural surroundings are most perfectly adapted for providing it with a continued supply of moisture. Eastward it opens broadly to the Atlantic, over which the trade winds from north-east and south-east carry to it directly the vapours which they have gathered in their passage over the ocean. Westward rises abruptly the great mountain wall of the Andes, on meeting which, and ascending to the cooler atmosphere of its summit, the moist winds are condensed in a copious rainfall, and provide a never failing supply of water for the great rivers of the plain.

Inundated tracts are frequent; and over these there is the most dense and impenetrable vegetation of umbrageous trees of the most varied species, and underwood matted together by creeping plants. The basin of the Amazon comprises an area of about two millions of square miles, or is nearly ten times the extent of France; yet the forests extend beyond this, northward over the Parime mountains and Guiana, to the coast of the Atlantic, along the isthmus of Panama and over Central America to the base of the high plateau of Mexico, across the whole chain of the West India Islands and Southern Florida.

Southward they stretch out from the Amazon basin along the plain next the inward descent from the highlands of Bolivia and thence into the north-western provinces of the Argentine Republic, round the Atlantic slope of Brazil to the Beira-mar in the province of Bahia, down the valleys of the Upper Parana and Paraguay rivers, carried south in narrower belts along the margins of the river courses.

The portion of this forest zone which falls in Africa seems to occupy that region of the continent, the outskirts of which have only been reached as yet by travellers; but this includes the whole of the country which lies westward of the Nile lakes, to as far as the Atlantic coast; and from the pasture zone round Lake Chad in the north, to near the upper water parting of the Zambezi southward. The vegetation in some of the western tributary valleys of the Nile, below the lake region, is described by the elephant hunters, who have penetrated these regions, as excessively luxuriant; the paths lead through long galleries in the forest, darkened by the rank overgrowth of great trees, with underwood and creeping plants between, rich in animal and insect life of every form and colour. On the west coast the portions of this zone which have been visited are the dense and gloomy forests of the gorilla country. Livingstone is the only traveller who has penetrated these from the eastern side. In describing the primeval forest of the Manyuema country, west of Lake Tanganyika, he says,* 'Into these the sun, though vertical, cannot penetrate, except by sending down at mid-day thin pencils of rays into the gloom. The rain-water stands for months in stagnant pools, made by the feet of elephants, and the dead leaves decay on the damp soil and make the water of the numerous rivulets of the colour ot strong tea. The climbing plants, from the size of a whip-cord

* Despatches to Foreign Office, 1870-72.

to that of a man-of-war's hawser, are so numerous, that the ancient path is the only passage. When one of the giant trees falls across the road, it forms a wall breast-high, to be climbed over, and the mass of tangled ropes brought down makes cutting a path round it a work of time which travellers never undertake. . . . The trees are so high that a good shot-gun does no harm to parrots or guinea-fowls on their tops; and they are often so closely planted that I have heard gorillas, here called "sokos," growling about fifty yards off without getting a glimpse of them.' Every word of this description, excepting the references to animals, might apply equally to a Brazilian or an East Indian forest.

The mysterious silence of these primeval woods have been graphically described. 'We often read in works of travel of the silence and gloom of the Brazilian forests. They are realities, and the impression deepens on longer acquaintance. The few sounds of birds are of that pensive or mysterious character which intensifies the feeling of solitude rather than imparts a sense of life and cheerfulness. Sometimes, in the midst of the stillness, a sudden yell or scream will startle one. Morning and evening the howling monkeys make a most fearful and harrowing noise.'*

The forest appears again in the lower portions of the island of Madagascar, in the Mauritius, in the tropical vegetation of the coasts of Oman in Southern Arabia, in the forests of the Lower Himalaya and of the Western Ghauts of India, of Ceylon, Further India, and the East India islands. It is especially developed in the islands of Sumatra, Borneo, and New Guinea, and touches on the northern coasts of Australia, in the mangrove woods of the Gulf of Carpentaria.

* Bates, 'The Naturalist on the Amazons.' The illustration on the opposite page is taken, by permission, from Mr Bates' work.

From Bates "Naturalist on the Amazon."

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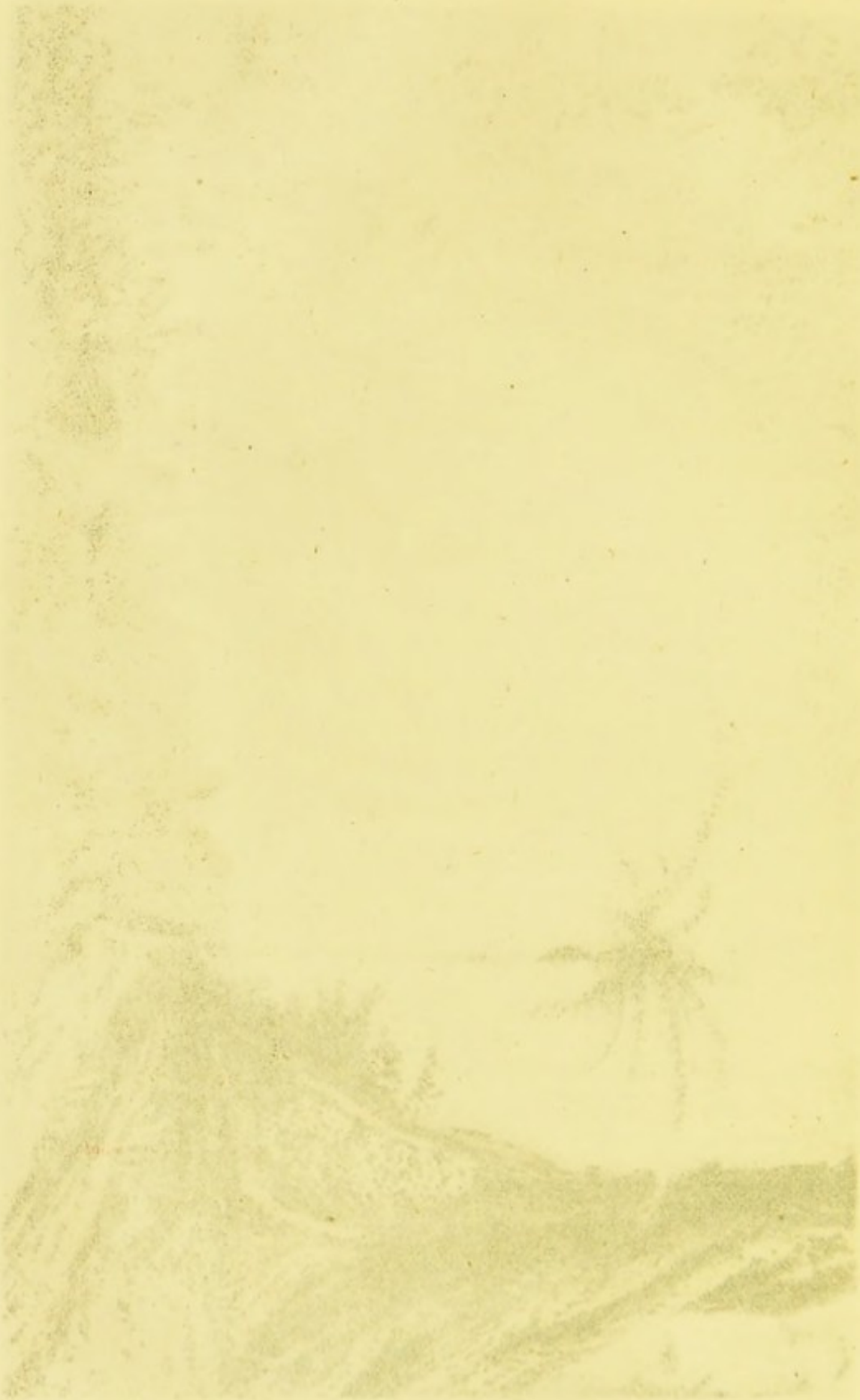
PRIMEVAL FOREST OF THE AMAZON.



The whole of the islands of the Pacific, within the tropical lines, may be said to continue and complete the circuit of this zone in so many separate points.

Seeing that the existence of this belt of luxuriant vegetation is the consequence of excessive heat, accompanied by moisture, it will be observed that it broadens itself out in those parts of it which appear in islands, isthmuses, and peninsulas, and along the banks of rivers, and that it becomes more contracted in width in the continents. The temperature of the equatorial forest zone is high, but it is in the bare deserts on the borders of the tropics, not here, that the greatest heat of the globe is experienced; the limits of average annual temperature of different parts of this belt probably lying between 75° and 85° Fahr., and the variation of temperature throughout the year being exceedingly small. The dense covering of vegetation is in itself the chief cause of this diminution of range of temperature, protecting the land beneath from rapid heating or cooling, and reducing evaporation. The rainfall of this zone seems to have its limits between a minimum of 50 inches in the year, and the highest known rainfall,* but recorded observations are few.

II. THE TROPICAL PASTORAL AND AGRICULTURAL LANDS.

1. The Northern Belt.

The representative portions of this zone in North America are pushed considerably out of place by the peculiar distribution of land and sea, and of elevation in the southern portions of this continent. The pastoral and agricultural high plains of the central part of the Mexican table-land, of which the rich district of the 'Baxio' may be taken as the chief, and of the plateau of Guatemala, appear

* About 600 inches, in the Cossyah hills in North Eastern Bengal, the greater part of which falls during the monsoon blowing from south-west.

in virtue of their elevation much nearer to the equator than other portions of the zone which are at a lower level in the continent. These are the prairies of the intermediate elevation of the state of Texas (between the wooded levels along the Gulf of Mexico and the arid salt plains of the northern part of the state), and the cultivated, or grass lands, of the southern states generally, which meet and unite with the prairies of the northern pasture zone in the western watershed of the Mississippi. The low and level 'llanos' of the Orinoco river, surrounded by forests, belong to this zone, but have an exceptional character due to the circumstances of their position. During the rainy season the Orinoco rises to such an extent as to inundate the greater part of the plain (the rise begins in April, is greatest in July, and sinks again in September), when a rich crop of grass springs up over it. For the remaining portion of the year the plain appears to be completely deprived of moisture, being screened from the rain bringing trade winds, by the heights of Venezuela, which lie eastward of it; the grass rapidly withers under the great heat and drought to which it is subjected, conflagrations are frequent, and terrible dust storms arise. From the shortness of the period during which vegetation can proceed, as well as from the above causes, it results that this area is almost treeless in the heart of the forest region.

The portion of this zone which falls in Africa, is well marked by the line of Negro states in Northern Soudan, in and south of the parallel of Lake Chad, where pasture land and park like country, corn and cotton fields, are characteristic of the landscape. The plains of the Benue river are specially rich and fertile, and support large herds of cattle.

In the east, the high table-land of Abyssinia carries an extension of this belt northward to beyond its general limit in the lower central land of Africa; and southward it seems to extend

over a great portion of the less known plateau which continues that of Abyssinia, to as far as the country east of the Victoria Lake, with occasional patches on the Indian Ocean slope.

In Arabia it is represented by the pasture lands of the Nejed, and with their 'countless herds of camels, and sheep droves, that graze throughout its extent,' and by the fertile and thickly peopled plain of Kaseem, both in the centre of the peninsula, and surrounded by the broad margin of outer deserts, owing their fertility to their elevation above the general level of the land. Rain falls here occasionally from November to February or March, and sometimes even heavily. Riad, the capital of the Nejed, is surrounded by the gardens which give it its name.

Next in order, the remains of a former more widely extended cultivation in the valley of the Euphrates and Tigris, connect this plain with the agricultural zone, and lead up to the cultivated districts of the outer southern edge of the plateau of Persia; and to the broad belt of pasture land on this highland which forms the southern margin of the interior dry salt plains and deserts, and extends into Beloochistan. Shiraz, one of the chief towns in the part of this zone which falls in Persia, is situated in a fertile plain surrounded by extensive gardens. In the Indian promontory, the peninsula of Gujerat, the pasture lands about the Runn of Cutch, the plateau of the Deccan, favourable to the growth of cotton, the vast tracts in its northern districts which are covered with green sward during the rainy season, and the cooler months which follow it, and the Gangetic plain, the most fertile, best cultivated, and most thickly inhabited portion of Hindustan, all belong to this zone.

In Further India the traces of this pastoral belt are nearly extinguished by the extension which the forest regions attain in the peninsula, over which moisture is carried by both mon-

soons; but the cultivated and well peopled valleys of Birma, and of the southern borders of China, may be considered as representing its termination eastward.

2. The Southern Belt.

The tropical pastoral zone, in the southern hemisphere, is most completely developed in the South American continent. Beginning in the eastern portion of Bolivia, and in the maize and wheat-growing valleys of the north-western province of the Argentine Republic, whose hills have rich pastures, and support great numbers of cattle, the belt of pasture-land extends across the llanos of Manso to northward of the desert of El Gran Chaco, and appears in the grassy lowlands of the Upper Paraguay basin, and in the plains of the table-land of the Parana, overgrown with coarse but nourishing grass, which serves as pasture for the innumerable herds of cattle, horses, and mules, that constitute the riches of this portion of Brazil. The lower grounds of the state of Paraguay afford excellent pastures; on the table-lands of Sao Paulo cattle and horses are reared in great numbers; Rio Grande do Sul is also rich in herds, and produces the European grains, vines, and rice. Uruguay contains a vast extent of pasturage, and a large portion of the state has most fertile land, adapted to the greatest variety of productions.

Southern Angola and Benguela, fertile and partly cultivated provinces of Western Africa, belong to this zone, and it continues across the continent between the forests of the equatorial region and the Kalahari desert in the south; it includes the upper basins of the Zambezi and Kassabi rivers, where are the open grassy plains and meadow-like valleys of the Balunda country. The 'Dambos,' or great plains of the Chambeze valley, form part of the belt; and the plateau of Usango, to the north of Lake Nyassa, affords pasturage for immense herds of cattle. The valley of the Zambezi is part of the great natural

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TROPICAL PASTORAL LANDS OF SOUTH AFRICA.

grazing lands of South Africa; buffaloes, giraffes, zebras, and antelopes are in abundance, and elephants and springboks repeatedly show themselves in vast herds to the traveller. The region of the water-parting between the Zambezi and Limpopo rivers is characterised by broad rounded grassy ridges.

Passing on to Australia, the tropical pasture zone is there represented in the margin of grassy plains which surrounds the whole of the northern parts of the continent, supplied with moisture by the north-west and north-east monsoon winds, ceasing entirely where the rain brought by these becomes spent. Such are the Baring Downs, in the northern district of West Australia, the Roe Downs on the Victoria River in North Australia, the 'plains of Promise,' south of the Gulf of Carpentaria, and the frequent 'Downs,' in the northern portion of Queensland.

III. THE DESERTS.

1. In the Northern Hemisphere.

Both in the northern and in the southern portion of the continent of America, the desert zone has a comparatively small development. This is due to the circumstance that just southward of the latitude at which we should otherwise expect to find great deserts in North America, the ocean has cut its way into the continent, and has narrowed the portion of it which lies nearest the tropical line to an isthmus, thereby altering the condition of its climate. South America, in the latitude of the desert zone, begins to become narrowed, so that the sea winds there may carry their moisture nearly across the continent.

The great basin, in the centre of which is the Salt Lake of Utah, is the best known desert region of North America. It comprises a large and separate continental drainage area, at an

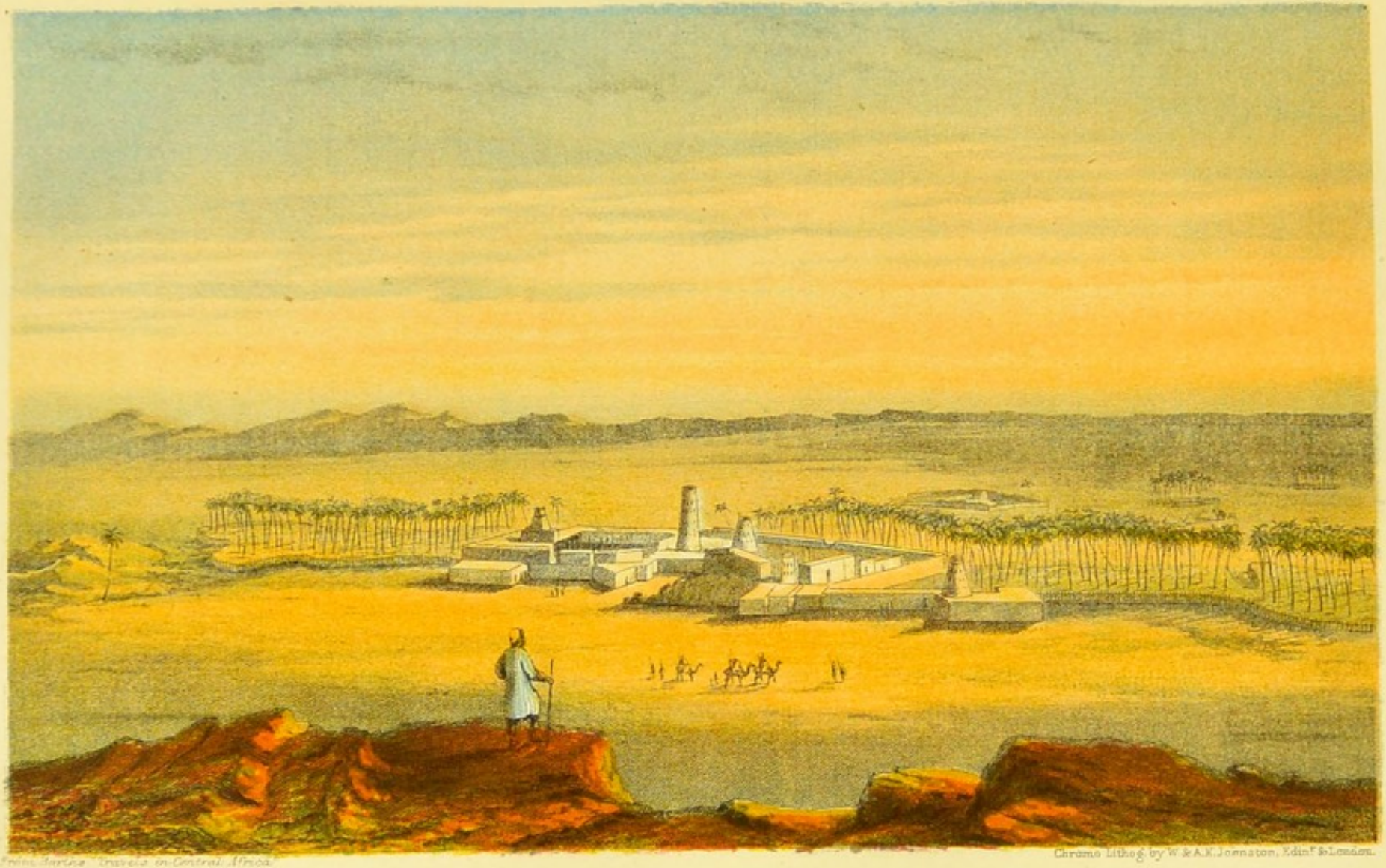
average elevation of 5000 feet above the sea, and extending over more than 300,000 square miles. The whole of this space is more or less completely a desert, of stony and sandy plains, with isolated hill ridges, bearing a few stunted trees, with mud flats, impregnated with salt, and frequent dried up lake-beds. Broad level districts, called by the settlers 'Alkali Flats,' are covered with glistening salts, usually nitrate of soda, and are thereby rendered perfectly barren. This basin, like the greater Gobi desert of Asia, appears at a much more northerly latitude than the average extension of the zone to which it belongs; and its existence must be ascribed to the presence of the greater heights of the Cascade and Rocky Mountains which screen it on both sides from the sea breezes; or, rather, deprive these of their moisture by condensation before they reach the lower basin. A belt of desert, or almost desert land, continues over the surface of the table-land northward of the 'Great Basin,' narrowed between the Cascade Mountains and the Blue Range, and occupies the central part of the plateau here till it joins the plain of the Columbia river, the northmost expansion of the desert in America. This sandy plain, nearly circular in form, and of about 100 miles in diameter, produces only stunted wormwood, no trees, underwood, or grass. Southward on the plateau, the table-land through which the Colorado River and its tributaries have cut their way, also belongs to this zone, for there complete barrenness is the rule, fertility the rare exception. Two depressions in the region westward of this basin, called Mojave desert, and next to the inner side of the Sierra Nevada, are below the level of the sea. One is a large saline flat, a little to the north of the Mexican boundary line, called Soda Lake, 70 feet below the sea-level; another most wonderful depression is Death Valley, or, the Sink of the Amargoza, further north, lying at 175 feet below the sea, and

in the midst of an arid desert. Round the head of the Gulf of California is the parched and sterile country known as the Colorado desert. The rainfall of the Colorado basin is estimated at only three inches annually, that of the Great Basin at five inches. The sterile region extends southward on the plateau into the great mining region of the Northern States of Mexico, forming there a second basin of continental drainage, containing numerous lagoons and dry salt lake beds. The largest lake is that of Mapimi, also called Laguna del Cayman, fed by the most important stream of the basin, the Rio Nasas. The cultivable land of the plain is limited to the banks of the rivers, and frequent gales of cold wind fill the air with immense clouds of dust and saline particles. The western margin of the basin of the Mississippi-Missouri, at the foot of the Rocky Mountain plateau, must be considered as the lower level portion of the desert zone in North America, and this region has been distinctively named the 'American desert.' As far north as the 44th parallel below the Big Shyenne tributary of the Missouri, the 'Mauvaises Terres,' or bad lands begin, and extend in a succession of tongues between the tributary rivers to an average distance of about 150 miles eastward from the base of the highland, till the Llano Estacado in the north-western part of the state of Texas is reached. Sandhills, with saline lakes between, characterise the greater portion of this area; other parts are rolling plains, dry and timberless, useless except for grazing.

The Llano Estacado, or 'Staked Plain,' so named by the Mexicans, who drove stakes into the ground to guide their way across it, is a vast bare wilderness without a single tree; on the west it is bounded by the Pecos River, a main tributary of the Rio Grande, and from its eastern edge there flow the head streams of the Red River, and the rivers of Texas. This vast tract of sandy ground, scantily supplied with coarse grass, is, at

some seasons of the year, totally destitute of water; it covers a space of nearly the same extent as the kingdom of Portugal.

In Northern Africa, the desert zones of the globe have their great representative waste. Just as the forest belt has its greatest development in the Amazon valley, because there the circumstances of position are most favourable, and the causes which bring about vegetation have their greatest power; so, in North Africa, the desert zone is at its greatest breadth, because there, the opposite or drying forces have the sway, and the form of the land is exactly that upon which these causes could exert the greatest influence. From a line drawn from Cape Verd, round the northern bend of the Niger, and thence past the northern side of Lake Chad, across the Nile valley to the northward of the Abyssinian plateau, and to the east coast, the whole extent of land northward to the inner edge of the plateau of Barbary and the coast of the Mediterranean, may be considered as one vast desert, equal in area to the whole of Europe. With the exception of the river Nile, which carries a narrow strip of fertility through the desert on each bank, it has no permanent streams and little water (the greater portion being completely rainless), save in distant wells or springs. It has few inhabitants; many large areas within its limits are completely uninhabited, others are only traversed at intervals by caravans, and stony plains or drifting sand-hills are characteristic of its surface. It is an error, however, to represent the Sahara as an 'ocean of sand, moving, and tossed into billows by every wind that sweeps its desolate surface,' for, throughout its extent, there are scattered 'wadis,' or 'oases,' periodical stream-beds near the outer margins of the desert, or depressions in its general level, in which a little herbage refreshes the eye of the traveller; these spots, or the neighbourhoods of a few more



From Barth's "Travels in Central Africa."

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THE SAHARA DESERT.

elevated, and therefore differently characterized points, are the only seats of permanent population.

The 'oases' occur most frequently in the central portion of the Sahara, within a triangular space, whose apex points to Lake Chad, with its base on the inner side of the highland of Barbary, and this portion of the desert appears to be at a generally higher elevation than the rest, and is broken into plateaux, between, and at the base of which, there are periodical streams. These are the 'Hammada' plateaux, sterile, and stony, and rocky, rather than sand covered. The 'oases' of Tuat and Tidikelt, or of Ghat, represent the inhabited portions of this area. The fertility, and palm growth, of the former valley are ascribed by the traveller Rohlfs, to the existence throughout the wadi of a subterranean river, which rises after the winter rains in the highland (for in Tidikelt, which is only 420 feet above the sea level, no rain whatever falls for years together), and sometimes oozes up to the surface of the soil in spring, though then it is saline. A great part of the waters flowing landward from the plateau of Barbary seem to collect at various points beneath the soil. In the plain of Tuggurt, in the Algerian Sahara, the digging of wells has proved the presence there of an underground lake, called the Bahr-taht-el-erd. The inhabitants dig through several layers of sand and gravel, till they reach a flaky slate-like stone, known always to be above the Bahr. This layer is easily broken through, and the water thereupon rushes up so quickly, that the man who digs through it is sometimes drowned.* The French engineers have sunk many wells in this region, which, however, is only on the verge of the true Sahara. The dryness and aridity of the Sahara are to be attributed, first, to the fact that it lies in the hottest region of the globe; the outskirts of the tropical zone remaining longest be-

* Morell's 'Algeria;' and Wilson, in R. G. S. Journal, 1865.

neath the vertical sun; second, that the winds which reach it, blow, for the most part, from a colder and moister, to a hotter region, and thus become dried in their passage; third, and perhaps chiefly, to its general lowness; clouds, burdened with rain, do indeed pass over the great desert, but the bare flat surface and generally low ridges of hills, present no sufficient elevation to meet and condense their moisture. Where there is a sufficient elevation, even in the midst of the Sahara, there a rainfall takes place, and there is consequent fertility. The oasis of Ghat, before mentioned, is probably the highest inhabited part of the whole of the 'Hammada' region, and is 2400 feet above the sea. Near it there are seven periodical streams, on the banks of which corn is cultivated. The mountains of Tibesti, southward of Fezzan, recently explored by Dr Nachtigal, rising to 7878 feet, form the highest known points of the Sahara. During August, the traveller observed that heavy rain clouds rose daily in the afternoon in the east or northward of the mountains, and frequently broke in heavy showers. In consequence of this, the valleys of the periodical streams, which reach down to the sterile plains beneath, have rich vegetation and beautiful woods of fahla-trees and bushes, enlivened by nesting-birds, apes, and troops of gazelles and antelopes, or afford crops of rank grass and herbage for camels and herds of goats.

The plateau of Air or Asben, north-west of Lake Chad, is also enclosed within the general desert region, but rising to 4000 or 5000 feet above it, enjoys a rainy season in the months of August, September, and October.

The most thoroughly waste region of the Sahara is the great belt of shifting sand hills or dunes, named 'El Erg,' which stretches uninterruptedly from near the Senegal river on the west coast, across the north-western part of the continent, in a line to the Mediterranean coast, between Tripoli and the

plateau of Barbary, a distance of more than 2000 miles. The average breadth of this belt is about 200 miles. The slopes of the plateau of Barbary, to north and south, are fertile; but the central part of the plateau, between its outer ranges, approaches nearly to the condition of a high lying desert. A long line of 'Schotts,' or salt lakes, which receive small streams from the enclosing ridges on each side, appearing in a belt of dry steppe-land, characterize the whole of the broader part of the plateau. Another line of salt lakes occurs beneath the plateau in the southern part of Tunis. The largest of these, named the 'Schott Kebir' (Palus Tritonis), is a depression, appearing at alternate seasons as a marsh of water, or, as a basin encrusted over with a thick deposit of salt. In extent it measures about 2500 square miles. The most westerly of the salt beds in this series, named the 'Schott Melgigh,' is believed to be 45 feet below the level of the Mediterranean. The Libyan desert, a subdivision of the Sahara in the east, is the most completely unknown portion of the region.

East of the narrow interrupting line of the Nile, the desert continues throughout Nubia and Upper Egypt, to the Red Sea. There is no permanent tributary to the Nile below the confluence of the Atbara or Takazze, which flows from the northern portion of the table-land of Abyssinia. This tributary has sufficient strength to maintain a supply of water to the Nile throughout the year, though its volume changes greatly with the season; but the Mareb or Gash, the river which takes its rise next above the Atbara northward, is only able to reach that river in seasons during which there has been an especially abundant rainfall; and the Barca, whose course is to the Red Sea, third in order, and the most northerly river of the plateau, is only a periodical stream.

The low region between the eastern base of the plateau of

Abyssinia and the Red Sea forms a southern and more isolated portion of the desert zone in North Africa. In the northern part of the plain there is a great salt basin, forty-five miles in length from north to south, and twenty miles in width, surrounded on all sides by a high wall, or edge, of gypsum, and depressed about 200 feet below the level of the sea, from which the salt blocks which serve as a money currency in Abyssinia are dug.* At the south end of this basin there is a lake fed by streams from the edge of the Abyssinian plateau; elsewhere the streams form oases in the salt encrusted plain.

Throughout the whole of the Arabian peninsula no river worthy of the name is to be found. The deserts which cover its surface (with the exception of the narrow fringe of inhabited slope of the 'Jebal,' or hill region, round the coast, and the higher portions of the Nejed plateau of the interior, before described as belonging to the lower pasture zone), may be broadly distinguished as the irremediably sterile and desolate sand desert of the south, and the stony, or gravelly deserts of the north, presenting in a greater or less degree, those conditions which allow a possibility of life and vegetation, and never wholly destitute of them.† Throughout this northern region lines of wells mark the course of subterranean streams, and water is generally to be obtained by digging; the great frequency of half-choked wells, points to a former populousness of many districts, which are still reclaimable. The immense extent of sand which covers the whole of the southern interior of the peninsula, is named by the Arabs the 'Dahna,' or 'Fire-red,' and from it two long branches extend northward, in rear of the inhabited margins which face the Red Sea and the Persian Gulf, and meet the stony deserts of the north, embrac-

* Munzinger, in R. G. S. Journal, 1870.
† Palgrave, in R. G. Journal, 1864.

ing, and, as it were, isolating the pasture lands in the central portion of Arabia. Narrower belts of sand, called 'Nefood,' or 'sand-passes,' stretch across the interior, nearly at right angles to, and uniting these outer branches of the Dahna. The most northerly of the 'Nefood' has an average breadth of fifty miles, and is formed of loose and deep sand, often not less than many hundred feet, generally heaped up in enormous ridges or waves, whose invariable direction is from north to south. Such is the lightness of the sand, that a camel's track is often effaced almost as soon as imprinted, and sand storms are not infrequent; but the stories of moving columns of sand, and of whole caravans suddenly overwhelmed by these, have no foundation of fact. Yet there are authentic records of troops of pilgrims to Mecca, and one of an Egyptian army, entangled in the waterless desert by treacherous guides, having perished there miserably of fatigue and thirst. Round the coasts of the peninsula, the saline margin of arid lowland beneath the more fertile 'Jebal' slope, and sometimes intersected by its streams, is named the 'Gaur,' or 'Tehama,' varying in width from one to two days' journey, or joining immediately into the deserts of the interior.

The connecting link between the deserts of Africa and Asia, is that portion of the Arabian desert which has been cut through to form the Suez canal. This leads at once into Arabia Petræa, or 'stony Arabia,' the southern portion of which has the mountain knot of Sinai, from which fertile and fruit-producing valleys descend to the barren lower land. The northern part of the Sinai peninsula is a plateau sloping gradually to the Mediterranean, and marked off from the group of mountains in the south by a curved line of cliffs, which forms its southern edge, and stretches from east to west. This barren plateau, with a soil partly hard and rocky, partly sandy, is the desert of the Tih, or Tiah-Bani-

Israïl, the desert of the wanderings of the children of Israel. Over the pass of the Wadi el Arabah, which extends from the Gulf of Akaba to the Dead Sea, this waste joins into the desert of Arabia, whose northern side, stretching towards the Upper Euphrates, forms the Syrian desert, covering the whole country between eastern Palestine and Mesopotamia.

We have seen that the northern portion of the Arabian desert bears frequent signs of a formerly inhabited and more fertile condition. This is also the case with the now desert and barren country south of Palestine, which presents traces of an extensive cultivation, which must have existed up to a comparatively modern period, and of a primeval race of inhabitants, in the remains of cairns and stone huts, and the ruins of ancient cities. 'El Harrah,' also a remarkable portion of the Syrian desert, covered with loose black basaltic stones, which begins in the east of the plateau beyond the Jordan, is filled with great stone-built cities, walled or unwalled, and long deserted, but so crowded together, that it becomes a matter of wonder how all their inhabitants could have lived in so small a tract of country.* Dr Beke has recently pointed out that a remarkable series of these black 'Harrahs,' or regions of former volcanic activity, stretch southward at intervals from the Trachonitis regions of lava in North Eastern Palestine far into the deserts of Arabia. One of these is still known as the fire Harrah. The same traveller has also described a region of precisely similar character in the low desert plain between the Red Sea and the Abyssinian highland. Everything seems to prove that barrenness and desolation have been for ages gradually creeping northward here, and the supposition is, that at one time woods were frequent in these countries.† It seems possible that a general subsidence of this

* Graham, R. G. S. Journal, 1859. † Palmer and Drake, 1870.

volcanic area may have taken place; the effect of this in a region situated on the borders of the desert zone would be to deprive it of rainfall, by leaving the moisture-bearing winds to pass undisturbed, and so to allow the desert to extend over it.

An eastward spreading of the Syrian desert is also traceable; along the whole length of the plains of the lower Euphrates, vast mounds marking the sites of ancient cities, are scattered in great numbers, showing that at one time these plains were densely peopled. The canals which irrigated them have long been neglected, cultivation has ceased, and the whole region has become little better than a desert; the habitable portions are confined to the river-sides, and, from the decay of the embankments, great swamps have formed between the rivers.

As in Arabia, so in Persia, the desert regions are divided, and there is a belt of low lying hot and sandy country round the coasts, and a higher interior desert separated from the other by a fertile zone on the outward slopes of the plateau. The lower desert of Persia begins immediately on the east of the mouths of the Euphrates and Tigris, and may almost be said to continue the Syrian desert; the sandy and barren soil of the portion of it which falls in the province of Khuzistan, is, however, intersected by some streams from the plateau, the banks of which are fertile, and it has also extensive morasses. South of this the low hot and sandy plain, called the 'Dushtistan' or 'Gurmsir,' begins, and continues along the whole of the eastern coastland of the Persian Gulf, with a varying breadth.

On the coasts of the Strait of Ormuz, at the entrance to the gulf, the edge of the plateau reaches to the coast, forming lofty cliffs, and causing a break in the coast plain. The low coastland of the province of Makran, in Southern Persia and Beloochistan, is, however, of exactly the same nature as the Dushtistan, and distinctly continues it eastward to the

mouths of the Indus. The Makran lowland is, however, more broken by the advance of the hills to the coast, and by the alluvial valleys of streams from the highlands. Notwithstanding this, an arid sandy soil, and desolate scenery, are its main characteristics; patches, or long ranges of pale ashy coloured hills, named 'Shors,' shrivelled and furrowed, distinguished like so many excrescences by the contrast of their colour from the rocky hills inland, forming a chief feature of the landscape. Volcanos, with 'Goops,' or basins of pale-coloured mud are frequent near the sea, and it is probable that the 'Shor' hills are the remains of similar eruptions. Towards Kurrachee and the mouths of the Indus, the plains have still a sandy soil, but are covered by rough grass; this approach to vegetation is evidently due to the exposure of this coast to the direct influence of the rain-bearing south-westerly monsoon.

Beyond the Indus begins one of the most remarkable regions of this zone. The vast plain which extends from the base of the lower ranges of the Himalaya to the Arabian Sea, and from the Indus to the Aravulli hills, is almost entirely occupied by the desert of India, and forms the widest extension of the low lying tropical deserts of Asia. The southern portion of the plain nearest the sea, is a flat tract 150 miles in length, and lying nearly at the same level as the sea; it is named the 'Runn' of Cutch. During the greater part of the year it appears as a plain of firm sand, saturated with salt, and totally without vegetation,* and is so level that a moderate rainfall remains like a vast pool on its surface, and is blown about by the wind till it evaporates. Travellers and caravans pass over it, but there are absolutely no landmarks except a beacon fire, which is regularly lighted by a Mohammedan family on the hills of Cutch, to whom has descended the religious duty of guiding the wanderers over the

* Frere, in Proceedings of R. G. S., 1870.

desert. When the south-west monsoon blows, high tides flow into and over it, and meeting the floods brought down at that season from the Aravulli hills, by the Loonee river, cover the 'Runn' with water to the depth of one or two feet. Though the Runn of Cutch, from its character, belongs distinctly to the desert zone, it must be noted that the cause of its appearance is quite a distinct and separate one from that which has produced the dry deserts of the globe. It is eminently a wet desert, comparable with that of the Gulf of Pe-Chili in Northern China, and it owes its desert character simply to its periodical flooding by the sea. The dry and waterless desert north of the Runn is called the 'Thurr;' this is covered with a succession of sandy ridges without a single stone, sometimes rising as high as 200 feet above the valleys, and 'the aspect of the country is like that of a billowy ocean converted into sand.' In districts where rain falls, and where the inhabitants have dug wells, some of which are 300 feet deep, cultivation and settlements appear.

The borders of the desert in the east and west, 'where a hard level plain exists as a basis, whence rise the abrupt sand-hills,' are called the 'Put.' Travellers crossing the Thurr are subject to sudden death, not only from the effects of sunstroke, but also from a peculiar condition of the atmosphere connected with the intense heat, and the nature of the soil, producing an attack somewhat like sunstroke in its effects, but which is not caused by the sun, since instances are known which have occurred after nightfall.

Both the Runn of Cutch, and the Thurr desert north of it, are very subject to volcanic disturbance, and the singular levelness of the salt plain of Cutch has been attributed to these vibrations.

The barren region of India extends also over the lower part of the 'doabs,' or spaces between the Punjab or 'five rivers,'

which join the Indus, but the northern portion of this region, to a distance of 100 miles from the base of the Himalaya, has the advantage of abundant rains, is populous and cultivated, and does not belong to this zone.

In consequence of the broken form of the lower land of Asia, eastward of India, both in its coast line and in its surface of hill and valley, allowing free access to the damp monsoon winds, it follows that there is no representative part of the desert zone in Further India or Southern China, and it is not until the northern part of the plain of China is reached that another region of the lower deserts of Asia makes its appearance. Over a great part of the province of Pe-chili, south and east of the capital city of Pekin, and partly surrounding it, the low plain is dry and sandy, though it is highly cultivated along the banks of the rivers which cross it, where, however, the fields require to be protected from the sand drift by long hedgerows. The flat northern coast-land of the Gulf of Pe-chili, is likewise barren and unfertile, being exposed to very extensive inundations, and the coast plain, of a breadth of from thirty to fifty miles from the sea, along the northern coast of the Gulf of Liau-tung, is of the same character,—a mud-flat, barely above the sea level, periodically flooded, and the home only of sea-birds. Northward an extensive region of the same plain, named the Korchin, stretching at the base of the Khinghan range, which separates it from the Gobi, partakes of the nature of the lower deserts, is chiefly covered with sand, and has salt lakes; but on its outskirts are great prairies of tall waving grass, which prove the fertility of its soil.

The high deserts of Asia may be said to begin to appear as far west as Asia Minor, where a large patch of barren salt steppe surrounds the Tuz Lake and its saline marshes, in the central part of the plateau. A little increase of the rainfall and moisture

supply of this basin would form in it a great fresh water lake, with an outlet to northward; a little decrease would dry up the existing salt lakes and marshes, converting their beds into dry salt deserts similar to that which now surrounds them. The balance of moisture supply and evaporation in this as in the other basin deserts, is such as to leave the margin dry, sandy, and sterile, whilst the most depressed portions are generally occupied by a lake, whose waters are salt, for the reason that it has no outlet.

Similar balancing has brought about the salt lakes of Van and Urumiah, further east on the high plateau of Armenia, but these are so closely encircled by the mountains whose streams supply them as to leave no appreciable extent of waste land round them.

Where the plateau broadens out, and the outer enclosing ranges of mountains run wide apart, screening the interior from rainfall, the deserts of Persia begin. Their outer border lies at an average distance of about 200 miles from the coast of the Persian Gulf, and at about 100 miles from that of the Caspian Sea, and they extend from eastward of the meridian of the towns Teheran and Ispahan, to the borders of Beloochistan and Afghanistan. The general character of this desert seems to be that of a saline, undulating plain, sandy and barren. The desert of Kirman, which forms the south-eastern part of the region, is here and there intersected by rocky ridges. In the centre of the Persian desert is the oasis and town of Yezd; the oasis being of considerable extent, produces silk and fruit, besides a small quantity of wheat. Westward from Yezd, a line of smaller oases leads to the town of Ispahan; southward there is a route over a less arid strip of country to Kirman, and north-eastward a passage towards Herat. The desert is thus divided broadly into three unequal portions. The hilly region on the western border of Persia, separates between its deserts and those of Afghanistan and Beloochistan. Nearest the Arabian Sea, in

the latter country, is the Sandy Desert,—an isolated patch, which lies west of the town of Bunpoor. The true desert of Beloochistan occupies the central portion of the north of the country, and stretches over into Afghanistan, and then north-eastward towards Kandahar and the spurs of the Soliman mountains; to north-westward it joins into the portion known as the desert of Seistan, extending to both sides of the Helmund river, which carries fertility on its banks, and shuts off a part of the sterile land to northward. Between this and the hills which bound the Persian deserts, is the Seistan Lake, or 'Hamoon,' of salt water, seventy miles in length, and joined by a strait to a second lake, named Dek-i-Tir.

Where the Persian highland begins to become narrower, approaching to the single line of the Hindoo Koosh Mountains, which unite it to the great table-land of Asia, there the moisture supply can extend over the plateau, and the deserts cease. The rainfall in spring is abundant (in Cabul), and in summer the melting snows from the mountains serve to maintain a vigorous vegetation in the dry season.

Beyond this isthmus the vast table-land of Asia spreads itself out, and the great outer heights of the plateau, the Himalaya, the mountains of China and the Khinghan range on the south and the east, the Thian Shan and Altai on the north-west, condensing the moisture supply, and feeding the great rivers of India, China, and Siberia, which flow outward from them, deprive the lower lying central regions of that rainfall which could render them fertile, and bring about the presence of great deserts there. The exploration of the surface of this great table-land has not as yet proceeded so far as to determine either the precise form of the table-land itself, or the limits of the deserts which it contains.

Broadly, its surface may be divided into three parts, two

outer more elevated, and a central, lower, plateau. The southmost third is the high plateau of Tibet, which extends from the inner water-parting range of the Sanpu valley behind the Himalaya to the Kuenlun Mountains, which have been supposed to form an inner edge of the Thibetan highland, sloping steeply to the central lower plateau, as the Himalaya does to the plains of India. The northern part is also a high plateau, stretching from the north slope of the Altai Mountain, to the eastward continuation of the Thian Shan range, which is again believed to form a distinct inner edge.

Between the inward slopes of these two highlands is a depressed region, extending in a curve over the whole of the remaining third of the table-land. The geography of this plateau is, as before mentioned, but little known; still, the great features of the two outer higher lands are certainly ascertained to be those of a series of wide basins, each containing one or more lakes fed by streams flowing from the surrounding heights. The greater number of these lakes have no outlet, and are therefore presumably salt.

This condition implies a deficient rainfall, and through wide tracts on the borders of the plateau, and possibly also round the higher portion of each basin, have good pasturage, yet the whole of the central regions are apparently dry and desert. In the basin which lies immediately eastward of the valley of the head stream of the Indus, is the Aksai Chin, or White desert, concerning which, however, little more is known to Europeans than the name. Its verge has been touched upon by the Pundits, who have partially explored this region under British direction,—and the country eastward of the gold fields of Tibet is described by them as having a perfectly arid and dazzlingly white soil, extending as far as the eye could reach. The nature of this desert is probably the same as that of a

portion of the plateau which is crossed on the route to Khotan (between the Cheng Chenmo and Yengi-dawan passes), and whose surface, in one part, is entirely covered with a substance resembling snow, with an underlying sheet of ice, but which is in reality soda with a crystallized salt beneath.* Southern Tibet generally is very little removed from a perfect desert and presents a picture of a land inhospitable, bleak, and sterile in the extreme; hills and valleys alike have a stubborn aspect, without vegetation, naked and bare.†

The surface of the northern division of the plateau of Asia is also formed of numerous separate lake basins, but not of such wide extent as those of the Tibetan plateau, nor, apparently so completely desert, though the rainfall is not abundant. One of these basins, named the Chagan Tala, or White Plain, is doubtless of the same character as the White Desert of Tibet. The great extension of the desert zone in the Asiatic plateau, is, however, in its lower central region. The portion of this, which lies between the Thian Shan and the Kuenlun Mountains, or in Eastern Turkestan, has been compared to a huge bay, with its mouth turned to the east, shut in on every other side by gigantic slopes. A broad desert, thirty days journey in extent, occupies the mouth of the bay, and separates the habitable parts of Eastern Turkistan from China, of which empire it was, till recently, a possession. Near the boundary is a large salt lake, the Lob Nor, occupying, perhaps, the lowest part of the whole plateau of Asia, receiving the Tarim River and its tributaries from the surrounding slopes. A broad belt of desert passes round the base of the mountains, enclosing within it a fertile cultivated and populous country artificially irrigated from the tributaries of the Tarim. The southern portion of this band of arid country is

* Shaw, Proceedings of R.G.S., 1870. † Turner's 'Embassy to Lama.'

distinguished as the Takla-Makan Desert, and the eastern is named by the Chinese the Han-Hai, or 'dry sea.'

Across the central plateau east of Lake Lob, ranges of lower mountains appear to unite the northern and southern highlands, enclosing several lake basins similar to those of Tibet. Beyond these, the 'Ta Gobi,' or 'great desert,' of Mongolia, called also 'Shamo,' or sea of sand, stretches over the plateau to its furthest eastward limits. A great part of it is covered with sand or gravel and small stones, and appears to be a vast plain, depressed to some extent in its centre, and lying at an elevation of from 3000 to 5000 feet above the sea, crossed most frequently in an ancient caravan route, which takes a direct line from the gate of the great wall of China, at Kalgan, or Chang-Kia-Kow, to Urga and Kiakhta, on the borders of Mongolia and Siberia. At all seasons of the year there is an exceedingly great daily variation of temperature on this part of the plateau, which cause, equally with the deficient rainfall, may account for its barren nature. Towards winter large portions of the sandy desert are covered with snow,* and cold north-east winds sweep with terrible force over the plain; there are, however, undulating and even hilly tracts on the main route, which have vegetation sufficient to support herds of cattle and flocks of sheep, but between these are wide flat plains or barren steppes. Whirlwinds of sand are frequent in April.

The low-lying deserts of the interior of Asia may be said to begin westward in the salt swamps and sand dunes, into which the steppes of Southern Russia merge, in the depressed region on the northern shores of the Caspian Sea. So flat is this desert, that though the surface of the Caspian is only 84 feet below the level of the sea, it is not until an average distance

* In end of October. Whyte, R. G. S. Proceedings, 1870.

of 150 miles inland, that the district on its northern shore rises to the same level as the Black Sea, and the lower course of the Volga is for more than 350 miles beneath the sea level. After a continuance of south-easterly winds, the waters of the Caspian overflow the flat country to a great distance; an instance is recorded of a ship having been stranded at a distance of 46 miles from the normal coast-line. But the greater extension of these deserts lies beyond the Caspian, and within the limits of a line joining the north coast of that sea, and the Balkash Lake, dividing them from the Siberian steppes and the slopes of the plateaux of Persia and Asia, south and eastward. The portion of this space named the plateau of Ust Urt, which falls between the Caspian and the Sea of Aral, can scarcely be reckoned as belonging to the deserts. It rises to an average height of about 700 feet above the sea, and has scattered habitations of Turkmans and Kirghiz, and falls north and south by a steep irregular edge named the 'Chink.'

The greatest extent of sandy desert in this region, more than 500 miles in length, occupies the triangular space between the river Oxus (Amu Daria), the plateau of Ust Urt, and the slope of the Persian highland, the streams from which form oases in its southern edge. The greater part of it is within the limits of the Khanate of Khiva, and it bears the name of the Desert of Chwaresm, or Desht-i-Chowar. The eastern corner is named the Desert of Balkh.

Khiva Proper, or the artificially irrigated and fertile delta of the Oxus, separates this desert from the next greatest in this region, the 'Kizil Kum,' or 'Red Sands,' which stretch over the plain between the Oxus and Syr Daria, to as far as a range of hills named the Kapkantash, which limits them on the south. These sand wastes have no fresh water whatever on their surface, and the caravans which cross them, rest only at

the artificial wells. 'Let the reader picture to himself a sea of sand, extending as far as the eye could reach, on one side formed into high hills, like waves, lashed into that position by the furious storm; on the other side again, like the smooth waters of a still lake, merely rippled by the west wind. Not a bird visible in the air, not a worm or beetle upon the earth; traces of nothing but departed life in the bleaching bones of man or beast that has perished, collected by every passer by in a heap, to serve to guide the march of future travellers.' . . . 'The "Tebbad," sand storm, was hurrying on. Entrenched behind the camels as a wall, the wind rushed over with a dull clattering sound, leaving us in its passage covered with a crust of sand two fingers thick. The first particles that touched me seemed to burn like flakes of fire.'*

Similar deserts extend from the Kizil Kum throughout the lower portions of Bokhara, along the northern side of the Amu Daria, to opposite the desert of Balkh, on arid clay soil, covered with drifting sand.

North of the Syr Daria, and east of the upper part of the Sea of Aral, is the desert of Kara-Kum, or 'Black Sand,' and a line of narrower eastward-stretching deserts, joins it to the vast extent of dry sand country which fills the space between the Balkash salt lake and the heights of the plateau. In the Bed-pak-dala, or 'Hungry Desert,' west of Lake Balkash, the desert zone merges in that of the pasture steppes of Siberia.

2. In the Southern Hemisphere.

In South America, as in Asia and North America, the deserts are high-lying and low-lying. The low outer desert of South America, comparable with the Dushtistan or Makran, in Asia, occupies the long strip of coast-land beneath the slope of the Andes from Tumbez in the north of Peru, in 3° 31′ S., to the valley of Copiapo

* Vambery, 'Travels in Central Asia,' 1864.

in Chile, in 27° S., a line of nearly 2000 miles in length. This arid and sandy waste, which appears here because the trade winds are constantly blowing away from the land, is at different parts from 30 to 60 miles in width,* and forms wide plains traversed by barren ranges; but it is crossed by numerous valleys, the greater number of which are abundantly watered by streams which rise in the slope of the Western Cordillera, and are remarkable for their fertility. It is these valleys of this generally desert belt, termed 'la Costa,' that are occupied by the most flourishing populations of Peru.

The whole of the high valley, or series of basins, between the outer Cordilleras of the Andes in Peru and Bolivia, is termed the 'Puna' (in the Quichua language), or, by the Spainards, the 'Despoblado,' or uninhabited regions; but it appears to be the southern, or Bolivian portion of the Puna, which belongs especially to the desert zone, the remainder partaking rather of the nature of steppe or pasture land.

South of the valley of Lake Titicaca, there is a chain of basins comparable to those of the Rocky Mountain plateau, or of the table-land of Tibet, which are completely barren and waste. The nearest of these is termed 'la Pampa de Salinas,' and is a level plain of about 3000 square miles in extent,† which, during the rainy season, is covered in most parts with water, sometimes to the depth of a yard, but in the dry season appears thickly encrusted with salt of dazzling whiteness. Round the base of the mountains, which enclose the pampa, sandy ground takes the place of the salt crust.

A similar 'arenal,' or sand-field, surrounds the 'Salina de Atacama,' a salt swamp of 70 English miles in length, in a basin further south; and desert basins, now sandy or stony, now

* Ledesma, in R. G. S. Journal, vol. xxvi.

† Reck, Mitt. 1865-67. Bolivia.

encrusted with salt, or presenting salt marshes or lagoons, each conveying the impression of its having at some recent period formed a part of the bed of the ocean,* extend over the high-land into Northern Chile and the Argentine Republic.

Very remarkable electrical conditions of the air prevail at some seasons in the high deserts of Bolivia. The traveller, Von Tschudi, relates, that in a high desert basin eastward of that of the salina of Atacama, a tiresome crackling accompanied every movement by day or at night, and that the slightest friction drew sparks from any woollen stuff. In saddling or unsaddling the mules, electrical sparks shot out of the points of the fingers, and on every hair of the animal there appeared a blueish light.

The most extensive part of the interior low-lying deserts of South America, appears in the southern part of the great central plain termed 'El Gran Chaco,' which lies westward of the Paraguay river, and north of the undulating and hilly country which extends from Cordova to the River Parana; this part of the Chaco is a complete desert, almost rainless, and without water, with sandy soil and incrustation of salt; it is uninhabited excepting along the banks of the rivers which bound it or cross it from the highlands.

South-westward of the Chaco, and between the mountains of Cordova and the Andes, is the 'Great Salina,' a plain believed to be scarcely above the level of the sea, covered for the most part with a thick salt efflorescence, and here and there interspersed with small hillocks. This desert is probably one of the hottest parts of the continent, and in summer the country in its vicinity is subject to intensely hot northerly winds.

Though the hills of Cordova stretching out from the Andes, cause a break in its continuance, the whole central and little explored region southward of the great salina to near the Negro

* G. G. Von Tschudi, 'Journey in the Andes,' 1858.

river, seems to belong to the desert region. Near the 65th meridian of west longitude, there are numerous salt lakes and large tracts of loose sand, impregnated with saline matter, and unfit even for the growth of grass.

Passing over to South Africa, we there find the southern desert zone represented in the great Kalahari desert, which fills the centre part of the continent south of the Zambezi Valley, extending northward from the Orange river for 600 miles, and occupying an area greater than that of the Spanish peninsula. This desert is a vast sandy plain, at an elevation of about 3500 feet above the sea, almost without water, which is only found in scattered wells, but supporting, in the cooler season, in most parts a rank growth of grass, which withers and falls to powder in the hand during the dry seasons. The regions of the Kalahari, and of Namaqua Land west of it, are dependent upon thunder-storms alone for rain; during these storms, which are exceedingly violent, rain frequently falls in torrents, and runs off very rapidly, rushing through the ravines, which may not have shown a drop of water for years previously, and not moistening the earth for more than a few inches in depth. Lagoons and 'salt pans,' great depressions, sometimes a hundred miles long, encrusted with salt, are frequent in the north-eastern part of the Kalahari. Lake Ngami is the only permanent and extensive lake of this region, 30 miles in length, and its waters vary from freshness to salt-ness with the extent of the lake, in the hotter and cooler seasons of the year. The sterile country extends beyond the Orange river, and over its southern water-shed, embracing the greater part of the interior of Cape Colony; and though river beds and water are less scarce here, yet there is no permanent supply, for the streams, filled only after heavy rains, rise and fall suddenly, becoming formidable torrents, which have cut deep ravines far below the level of the land, which they completely drain. In

the space between the second and the innermost ranges of the mountains which rise parallel with the coasts of Cape Colony, a barren waste, named the 'Great Karoo,' extends in a long elevated trough for more than 350 miles, with an average breadth of 50 miles across. North-westward from the Kalahari, also, less extended areas of barren sand stretch out towards inner Benguela, crossed however by permanent rivers and broken up by swamps.

South Africa has its low-lying coast desert also, which corresponds in position, and in cause to that of South America. It stretches for more than 700 miles along the whole of that portion of the west coast-land, away from which the S.E. trade wind blows, from the Cunene River, in the south of Benguela, to the north of the Orange River, an uninhabited sandy tract, only crossed by a few periodically filled water-courses. Walfisch Bay, a resort of whaling vessels, and Angra Bay, in the vicinity of which there are deposits of potash and soda, are the only visited portions of this desert, but ships going here must take a supply of water with them, since not a drop can be obtained on this coast.

The continent of Australia presents many points of resemblance to the northern part of Africa. In form these two areas are more rounded and compact than any other region of the globe of similar extent; both lie centrally beneath the tropical lines, one under the southern, the other under the northern tropic, both are generally lowlands; they comprise the two greatest areas of the globe, from which no streams escape to the sea, and two of the greatest desert regions of the world. With the single exception of the Murray-Darling River, no one of the streams of Australia, which pour their waters into the sea, has its source at any greater direct distance from the coast than 250 miles; and within the line joining the heads of

these ocean-seeking rivers, there remains an area considerably greater than the half of that of the continent, from which no water whatever reaches the sea. The region of the outer drainage of Australia is uniformly fertile, and a belt within the water-parting line, reached in the south by the winter rains (from March to November), and in the northern part of it by the tropical or summer rains (from November to March) affords an extension of the grassy plains into the outer margin of the central basin; but within the irregular line thus formed a central area of nearly one-third of the continent belongs to the desert zone.

The interior desert reaches to the high coast of the Australian Bight in the south, from Cape Arid to Spencer Gulf, and along the whole of this margin there is not a single stream. Round a great part of the Bight, bluff cliffs of fossiliferous formation rise from the sea. Low shrubs and salsola cover the ground immediately over the cliffs, and behind these the arid desert stretches into the interior. North of Spencer Gulf is the region of the Australian salt lakes, comparable with those of the other desert regions of the globe, with the 'Salinas' of South America, the 'Schotts' of Tunis, or the salt lakes of the interior low deserts of Asia. Of these, Lakes Eyre, Gairdner, and Torrens, are the chief. The first of these is a great shallow and swampy lake of variable extent, and with salt encrusted shores, only 70 feet above the sea level, and the last is rather a long depression, with shallow salt pools, than a lake, and is surrounded by sand hills, strewn with boulders.

North of the lake region, and near the western centre of the continent, is the 'Great Stony Desert' of Australia, an undulating plain thickly strewn with boulders, extending over 3000 square miles; and to west and northward of this a boundless arid plain appears. Waterless plains and sandy deserts have stayed

the traveller at almost every point in which the water-parting line of the coast streams has been crossed on the north and west of the continent.

The climate of this great primary zone thus presents the strongest possible contrast to that of the Equatorial Forests; in the region of forests, moisture is in excess, in the deserts it is so deficient that some parts are completely deprived of it; if rain occurs at all in any portion of the deserts it is in sudden thunder showers of short duration, which do little more than wet the surface of the land. The temperature of the forest belt throughout the year is equable, and its variations are slow and small; but in the deserts the greatest and most rapid changes from burning heat at midday to almost freezing cold at night, due to the extreme radiation from the bare surface, are characteristic; and there is a considerable variation in the average temperatures of the months of the year. The temperatures of the desert zone therefore range from below the freezing point to the very highest temperatures known. In the tropical deserts the sand has been frequently observed to rise to a heat of 120° or 140° F., more rarely to 200°, and when these hot particles have been raised by the 'simoom,' the air itself has been known to rise to a temperature of 120° F.*

THE UPPER PASTURE LANDS.

1. In the Northern Hemisphere.

One of the most extensive regions of this zone, only exceeded in area by the steppe-lands of Asia, appears in the prairies of North America. Almost the whole extent of these apparently boundless, level, or undulating and treeless grass-lands, lies

* Buchan, 'Handy Book of Meteorology.'

within the basin of the Mississippi-Missouri, occupying there a compact area of about 1,145,000 square miles, or a space equal to nearly twenty times that of England. The prairies stretch from the basin of the Saskatchewan River, between Lake Winnipeg and the base of the Rocky Mountains in the north, southward over the central plains, to the 'pine barrens' which skirt the Gulf of Mexico. On the west their limit is given by the arid belt of desert, which has been described as extending along the base of the interior slope of the Rocky Mountain plateau, its outer edge forming an irregular line passing through the western portion of the states of Dakota, Nebraska, Kansas, and Texas, to the Rio Grande, on the boundary of Mexico. North and eastward its edge is formed by that of the woodlands and forests of the temperate forest zone. The limit of the true prairie land northward forms a line running east and westward between the two branches of the Saskatchewan River; south of this no trees whatever appear, excepting on moist northern exposures;* but above this is a region termed the 'fertile belt,' which, by successive fires, has been cleared of the greater part of its original forest, remaining only partially wooded with poplars, willows, and a few pines, and possessing a deep rich soil of vegetable mould, watered by the north branch of the Saskatchewan and its tributaries, and abounding in luxuriant herbage.

This artificially formed belt immediately continues the prairie, and must be considered as a part of this upper pasture zone, though it differs entirely from those natural grass-lands, in being capable, from its moisture, of supporting a forest growth, whilst the prairies, owing to their deficient rainfall, and more unequal temperature, are naturally treeless. The boundary of the true prairie on the eastward begins at the western coast of

* Palliser's Exploring Expedition.

Lake Winnipegos, and continues thence in a curve to where the Red River joins Lake Winnipeg; from this it passes southward between the Red River and the Lake of the Woods westward of the head lakes of the Mississippi, round these, in a south-easterly line, to the south end of Lake Michigan, and thence to the Ohio valley, on the borders of Virginia. From this, the mutual limit of the woodlands and cultivated lowland or prairies is formed by the western decline of the plateau of the Alleghanies, down to the base which the woodlands extend, and runs generally south-westward towards the mouth of the Mississippi, where the woods of the Atlantic slope nearly joins into the tropical belt of forests which skirts the shores of the Gulf of Mexico.

An opening between these distinct forests allows the prairie to re-appear in the State of Alabama. Though the line of division between the prairie and the woodland is often decidedly marked, there is generally between these, as well as in the case of the other surface zones, a gradual transition from one state to another, a thinning out of the trees towards the true prairie, and a change from luxuriant grass-land to poor pasture, on the side which is bounded by the sandy deserts. The faces of nature along these meeting lines are indeed so nicely balanced, that slight causes would make one or other condition of surface preponderate, and here local causes, such as the special geology of the soil, come into action. 'Belts of timber border the streams, and cover the more porous and absorbent soils, while level surfaces, with fine unporous soils, sometimes very wet, and sometimes very dry, sustain only a growth of grass, which could endure the alternations fatal to trees.'*

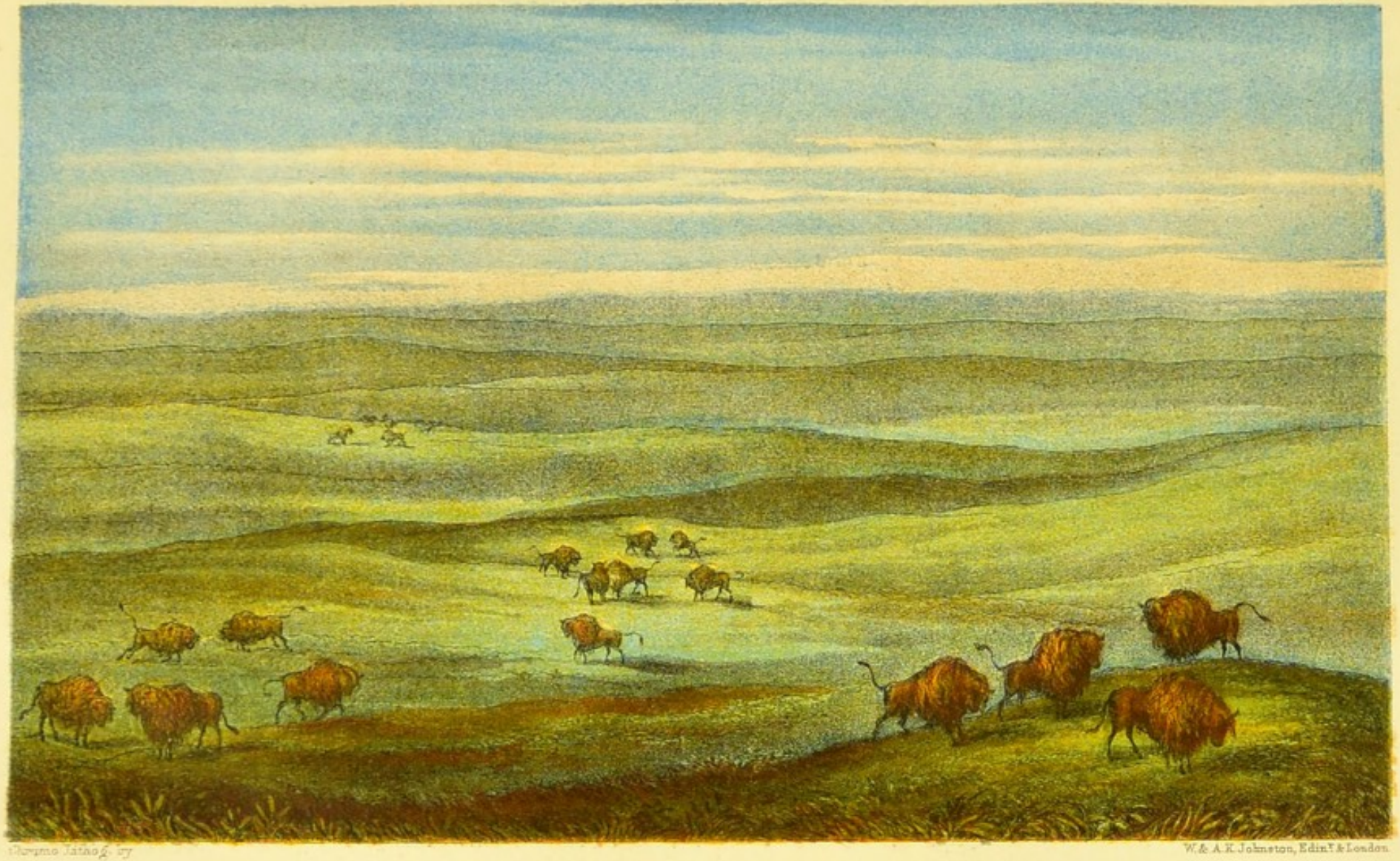
The prairies are the grazing-grounds of vast herds of ani-

* Brown, 'On the Formation of Prairies,' R.G.S. Journal, 1870.

mals. In describing their great abundance of big game, Mr Bell says*—'One herd of antelope was so large that, although they commenced to bound like lightning across the road in single file as soon as they caught sight of us, the tail of the herd nearly came in contact with our leaders. Like many other wild animals which congregate in herds and follow a chief, all considered themselves bound to keep exactly in the same track. As for the buffalo they were in prodigious numbers. . . . On one occasion, about 150 miles from Denver, to the left of the road, that is as far as the eye could reach, that is for very many miles, the plain was completely covered with them. There were thousands, millions if you like, for such numbers were beyond calculation.'

Many other comparatively small areas of the central portion of the North American plateau, lying between its outer belts of forest and the arid basins of its middle surface, have the name and character of prairie land. Such are the grassy plains of the interior of British Columbia; the prairies of Washington territory, extending to the base of the Cascade Mountains, surrounding the lower valley of the Columbia, which produces rich and nutritious 'bunch grass,' and affords sustenance to thousands of horses, sheep, and other cattle; the pastoral valleys of Idaho; the rich grazing land of the Laramie Plains, between the Black Hills and the Wasatch Mountains, in Wyoming; the 'parks' of alternate forest and meadow land in Colo rado, and the pastures of New Mexico and Eastern Arizona. The fertile lowlands on the narrow Pacific coast, also belong to this zone; and among these may be more specially noticed the prairies and cultivable lowlands which lie round the coasts of

* Bell, 'New Tracks in North America,' 1870. The sketch of this herd in the prairie, given by Mr Bell, has been taken (by permission) as the basis of the illustration on the opposite page.



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TEMPERATE PASTORAL LANDS, THE AMERICAN PRAIRIES.

Vancouver Island, as well as in some parts of the islands and coasts of the Strait of Juan de Fuca and Puget Sound, in Washington, but chiefly the rich valley of the Sacramento and Joaquin Rivers in California, which produces crops of grain and fruits of every sort, and affords the most excellent pasturage.

To this zone might also be added the cultivated lands of the Eastern United States on the Atlantic slope, cleared part of the forest growth which once extended over their whole surface, now forming the most productive and populous region of America, though these belong truly to the northern forests.

Passing over the Atlantic to the Old World, we find the continuation of the pastoral and agricultural zone in Southern Europe and in North Africa. The portions of Africa which represent it are the inward and outward watersheds of the plateau of Barbary; the former slopes, termed the 'Algerian and Maroccan Sahara,' have abundant pastures in winter and spring, though, in summer, these are in great part dried up; fruit gardens are numerous, and, higher up the slope, the date palm is most abundant. The outer slope, or 'Tell' country, extends over the whole northern watershed, and its plains and fertile valleys are in great part cultivated; beneath the forests which cover the high northern slopes of the Atlas are wide pasture lands, supporting great flocks of sheep and goats, as well as the famous horses of native or Arab breed.

Europe, considered as the western extension of the great continent of Asia, is so broken up into peninsulas of every form, so cut into by branches of the sea, and is of such varied elevation, especially in its peninsular portion, that the climatic arrangement of its surface, according to latitude, is more disturbed than that of any other portion of the globe. The dis-

tribution of moisture over its surface is in consequence irregular; hence the landscape zones are here, most of all, thrown out of place by natural causes, and to this must be added the great artificial changes made in its appearance by civilized man.

The valleys, lowlands, and minor elevations of South-Western Europe, generally belong to the agricultural and pastoral zone; the more continental plains, and the mountainous surfaces, on the other hand, belong to the northern forest belt. A few of the more prominent agricultural and pastoral districts here, are the fertile and green plain of Granada, in the south of Spain; the corn-producing plains and vineyards of the Guadalquiver valley; the immense pasture lands of the sierras and table-lands of Central Spain, and the wheat-growing districts of its northern provinces. The cultivated land of France, corn-producing in the north, and mainly a vine country in the south, with pasture lands on the slopes of the mountains of Auvergne and the Cevennes, forms a prominent part of the belt. Next come the industriously cultivated western provinces of Belgium, and the artificially protected and low-lying 'polders' of the Netherlands, affording corn crops and rich pastures; then the agricultural lowlands of Britain and Ireland, and the pastures of their higher lands; the agricultural districts of the lowland of Central Sweden, and the wheat-growing plain of Linköping, toward the south of the peninsula; and the Baltic provinces of Russia, supplying great quantities of corn to western Europe, form the most marked northerly portion of the zone on the mainland. The pastures of Iceland may be considered as the part of this zone which attains the highest latitude in either hemisphere. In Central Europe, belonging to this zone, are the agricultural lower-lands in Bavaria, Bohemia, and Hungary, reclaimed from the moors, sandy steppes, and

morasses ('moos'), which once covered the greater part of these countries, and the naturally productive and artificially irrigated plain of Lombardy and Venice; southward are the luxuriantly fertile slopes and coast plains of the Mediterranean peninsulas of Italy and Greece.

The plains of the Danube, in Bulgaria and Wallachia, partly agricultural and partly pastoral, continue the zone eastward; hence it passes through Southern Bessarabia into the plain of South Russia, where it is well represented in the cultivated lands and rich pastures of the 'Ukraine.'

A line drawn westward from near the southern termination of the Ural chain to the Volga River near Simbirsk, and thence west-south-west to the north of Bessarabia, marks the southern limit of the Russian forests, and separates between them and the region of steppes, which is one vast pasture land, extending southward to the shores of the Black Sea into the Crimea and to the base of the Caucasus Mountains; south-eastward it is only limited by the deserts which surround the northern shores of the Caspian, and between this and the Ural forests it joins into the great steppes of Asia. These vast monotonous and dreary grass-lands stretch over an area of about 1,170,000 square miles (twenty times the extent of England) in the united steppes which occupy Southern Russia and a large portion of the lowland of Central Asia, and are comparable both in nature and extent with the great prairies of North America.

The Asiatic portion of the steppe-land is bounded by a line drawn from the northern edge of the desert in the depression north of the Caspian, eastward towards the southern end of Lake Balkash, thence round the line of heights which form the water-parting between the streams of the steppe and the arid basin surrounding the lake; next northward past the town

of Barnaul to near Tomsk on the Obi, then eastward past Omsk and south of Tobolsk to the base of the Urals and across their southern slopes to the boundary of the European steppes. The Asiatic portion thus includes the basins of the Tobol, the Ishim and Upper Irtish Rivers, and a large number of salt lakes, with the streams which flow into them.

The various parts of the Asiatic steppe land are distinguished as the Kirghiz steppe in the south, extending from above the Caspian to near Lake Balkash, the steppe of Ishim in the centre, and those of Isset and of Barabinsk in the north-west and north-east.

The fertile northern slopes of the plateau of Persia and the cultivated portion of Afghanistan, such as the valley of Cabul, belong to this zone, as also the inhabited margin of Eastern Turkistan, 4000 feet above the sea; near Yarkand, where grains and cotton are largely cultivated, flocks of sheep and goats are everywhere seen. The country is a perfect network of canals, great and small, and 'many of the rivers are absolutely drained of their water for the benefit of the thirsty fields, even before reaching the great desert which would, at any rate, engulf them.'*

From Eastern Turkistan the outer high pasture lands of Tibet lead round the south of the central desert region towards China and to the fertile valleys which break the eastern edge of the plateau. Among these the Valley of Bathang, a part of the upper course of the Kinsha-Kiang, has been called the 'Eden of Eastern Tibet,' and yields annually two crops of wheat. Next come the valleys and plains of China, in which agriculture is pursued with the greatest industry. All kinds of grains are cultivated in China, but three products are specially characteristic; these are rice, the mulberry tree for feeding

* Shaw, in R.G.S. Proceedings, 1870.

silkworms, and the tea-shrub. The principal tea districts lie between the parallels of 25° and 31° N. latitude.

The plain of Southern Manchuria, producing wheat and cotton, indigo and opium, belongs to this belt, as do also the valleys of the Corea, cultivated on the banks of the rivers, and pastoral on the slopes of the mountains; and further eastward the islands of Japan, in the two southern of which agriculture is carried to, perhaps, the highest degree of perfection in the world, and every available patch of land is cultivated with the utmost care.

Along the northern slopes of the great Asiatic plateau, and surrounding the desert basins of its northern division, there are many districts which belong to the pastoral belt; such as that of the Selenga River, near Lake Baikal, supporting numerous herds of horses, cattle, and camels; eastward the valley of the Amur has agricultural and meadow tracts; and in the district round Yakutsk, on the Lena, between the tributary Rivers Vilui and Aldan, though it is sparsely wooded, innumerable herds of cattle find pasture.

2. In the Southern Hemisphere.

It is noticeable, as the direct result of the meterological conditions which give rise to the grass lands of the world, that on the eastern side of each of the continents which have an open space of ocean to eastward of them, the upper and lower pasture zones meet, and surround the deserts there. Thus the prairie lands of North America run from the edge of the northern forests, near Lake Winnipeg, southward to the narrow belt of tropical forest, which skirts the shores of the Gulf of Mexico. The agricultural or pastoral zones in Asia meet, completing a circle round the interior deserts in Mongolia; in Australia, the pastoral and cultivable lands occupy the whole eastern margin of the continent; in South Africa the Kalahari desert is surrounded by

a fertile, grassy, region, extending from the Zambezi Valley to Cape Colony. The same condition is observed in South America, where the pampas extend from the upper basin of the Paraguay river round the central deserts at the base of the Andes into Patagonia; and it is only in North Africa, deprived of the ocean influence eastward, by the great continent of Asia, that the desert extends to the east coast. Perhaps the most convenient division of the upper and lower pasture zones in South America, is that given by the inlet of the Rio de la Plata, separating the fertile province of Uruguay from Buenos Ayres, southward. Buenos Ayres is eminently a pastoral country, occupying a large portion of the 'pampas' region, and is generally a level plain covered with coarse luxuriant grasses; and the whole of the eastern provinces of the Argentine Republic (Santa Fe, Cordova, and San Luis) have the same character, gradually becoming more dry and parched as the base of the Andes chain is approached. The country is entirely devoid of trees and shrubs, but large tracts are overgrown with tall thistles, which are used as fuel. Immense herds of cattle, sheep, and horses, find pasture on these plains, and their rearing is almost the sole occupation of the population.* In the parts not yet occupied by farms, herds of deer, flocks of ostriches, and innumerable partridges alone break the monotony of the pampa scenery. Farther south, in the plains of Patagonia, the land surface appears to have generally a similar nature, though less fertile, and the pampas, deprived of moisture from the prevailing west winds, by the high range of the Andes, sometimes present a barren surface with no vegetation, save occasional tufts of brown grass and thistles; the higher parts of the pampas are sometimes strewn with sharp stones. The river beds,

* Lieut. Page, in his 'La Plata,' mentions an 'Estancia' or cattle-farm of five square leagues in extent, which had 18,000 head of cattle.

which are cut deep into the pampa, and descend from it by steep cliffs, form a contrast to the higher land in having grassy plains and wooded banks; and many parts of the country abound with game, the chief animals being the guanaco, a kind of llama, rather larger than the red deer, and the ostrich.

The high plains, or 'Hoogevelt' of the Transvaal Republic in South Africa, belong to this zone, and stretch inland from the coast slopes of the plateau to the country of the Bechuanas, merging there into the dry desert lands of the interior. The landscape here presents green valleys, sometimes overgrown with mimosa-bush, or grassy treeless uplands, pasturing herds of cattle, sheep or goats, and rich waving corn-fields; in the vast unsettled portion countless herds of springboks, gnus, or zebras, gallop over the plains, and the ostrich is commonly met with. The surface of the Orange River Free State is a similar area of transition from the highly fertile and well watered coast slope to the desert Kalahari, as it consists of great undulating plains, with 'Velds,' and 'Vlachte' or 'flats,' abounding in game, the herds of the wilde-beeste or black gnu being specially frequent.

The outer eastern margin of the continent in this latitude, slopes steeply down from the highest edge of the plateau, called the Drakenberg mountains, to the coast, and thus passes through several climates, each having a different degree of heat and moisture. Every different level has consequently its own particular aspect; in the colony of Natal these may be broadly distinguished, first as the band of tropical vegetation, characterized by dark mangrove woods, which skirts the moist and hot coastland; above this, occupying a central belt, is the pasture land of the colony, which is also in part agricultural, and adapted for the growth of maize, and corresponding to the

lower pasture zone; next follows a wooded terrace, and higher still a second pastoral belt, with a climate adapted for the growth of wheat and other European products.

Round the south of Africa, on the fertile outer margin of Cape Colony, the tropical vegetation dies out, and the pastoral belt is characteristic. Corn and vine-growing, and grazing land extends over the outer terraces to the borders of the dry 'Karoo' desert, which only presents an ephemeral vegetation after heavy rains.

Across the Indian Ocean the upper pasture zone is imperfectly represented in the scattered grass lands and bush of Western Australia. Sandy plains characterize a great part of the coastland of this region, and it is only in the valleys of the narrow slope from the coast to the plateau, or on the heights nearest the sea, that any continuous extent of grassy land appears. Further inland, between the partly dried up salt lakes, occasional thickets of grass or salt-bush show themselves, but only at intervals, between sandy plains or arid hill ridges.

The chief pastoral and agricultural region in the colony of South Australia, lies eastward of the Gulf of St Vincent, in the Adelaide plains and hills; and on both sides of the chain of mountains which runs northward from this—the Flinders Range—to as far as the region of the great lakes. Here the European grains and fruits, especially the vine, are cultivated with success. Scattered and isolated pastoral districts lie also beyond this main one, along the coast and north of Spencer Gulf. Next to it are the open grassy plains of the Murray River in Victoria, and the richly fertile and cultivated plains and lower lands between the central range of mountains in this colony and the southern coasts. Then follow the vast pastoral regions of the inner watershed of New South Wales,

named the Riverina district, where the 'runs'* support vast herds of cattle and sheep, originally imported from England. The same pastoral downs and plains, each bearing generally the name of the river which flows through it, extend northward through Central Queensland, between the hill ranges, towards the coast and the arid land of the interior deserts, merging into the tropical pastoral zone, which occupies the northern borders of the continent.

V. THE NORTHERN AND SOUTHERN FOREST REGIONS.

1. The Northern Forests.

From the greater extent of land in the northern hemisphere, and from its position nearer the pole, both in the old and new worlds, it follows that some of the surface zones are largely developed in this hemisphere, whilst, in the southern, they are hardly traceable. One of these, which covers a vast extent of the land in the north temperate zone, is the region of the northern forests.

In North America the temperate forests are co-terminous southward with the prairie lands, the boundaries of which have previously been described as following a line drawn from near the mouth of the Mississipi River along the slope of its eastern watershed, south of the great lakes, and thence north-westward, round the 'fertile belt' of the Saskatchewan basin. From this the limits of the forest are traced southward along the outer slope of the highest ridges of the Rocky Mountains, which they cover, to as far as the Mexican frontier; thence north again, along the margins of the arid basins of the plateau and round the prairie lands of British Columbia, to turn once more south, embracing the forests which cover the sides of the Cascade Mountains and the Sierra Nevada, as far as the peninsula

* Leased pastoral estates not generally exceeding 25 miles in area.

of California. The Pacific coast forms the limit westward, and it is not until Behring Sea is reached, that the woods begin to retire from the coast land. A margin of the shores of South-Western Alaska is free from the woods which occupy the interior; but when Behring Strait is passed, their limit turns inland, leaving a wide belt of barren frozen ground along the north and east of the continent. The woods are scanty and thinly spread on the banks of the Yukon River, at its northmost bend,* and a line drawn from above Kotzebue Sound, in Behring Strait, to near this point, seems to form their northern boundary.

In tracing the southern limits of these forests, it is observed that the woods follow the heights of the mountains, finding in their elevations a sufficient moisture to support their growth, and thus carrying a series of tongues of forest through the midst of a region which is eminently dry; but here on the northern edge, the reverse is the case; the hills are bare, and the woods reach to a far higher latitude in the moist and sheltered valleys of the rivers, than on the mountains, for on these heights the same conditions of frost prevail that prevent tree growth in the low sterile grounds of the Arctic coast.

The forests stretch northward in the valley of the Peel River nearly to its mouth, clothing the banks to a breadth of between 4 or 5 miles on each side;† but between this and the Mackenzie River, where they again extend northward to near its delta, it is probable that the limit is carried more than a hundred miles southwards, on the bare heights of the Rocky Mountains, which separate the valleys of these rivers. From the Lower Mackenzie, the boundary of the woods passes close round the northern shores of the Great Bear Lake, and thence apparently south-eastward along the water parting between the Mackenzie

* Dall. Mitt. 1869.

† Isbister, R. G. S. Journal, vol. xx.

basin and the rivers which flow to Hudson Bay, to near the mouth of Nelson River. Here the woods extend to as far as the swampy tracts which form the southern coastland of Hudson Bay.

On the great peninsula of Labrador their northern limit is uncertain, but it appears to lie near a line drawn westward from the head of Ungava Bay, which leaves only the small north-west corners of the land in the treeless region.

Northern Labrador is a land of bare rocks and boulders, of swamps and small lakes, each of which is more or less completely surrounded by woods.* In the more southern portions of the peninsula, the vast forests seem to the traveller only to be limited by the horizon, though there are wide districts over which great conflagrations have swept, leaving a black and gloomy country, in which the white-weathered boulders, strewn in myriads over the hills and valleys, form a prominent feature.† Newfoundland has a broad belt of forest, generally of stunted growth, round a country of heaths, fens, and ponds, in the interior of the island. From Labrador to the southward slopes of the Alleghanies, the eastern coast of America forms the limit of the northern forests, excepting the cultivated lands which have been cleared and which have their greatest extension in the Eastern United States on the Atlantic slope. In the peninsula of Florida the temperate and tropical forests meet in a remarkable manner. The northern part is covered with heavy forests of pitch pine and oak, but in the 'everglades,' an immense lake in the peninsula of between 3000 and 4000 square miles in area, the islands which stud its surface have dense thickets of vines and palmettos, and in the south the palm and banana grow in as great perfection as in Brazil.

It is in the Eastern United States and in Canada, over

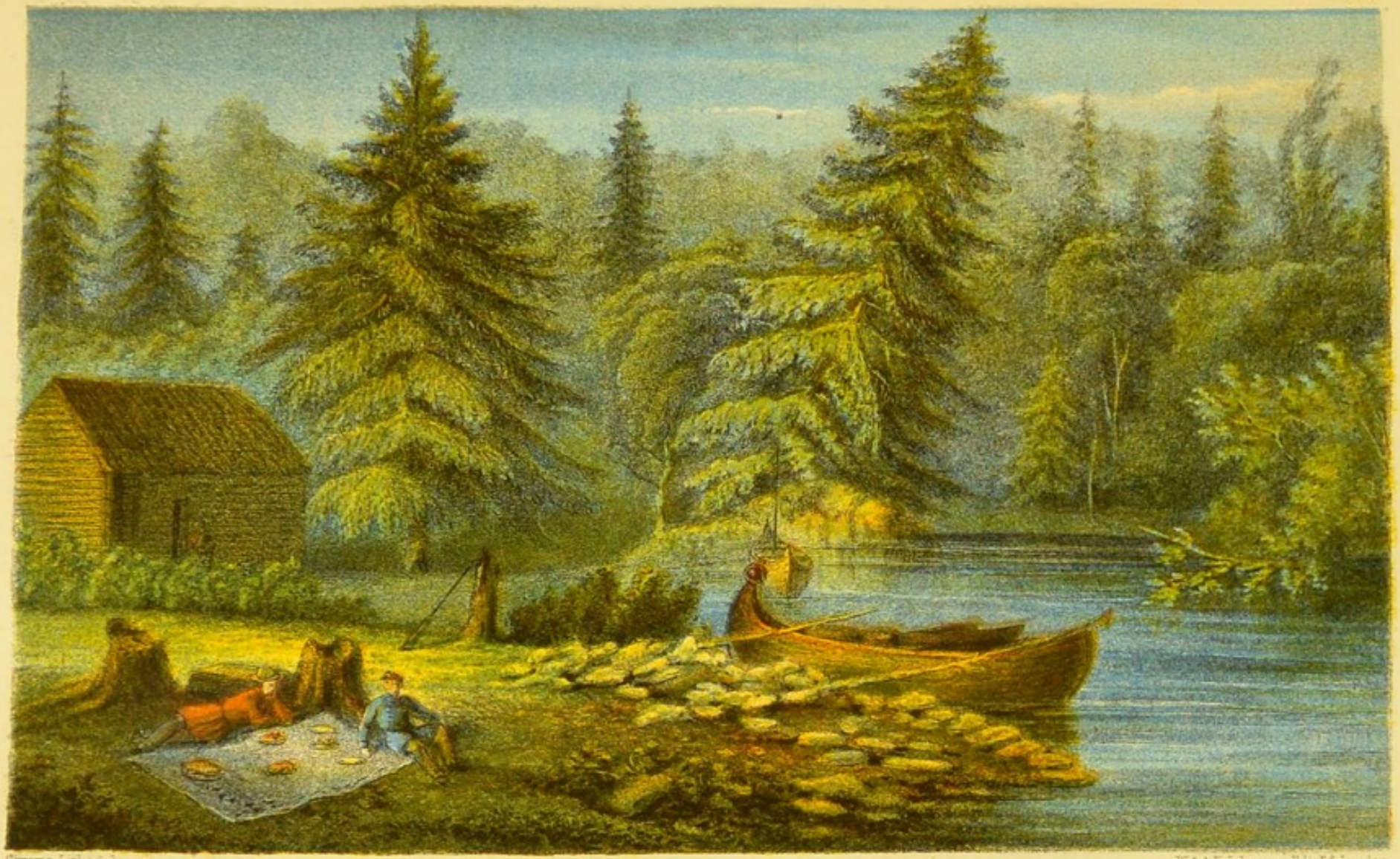
* Reichel, Mitt. 1863.

† Hind, R. G. S. Journal, xxxiv.

which countries the temperate forests naturally extend, that the greatest changes have been wrought by man on the face of nature. From the time of the first settlement of Europeans in these regions, every new comer has helped to effect the change, since the first labour of every emigrant to the 'backwoods' was to clear the land alloted to him, by hewing down the trees and digging out their roots. Thus the whole natural aspect of the Eastern States has been in great part altered, and at the present time a vast, close, network of railways extends from the Atlantic coast to the prairies of the west. In Canada, to a less extent, similar changes are in progress, and the trade in timber or 'lumber,' which is floated down the rivers in great rafts for export, is one of the most extensive in the land.

In the continent of Europe and Asia, the distribution of the northern forests follows precisely the same laws as in America, occupying an immense and continuous area of the continent, stretching southward in long capes, where mountain ranges extend through the main mass of forest in this direction, and retreating in deep bays where the mountains cross its northern edge. In Western Europe their limits have been greatly altered by the advance of agricultural clearing and cultivation, but it is not difficult to trace a complete connection between the remnants of the original forests, now almost confined to the mountain ranges, and the great mass of woodland in the north of the continent.

In the British Isles, the forests which at one period covered the greater part of their surface, have been entirely reduced by the hand of man; and the small patches of woods and plantations which still remain, are shaped, thinned out, and pruned with scientific care. Of the existing and preserved woods in England, the most extensive are, the New Forest and those round it in Hampshire, which supplies oak and beech timber



Chromo Lith.og by W.&A.K.Johnston, Edin.r & London.

NORTHERN FORESTS—VIEW IN CANADA.

for the use of the navy; and St Leonards and Ashdown Forests in Sussex, the remains of the Great Saxon 'Weald;' Windsor Forest, Wychwood in Oxford, Dean Forest in West Gloucestershire, Epping Forest, or the Forest of Essex, the once extensive Forest of Arden in Warwickshire, Rockingham Forest in Northamptonshire, and Sherwood Forest in Nottingham. Many districts named originally from the wooded nature of their surface still retain the name of 'forest,' though the trees have been almost or even entirely removed from them. Such are the Weald (wood) in Kent, and the Wolds of Lincoln, Dartmoor Forest (now moorland) in Devonshire, the Black Forest, Radnor Forest, and the Forest of Clun in Wales, Knaresborough, Martindale, Stainmoor, Lune and Milburn Forests, on the Pennine Chain and Cumbrian Mountains. Most of these now treeless 'forests' are in mountainous districts, and it is probable that portions of the original woods remained on these heights undisturbed for a long period after the lower lands had been cleared. In Southern Scotland the once extensive forests, the names of which, such as Ettrick Forest, in the basin of the Tweed, still remain, have been entirely broken up, though many parts remain well wooded or planted; and almost every part of the highlands beyond the Grampian range, belongs to one or other of the districts which still bear the name of 'forest' or 'deer forest,' though the woods which at first gave them this name have been almost entirely cut down, leaving bare moorlands. Perhaps the most extensive remnant of the Scottish forests is in the pine woods of Rothiemurchus, which cover a considerable portion of the western slope of the Cairngorm Mountains, extending down into the valley of the Spey. Woods are scattered over every part of Ireland; and the 'black bogs,' which cover large areas of its surface, are the decaying remains of its more ancient forests. Passing over

to the continent, the most westerly extension of the northern forests appears in the woods of pine timber which cover the Cantabrian Mountains and the southern slopes of the Pyrenees in Spain. Next are the pine forests of the Cevennes, the woods of the plateau of Langres, leading into the forests of the Vosges Mountains; continuing these are the woods which cover the heights of the valleys of the Moselle, the Upper Meuse, the forests of Argonne and of Ardennes.

The termination of a second arm of the northern forest is in the Island of Sicily; most of its mountains have been in the course of ages stripped of their ancient forests, and now present a naked and barren appearance; the sides of Mount Etna, however, are still covered with pine forests, and other extensive woods are scattered over the island. Continuing this line are the woods which cover the sides of the Apennines throughout Italy, of pine, oak, beech, and chestnut, from summit to base, joining into those of the Alps. As a branch from this line may be noted the mountain forests of the islands of Sardinia and Corsica.

From the forests of the Alps and the highlands of Switzerland, branches extend in all directions. Northward the forests continue over the Jura Mountains to meet the Schwarzwald or Black Forest of Baden, ramifying eastward in the woods of the Rauhe Alp in Würtemberg, and passing on to the Oden Wald in Hessen, the wooded chain of the Spessart, the Steigerwald, Rhon, and the Harz Mountains. Throughout Germany, from the fact that the woods have been left standing only on the high parts of the country, the word 'wald' has come to signify a mountain.

From the eastern Alps a line of forest mountains extends to meet this one, over the Böhmer Wald, the Fichtel-Gebirge, the Franken Wald and the Thüringer Wald; the forests of the Erz-

Gebirge, Riesen-Gebirge and Sudetic Mountains, form a link between the woods of Bohemia and those of the Carpathian Mountains.

South-eastward from the Alps extend the dense forests of the mountains of Bosnia, continued through Albania, and over the Pindus range, into northern Greece and the mountains of Morea, and eastward over the mountains of Servia, and by the Balkan range, the declivities of which are covered with forest, thickest and most continuous on the northern slope.

The forests of the Carpathians and of the Transylvanian Alps, meeting those of Austria and of Turkey at the points where the mountains narrow the valley of the Danube, connect the peninsular branches to the main area of the woods, which approaches closely to the Carpathian chain on the east. A great proportion of the surface of the plain of Prussia is covered with wood, though it is often of a stunted growth, owing to the infertility of the soil, but eastward in Poland the true forests begin.

These forests, extending continuously in a broad belt from the Scandinavian Peninsula on the west to the Sea of Okhotsk and Kamtchatka form the second, and only important division of this zone besides that in North America. On the north their limit is that of the Tundra or sterile frozen margin of the Arctic seas, and this has been traced at various points. The warming and equalizing influence of the Gulf Stream drift allows the woods to extend nearly to the furthest valleys of Norway, but eastward in Lapland, which is out of the path of the warm drift, their limit turns southward, and a great portion of the higher eastern slope of the Norwegian mountains in Lapland and northern Sweden, is a branch of the Tundra, entirely destitute of trees, a region of swamps and lakes, covered with reindeer moss between.

A line drawn south eastward from the entrance of Varanger

Fjord to that of the White Sea, divides the peninsula of Lapland into two nearly equal portions, and separates between the northmost woods of the forest region, and the treeless, mossy, Tundra.* On the opposite coast of the White Sea in Northern Russia, the boundary of the woods leaves the coast in nearly the same latitude as that in which it reached the east coast of Lapland, and passing south of the peninsula of Kanin, at a distance of about 50 miles from the sea, touches the coast again at the estuary of the Petchora river, the banks of which carry the trees northward. From the further side of the estuary the limit runs southward to the Petchora, and along the northern side of its tributary, the Ussa river, to the Ural chain. On the mountain heights the limit runs still further southward to below the 66th parallel, but turns sharply northward on the eastern slope in the valley of the Obi river, which again carries the wooded region near the Arctic Sea coast. Eastward between the lower courses of the Obi and Yenisei, there appears to be a considerable southward extension of the Tundra, which drives the tree limit back probably as far as the 62d parallel. Approaching the Yenisei River, the limit of the woods again runs northward in that valley to near the estuary of the river, and afterwards apparently forms a series of loops north of the 70th parallel, running towards the coast in the river valleys, and bending southward on the higher ground between these; lastly approaching close to the Frozen Sea at the delta of the Lena River.

Still further east the limit is carried southward by the Verkhoiansk Mountains out of the Arctic circle, but turns again to the coast along the valley of the Indigirka. By similar loops it reaches the mouth of the Kolima, and then turning first southeastward to the Stanovoi Mountains, is apparently carried back

* Prof. Friis, Mitt. 1870.

by these on their northern slope to nearly as far as the meridian of Okhotsk, then eastward on the southern watershed of the range to cover the lower slope of the mountains of Kamtchatka. The east coastline now forms the boundary of the forests, and they appear to stretch continuously southward along it on the maritime ranges to the mountains of the Corea. The island of Saghalien belongs to this forest zone, for the greater part of its hilly surface is covered with full grown trees; and Yesso, the north island of Japan, has abundant timber.

On the mainland the cultivated plain of Manchuria, and the pastures of the valleys of the Amoor, and of its tributaries the Sungari and Usuri, carry the boundary of the forests northward round these; but it turns again south in a belt of forests which covers the outer slope of the plateau, in the Khinghan Mountains, which are exactly comparable, in their effect and position, and forest covering, to the Rocky Mountains in America. Continuing this line are the forests of the Inshan range, and the whole of the high mountains of Western China appear to carry ramifications from the main forest southward to the broken edges of the plateau of Tibet. The high mountains which rise between and feed the head waters of the Yang-tsi and Cambodia Rivers, on the borders of China and Tibet have magnificent pine forests, which afford shelter to numerous herds of deer,* and the Himalaya edge rising through every zone, has a band of northern forest along its slope, between the average height of 6000 and 12,000 feet above the sea. This band continues round the declivity to Kafiristan, in which the mountain sides are overgrown with forest to a height of 10,000 feet. Returning to the main forest, its limit passes westward from the upper Khinghan Mountains along the northern slopes of the Mongolian plateau, past the Kosgol Lake, to follow the line of

* Cooper, R. G. S. Proceedings, 1871.

the Altai, as far as the eastern boundary of the steppe. From this corner of the forests also, branches extend southward over the Thian Shan and the mountains west of Lake Issyk-Kul. The central heights of the Bolor and Hindoo Koosh Mountains seem to be almost destitute of trees; but the forests reappear on the mountains which first meet the sea-winds from the Indian Ocean; these are the woods of the Sufaid-Koh, south of the Cabul valley, and of the highest ridge of the Suleiman Mountains. Still further west are the forests of the northern slopes of the Elburz Mountains, south of the Caspian Sea; then the woods of the mountains of Kurdistan, and of the outer ranges of Armenia; next the noble forests of the Caucasus range, attaining an altitude of 8000 feet, and uniting eastward with those of the Euxine slopes of the plateau of Asia Minor. One of the great forests in the central part of this slope, west of Boli, is known by the Turks as the 'Sea of Trees,' and gives an inexhaustible supply of timber for the Ottoman navy.

Corresponding to the forests of the northern slope are those of the Taurus Mountains on the opposite declivity of Asia Minor, branching southward in the woods of the mountains in northern Syria, and of Lebanon, though these seem to be fast disappearing, and having a detached portion in the thickly wooded steeps of the Island of Cyprus.

From the base of the Western Altai, the limit of the great Siberian forest runs northward co-terminous with the steppes, the boundary of which has been previously described. A remarkable branch or extension of the forest occurs between the Upper Irtish and Obi Rivers, south of the steppe of Barabinsk, where a belt of pine wood leaves the main forest near Barnaul, and extends westward in the river valleys for more than 200 miles through the steppes to beyond the town of Semipalatinsk. The cause of this extension of the forest is probably to be

found in the greater moisture of the valley in which it occurs. In Orenburg, on the borders of Asia and Europe, the Ural heights carry a broad promontory of the forest southward, but rounding this, their limit over the plain of South Russia runs in a line almost exactly continuing that of the northern side of the Asiatic steppe, or from north-east to south-west. This limit, which is also that of the steppe and pasture lands of Russia, meeting the wooded mountains of Transylvania and Northern Turkey, completes the outer boundary of the great forest.

2. The Southern Forests.

The temperate forests occupy a distinctly marked and separate area in South America, though from the smallness of the portion of this continent which reaches to a high southerly latitude, the woods are of insignificant extent in comparison with the northern forests. The tropical forests of the Amazons are continued southward on the inner slope of the Andes, to as far as the spurs of the Sierra de Aconquija in the Argentine province of Tucuman (27° 5′), but the southern forests are distinctly separated from these by the pastoral zone, which meets over the treeless mountain heights between Mendoza and Santiago, in Chile. The forests of Southern Chile and Patagonia are found only on the outer slopes of the Andes, and this is accounted for simply by the difference of climate of the two watersheds in this latitude, for while the western declivity may be drenched with the rains brought by the prevailing westerly wind, scarcely a drop reaches the opposite slope. The province of Colchagua (34° S.) is the northern limit of these forests, and from this they extend continuously to the Island of Tierra del Fuego. In Valdivia vast conflagrations have been resorted to in summer to clear the dense underwood of the forests, and allow the ground to be utilised for pasturage. At their furthest south, in

western Tierra del Fuego, the southern forests only reach the same latitude as the middle of the northern forests of America, but the declivities of the mountains are covered, from the water's edge up to 1000 or 1500 feet, with dense forests.

The forests which cover the higher slopes of the Drakenberg Mountains of South Africa, in Natal and Kaffraria belong to this zone, and these are continued in the woods of the southern face of the terraces of Cape Colony, terminating in Africa in the fir woods of Table Mountain, above Cape Town. In Australia the zone is represented by the woods of the narrow outer watershed of the mountains in the east of the continent, extending from the pine woods of Moreton Bay to the Victorian Alps in the south, where the evergreen beech constitutes the main forest.

The woods of Tasmania, remaining now chiefly in the western districts, and the dense forests of both islands of New Zealand, complete the circuit of the southern belt.

These forests extend between greatly different limits of average temperature. On their northern borders, where they touch the tundra, the trees of the deciduous forests appear to be able to withstand an average temperature in January, as low as —30° Fahr. But it is to be remembered that the whole region lies far within the limits of snowfall, and that as soon as the temperature sinks below the freezing point, the whole forest may be covered up in a protecting mantle of snow. On their southern edge the highest average of the summer months may be as much as 70° Fahr.; but a greater variation of temperature than 80°, between the extreme months of winter and summer, is seldom found at any one part of the forest belt. The daily range of temperature is small, since these forests act in conserving temperature, though in a less degree, in precisely the same way as the forests of the equatorial region; rapid

changes of daily temperature seem to be fatal to tree growth. The moisture supply of the northern forests is partly from snow, partly from rainfall, but they lie in a zone in which these may occur at any time of the year. The deposition of moisture over them seems to vary from a minimum of perhaps 15 inches, to upwards of 100 inches, and at special points which first intercept a moist current of air from the sea, this high average may be exceeded.

VI. THE TUNDRA REGIONS.

It was observed that whilst the upper region of forests is well developed in the Northern Hemisphere, in the southern the area which it could possibly occupy is comparatively small; the same is true in a greater degree of the tundra region, for, in the latitude in which we should expect to find such barren mossland, in the Southern Hemisphere the ocean has the sway. The inward limits of the sterile lands of America and the tundra of Asia, are the northmost points to which the last trees of the forest regions extend, and they occupy the land between these limits and the north coasts, forming a circle round the shores of the great Arctic Gulf. In America, but more especially in Asia, the inner edge of the tundra belt forms a series of capes which runs southward into the forest region, wherever a higher and consequently colder and more exposed part of the land occurs, and this is generally between the valleys of the northward flowing rivers. The belt has an average width of about 200 miles, and has a nearly similar character throughout. That part of it which falls in the north of Alaska territory (formerly Russian America) is described * as having a peat soil covered with moss and tufted grass, completely free from rocks or stones, which

* Simpson, Parliamentary Papers, 1855.

are only occasionally seen in the river beds. The fossil bones of elephants and other animals are found in many places. Further east, the 'barren grounds' and sterile regions are higher and more rocky.

The Siberian tundra agrees also to this description, and has a dead level surface completely destitute of trees, covered with moss in those parts of it which are not entirely destitute of vegetation. The soil of these regions is constantly frozen to a great depth, and in summer only a thin stratum of the upper surface is thawed. The Island of Nova Zembla, covered in some of the lower parts with mosses and lichens, may be considered as forming part of the Siberian tundra belt.

In the northern borders of the temperate forests, and in the Tundra, the reindeer finds its home, and it is the indispensable companion of the inhabitants of these northern climes. It is their beast of burden, its flesh is their staple food, its skin gives them clothing, and even its dried sinews are utilized for sewing together the native garments and fastening the planks of sledges and boats. 'Two most important epochs of the year are the spring and autumn migrations of the reindeer. About the end of May these animals leave the forests, where they had found some degree of shelter from the winter cold, in large herds, and seek the northern plains nearer the sea, partly for the sake of the better pasture afforded by the moss tundras, and partly to fly from the mosquitos and other insects which, literally speaking, torment them to death.' . . . 'In good years, the migrating body of reindeer consists of many thousands; and though they are divided into herds of two or three hundred each, yet the herds keep so close together as to form one immense mass, which is sometimes from 50 to 100 versts (33 to 66 miles) in breadth.'*

* Wrangell's 'Siberia and Polar Sea.'

In driving the reindeer sledges over the level tundras, the natives of these trackless wilds guide their course for hundreds of miles, only by the 'long wave-like stripes of snow' called 'sastrugi,' formed by the prevailing winds, crossing these with practised skill at the proper angle which will lead to their destination.

The only small portion of the Southern Hemisphere which can be considered as representing the tundra belt there, is the barren Kerguelen Island, in the South Indian Ocean. From the influence of the surrounding sea, its coasts have some appearance of greenness and fertility, but the higher parts of the island are scantily covered with moss, and at an elevation of 1000 to 1200 feet growth ceases entirely.

VII. THE ICY POLAR REGIONS.

1. The Arctic Region.

The icy regions which cap the poles of the globe, are, more than any of the surface zones, subject to a yearly change in aspect and extent, according to the season. The other zones are confined to the land alone, but in these the characteristic snow and ice occupy also a great area of the Frozen Ocean, so that land and sea together must be considered as forming part of these divisions. In the equatorial belt of the globe, there is an unvarying round of almost equal day and night within each twenty-four hours, and the yearly variation of temperature is small; but within the polar areas, between the one long night and day which divide the year, a great change takes place in the temperature of their surface.* The result of this variation of temperature is, that

* It must, however, be remembered, that the yearly variation of temperature in some parts of the continents of the northern hemisphere, outside the margin of the Arctic circle, far exceeds that of the poles.

the icy cap of each hemisphere is constantly either expanding outward on all sides to its maximum, or contracting to a minimum of extent, and it can be shown that, at the time of its widest range, during its winter night, the ice of each pole stretches over an area three times as great as that to which it diminishes under the warmth of the long daylight. It may extend to every point of the earth at which the thermometer falls below 32°, and includes within its permanent grasp the region in which the lowest temperature of the air may be experienced, where the thermometer may indicate a fall to 40 or even 60 degrees below the zero point of its scale. Of the land portions of the icy regions, by far the most considerable is the glacier field of Greenland. The whole of the interior of this vast island, the northern limits of which are as yet completely unknown, is believed to have one continuous covering of ice and snow, reaching down to near its coasts on all sides. Numerous fiords, or deep clefts, with perpendicular walls, formed in the rocky basis of the island, intersect its coast line, and run far into the interior. The marginal ice, probably from the weight of the interior and higher ice, the 'inlands iis' of the Danes, which must constantly receive fresh accumulations of snow on its surface, moves slowly towards the coast. Where it reaches a low part of the coast-land, the edge of the inland ice appears as a steep glacier wall, called 'sermik soak' by the Eskimo, which may advance or retreat to some extent after a period of colder or warmer weather; but each fiord which cuts more deeply into the land, is filled in its upper part by a glacier, which, pressed forward by the inland ice, constantly launches great 'icebergs' into the waters of the inlet. This movement is more marked in some parts of West Greenland, which are hence termed the 'ice-streams' of the inland ice. Moving slowly outward to the mouths of the fiords, driven

forward by the daily land breeze, these icebergs are caught into the great icy currents which flow round the coast of Greenland, and afterwards, borne southward along the American coast, appear frequently off the banks of Newfoundland, within or even past the limits of the warm Gulf Stream, at a distance of more than 2000 miles from their original glacier. Ice streams are also known on the east coast of Greenland, between the 70th and 75th parallels, and the bergs brought down that coast by the Greenland ice current, which bends round Cape Farewell, are often stranded on the shallower capes of the west coast.

The part of the inland ice of Greenland, named the Humboldt glacier, which offers the longest continuous face to the coast, and is the largest true glacier known to exist, occurs in the coast of the Kane basin, north of Smith Sound. Its escarpment, abutting upon the water, presents a perpendicular face, varying from 300 to 500 feet in height, and extends for fifty miles. The bergs are ejected in lines from the glacier, and its crevasses and fractures are on an unexampled scale.

Next to Greenland, the islands of Spitzbergen present the most completely glacial land known in the Arctic regions. The greater part of the interior of the main islands is covered by the inland ice, which, in some parts, has an elevation of 2000 feet. Here and there sharp black mountain peaks rise out of its white surface, and on all sides it reaches down to the outer coasts or in the fiords, in great glaciers, which, like those of Greenland, throw off numerous icebergs. The inland ice of North-eastland is bounded westward by a very remarkable ice wall, or ice-covered cliff, which rises to a height of 1500 or 2000 feet, and one of the most extensive glacier faces (named King John Glacier), about 30 miles in length, and from 20 to 100 feet high, appears on the south-easterly coast of Edge Island, or Stans Foreland.

With the exception of Ellesmere Land and North Devon, on the west side of Smith Sound, and of the mountains of Northern Norway, it does not appear that any other known land within the Arctic circle possesses considerable glaciers.

The Arctic archipelago, west of Baffin Bay, seems to have a uniformly monotonous, rocky, and barren aspect. No one of the islands has any great mountain peak or summit range, but they frequently present the appearance of irregularly tumbled and broken hills, cliffs, and perpendicular capes, with deep inlets or narrow channels between. Where the coasts are low, it has often been difficult to distinguish between the snow-covered land and the 'hummocked' ice of the frozen sea. Only in the height of the Arctic day, when the snow covering is partly removed, a scanty vegetation of mosses and lichens may appear on their surface.

Since the existence of the glaciers of the polar regions is due to the condition of their climate, or mainly to the presence of a considerable snowfall, a low average temperature, and a suitable formation of highland,* receiving an accumulation of snow on its surface, it follows that, in whatever other parts of the earth's surface these conditions may exist, the same phenomena will appear. The temperature of the atmosphere, as a rule, decreases from the earth's surface upwards; and thus, in every latitude, there is a certain elevation at which descending moisture appears in the form of snow. The snow limit, or 'snow line,' may then be conceived as a second delicate shell enveloping the globe, touching it at the polar regions, and raised to a height of about 16,000 feet above it, at the equator, but irre-

* A considerable slope and height appear to be necessary for the production of glaciers, since they do not appear on any level or low surface of the Arctic region, excepting such as is in the immediate vicinity of mountains.

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VIEW IN THE ARCTIC REGIONS.

gularly depressed or elevated, according to the peculiar climatic conditions of each region beneath it, alternately drawn close over the hemisphere which has its winter, and expanded over the opposite one, which has summer.

Many mountains of the Northern Hemisphere raise their heads through this outer envelope at all seasons, but there are only a few of the elevated masses, the form and moisture supply of which are so combined as to allow the presence of glaciers.

The snow-fields of Greenland continue southward beyond the Arctic circle, to the latitude of the Shetland Isles; and those of Norway tend to expand where there is a greater mass of mountains toward the south of the peninsula, till in Jostedals or Snee Braen, the greatest snow-field of the European continent appears with its dependent glaciers, covering a surface of more than 600 square miles. Lying completely beyond the Arctic circle, there is an extensive mass of icy mountains in the south-eastern part of Iceland, named the Vatna or Klofa Jökull, from which magnificent glaciers slope down to the plains and to the sea. These icy masses are often rent by the eruptions of the volcanos, when great avalanches occur.

The glaciers of the mountains of Switzerland are the most widely known and explored of all, and, especially in the Pennine and Bernese Alps, cover a considerable area of the mountain slopes down to an extreme limit of 3200 feet. Some of them, such as the Aletsch, are of greater extent than any of the Norwegian glaciers, yet the snow-fields from which they spring are comparatively insignificant. There is a small glacier on the north-east side of the summit of Monte Corno, the highest point of the Gran Sasso d'Italia in the Central Apennines. In the Pyrenees a few partially developed glaciers appear on the northern sides of the highest summits and under their shelter;

two of the more important of these are on the Spanish, and four on the French slope, but on neither side do they reach down to the inhabited or cultivated valleys, or below a level of 7200 feet. The only other glaciers of the Spanish peninsula, and the most southerly in Europe, are a very small one on the summit of the Sierra de Gredos, west of Madrid, and the glacier in the Corral de Veleta of the Sierra Nevada, the lowest part of which is 9300 feet above the sea. Though the Tatra group in Hungary rises considerably above the snow line, its steep form prevents the existence of any snow-fields sufficiently extensive to produce glaciers; still true glacier ice appears here and there near the summits. On the Caucasus chain, owing partly to their form and partly to their position between two seas, the glaciers have not such an extension as might be looked for from their height and latitude, or as compared with the Alps, and this is certainly due to the drier nature of the surrounding region. Their greatest development on this chain appears to be between the Kasbek at Mount Elbruz, and chiefly on the slopes of these two summits. On the north side the Devdorak, the largest of the Kasbek glaciers, descends to a level of 6300 feet towards the valleys of the Terek; and on the south the glaciers from Mount Elbruz reach down to a level of about 7000 feet.*

In Central Asia it is probable that a number of yet undescribed glaciers exist on the mountains which form the northern slope of the great plateau. Mount Munku-Sardik, in the eastern part of the Saiansk range, north of the Kos-gol, has two considerable glaciers, one of which extends down to 7100 feet above the sea;† and the Katunja glacier, in the Altai range, descends to 4300 feet. A circle of Alpine glaciers exceeding in extent the 'Mer de Glace' of Chamounix, surrounds the Tengri-

* Freshfield, in R. G. S. Journal, 1869. † Radde.

Tag, one of the most elevated groups of the Thian-Shan, or Celestial Range, but their lowest limit is 9800 feet above the sea,* and west of this, M. Fedchenko recently described the glaciers of the continuation of the Thian Shan on the north of the Pamir plateau. The glaciers of the Mustagh ('Mus,' snow, 'Takh,' pass in Yarkundi), and Karakoram ranges, extend almost continuously from the basin of the Shigar River, a tributary of the Indus, eastward to that of the Pangkong Lakes, and form one of the most considerable icy regions of the southern side of the Asiatic plateau. Long trains of ice, with tributary glaciers, debouch into the drainage lines of the chief valleys. Of these, the glacier of Biafo is perhaps the most extensive, and stretches in a continuous line in one of the upper valleys of the Shigar River, for a distance of 60 miles (or is nearly ten times the extent of the largest of the Alpine glaciers), terminating at a level of 9880 feet above the sea. Minor glaciers appear both in the northern and southern enclosing mountains of the valley of Kashmir. In the Kuenlun Mountains, the glacier limit is believed to be 9900 feet. The snows of the Himalaya, in Kumaon and Gurhwal, form an extensive and continuous belt, from which vast glaciers depend into the valleys. Two of these, near the peak of Nanda Devi, reach down southward, the one to a limit of 11,400 feet, the other to 11,900 feet above the sea, or to 3000 feet beneath the snow line. Eastward in Sikkim, the glaciers from the snow fields of Mount Kantchinjinga, the most southerly of the old world, descend in the winding gorges to 15,000 feet.

Isolated glaciers are found on some of the higher mountains of Western Asia, such as that of Mount Demavend, in the Elburz range, limited to 9500 feet; the small glacier in Jacob's valley, on the northern slope of Mount Ararat, extending down

* Semenoff, R. G. S. Journal.

to about 10,000 feet above the sea; and the glaciers of the ancient volcano crater of Mount Argaeus, in the Anti-Taurus range, reaching to 9800 feet.

It does not appear that there are any glaciers whatever in the mountains of the African continent, though Mr New, in ascending Mount Kilima-njaro, beneath the equator in East Africa, found the great dome-shaped summit thickly covered with perennial snows.

The most northerly glaciers of the mainland of America seem to be those which stretch down from the coast range south of Alaska territory to the fiords and inlets of the coast. From Mount St Elias, in this region, the glaciers reach down to the sea. Numerous glaciers descend from the heights of the Cascade Range to the fiords of British Columbia, bordering the Gulf of Georgia. The 'great glacier' of this region, three-quarters of a mile in width at its termination, occupies the head of Bute Inlet.

In the Rocky Mountain range, between the 51st and 52d parallels of latitude, considerable ice fields and glaciers have been found.* The high valleys between Mounts Forbes, Lyell, and Balfour, are occupied by a great field of ice, from which numerous river-feeding glaciers descend to a limit of 4300 feet. A second group of glaciers, in this region, occupies the valleys of Mounts Lefroy, Ball, and Goodsir. South of this, in the Rocky Mountains, no glaciers are as yet known, and their absence should probably be ascribed to the dryness of the surrounding regions. In the Cascade Range of the west coast the sides of Mount Rainier, for 2000 feet, are covered with an immense sheet of granular ice, broken by crevasses; lower down the ice sheet is divided by rocky masses into cascades for 3000 feet, and from these true glaciers descend. Mt. Hood,

* Palliser.

in the same range, supplies three distinct glaciers from the snow and ice basin of its extinct crater; glaciers have also been discovered in the northern crest of Mt. Shasta, though neither ice nor snow appeared at all in the southern slope.

Where the continent is narrower southward, and the high mountains are in consequence nearer the moisture supply of the sea, glaciers again appear on the summits of Ixtaccihuatl and Orizaba, in Mexico, though, in the latter, only above a limit of 13,100 feet. The summit of the Sierra Nevada de Santa Marta, near the coast of the Caribbean Sea, in South America, has also glaciers which extend downwards beneath the snow limit. On the Nevado de Tolima, in the central cordillera of Columbia, they appear above an elevation of 14,000 feet, and are present, even under the equator, on the summit of Mount Cayambe, on the eastern cordillera of the Andes.

The land of the Arctic region appears then, partly as snow field, inland ice, and glacier, partly as barren rock, covered with snow during the greater part of the year. The sea ice, which forms an essential part of the region, is variously distinguished in the changes of aspect which it undergoes from the time of its first formation as a solid covering of the sea, to that of its breaking up and melting at the margin of the polar cap, borne outwards by the constant circulation of the ocean currents. From the unvisited central regions round the pole, where great areas of the sea surface are believed to be annually frozen, as well as from the straits and channels west of Greenland, there are loosened at the commencement of the Arctic day, in the end of February or beginning of March, vast level sheets of ice, which begin to move with the tidal streams and surface currents. Round the coast, in high latitudes, there remains a fringe of 'land ice,' called the

'ice-foot' by the Danes, permanently attached to the shore, and of great thickness. Between this land ice and the great sheets which have become loosened, or afterwards across the surface of the ice sheets themselves as they begin to be further broken, there appear navigable 'leads' or channels, and narrower 'lanes' or passages. Separated portions of the ice sheets, still so extensive that the eye cannot reach over their surface, are termed 'fields.' When the whole extent of the piece can be viewed at one time, it bears the name of a 'floe.' Pieces of less than a mile in width come under the designation of 'drift ice,' and an accumulation of broken ice forms a 'pack.' When a ship can make its way through the floating pieces, the ice is termed 'loose,' and when it is so scattered as to offer no direct opposition to the free passage of a vessel, it is known as 'sailing ice.' 'Brash ice' swims in small pieces, and is on the point of melting.

The fields and floes of ice are sometimes driven and ground together by opposing currents or winds with great force; the edges are broken, and pieces are forced up and piled one above another on the top of the floe, where, pressing together, they form the masses called 'hummocks' by English navigators, which are sometimes 60 feet high; in the Siberian seas, where they are called 'toross' by the Russians, they are even more frequent, and appear in long lines of hillocks, or in great solitary masses. At first the layers of sea ice, of which they are composed, may be easily seen, and the broken edges are sharp, but after a time the heaps become weathered and rounded.

There are great variations in the thickness and character of the ice which is formed in different parts of the Arctic basin, depending very much on the position in which congelation has taken place, and its freedom, or the reverse, from disturbance

by winds, tides, and currents. Along the Siberian coast, where the sea is shallow, and strong tides and winds frequently break the ice, it becomes so thin at a certain distance from the land, as hardly to support the weight of sledges driven over it. In the Spitzbergen seas the field ice moving south is found to be from 10 to 15 feet in thickness, and the fields vary from 30 to 100 miles in length. In Baffin Bay the average thickness is only from five to six feet, but in the sounds and channels of the archipelago westward it is again greater. In the space between the Parry Islands and the North American coast of Alaska, which is believed to be a land-locked sea,* the undisturbed ice has attained an enormous thickness, and has been found to be from 70 to 80 feet below water, rising above in hillocks, some of which are more than 100 feet above water. This ice must be of great age, since the mounds on its surface are of perfectly fresh ice, formed there by long deposition of snow.

Neither on sea nor land, does the limit of the icy Arctic region agree with the mathematical Arctic circle; and its extent, as before noticed, varies exceedingly according to the season of the year. The snows which cover a large part of the land in the north temperate zone, reach their most southerly limits during the months of mid-winter, from December to January; but the drift ice on the sea does not reach its widest bounds until after the field ice, formed and bound together about the pole in mid-winter, is released by the approaching summer. Icebergs, from their great mass, resist the melting power of the warmer regions, into which they are borne by the currents, for a much longer time than the ice formed on the sea surface, and thus appear in far more southerly latitudes or at warmer seasons, than the last fragments of the drift ice; but the points to which

* Sherard Osborn, in R.G.S. Journal, 1873.

the drift sea ice may reach, and which are in some parts nearer the pole than the limit of icebergs, mark more truly the extent of the icy regions.

The extreme limit of the appearance of ice in the Atlantic, marked by a white line on the large chart, begins on the American coast at the southern entrance of the Gut of Canso, between Nova Scotia and Cape Breton Island, since a small quantity of ice escapes to the Atlantic through this strait from the Gulf of St Lawrence; from the Nova Scotian side of the strait the limit seems to pass almost due south to about the 40th parallel of latitude, and to turn eastward along this line across the ocean more than half way to the Azores Islands; as far as this line, which is in the same latitude as the south of Italy, icebergs may be carried across the Gulf Stream by under currents, which continue the icy current of Labrador beneath the warm stream. At about the meridian of 40° W. of Greenwich, the limiting line turns again due north to the border of the ice current of East Greenland; thence it passes south of Iceland towards the Faroe Islands, and afterwards turning more to the north-east runs midway in the sea between Iceland and Norway, and between the North Cape and Spitzbergen to near the south island of Nova Zembla; approaching this island, however, the limit recurves along the north coast of Asia and Lapland to the eastern side of Varanger Fiord, including the White Sea within the icy region. The very remarkable curve formed by the northern part of this limit, which leaves the seas round Britain, and for an average distance of 300 miles round Norway, clear of ice at all seasons of the year, is due to the warm drift current which prolongs the Gulf Stream.

On the Pacific side the drift ices of Behring Sea extend to a line passing from the American coast along the northern side

of the Aleutian Islands to near the middle of the chain, then northwards towards St Lawrence Island, carried up in a curve similar in character to that formed by the Gulf Stream drift in the Atlantic, by a branch of the warm Japan current, afterwards curving south-westward to the coast of Kamtchatka above Petropaulovsk. Further west the ice of the sea of Okhotsk, the shores of which are frozen from November to April, may reach down to a limit drawn from the South Cape of Kamtchatka south-west towards the Island of Iturup and Southern Saghalien. During the winter of the Northern Hemisphere the portions of the continents of the old and new worlds, which lie northward of a line termed the equatorial limit of the fall of snow may be enveloped in that Arctic covering,* and the inland seas which they surround, or the lakes on their surface may be frozen over for a longer or shorter period, according to their situation nearer or further from the Arctic region. Within the Scandinavian peninsula, the shores of the Baltic Sea are annually covered with ice, which closes the harbours from the end of December to the beginning of April, but the ice forms sooner and remains longer in the northern Gulfs of Finland and Bothnia. The northern coasts of the Black Sea may also be frozen up from the beginning of January till the end of February, and the navigation of the Sea of Azov is impracticable during the whole winter. The northern portion of the Caspian is annually covered with ice, and in the line of great Asiatic lakes, those of Balkash and Ala-Kul freeze over in the last days of November, and do not thaw till April.† Zaisan-Nor, at the head of the Irtish, is frozen from the beginning of November till May; Kosgol,‡ from

* The small charts to the right, at the foot of the large diagram, have been coloured to illustrate the changes in the extent of the polar ice and snow in the extreme months of the year; January and July in both hemispheres.

† Abramot and Golubef.

‡ Permikin.

November till the beginning of June; and Lake Baikal, at a lower level than the Kosgol, though further north, is frozen over from the middle of December till the beginning of May, during which period the whole of the caravan traffic between Irkutsk and Kiakhta passes across it on the ice. The larger lakes of Central Europe, of Geneva and Constance, are rarely frozen.

The ices of Hudson Bay close that inland sea to traffic, excepting in the months of July and August, when the ships which carry to Europe the furs collected during a year at the forts of the Hudson Bay Company, make a rapid passage into and out of this mediterranean; the Great Bear Lake freezes in the beginning of November, and is not clear of ice till June; the Slave Lake* is iced over from the end of November till June, and Lake Superior freezes from the middle of December till April, though none of the great Canadian lakes become ice bound in their centres. It is remarkable that some lakes, though apparently within the embrace of the Arctic frosts for some portions of the year, never freeze. Such are the Issyk-Kul, or 'warm lake,' in the Thian Shan Mountains of Central Asia, 4900 feet above the sea, and Lake Hoktchia in the Caucasus,† still higher. The great depth of these lakes, and the protection of the closely surrounding hills, are believed to account for this peculiarity.

The equatorial limit of snow in the Northern Hemisphere passes through Upper California, Northern Mexico, and the Southern United States in America; through the Mediterranean, the southern part of the Caspian Sea, along the Himalaya slope, and through Southern China, in the old world. It thus includes the larger part of the temperate zone; but the sway of the Arctic climate over the most part of this area is

* Franklin.

† Semenoff, R. G. S. Journal, 1870.

of such short duration, that it cannot be considered as forming part of the icy region. The normal boundary of the Polar cap should rather be drawn on the land along the inner border of the tundra, on the line which separates these frozen levels from the northmost woods. Taking this limit in connection with the extreme boundary of pack ice, upon the sea surface, the Arctic region at its widest, embraces an area of about 9,500,000 square miles, or an extent equal to that of the North American continent.

After the summer of the Northern Hemisphere has set in, the ice, first disappearing from these lakes and inland seas which lie farthest south, shrinks poleward to within the Arctic circle at almost every point, leaving no part of the ocean ice-covered outside of that limit, save the southern coasts of Greenland, and no unthawed surface of the land, excepting the permanent glacier fields, and the highest snow peaks.

The 'Middle Ice' of Baffin Bay and Davis Strait, which has a constant movement southward, even during the winter,* becomes completely detached in summer from the shores of the gulf, so that the whaling vessels proceeding along the 'leads' on the Greenland coast, find every year an open space, termed the 'north water,' between Melville Bay and Lancaster Sound on the opposite side, and are able to effect the 'crossing' of the bay at this point, returning by the American coast.

Lancaster and Melville Sounds are seldom passable before the latter half of July, and the most northerly islands of the

* The Fox (Captain Sir F. L. M'Clintock) was frozen into the upper side of the middle ice between Melville Bay and Lancaster Sound, on 18th August 1857, and was not freed until the 25th April 1858, when the vessel had moved south to latitude 63° 30′ N., and the ice was broken up by a storm from S.E. The slow drift on the middle ice of a part of the crew of the ill-fated American Polar Expedition, during the winter of 1872–73, from the entrance of Smith Sound to the Atlantic, also proves this southward movement.

archipelago have been found to be surrounded with ice till this month. The point nearest the pole which has yet been attained by ship, 82° 16′ N., was reached by the American expedition of Captain Hall in 1872, through Smith Sound which directly continues Baffin Bay northward. No vessel has been able to pass the 77th paralled on the east coast of Greenland * at any season of the year; between this point and the north of Spitzbergen there is a constant barrier of ice, and northward of Spitzbergen the point in latitude 82° 45′ N., attained in a boat-sledge journey over the ice, by Parry in July 1827, has never since been reached. The Kara Sea is free of ice during the months of July and August, but eastward of Nova Zembla, and between the Asiatic coast and eastern Spitzbergen, a line of ice has constantly prevented access to the polar basin in this direction. Sailing through Behring Strait, which conveys a warm stream from the Pacific into the Arctic basin in summer, navigators have reached as far as the 73d parallel from this side towards the pole, in July or August; and a 'polynia,' or open water of unknown extent, is believed to exist at almost all seasons in the shallow sea northward of the New Siberian islands off the Asiatic coast.

Beyond these barrier points of the ice at its season of least extension, there stretches the great unknown central Arctic region. It is doubtful whether the whole of this undiscovered area is permanently ice covered; there are indeed many grounds, such as the annual passage in summer of great flocks of birds into the unknown region, for believing that a milder climate and perhaps an open polar sea, with a surrounding margin of ice, exists, at least for some part of the year within this space; but

* Sledges from the 'Germania' reached the highest point on this coast, 77° N., in April 1870. Land in 78° 20′ N., said to have been seen in 1670, is marked on old Dutch charts.

including all within the limit of least outer extension, we observe that the icy region of the northern pole has diminished in the height of its long day, to an area of about 3,000,000 of square miles, or to less than a third part of its greatest extent.

2. The Antarctic Region.

From the completely different and unequal distribution of land and sea about the two polar regions, it follows that the conditions of the ice in these are also varied. The Arctic circle passed almost entirely through the land of the American and Asiatic continents, enclosing within it a greater share of sea than land; the Antarctic circle, on the contrary, is drawn for nearly its whole length over the ocean, including perhaps more land than sea, and the ice which forms within it expands in the wide surrounding extent of water in a much more regular and concentric manner than about the north polar region, where its form is compelled by the warm or cold currents which take the direction of the opposing coasts.

Land has been discovered at various points of the South Polar region, close to the Antarctic circle, but the various portions are believed to be disconnected one with another, and to be the shores of the islands of an archipelago. The longest united coastline which has been traced in this region is that of Victoria Land, discovered by Ross in 1842, extending through 7 degrees of latitude, and comparable in extent with the South Island of New Zealand. Though this coastline especially rises to a great elevation (to 12,367 feet in the volcano of Mount Erebus), no ordinary glacial development has been noticed by voyagers within the Antarctic circle. Outside its limit, however, both in the Andes south of the equator in America, and in the Southern Alps of New Zealand, glaciers exist which fall to be considered with the land portion of this region.

In the whole of the south and western, or mountainous por-

tion of King Charles Southland, in Tierra del Fuego, every valley, and almost every channel which penetrates far inland, has a glacier of greater or less size, descending into the sea.*

Glaciers also appear on the western slope of the Patagonian Andes. Those of Eyre Sound, near the 49th parallel, are described as enormous, although the neighbouring mountains do not rise above 6200 feet, and they throw off great numbers of icebergs; one glacier in lat. 47° S. is 15 miles in length and 7 miles wide, reaching down to the sea level.

On the volcano of Chillan, in Southern Chile, a glacier descends to 7500 feet; and nearer the equator, in the Andes of the province of Colchagua, glaciers are known at the sources of some of the rivers, lying generally upon the southern slopes of the mountains. The most remarkable of these gives rise to the Rio de los Cipreses, and has its lowest point at a level of 5800 feet,† or considerably more than 1000 feet beneath the snow line.

Among the mountains which rise above the snow limit on the plateau of Bolivia, Mount Illimani is believed to have a glacier at a height of 16,500 feet on its southern slope.‡

The chain of mountains which form the backbone of the South Island of New Zealand, rises in many parts high above the line of perpetual congelation (here at an elevation of 8000 feet), and great glaciers descend from the snow fields which lie between and around the summits. Large ice fields and glaciers are congregated round Mount Aspiring, on the borders of Otago, but the range attains its greatest general altitude in Canterbury Province; there the glacier system of New Zealand has its greatest development, and, on the inner or eastern slope, forms a continuous series of ice fields. The most important among these glaciers, and the one which reaches

* Darwin. † Pissis (Philippi). ‡ Somerville.

lowest in New Zealand,* is the great Tasman glacier, which is 12 miles in length, and, even at its terminal face has a width of $1\frac{3}{4}$ miles. Its extremity is at a level of 2770 feet above the sea. Two other glaciers of large extent are the Alassen, which descends to 3528 feet, and the Godley glacier close to it, termed the 'mer de glace' of New Zealand, since its width, in some parts, exceeds 2 miles, reaching down to 3583 feet.

The widest limit to which the drift ice and icebergs of the South Polar region may extend during the summer months of December, January, and February, is an irregular line drawn between the 34th and 57th parallels of latitude; this limit is furthest from the equator below Cape Horn in South America, since a branch of the warm Brazil current flows down the whole east coast to the Cape; and is nearest, off Cape Colony in South Africa, since drift ice is brought near the Cape of Good Hope, in all months excepting the winter ones of June and July, by the cold Antarctic drift, which is here drawn up towards the current produced by the south-east trade winds off the coast of Africa. The line also advances equator-ward, to as far as the latitude of the north island, in the ocean beyond New Zealand.

The average boundary of drift ice follows a parallel course to that of the extreme limit of the appearance of ice, but at a distance of about 10° of latitude nearer to the pole, embracing an area of about 18,400,000 square miles, which may be considered as the widest extension of the icy cap of the South Pole. The extreme points to which discoverers have been able to penetrate, during the summer, of this pole, mark out an irregular figure, partly bounded by the outer coasts of the lands which have been seen, partly by impenetrable pack ice, or by a remarkable ice-wall, sometimes from 150 to 300 feet in per-

* Haast.

pendicular height. The pack ice of the Antarctic region differs in its formation from that of the comparatively tranquil and land-surrounded North Polar region, in consisting of heavy floes, which have been much broken up, and pressed and heaped together by the violent agitation of the sea;* the vertical ice cliffs are also peculiar to the South Polar region, and are probably in connection with some great areas of inland ice, the margin, perhaps, of a vast glacier field stretching out into the ocean beyond the hidden coasts of the land upon which it has been formed. Compared with the permanently icy region of the North, that of the Antarctic Pole has a vastly greater extent, amounting to more than double the other, or of upwards of 6,000,000 square miles; and this may be considered as the area of the ice cap of the South Pole, at the season of its least extension.

* Ross.

GENERAL INDEX.

A

	PAGE
Abyssinia, the Nile tributaries of	27
Abyssinia, the pastoral lands of	18
Abyssinian plateau, the, breaks the African deserts,	24
Aconquija, Sierra de	69
Adelaide plains, the	58
Afghanistan, the deserts of	35
Africa, forests of Central,	15
Africa, northern, the deserts of	24
Africa South, the tropical pastoral lands of	20
Africa, the tropical pasture lands of	18
Air or Asben, the fertile mountains of	26
Aksai chin, or White desert of Asia,	37
Alabama, the prairies of	49
Alakul lake, the time of its freezing,	85
Alaska territory, the glaciers of	80
Alaska territory, the mossy lands of the	71
Alaska, the ice on the coasts of	83
Alaska, the limit of the woods in	60
Alassen glacier,	90
Albania, the forests of	65
Aldan river, the pastures of the	55
Aletsch glacier, the	77
Algerian Sahara,	51
Algerian Sahara, the	25
Alkali flats of the 'Great basin,'	22
Alleghanies Mountains, the	49
Alps of New Zealand, the glaciers of	89
Alps, the glaciers of the	77
Alps, the woods of the	64
Altai Mountains, the	37
Altai Mountains, the glaciers of the	78
Altai, the forests of the	68
Ama Daria river,	40
Amargoza, the sink of the	22
Amazon's basin, its area,	14
Amur river basin, the pastures of the	55
America, Central, forests of	14
America, North, the deserts of	21
America, North, the glaciers of	80
America, South, the glaciers of	89
America, South, the deserts of	41
America, South, the temperate forests of	69
America, South, the tropical pasture lands of	20
'American desert,' the	23
American Polar expedition,	87
Andes, the glaciers of the	81
Andes, the deserts of the	42
Andes, the temperate forests of the southern,	69
Angola, the cultivation of	20
Angra Bay, in South Africa,	45
Antarctic icy region, its greatest and least extent,	91
Antarctic region, the ice of the	89
Apennines Mountains, the glaciers of the,	77
Apennines, the forests of the	64
Arabah, Wadi-el,	30
Arabia Petræa, the desert of	29
Arabia, the deserts of	28
Arabia, the pastoral lands of	19
Ararat, Mount, the glaciers of	79
Aravulli Hills,	32
Arctic archipelago, its character,	75
Arctic circle, the glaciers fields within the	75
Arctic region, its minimum extent,	88
Arctic region, the maximum extent of the	86
Arden, the forest of,	63
Ardennes, the forest of	64
'Arenal,' or sand fields of the Andes deserts,	42
Argaeus, Mount, the glaciers of	79
Argentine Republic, the cultivated lands of the	20
Argentine Republic, the limits of the woods in the	69
Argonne, the forest of	64
Arizona, Eastern, the pastures of	50
Asben or Air, the fertile mountains of	26
Ashdown forest in Sussex,	63
Asia, the tropical pasture lands of	19
Asia, the tundra regions of	70
Aspiring Mount, the glaciers of	90
Atacama, the Salina of	42
Atbara, or Takazze, the river,	27
Atlantic, the limits of ice in the	83
Atlas Mountains, the pastures of their slopes,	51
Australia, the deserts of	45
Australia, the rains of	46
Australia, the rivers of	45
Australia, the salt lakes of	46
Australia, the temperate forest in,	70
Australia, the tropical pastoral lands of	21
Australia, west, the pastures of	21
Australian Bight, the	46
Auvergne Mountains, the pastures of the	52
Azov, sea of	85

B

	PAGE
Baffin Bay, the ice of	83
Bahr-taht-el-erd, the, or underground lake,	25
Baikal lake	55
Baikal lake, its freezing,	85
Balfour Mount, the glaciers of	80
Balgaria, the plains of	53
Balkan mountains, the woods of the	65
Balkash lake,	40
Balkash lake, the time of its freezing,	85
Balkh, the desert of	40
Ball, Mount, the glaciers of	80
Baltic sea, the ice of the	85
Barabinsk, the pine wood belt of	68
Barabinsk, the steppe of	54
Barbary, the pastures of the slopes of the plateau of	51
Barbary, the plateau of	24
Barca, the river,	27
Baring downs in Australia, the	21
Barnaul,	68
'Barren grounds' of America, the	71
Bathang, the valley of 'Eden,' the, of Eastern Tibet,	54
Bavaria, the agricultural lands of	52
Baxio, the, in Mexico,	17
Bechuanas, the country of the	57
'Bed-pak-dala,' or Hungry desert, the	41
Behring Sea, the limit of the woods in	60
Behring Straits, the currents and ice of	88
Beira-mar of Brazil,	15
Beke, Dr, on the 'Harrahs,'	30
Bell's 'New Trades in North America, quoted,	50
Beloochistan, the interior deserts of	35
Beloochistan, the pastoral lands of	19
Benguela, the cultivation of	20
Benguela, the deserts of the interior of	45
Benue river, the plains of the	18
Bermnal, on the border of the Asiatic steppes,	54
Bernese Alps, the glaciers of the	77
Bessarabia, the plains of	53
Biafo, the glacier of	71
Big Shyenne river,	23
Birma, the valleys of	20
Black forest,	63
Black forest, the, of Baden,	64
Black Hills, the	50
'Black Sand,' or Kara Kum, the desert of	41
Black Sea, the	40
Black Sea, the ice in the	85
Blue range, the, of the Rocky Mountains,	22
Bogs, the black, of Ireland,	63
Bohemia, the hop cultivation of	52
Bohmer Wald,	64
Bokhara, the desert of	41
Bolar mountains, destitute of trees,	68
Boli, the forest of	68
Bolivia, the glaciers of the mountains of	90
Bolivia, the deserts of	42
Bolivia, the pasture lands of	20
Borneo, forests of	16
Bosnia, the forests of	65
Bothnia, gulf of, the ice in the	85
'Brash ice,'	82
Brazil current, the	99
Brazil, primeval forests of	16
Brazil, the pastures of	20
Britain, the agricultural lands of	52
British Columbia, the glaciers of	80
British Columbia, the grass plains of	50
British Isles, the woods of the	62
Brown Dr, on the formation of prairies, quoted,	49
Buenos Ayres, the pastures of	56
'Bunch Grass,' the, of the valley of the Columbia river,	50
Bunpoor, the deserts W. of	63
Bute Inlet, the glaciers of	80

C

Cabul, the valley of	54
Cabul, the fertility of the valley of	36
California, its deserts,	23
California, the rich valleys of	51
Canada, the lumber trade of	62
Canadian lakes, the freezing of the	86
Canso, the Gut of	83
Cantabrian mountains, the wood of the	64
Canterbury prov., the glaciers of	90
Cape Arid, in Australia,	46
Cape Breton island,	84
Cape Colony, the vine growing districts of	58
Cape Colony, the woods of	70
Cape of Good Hope, the southern polar ice approaches the	91
Cape of Good Hope, the woods of	70
Cape Horn, the warm current of	91
Cape Verd, the South limit of the North African desert,	24
Cairngorm mountains, the woods of the	63
Carpathian mountains, the woods of the	65
Carpentaria, Gulf of	16
Carpentaria, Gulf, pastures south of the	21
Cascade mountains, the screen formed by the	22
Cascade range, the glaciers of the	80
Caspian Sea, the depressed region of the	39
Caucasus Mountains, the glaciers of the	78
Caucasus Mountains, the woods of the	68
Caucasus, the remarkable lake of Hoktchia in the	86

	PAGE
Cayambe, Mount, the glaciers of	81
Celestial Range, the glaciers of the	78
Central America, forests of	14
Central Asia, the glaciers of	78
Cevennes, the woods of the	49
Cevennes, the pastures of the	52
Ceylon, forests of	16
Chaco, El Gran,	20
Chaco, El Gran, the deserts of	43
Chad, lake, in the African pastoral zone,	18
Chagan Tala, or White plain Mangolia,	38
Chambeze river basin, the grass plains of the	20
Chang Chenmo pass,	38
Chang-kia-kow or Kalgan,	39
Chile, the coast desert of	42
Chile, the deserts of	43
Chile, the forests of	69
Chillan, the glaciers of the volcano of	90
China, the cultivation of	20
China, the fertile plain of	54
'Chink,' the, or edge of the plateau Ust Urt,	40
Chwaresem, the desert of	40
Cipreses, Rio de los, the glacier of the	90
Climate of the equatorial forests,	17
Climate, the, of the temperate forest zone,	70
Colchagna, the glaciers of the prov. of	99
Colchagna, the limit of the forest in	60
Colorado desert, the	23
Colorado, the 'parks' of	50
Columbia River, the grass lands of the	50
Columbia river, the plain of the	22
Constance lake, its freezing,	86
Copiapo in Chile,	42
Cordova province, the pastures of	56
Cordova, the deserts of	43
Corea, the cultivated lands of the	55
Corea, the forests of eastern,	67
Corral de Veleta, the glacier of the	78
Cossyah Hills, their rainfall,	17
'Costa, la,' in Peru,	42
Crimea, the pasture lands of the,	53
'Crossing,' the, of Baffin bay,	87
Cumbrian mountains, the woods of the	63
Cunene river,	45
'Cutch,' the 'Runn' of	32
Cutch, the Runn of, the pastures which surround it,	19
Cyprus, the wooded slopes of	68

D

'Dahna,' or Fire-red,' the, desert of the	28
Dakota, the prairies of	48
Dambos, the, of South Africa,	20
Danube, the plains of the	53
Darling river, the	45
Dartmoor forest, in Devon,	63
Dead Sea,	30
Dean forest in Gloucestershire,	63
Death valley, its depression,	22
Deccan plateau, its cultivation,	19
Deer forests, the, of Scotland,	63
Dek-i-tir, lake,	36
Demavend, Mount, the glaciers of	79
Desert zone, the climate of the	46
Deserts, caused by dryness,	7
Deserts, frequently described as former sea beds,	8
Deserts, the, of the Northern Hemisphere,	21
Desht-i-Chowar, the desert of	40
'Despoblado,' or 'Puna,' the	42
Devdorak glacier,	78
'Doabs,' the, of the Punjab,	33
Downs, the, of Australia,	21
Drakenberg Mountains, the	57
Drakenberg mountains, the woods of the	70
'Drift ice,' the application of the term,	82
Drift ice, the limits of	83
Drift of the ice in Baffin Bay,	87
'Dry Sea,' or 'Han Hai,' the	39
'Dushtistan,' or 'Gurmsir' desert,	31
Dust storms of the Orinoco basin,	18

E

Eastern Turkistan, the cultivated lands of	54
Eastern Turkistan, the deserts of	38
Edge island, the glaciers of	75
Egypt, Upper, the deserts of	27
Elbury mountains, the forests of the	68
Elbruz, the glaciers of Mount	78
Elburz range, the glaciers of	79
El Erg, the most desert belt of the Sahara,	26
El Gran Chaco desert, the	43
El Gran Chaco, the pastures of	20
'El Harrah,' basaltic regions,	30
Ellesmere land, the glaciers of	75
England, the forests of	63
Epping forest, or the forest of Essex,	63
Equatorial forests,	14
Equatorial forests, their climate,	17
Ery Gebzirge, the woods of the	64
Essex, the forest of	63
'Estancias,' or cattle farms of the Pampas of South America,	56
Etna, mountain, the woods of	64
Ettrick forest, in South Scotland,	63
Euphrates valley, the former cultivation of the	19

	PAGE
Europe, the pasture lands of	51
'Everglades,' the, of Florida,	61
Eyre lake, in Australia,	46
Eyre Sound, the glaciers of	89

F

Fedchenko, Mr, the glaciers discovered by him in Central Asia,	78
Fens, the, of Newfoundland	61
Fertile belt, the, of North America,	48
Fezzan, in the Sahara,	26
Fichtel-Gebirge,	64
'Fields' of ice,	82
Finland, the gulf of, the ice in the	85
Fiords, the, of Greenland,	74
Fire Harrah,	30
'Fire-red,' or 'Dahna,' the desert of the	28
Flinders range, in Australia,	58
'Floes' of ice,	82
Florida, forests of southern,	14
Florida, the temperature of tropical forests of	61
Forbes, Mount, the glaciers of	80
Forest of Clun in Wales,	63
France, the cultivated lands of	52
Franken Wald,	64
Freshfield, M., description of glaciers in the Causcus,	78
Frozen ocean, the,	73
Further India, the pasture lands of	19
Further India, forests of	16

G

Gairdner lake, in Australia,	46
Gangetic plain, its fertility,	19
Gash or Mareb, the river,	27
'Gaur,' or 'Tahama' the deserts of	29
Geneva lake, its freezing,	86
Georgia, gulf of, the glaciers descending to the	80
'Germania,' the points reached in the expedition of the	88
Ghat, the oasis of	25
Glaciers of the South Hemisphere,	89
Glaciers, the, of Greenland,	74
Glaciers, their compelling causes,	76
Gobi, the great desert of	39
Godley glacier,	90
Goodsir, Mount, the glaciers of	80
'Goops,' the, of the desert of Makran,	32
Granada, the fertile plains of	52
Gran Sasso d'Italia, the glacier of	77
'Great basin,' its rainfall,	23
Great basin of Utah, the	21
Great Bear lake, its freezing,	86
Great Bear lake, the limit of the woods near	60
'Great Glacier,' the, of British Columbia,	80
'Great Karoo,' the, of South Africa,	45
Great Salina, the, of South America,	43
'Great Stony Desert,' the, of Australia,	46
Greece, the fertile lands of	53
Greenland, east coast, the highest latitude reached on the	88
Greenland ice current, the	74
Greenland, the glacier field of	74
Guadalquivir river, the vineyards of the	52
Guanaco, the	57
Guatemala, the plateau of	17
Guinea, New, forests of	16
Gujerat, in India, the pastures of	19
Gulf of California, its deserts,	23
Gulf of Liau-tung, the coast of the	34
Gulf of Mexico, the wooded shores of the	18
Gulf of Pe-chili, the mud flats of the	34
Gulf of St Vincent, the	58
Gulf Stream, the Greenland icebergs cross the	74
Gulf Stream, the influence of the	65
Gurhival, the glaciers of	79
'Gurmsir,' or 'Dushtist' desert,	31

H

Hall, Captain, his furthest point North	88
'Hammada,' plateau in the Sahara,	25
'Hamoon,' or Seistan lake,	36
Hampshire, the woods of	62
Han Hai, or 'dry sea,' the	39
Harrah, el,	30
Harz, mountains, the woods of the	64
Heaths, the, of Newfoundland,	61
Herat, in Persia,	35
Himalaya Mountains, forests of	16
Himalaya Mountains, the glaciers of the	79
Himalaya Mountains, the temperate forests of the	67
Hindoo Koosh, Central, destitute of trees,	68
Hindoo Koosh Mountains,	36
Hindustan, the fertile portions of	19

	PAGE
Hoktchia lake, never freezes,	86
Hood, Mount, the glaciers of	80
'Hoogevelt,' the, of the Transvaal Republic,	57
Hudson bay,	61
Hudson bay, the ice of	86
Humboldt glacier, the	75
'Hummocks,' the use of the term	82
Hungary, the agricultural lands of	52
'Hungry desert,' the, or Bedpak dala,	41

I

	PAGE
Icebergs, the, of Greenland,	74
Icebergs, the, of Spitzbergen	75
Icebergs, the limit of, in the northern hemisphere,	83
'Ice foot' or 'land ice,'	81
Ice in the Antarctic region,	89
Ice of Baffin bay, its southward drift,	87
Iceland, the glacier fields of	77
Iceland, the pastures of	52
Ice-streams, the, of Greenland,	74
Ice, the, of the Greenland seas,	81
Ice, the thickest known in the Arctic region,	83
Ice, the inland, of Greenland,	74
Ice, the limits of, in the Southern Hemisphere,	91
Ice wall, the, of the Antarctic region,	91
Icy polar regions, the	73
Idaho, the pastoral valleys of	50
Ikrutsk, the caravan traffic of	85
Illimani, Mount, the glaciers of	90
India, forests of	16
Indigirka, the valley of the	66
Indus river,	32
Inland ice, the, of Greenland,	74
Inshan mountains, the woods of the	67
Ireland, the agricultural lands of	52
Ireland, the black bogs of	63
Irtish river,	54
Ishim river,	54
Ishim, the steppe of	54
Islands of the Pacific in the forest zone,	16
Ispahan in Persia,	35
Isset, the steppe of	54
Issyk-kul (lake), never freezes,	86
Isthmus of Panama,	14
Italy, the fertile lands of	53
Italy, the glaciers of the mountains of	77
Ixtaccihuatl, Mount, the glaciers of	81

J

Jacob's valley in Mount Ararat, the glacier of	79
Japan current, the effect of the	84
Jebal, or hill region of Arabia, the	28
Jostedals Braen, snow fields in Norway,	77
Juan de Fuca, Strait,	15
Jura Mountains, the woods of the	64

K

Kaffraria, the woods of	70
Kafiristan, the forests of	67
Kalahari desert, the, of South Africa,	44
Kalgan, or Chang-kia-kow,	39
Kamtchatka, the forests of	65
Kandahar, the deserts near	36
Kane basin, the	75
Kanin, the peninsula of	66
Kansas, the prairies of	48
Kantchinjinga, Mount, the glaciers of	79
Kapkantash Hills, the	40
Karakoram mountains, the glaciers of the	79
Kara Kum, or 'Black Sand,' the desert of	41
Kara Sea, the ice of	88
'Karoo,' the Great, of South Africa,	45
Kasbek, the glaciers of Mount	78
Kaseem, the pastures of, in Arabia,	19
Kashmir, the glaciers of	79
Kassabi river basin, in the tropical pastoral zone,	20
Katunja glacier, the	78
Kerguelen island,	72
Khinghan mountains, the woods of the	67
Khiva, the deserts of	40
Khotan,	37
Khuzistan, the deserts of	31
Kiakhta,	39
Kiakhta, the caravan traffic of	85
Killma-njaro, Mount, the snows of	80
King Charles Southland, the glaciers of	89
King John glacier, in Spitzbergen,	75
Kirghiz,	40
Kirghiz steppe, the	54
Kirman, the desert of	35
'Kizil Kum,' or Red sands,	40
Klofa Jökull, the glaciers of	77
Knaresborough forest,	63
Kolima river,	66

	PAGE
Korchin, the desert of	34
Kosgol lake, on the borders of the forests of Siberia,	67
Kosgol lake, its freezing,	85
Kotzebue Sound, near the boundary of the northern forests,	60
Kuenlun mountains, the glaciers of the	79
Kuenlun mountains, the	37
Kumaon, the glaciers of	79
Kurdistan, the woods of	68
Kurrachee, the grass plains near	32

L

Labrador, the forests of	61
'La Costa,' in Peru,	42
Lake Baikal,	55
Lake Baikal, its freezing,	85
Lake Balkash,	40
Lake Balkash, its freezing,	85
Lake Constance, its freezing,	86
Lake Dek-i-tir, in Seistan,	36
Lake, Great Bear,	60
Lake, Great Bear, its freezing,	86
Lake Hotchia, never freezes,	86
Lake Issyk-kul, never freezes,	86
Lake Kosgol, its freezing,	85
Lake Lob Nor,	38
Lake Michigan,	49
Lake Ngami in the South African desert,	44
Lake of Geneva, its freezing rare,	86
Lake of the woods, the	49
Lake Seistan,	36
Lake, Slave, its freezing	86
Lake Superior, its freezing,	86
Lake Titicaca, the basin of	42
Lake Tuz,	34
Lake Urumiah,	35
Lake Van,	35
Lake Winnipeg,	48
Lake Winnipegos,	49
Lake Zaisan, its freezing,	85
Laguna del Cayman, the	23
Lancaster Sound,	87
'Land ice,' or 'ice foot,'	81
'Lanes' in the ice,	81
Langroes, the plateau of	64
Lapland, the woods of	65
Laramie plains,	50
'Leads' in the ice,	81
Lebanon, the trees of	68
Ledesma, on the coast desert of Peru,	42
Lefroy, Mount, the glaciers of	80
Lena river, the delta of	66
Leonee river,	33
Lian-tung, the coasts of the gulf of	34
Libyan desert, the	27
Limit of ice in the N. Hemisphere,	83
Limits of ice in the Southern Hemisphere,	91
Limit of snow, the	76
Limits of temperature of the equatorial forests,	17
Limpopo river basin, the grasslands of the	21
Linköping, the plain of	52
'Llano Estacado,' the	23
Llanos of Manso, the	20
Llanos, the, of the Orinoco river,	18
Lob Nor, lake,	38
Lombardy and Venice, the cultivated plain of	53
'Loose ice,' the use of the term,	82
'Lumber' trade, the, of Canada,	62
Lune forest,	63
Lyell Mount, the glaciers of	80

M

Mackenzie river, the forests of the	60
Madagascar, forests of	16
Makran, the desert of	31
Manso, the 'Llanos' of	20
Manchuria, the plain of	54
Manyuema country, the forests of	15
Mapimi, the lagoon of	23
Mareb, or Gash, the river,	27
Maroccan Sahara,	51
Martindale forest,	63
'Mauvaises terres,' of North America, the	23
Melville Sound,	87
Mendoza, the treeless heights of	69
'Mer de Glace,' the, of New Zealand,	91
Meuse, the woods of the	64
Mexico, the deserts of northern	23
Mexico, the pasture lands of	17
Michigan, lake,	49
'Middle ice' of Baffin bay, the	87
Milburn forest,	63
Mississippi-Missouri basin, the prairies of the	47
Mississippi, Missouri, the deserts in the basin of the	23
Mississippi, the head lakes of the	49
Mojave desert,	22
Monte Corno in Italy, the glacier of	77
Moors, the, of Hungary and Bohemia,	53
Moreton Bay, the woods of	70
Moselle, the woods of the	64
Mosslands, the, of the tundra,	70
Mountains, their covering,	9
Mount Aspiring, the glaciers of	90
Mount St Elias, the glaciers of	80

	PAGE
Munka-Sardik, the glaciers of Mount	78
Murray-Darling river, the	45
Murray river, the plains of the	58
Munzinger's explorations,	28
Mustagh mountains in Asia, their glaciers,	79

N

Nabal, the woods of	70
Nachtigal, Dr, his explorations in the Sahara,	26
Namaqua land, the deserts of	44
Nanda Devi peak, the glaciers of	79
Natal, the different belts of	57
Nebraska, the prairies of	48
'Nefood,' sand belts in Arabia,	29
Negro river, the	43
Negro States of Africa, the pastoral	18
Nejed, in Arabia, the pastures of	19
Nelson river,	61
Netherlands, the polders of the	52
Nevado de Toimla, in Columbia, the glaciers of	81
New, Mr, his exploration of Mount Kilima-njaro,	80
New forest of England, the	62
Newfoundland, the icebergs off	74
Newfoundland, the woods of	61
New Guinea, forests of	16
New Mexico, the pastures of	50
New Siberian islands, the	88
New South Wales, the pastoral lands of	58
New Zealand, the forests of	70
Niger river, the deserts of North Africa approach the	24
Nile lakes, in the forest region,	15
Nile, the fertility of its banks,	24
North Devon, the glaciers of	75
North-east-land, of Spitzbergen,	75
Northern forests,	59
'North water,' the, of Baffin bay,	87
Norway, the glacier fields of	77
Norway, the glaciers of North,	75
Norway, the woods of	95
Nova Scotia, on the border of, the appearance of ice,	84
Nova Zembla, the ice near,	88
Nova Zembla, the tundras of	71
Nubia, the deserts of	27
Nyassa, Lake, in the African pastoral belt,	20

O

Oases, the, of the Sahara,	24
Obi river,	66
Oden Wald,	64
Okhotsk, the sea of	65
Okhotsk, sea of, the ice in the	84
Oman, tropical vegetation of	16
Omsk, on the border of the Asiatic steppes,	54
Orange river, the deserts near the	44
Orange river, Free State, the	57
Orenburg, the woods of northern,	69
Orinoco river, the 'llanos' of the	18
Orizaba, Mount, the glaciers of	81
Otago prov., the glaciers of	90
Oturup island,	85
Oxus river,	40

P

Pacific, the islands of the, in the forest zone,	16
'Pack ice,' the use of the term,	82
Page, Lieut., quoted,	56
Palgrave's explorations in Arabia,	28
Palliser's exploring expedition,	48
Pamir plateau, the glaciers of the N. slope of the	78
'Pampa de Salinas,' the	42
Pampas the, of South America,	56
Panama, Isthmus of	14
Pangkonk lakes, the	79
Paraguay, forests of	15
Parana, forests of the	15
Parana, the table lands of the	20
Paraquay basin, the grass lands of the	20
Parime Mountains in the tropical forest zone,	14
'Parks,' the, of Colorado,	50
Parry island, the ice round the	83
Pastoral zone, the tropical,	17
Patagonia, the forests of western,	69
Patagonia, the plains of	56
Patagonian Andes, the glaciers of the	89
Pe-chili, the deserts of	34
Pecos river, the	23
Peel river,	60
Pekin, the desert round	34
Pennine Alps, the glaciers of the	77
Pennine Chain, the forests of the	63
Persia, the interior deserts of	53
Persia, the pastoral borders of	19
Persia, the coast deserts of	31
Persian Gulf, the desert coastlands of the	31
Peru, the coast desert of	41
Petchora river, the woods of the	66
Petropaulovsk,	84
Pindus, the forests of	65

	PAGE
Plains of Promise, the, in Australia,	21
Plateau of Barbary, the	24
Poland, the forest of	65
Polar regions, the icy,	73
'Polders,' the, of the Netherlands,	52
'Polynia,' the, of the Siberian seas,	88
Prairies, the, of the Mississippi, Missouri basin,	48
Primary belts of landscape,	8
Primeval forests of Brazil,	16
Puget Sound,	51
'Puna,' or 'Despoblado,' region, the	42
Punjab, the deserts of the	33
'Put,' the desert of the	33
Pyrenees, the glaciers of the	77
Pyrenees, the woods of the	64

Q

Queensland, the Downs of	21
Queensland, the pastoral lands of	59

R

Radnor Forest,	63
Railways, the, of the United States,	62
Rainfall in Central Arabia, the	19
Rainfall of the equatorial forests,	17
Rainfall of the 'Great basin,'	23
Rainfall, the greatest known,	17
Rainier Mount, the glaciers of	80
Rauhe Alp, the	64
Reck, M. Hugo, on Bolivian deserts,	42
Red River, the	49
Red River of Texas, the	23
'Red Sands,' or Kizil Kum,	40
Red sea coasts, the deserts of the	28
Reindeer, the migrations of the	71
Rhon Gebirge, the woods of the	64
Riad, the gardens of, in Arabia,	19
Riesen Gebirge, the forests of the	65
Rio de la Plata,	56
Rio de los Cipreses, the glaciers of the	90
Rio Grande, the	23
Rio Grande, the	48
Rio Grande do Sul, the herds of	20
Rio Nasas, the	23
Riverina district, the, of Australia,	59
Rockingham forest,	63
Rocky Mountains, the glaciers of the	80
Rocky Mountains, the screen formed by the	22
Roe downs, the, in Australia,	21
Ross' discoveries,	89
Rothiemurchus, the pine woods of	63
Runn of Cutch, the pastures about the	19
'Runn,' the, of Cutch,	32
'Runs' the, or pastoral estates of Australia,	59
Russia, the Baltic provinces of	52
Russia, South, the plains of	53

S

Sacramento river, the rich valley of the	51
Saghalian island,	85
Sahara, the desert of the	24
Sahara, desert, the causes of its aridity,	25
Sahara, the, has not an infertile soil,	25
Saiansk Mountains, the glaciers of the	78
'Sailing ice,'	82
Salina de Atacama, the	42
'Salina,' the Great of South America,	43
Salt basin, the, of Lower Abyssinia,	28
'Saltpans,' the, of the South African desert,	44
Salt plain of Cutch, the	33
'Sandy desert,' of Beloochistan,	35
San Joaquin river valley, in California,	51
San Luis, province, the pastures of	56
Sanpu river, the valley of the	37
Santa Fe province, the pastures of	56
Santiago, the treeless heights of	69
Sao Paulo, the grass lands of	20
Saskatchewan river, the	48
Saxon Weald, the	63
Schott Kebir (Palus Tritonis), in Tunis,	27
Schott Melgigh, in Tunis, its depression,	27
'Schotts,' or salt lakes, the, of Tunis	27
Schwarzwald, the	64
Scotland, the forests of	63
Sea ice, the, of the Arctic basin,	81
'Sea of sand,' the	39
'Sea of Trees,' the, in Asia Minor,	68
Seistan, the desert of	36
Selenga river, basin, the pastures of the	55
Selvas of the Amazons,	14
Semenoff, M., on glaciers in Central Asia,	78
Semipalatinsk,	68
Senegal river, on the border of the deserts,	26
'Sermik soak,' the, of Greenland,	74
Servia, the woods of	65
'Shamo,' the 'sea of sand,'	39
Shaw's explorations in Central Asia,	38
Shasta Mount, the glaciers of	80
Sherwood forest, in Nottingham,	63
Shetland islands are in the latitude of South Greenland icefields,	77

	PAGE
Shigar river basin, the glaciers of the	79
Shiraz, in Persia the gardens of	19
'Shors,' the, of the desert of Makran,	32
Siberia, the forests of	65
Siberian coast, the condition of the sea ice, off the	82
Siberian seas, the 'toross,' of the	82
Siberian tundra, the	71
Sicily, the woods of	64
Sierra de Aconquija,	69
Sierra de Gredos, the glacier of	78
Sierra Nevada of Spain, the glaciers of the	78
Sierra Nevada de Sta Marta, the glaciers of	81
Sierra Nevada, the	22
Sikkim, the glaciers of	79
Simbirsk on the borders of the Russian steppes,	53
Sinai peninsula, the deserts of	29
Sink of the Amargoza, the	22
Slave lake, its freezing,	86
Smith Sound, the glaciers of	75
Smith Sound route,	87
Snee Braen (snow slopes), in Norway,	77
Snow line, the	76
Snow, the equatorial limits of	85
Soda Lake, its depression,	22
Soudan, the pastoral states of the	18
South America, the glaciers of	89
South America, the temperate forests of	69
South America, the tropical pasture lands of	20
South Australia, the pastoral lands of	58
South Polar region, the ice of the	89
South Polar region, the ice of the	91
South Russia, the plains of	53
Southern Hemisphere, the glaciers of the	89
Southern Hemisphere, the tundras of the	72
Spain, the glaciers of	77
Spain, the pastoral lands of	52
Spencer gulf,	58
Spencer gulf in Australia,	46
Spessart, the woods of the	64
Spitzbergen, the glaciers of	75
Spitzbergen, the highest latitude reached north of	88
Spitzbergen seas, the ice of the	82
Springboks,	21
St Elias, Mount, the glaciers of	80
St Lawrence, gulf of, the ice in the	84
St Leonards forest, in England,	63
St Vincent, the gulf of	58
Stainmoor forest,	63
'Staked plain,' the	23
Stanovoi mountains, the	66
Stans foreland, the glaciers of	75
Steigerwald, the woods of the	64
'Steppes,' the, of South Russia,	53
Stony Arabia, the desert of	29
Stony desert, the great, of Australia,	46
Strait of Ormuz,	31
Subsidence, a possible, of the Syrian desert,	30
Sudetic mountains,	65
Sufaid-Koh, the woods of the	68
Suleiman Mountains,	68
Sumatra, forests of	16
Superior Lake, its freezing,	86
Surface zones, due to meteorological conditions alone,	6
Syria, the woods of northern,	68
Syrian desert,	30
Syr Daria river,	40
Sweden, the agricultural districts of	52
Switzerland, the glaciers of	77

T

Table Mountain, Cape of Good Hope, the fir woods of	70
Ta Gobi or great desert,	39
Takla-Makam desert,	39
Tanganyika Lake, on the border of the African forests,	15
Tarim river,	38
Tasman glacier, the great	90
Tasmania, the forests of	70
Tatra mountains in Hungary,	78
Taurus Mountains, the woods of the	68
'Tebbad' or sand storm, the	41
'Tehama' or 'Gaur,' the deserts of	29
Teheran in Persia,	35
'Tell,' country of the plateau of Barbary,	51
Temperature limits of the equatorial forests,	17
Temperature of the air, its decrease by elevation,	9
Tengri-Tag, Mount, the glaciers of	78
Terek valley, glaciers descending to the	78
Texas, the deserts of	23
Texas, the prairies of	18
Thian-Shan mountains, the	37
Thian-Shan mountains, the glaciers of the	78
Thüringer Wald,	64
'Thurr,' desert, the	33
'Tiah-Bani-Israel,' the desert of	29
Tibesti, the fertile mountains of	26
Tibet, the bare character of	38
Tibet, the pasture lands of	54
Tidikelt, the oases of,	25
Tierra del Fuego, the forests of	69
Tierra del Fuego, the glaciers of	89
Tigris valley, the former cultivation of the	19
'Tih,' the desert of	29
Titicaca lake, the basin of	42
Tobol river,	54
Tobolsk, on the border of the Asiatic steppes,	54
Tolima, Nevado de, the glaciers of	81
Tomsk on the Obi,	54

	PAGE
'Toross,' the, or 'hummock,' of the Siberian seas,	82
Torrens lake, in Australia,	46
Trachonitis,	30
Transvaal Republic, the 'Hoogevelt' of the	57
Transylvanian Alps, the woods of the	65
Tripoli, the deserts of	26
Tropical forests,	14
Tropical forests, depend on excess of moisture and heat,	
Tropical forests, their climate,	1
Tropical pastoral zone, the	17
Tuat, the oasis of	25
Tucuman, the prov. of	69
Tuggurt, the plain of	25
Tumbez in Peru,	41
Tundra regions, the	70
Tunis, the 'Schotts' or Salt lakes of	27
Turkistan Eastern, the deserts of	38
Turkmans	40
Turner's 'embassy to Lama,'	38
Tuz Lake in Asia Minor,	34

U

'Ukraine, the, in South Russia,	53
Underground lake of the Algerian Sahara,	25
United States, the altered nature of the surface of the	62
Ural mountains, the forests of the	66
Urga,	39
Uruguay, the pastures of	56
Urumiah, lake	35
Usango, the plateau of	20
Ussa river, the	66
Ust Urt, the plateau of	40
Utah, the great salt basin of	21

V

Vambery's travels in Central Asia,	41
Valdivia, the forests of	69
Vancouver island, the lowlands of	50
Van Lake, in Armenia,	35
Varanger Fjord,	66
Vatna Jökull, the glaciers of	77
'Velds,' or 'Vlachte,' of South Africa,	57
Venezuela, the mountains of	18
Venice and Lombardy, the cultivated plain of	53
Verkhoiansk, the mountains of	66
Victoria Lake, on the border of the African pastoral lands,	19
Victoria Land, in the Antarctic region	89
Victoria river, the pastures of	21
Victorian Alps, the woods of the	70
Vilui river, the pastures of the	55
Virginia,	49
'Vlachte,' or 'Velds,' of South Africa,	57
Volga river, the	40
Von Ischudi, the traveller, quoted,	43
Vosges, the forests of the	64

W

Wadi-el-Arabah,	30
Wadis, the, of the Sahara,	24
Walfisch bay, in South Africa,	45
Wallachia, the plains of	53
Wanderings, the desert of the	29
Wasatch Mountains, in Wyoming,	50
Washington territory, the prairies of	50
Weald, the Great Saxon,	63
Weald, the, of Kent,	63
Wells, the, of the Algerian Sahara,	25
West Australia, the pastures of	21
West India Islands, forests of	14
Western Australia, the grass plains of	58
Whirlwinds of sand, the, of Mongolia,	36
White desert, or Aksai-chin of Asia,	37
White plain, or Chagan Tala of Mangolia	38
White Sea, the	66
Windsor forest,	63
Winnipeg, lake	48
Winnipegos, lake	48
Wolds, the, of Lincoln,	63
Woods, the lake of the	49
Wychwood in Oxford,	63
Wyoming, the grazing lands of	50

Y

Yakutsk, on the Lena,	55
Yengi-dawan pass,	38
Yenisei river,	66
Yesso island, the forests of	67
Yezd, the oasis of	35
Yukon river, the limit of the woods near	60

Z

Zaisan Nor, its freezing,	85
Zambezi river basin, in the tropical pastoral zone,	20

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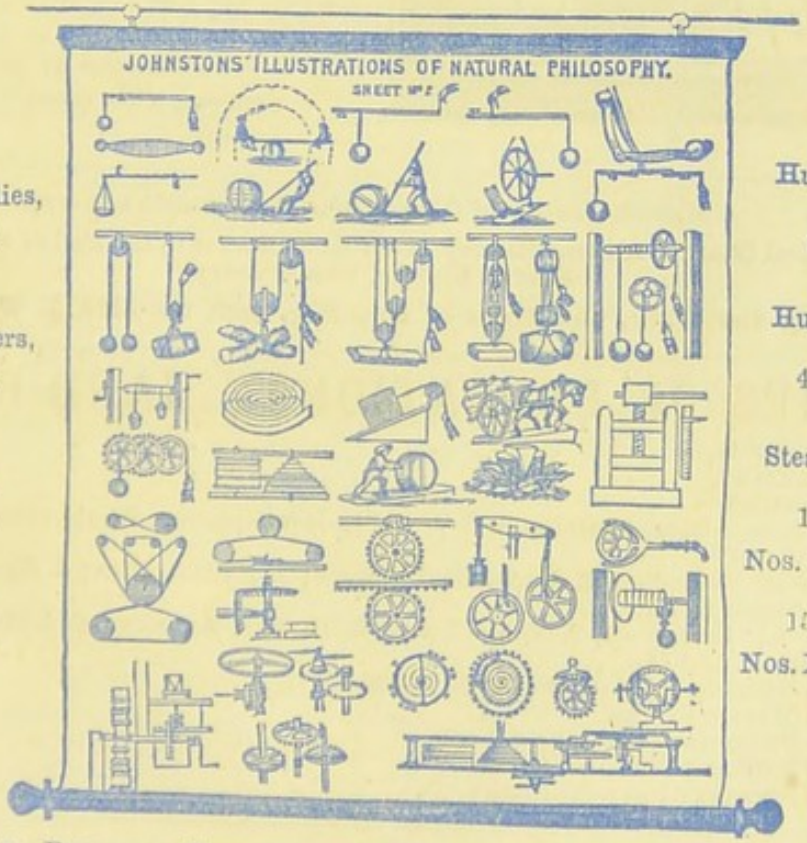

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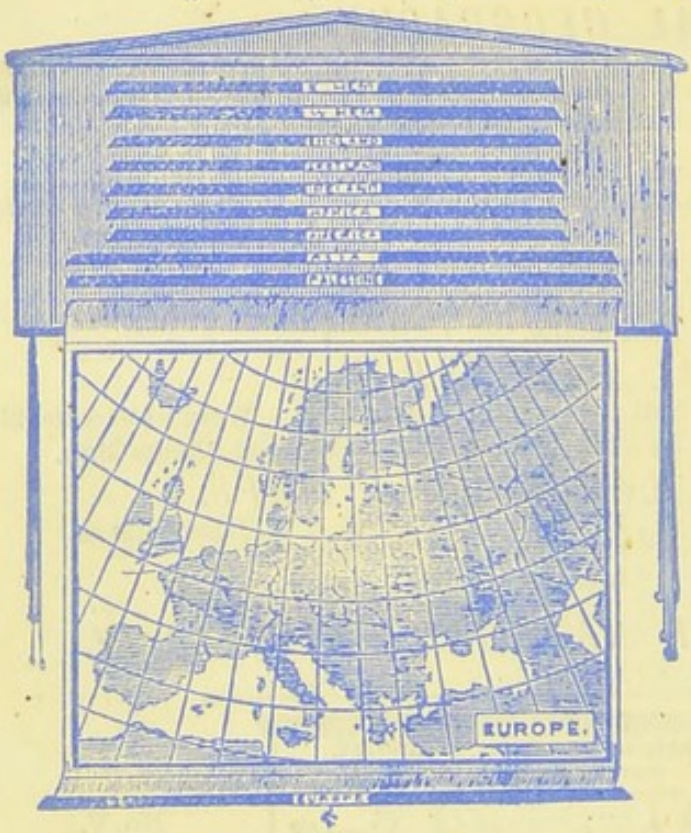

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