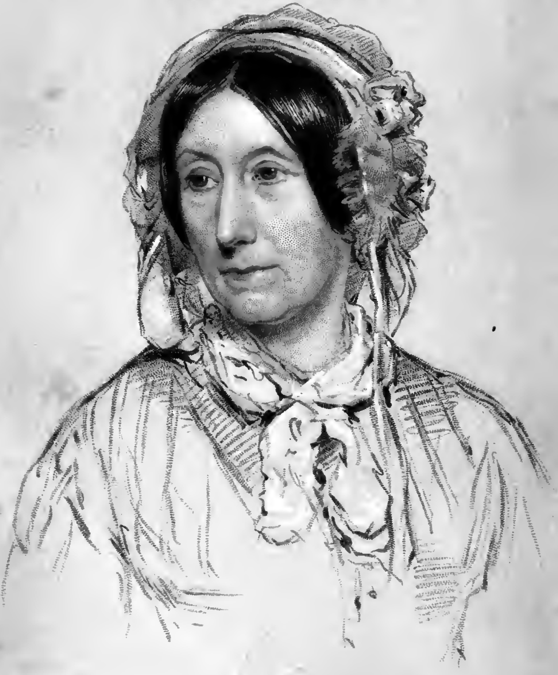
R. C. Smith

I

PHYSICAL GEOGRAPHY.

VOLUME I.


W. Holl, sc.

Mary Somerville.

From a drawing by James R. Swinton, Esq. 1848.

London, John Murray, Albemarle Street, 1848.

PHYSICAL GEOGRAPHY.

BY

MARY SOMERVILLE,

AUTHOR OF THE 'CONNEXION OF THE PHYSICAL SCIENCES,'
'MECHANISM OF THE HEAVENS,' ETC. ETC.

NEW EDITION, THOROUGHLY REVISED.

IN TWO VOLUMES.—VOL. I.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1849.

12

10090
29/11/90
2 vols.

London: Printed by William Clowes and Sons, Stamford Street.

TO

SIR JOHN F. W. HERSCHEL, BART., K.H.

&c. &c.

DEAR SIR JOHN,

I AVAIL myself with pleasure of your permission to dedicate my book to you, as it gives me an opportunity of expressing my admiration of your talents, and my sincere estimation of your friendship.

I remain, with great regard,

Yours truly,

MARY SOMERVILLE.

London, 29th February, 1848.

PREFACE

TO THE NEW EDITION.

SINCE the publication of the first edition of this work, the Author has been able to correct many inaccuracies that had crept into it, and to collect much new matter from works since published, which is embodied in the present edition, and has considerably added to its size. The recently published Second Volume of Baron Humboldt's invaluable 'Cosmos,'[1] with Colonel Sabine's learned notes, and sundry papers that have appeared in the scientific periodicals of Europe, America, and India, bearing on questions of Physical Geography, have yielded profitable information.

It was the Author's wish, and her Publisher's intention, that the present edition should be accompanied by a series of Maps to illustrate the more important questions of Physical Geography treated of in it; but Mr. A. Keith Johnston having announced the publication of a new edition of his 'Physical Atlas' in a reduced size, at a low price,[2]

[1] 'Cosmos,' by Alexander Von Humboldt, translated under the superintendence of Colonel E. Sabine, F.R.S. Second Edition. London, 1848.

[2] Alexander Keith Johnston's 'Physical Atlas,' 4to., in Monthly Numbers. Edinburgh, 1849.

the first two Nos. of which have already appeared, the project was relinquished, in the belief that Mr. A. K. Johnston's smaller Atlas will furnish suitable illustrations to this work.

The reader will find this edition enriched with some of the results of the recent researches of Messrs. Campbell, Thomson, Strachey, and Dr. Hooker in the Himalaya, which tend largely to elucidate the Physical History of that gigantic chain. The book is also indebted to Mr. Pentland for some new matter, hitherto unpublished, on the countries of South America visited by him during his two public missions to Peru and Bolivia.

The absence of the Author from England during the printing of the following sheets has obliged her to have recourse to a friend conversant with her subject to revise the press; to him she begs to express her acknowledgments, as well as to Sir William Jackson Hooker, who very kindly undertook to correct the portion of this new edition connected with Geographical Botany and Vegetable Physiology—subjects respecting which he has so much contributed to extend our knowledge. Captain Beechey has been good enough to render similar service, in revising certain passages bearing upon Hydrography.

May, 1849.

CONTENTS OF VOL. I.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

CHAPTER XV.

CHAPTER XVI.

CHAPTER XVII.

CHAPTER XVIII.

CHAPTER XIX.

PHYSICAL GEOGRAPHY.

CHAPTER I.

GEOLOGY.

Of Physical Geography — Position of the Earth in the Solar System — Distance from the Sun — Civil Year — Inclination of Terrestrial Orbit — Mass of the Sun — Distance of the Moon — Figure and Density of the Earth from the Motions of the Moon — Figure of the Earth from Arcs of the Meridian — from Oscillations of Pendulum — Local Disturbances — Mean Density of the Earth — Known Depth below its Surface — Outline of Geology.

Physical Geography is a description of the earth, the sea, and the air, with their inhabitants animal and vegetable, of the distribution of these organized beings, and the causes of that distribution. Political and arbitrary divisions are disregarded, the sea and the land are considered only with respect to those great features that have been stamped upon them by the hand of the Almighty, and man himself is viewed but as a fellow-inhabitant of the globe with other created things, yet influencing them to a certain extent by his actions, and influenced in return. The effects of his intellectual superiority on the inferior animals, and even on his own condition by the subjection of some of the most powerful agents in nature to his will, together with the other causes which have had the greatest influence on his physical and moral state, are among the most important subjects of this science.

The former state of our terrestrial habitation, the successive convulsions which have ultimately led to its present geographical arrangement, and to the actual distribution of land and water, so powerfully influential on the destinies of mankind, are circumstances of primary importance.

The position of the earth with regard to the sun, and its connexion with the bodies of the solar system, have been noticed by the author elsewhere. It was there shown that our globe forms but an atom in the immensity of space, utterly invisible from the nearest fixed star, and scarcely a telescopic object to the remote planets of our system. The increase of temperature with the depth below the surface of the earth, and the tremendous desolation hurled over wide regions by numerous fire-breathing mountains, show that man is removed but a few miles from immense lakes or seas of liquid fire. The very shell on which he stands is unstable under his feet, not only from those temporary convulsions that seem to shake the globe to its centre, but from a slow almost imperceptible elevation in some places, and an equally gentle subsidence in others, as if the internal molten matter were subject to secular tides, now heaving and now ebbing, or that the subjacent rocks were in one place expanded and in another contracted by changes of temperature.

The earthquake and the torrent, the august and terrible ministers of Almighty Power, have torn the solid earth and opened the seals of the most ancient records of creation, written in indelible characters on the "perpetual hills and the everlasting mountains." There we read of the changes that have brought the rude mass to its present fair state, and of the myriads of beings that have appeared on this mortal stage, have fulfilled their destinies, and have been swept from existence to make way for new races, which, in their turn, have vanished from the scene, till the creation of man completed the glorious work. Who shall define the periods of those mornings and evenings when God saw that his work was good? and who shall declare the time allotted to the human race, when the generations of the most insignificant insect existed for unnumbered ages? Yet man is also to vanish in the ever-changing course of events. The earth is to be burnt up, and the elements are to melt with fervent heat—to be again reduced to chaos—possibly to be renovated and adorned for other races of beings. These stupendous changes may be but cycles in those great laws of the universe, where all is variable but the laws themselves, and He who has ordained them.

The earth is one of seventeen planets which revolve about the sun in elliptical orbits: of these, twelve have been discovered since the year 1787.[1] Mer-

[1] The Solar System:—

Mercury, nearest the Sun, known to the ancients.
Venus, known to the ancients. The

cury and Venus are nearer the sun than the earth, the others are more remote. The earth revolves at a mean distance of 95,000,000 miles from the sun's centre, in a civil year of 365 days 5 hours 48 minutes 49·7 seconds, at the same time that it rotates in 24 hours about an axis which always remains parallel to itself, and inclined at an angle of 23° 27′ 34″·69 to the plane of the ecliptic; consequently the days and nights are of equal length at the equator, from whence their length progressively differs more and more as the latitude increases, till at each pole alternately there is perpetual day for six months, and a night of the same duration: thus the light and heat are very unequally distributed, and both are modified by the atmosphere by which the earth is encompassed to the height of about forty miles.

The Solar System—*continued.*

The Earth.
Mars, known to the ancients.
Flora, discovered by Mr. Hind in 1847.
Vesta, „ „ Mr. Olbers in 1807.
Iris, „ „ Mr. Hind in 1847.
Metis, „ „ Mr. Graham in 1848.
Hebe, „ „ Mr. Hencke in 1847.
Astræa, „ „ Mr. Hencke in 1845.
Juno, „ „ Mr. Harding in 1804.
Ceres, „ „ M. Piazzi in 1801.
Pallas, „ „ Mr. Olbers in 1802.
Jupiter, known to the ancients.
Saturn, „ „
Uranus, discovered by Sir William Herschel in 1781.
Neptune, „ „ M. Le Verrier and Mr. Adams in 1846.

With regard to magnitude, Mars, Jupiter, Saturn, Uranus, and Neptune are larger than the earth, the rest are smaller, but even the largest is incomparably inferior to the sun in size: his mass is 354,936 times greater than that of the earth, but the earth is nearly four times as dense.

Though the planets disturb the earth in its motion, their form has no effect on account of their great distance; but it is otherwise with regard to the moon, which revolves about the earth at a mean distance of 240,000 miles, and is therefore so near that the form of both bodies causes mutual disturbances in their respective motions. The perturbations in the moon's motions from that cause, compared with the same computed from theory, show that the earth is not a perfect sphere, but that it bulges at the equator, and is flattened at the poles: it even gives a value of the compression[1] or flattening. Again, theory shows that, if the earth were throughout of the same density, it would be much less flat at the poles than the moon's motions show it to be, but that it would be very nearly the same were the earth to increase regularly in density from the surface to its centre; and thus the lunar motions not only make known the form, but reveal the internal structure of the globe. Actual measurement has proved the truth of these results.

The courses of the great rivers, which are gene-

[1] The compression of the earth is the flattening at the poles. Its numerical value is equal to the difference between the equatorial and polar diameters, expressed in feet or miles, divided by the equatorial diameter.

rally navigable to a considerable extent, show that the curvature of the land differs but little from that of the ocean; and as the heights of the mountains and continents are inconsiderable when compared with the magnitude of the earth, its figure is understood to be determined by a surface at every point perpendicular to the direction of gravitation, or of the plumb-line, and is the same which the sea would have if it were continued all round the earth beneath the continents. Such is the figure that has been measured in various parts of the globe.

A terrestrial meridian is a line passing through both poles, all the points of which have their noon contemporaneously, and a degree of a meridian is its 360th part. Now, if the earth were a sphere, all degrees would be of the same length; but, as it is flattened at the poles, the degrees are longest there, and decrease in length to the equator, where they are least. The form and size of the earth may therefore be determined by comparing the length of degrees in different latitudes.[1] Eleven arcs have been measured in Europe, one in Peru, and two in the East Indies; but a comparison of no two gives the same result, which shows that the earth has a slightly irregular form. From a mean of ten of these arcs M. Bessel found that the equatorial radius

[1] The theoretical investigation of the figure of the earth, the method employed for measuring arcs of the meridian, and that of finding the form of the earth from the oscillations of the pendulum, are given in the 'Connexion of the Physical Sciences,' by Mary Somerville, 7th Section, 7th edition.

of the earth is 3963·025 miles, and the polar radius 3949·8 miles nearly. Whence, assuming the earth to be a sphere, the length of a mean degree of the meridian is 69·05 British statute miles; therefore 360 degrees, or the whole circumference of the globe, is 24,858 miles; the diameter, which is something less than a third of the circumference, is about 8286, or 8000 statute miles; and the length of a geographical mile of 60 to a degree is 6086·76 feet. The breadth of the torrid zone is 705 geographical miles, the breadth of each of the temperate zones is 645 miles, and that of each of the spaces within the arctic and antarctic circles 11,431 miles nearly. The Astronomer Royal Mr. Airy's results, obtained ten years afterwards, only differ from those of M. Bessel by 127 feet in the equatorial, and 138 feet in the polar radius, quantities not greater than the length of a ballroom. In consequence of the round form of the earth, the dip or depression of the horizon is a fathom for every three miles of distance; that is to say, an object a fathom or six feet high would be hid by the curvature of the earth at the distance of three miles. Since the dip increases as the square, a hill 100 fathoms high would be hid at the distance of ten miles, and the top of Dhawalagori, the culminating point of the Himalaya, 28,000 feet high, would be seen to sink beneath the horizon by a person about 167 miles off; thus, when the height is known, an estimate can be formed of the distance of a mountain.

The oscillations of the pendulum have afforded another method of ascertaining the form of the earth. Like all heavy bodies, its descent and consequently its oscillations are accelerated in proportion to the force of gravitation, which increases from the equator to the poles. In order, therefore, that the oscillations may be everywhere performed in the same time, the length of the pendulum must be increased progressively in going from the equator to the poles, according to a known law,[1] from whence the compression or flattening at the poles may be deduced. Experiments for that purpose have been made in a great number of places, but, as in the measurement of the arcs, no two sets give exactly the same results; the mean of the whole, however, differs very little from that given by the degrees of the meridian and the perturbations of the moon; and as the three methods are so entirely independent of each other, the figure and dimensions of the earth may be considered to be known. The sea has little effect on these experiments, both because its mean density is less than that of the earth, and that its mean depth of perhaps four miles is inconsiderable

[1] A pendulum which oscillates 86,400 times in a mean day at the equator, will do the same at every point of the earth's surface if its length be increased progressively to the pole as the square of the sine of the latitude. The sine of the latitude is a perpendicular line drawn from any point of a terrestrial meridian to the equatorial radius of the earth. That line expressed in feet or miles, and multiplied by itself, is the square of the sine of the latitude. Gravitation increases from the equator to the poles according to that law, and the length of the degrees augments very nearly in the same ratio.

when compared with 4000 miles, the mean terrestrial radius.[1]

The discrepancies in the results, from the comparison of the different sets of pendulum experiments, and also of degrees of the meridian, arise from local attraction, as well as from irregularities in the form of the earth. These attractions, arising from dense masses of rock in mountains, cause the plumb-line to deviate from the vertical, and when under ground they alter the oscillations of the pendulum. Colonel Sabine, who made experiments with the pendulum from the equator to within ten degrees of the north pole, discovered that the intensity is greatly augmented by volcanic islands. A

[1] The compression deduced by M. Bessel from arcs of the meridian is $\frac{1}{299}$; that deduced by Colonel Sabine from his experiments with the pendulum is $\frac{1}{288 \cdot 7}$. Other pendulum experiments have given a compression of $\frac{1}{298 \cdot 2}$ and $\frac{1}{266 \cdot 4}$. The protuberant matter at the earth's equator produces inequalities in the moon's motions, from whence the compression of the earth is found to be $\frac{1}{305 \cdot 05}$; and although the reciprocal action of the moon on the protuberant matter at the earth's equator does not actually give the compression, it proves that it must be between $\frac{1}{279}$ and $\frac{1}{573}$. Coincidences so near and so remarkable, arising from such different methods, show how nearly the irregular figure of the earth has been determined. The inequalities in the motions of the moon and earth alluded to are explained in Sections 5 and 11, 'Connexion of Physical Sciences.'

variation to the amount of a tenth of a second in twenty-four hours can be perfectly ascertained in the rate of the pendulum, but from some of these local attractions a variation of nearly ten seconds has occurred during the same period. The islands of St. Helena, Ascension, St. Thomas, the Isle of France, are some of those noted by Colonel Sabine.

There are other remarkable instances of local disturbance, arising from the geological nature of the soil; for example, the intensity of gravitation is very small at Bordeaux, from whence it increases rapidly to Clermont-Ferrand, Milan, and Padua, where it attains a maximum (owing probably to dense masses of rock under ground), and from thence it extends to Parma. In consequence of this local attraction, the degrees of the meridian in that part of Italy seem to increase towards the equator through a small space, instead of decreasing, as if the earth were drawn out instead of flattened at the poles.

It appears from this that the effect of the whole earth on a pendulum or torsion balance may be compared with the effect of a small part of it, and thus a comparison may be instituted between the mass of the earth and the mass of that part of it. Now a leaden ball was weighed against the earth by comparing the effects of each upon a balance of torsion; the nearness of the smaller mass making it produce a sensible effect as compared with that of the larger, for by the laws of attraction the whole earth must be considered as collected in its centre; in this manner a value of the mass of the earth was obtained, and, as its volume was known, its mean density was found to be 5·675 times greater than that of water at the temperature of 62° of Fahrenheit's thermometer. Now, as that mean density is double that of basalt, and more than double that of granite, rocks which undoubtedly emanate from very great depths beneath the surface of the earth, it affords another proof of the increase in density towards the earth's centre. These experiments were first made by Mr. Cavendish and Mitchell, and latterly with much greater accuracy by Mr. Baily, who devoted four years of unremitted attention to the accomplishment of this important and difficult object.[1]

Although the earth increases in density regularly from the surface to the centre, as might naturally be expected from the increasing pressure, yet the surface consists of a great variety of substances of different densities, some of which occur in amorphous masses; others are disposed in regular layers or strata, either horizontal or inclined at all angles to the horizon. By mining, man has penetrated only a very little way; but by reasoning from the dip or inclination of the strata at or near the surface, and from other circumstances, he has obtained a pretty accurate idea of the structure of our globe to the

[1] It is clear that the mean density of the earth may be found from the attraction of the plumb-line by mountains, or by the irregularity in the oscillations of the pendulum, but the torsion balance is a much more sensible instrument than either. The density determined by M. Reich differs from that found by Mr. Baily by only one twenty-eighth part.

depth of about ten miles. All the substances of which we have any information are divided into four classes, distinguished by the manner in which they have been formed: namely,—plutonic and volcanic rocks, both of igneous origin, though produced under different circumstances; aqueous or stratified rocks, entirely due to the action of water, as the name implies; and metamorphic rocks, deposited by water, according to the opinion of many eminent geologists, and consequently stratified, but subsequently altered and crystallized by heat. The aqueous and volcanic rocks are formed at the surface of the earth, the plutonic and metamorphic at great depths; but all of them have originated simultaneously during every geological period, and are now in a state of slow and constant progress. The antagonist principles of fire and water have ever been and still are the cause of the perpetual vicissitudes to which the crust of the earth is liable.

It has been ascertained by observation that the plutonic rocks, consisting of the granites and some of the porphyries, were formed in the deep and fiery caverns of the earth, of melted matter, which crystallized as it slowly cooled under enormous pressure, and was then heaved up in unstratified masses by the elastic force of the internal heat even to the tops of the highest mountains, or forced in a semi-fluid state into fissures of the superincumbent strata, sometimes into the cracks of the previously formed granite: for that rock, which constitutes the base of so large a portion of the earth's crust, has not been all formed at once; some portions had been solid, while others were yet in a liquid state. This class of rocks is completely destitute of fossil remains.

Although granite and the volcanic rocks are both due to the action of fire, their nature and position are very different; granite, fused in the interior of the earth, has been cooled and consolidated before coming to the surface: besides, it generally consists of few ingredients, so that it has nearly the same character in all countries. But as the volcanic fire rises to the very surface of the earth, fusing whatever it meets with, volcanic rocks take various forms, not only from the different kinds of strata which are melted, but from the different conditions under which the liquid matter has been cooled, though most frequently on the surface—a circumstance that seems to have had the greatest effect on its appearance and structure. Sometimes it approaches so nearly to granite that it is difficult to perceive a distinction; at other times it becomes glass; in short, all those massive, unstratified, and occasionally columnar rocks, as basalt, greenstone, porphyry, and serpentine, are due to volcanic fires and are devoid of fossil remains.

There seems scarcely to have been any age of the world in which volcanic eruptions have not taken place in some part of the globe. Lava has pierced through every description of rocks, spread over the surface of those existing at the time, filled their crevices, and flowed between their strata. Ever changing its place of action, it has burst out at the bottom of the sea as well as on dry land. Enormous quantities of scoriæ and ashes have been ejected from numberless craters, and have formed extensive deposits in the sea, in lakes, and on the land, in which are embedded the remains of the animals and vegetables of the epoch. Some of these deposits have become hard rock, others remain in a crumbling state; and as they alternate with the aqueous strata of almost every period, they contain the fossils of all the geological epochs, chiefly fresh and salt water testaceæ.[1]

According to a theory now generally adopted, which originated with Sir Charles Lyell, whose works are models of philosophical investigation, the metamorphic rocks, which consist of gneiss, mica-schist, clay-slate, statuary marble, &c., were formed of the sediment of water in regular layers, differing in kind and colour, but, having been deposited near the place where plutonic rocks were generated, they have been changed by the heat transmitted from the fused matter, and, in cooling under heavy pressure and at great depths, they have become as highly crystallized as the granite itself, without losing their stratified form. An earthy stratum has sometimes been changed into a highly crystallized rock, to the distance of a quarter of a mile from the point of contact, by transmitted heat; and there are instances of dark-coloured limestone, full of fossil shells, that has been changed into statuary marble from that

[1] Testaceæ are shell-fish.

cause. Such alterations may frequently be seen to a small extent on rocks adjacent to a stream of lava. There is seldom a trace of organic remains in the metamorphic rocks; their strata are sometimes horizontal, but they are usually tilted at all angles to the horizon, and form some of the highest mountains and most extensive table-lands on the face of the globe. Although there is the greatest similarity in the plutonic rocks in all parts of the world, they are by no means identical; they differ in colour, and even in ingredients, though these are few.

Aqueous rocks are all stratified, being the sedimentary deposits of water. They originate in the wear of the land by rain, streams, or the ocean. The débris carried by running water is deposited at the bottom of the seas and lakes, where it is consolidated, and then raised up by subterraneous forces, again to undergo the same process after a lapse of time. By the wasting away of the land the lower rocks are laid bare, and, as the materials are deposited in different places according to their weight, the strata are exceedingly varied, but consist chiefly of arenaceous or sandstone rocks, composed of sand, clay, and carbonate of lime. They constitute three great classes, which, in an ascending order, are the primary and secondary fossiliferous strata and the tertiary formations.

The primary fossiliferous strata, the most ancient of all the sedimentary rocks, consisting of limestone, sandstones, and shales, are entirely of marine origin, having been formed far from land at the bottom of a very deep ocean; consequently they contain the exuviæ of marine animals only, and after the lapse of unnumbered ages the ripple-marks of the waves are still distinctly visible on some of their strata. This series of rocks is subdivided into the Cambrian and the upper and lower Silurian systems, on account of differences in their fossil remains.

The Cambrian rocks, sometimes many thousand yards thick, are, for the most part, destitute of organic remains, but the Silurian rocks abound in them more and more as the strata lie higher in the series. In the lower Silurian group are the remains of shell-fish, almost all of extinct genera, and the few that have any affinity to those alive are of extinct species; crinoidea, or stone lilies, which had been fixed to the rocks like tulips on their stems, are coëval with the earliest inhabitants of the deep; and the trilobite, a jointed creature of the crab kind, with prominent eyes, are almost exclusively confined to the Silurian strata, but the last traces of them are found in the coal-measures above. In the upper Silurian group are abundance of marine shells of almost every order, together with crinoidea, vast quantities of corals, and some sea-weeds: several fossil sauroid fishes,[1] of extinct genera, but high organization, have been found in the highest beds—the only vertebrated animals that have yet been discovered among the countless profusion of the lower orders of creatures that are entombed in the primary fossiliferous strata. The remains of one or more land

[1] Sauroid fish have somewhat of the form of the lizard.

plants, in a very imperfect state, have been found in the Silurian rocks of North America, which shows that there had been land with vegetation at that early period. The type of these plants, as well as the size of the shells and the quantity of the coral, indicate that a uniformly warm temperature had then prevailed over the globe. During the Silurian period an ocean covered the northern hemisphere, islands and lands of moderate size had just begun to rise, and earthquakes, with volcanic eruptions from insular and submarine volcanos, were frequent towards its close.

The secondary fossiliferous strata, which comprise a great geological period, and constitute the principal part of the high land of Europe, were deposited at the bottom of an ocean, like the primary, from the débris of all the others, carried down by water, and still bear innumerable tokens of their marine origin, although they have for ages formed a part of the dry land. Calcareous rocks are more abundant in these strata than in the crystalline, probably because the carbonic acid was then, as it still is, driven off from the lower strata by the internal heat, and came to the surface as gas or in calcareous springs, which either rose in the sea and furnished materials for shell-fish and coral insects to build their habitations and form coral reefs, or deposited their calcareous matter on the land in the form of rocks.

The Devonian or old red sandstone group, in many places 10,000 feet thick, consisting of strata of dark red and other sandstones, marls, coralline limestones, conglomerates, &c., is the lowest of the secondary fossiliferous strata, and forms a link between them and the Silurian rocks, by an analogy in their fossil remains. It has fossils peculiarly its own, but it has also some shells and corals common to the strata both above and below it. There are various families of extinct sauroid fishes in this group, some of which were gigantic, others had strong bony shields on their heads, and one genus, covered with enamelled scales, had appendages like wings. The shark approaches nearer to some of these ancient fish than any other now living.

During the long period of perfect tranquillity that prevailed after the Devonian group was deposited, a very warm, moist, and extremely equable climate, which extended all over the globe, had clothed the islands and lands in the ocean then covering the northern hemisphere with exuberant tropical forests and jungles. Subsequent inroads of fresh water, or of the sea, or rather partial sinkings of the land, had submerged these forests and jungles, which, being mixed with layers of sand and mud, had in time been consolidated into one mass, and were then either left dry by the retreat of the waters or gently raised above their surface.

These constitute the remarkable group of the carboniferous strata, which consists of numberless layers of various substances filled with a prodigious quantity of the remains of fossil land-plants, intermixed with beds of coal, which is entirely composed of vegetable matter. In some cases the plants appear to have been carried down by floods, and deposited in estuaries; but in most instances the beauty, delicacy, and sharpness of the impressions show that they had grown on the spot where the coal was formed. More than 300 fossil plants have been collected from the strata where they abound, frequently with their seeds and fruits, so that enough remains to show the peculiar nature of this flora, whose distinguishing feature is the preponderance of ferns; among these there were tree-ferns which must have been 40 or 50 feet high. There were also plants resembling the horse-tail tribe, of gigantic size, others like the tropical club mosses; an aquatic plant of an extinct family was very abundant, beside many others to which we have nothing analogous. Forest-trees of great magnitude, of the pine and fir tribes, flourished at that period. The remains of an extinct araucaria, one of the largest of the pine family, have been found in the British coal-fields; the existing species now grow in very warm countries; a few rare instances occur of grasses, palms, and liliaceous plants. The botanical districts were very extensive when the coal-plants were growing, for the species are nearly identical throughout the coal-fields of Europe and America. From the extent of the ocean, the insular structure of the land, the profusion of ferns and fir-trees, and the warm, moist, and equable climate, the northern hemisphere during the formation of the coal strata is thought to have borne a strong resemblance to the South Pacific, with its fern and fir clothed lands of New Zealand, Kerguelen islands, and others.

The animal remains of this period are in the mountain limestone, a rock occasionally 900 feet thick, which in some instances lies beneath the coal-measures, and sometimes alternates with the shale and sandstone. They consist of crinoidea and marine testaceæ, among which the size of the chambered shells, as well as that of the corals, shows that the ocean was very warm at that time, even in the high northern latitudes. The footsteps of a very large reptile of the frog tribe have been found on some of the carboniferous strata of North America.

The coal strata have been very much broken and deranged in many places by earthquakes, which frequently occurred during the secondary fossiliferous period, and from time to time raised islands and land from the deep. However, these and all other changes that have taken place on the earth have been gradual and partial, whether brought about by fire or water. The older rocks are more shattered by earthquakes than the newer, because the movement came from below; but these convulsions have never extended all over the earth at the same time —they have always been local: for example, the Silurian strata have been dislocated and tossed in Britain, while a vast area in the south of Sweden and Russia still retains a horizontal position. There is no proof that any mountain-chain has ever been raised at once; on the contrary, the elevation has always been produced by a long-continued and reiterated succession of internal convulsions with intervals of repose. In many instances the land has risen up or sunk down by an imperceptible equable motion continued for ages, while in other places the surface of the earth has remained stationary for long geological periods.

The magnesian limestone, or permian formation, comes immediately above the coal-measures, and consists of breccias or conglomerates, gypsum, sandstone, marl, &c.; but its distinguishing feature is a yellow limestone rock, containing carbonate of magnesia, which often takes a granular texture, and is then known as dolomite. The permian formation has a fossil flora and fauna peculiar to itself, mingled with those of the coal strata. Here the remnant of an earlier creation gradually tends to its final extinction, and a new one begins to appear. The flora is, in many instances, specifically the same with that in the coal strata below. Certain fish are also common to the two, which never appear again. They belong to a race universal in the early geological periods, and bear a strong resemblance to saurian reptiles. A small number of existing genera only, such as the shark and sturgeon, make some approach to the structure of these ancient inhabitants of the waters. The new creation is marked by the introduction of two species of saurian reptiles;[1] the fossil remains of one have been found in the magnesian limestone in England, and those of the other in a corresponding formation in Germany. They are the earliest members of a family which was to have dominion on the land and water for ages.

[1] Saurian reptiles are lizards, crocodiles, &c.

A series of red marls, rock-salt, and sandstones, which have arisen from the disintegration of metamorphic slates and porphyritic trap, containing oxide of iron, and known as the trias or new red sandstone system, lies above the magnesian limestone. In England this formation is particularly rich in rock-salt, which, with layers of gypsum and marl, is sometimes 600 feet thick; but in this country the muschelkalk, a peculiar kind of shell limestone, is wanting, which in Germany is so remarkable for the quantity of organic remains. At this time creatures like frogs, of enormous dimensions, had been frequent, as they have left their footsteps on what must then have been a soft shore. Forty-seven genera of fossil remains have been found in the trias in Germany, consisting of shells, cartilaginous fish, encrinites, &c., all distinct in species, and many distinct in genera, from the organic fossils of the magnesian limestone below, and also from those entombed in the strata above.

During a long period of tranquillity the oolite or Jurassic group was next deposited in a sea of variable depth, and consists of sands, sandstones, marls, clays, and limestone. At this time there was a complete change in the aqueous deposits all over Europe. The red iron-stained arenaceous rocks, the black coal, and dark strata, were succeeded by light-blue clays, pale-yellow limestones, and, lastly, white chalk. The water that deposited the strata must have been highly charged with carbonate of lime, since few of the formations of that period are without calcareous matter, and calcareous rocks were formed to a prodigious extent throughout Europe: the Pyrenees, Alps, Apennines, and Balkan abound in them; and the Jura mountains, which have given their name to the series, are formed of them. The European ocean then teemed with animal life; whole beds consist almost entirely of marine shells and corals. Belemnites and ammonites, from an inch in diameter to the size of a cart-wheel, are entombed by myriads in the strata: whole forests of that beautiful zoophyte the stone-lily flourished on the surface of the oolite, then under the waters; and the encrinite, one of the same genus, is embedded in millions in the enchorial shell-marble, which occupies such extensive tracts in Europe. Fossil fish are numerous in these strata, but different from those of the coal series, the permian formation, and trias: not one genus of the fish of this period is now in existence. The newly-raised islands and lands were clothed with vegetation like that of the large islands of the intertropical archipelagos of the present day, which, though less rich than during the carboniferous period, still indicates a very moist and warm climate. Ferns were less abundant, and they were associated with various genera and species of the cicadeæ, which had grown on the southern coast of England, and in other parts of northern Europe, congeners of the present cycas and zamia of the tropics. These plants had been very numerous, and the pandanæ, or screw-pine, the first tenant of the new lands in ancient and modern times, is a family found in a fossil state in the inferior oolite of England, which was but just rising from the deep at that time. The species now flourishing grows only on the coasts of such coral islands in the Pacific as have recently emerged from the waves. In the upper strata of this group, however, the confervæ and monocotyledonous plants[1] become more rare—an indication of a change of climate.

The new lands that were scattered on the ocean of the oolitic period were drained by rivers, and inhabited by huge crocodiles and saurian reptiles of gigantic size, mostly of extinct genera. The crocodiles come nearest to modern reptiles; but the others, though bearing a remote similitude in general structure to living forms, were quite anomalous, combining in one the structure of various distinct creatures, and so monstrous that they must have been more like the visions of a troubled dream than things of real existence; yet in organization a few of them came nearer to the type of living mammalia than any existing reptiles do. Some of these had lived in rivers, others in the ocean—some were inhabitants of the land, others were amphibious; and the various species of one genus even had wings like a bat, and fed on insects. There were both herbivorous and predaceous saurians; and from their size and strength they must have been formidable enemies. Besides, the numbers deposited are so great, that they must

[1] Confervæ are plants with nearly imperceptible fructification, found in ponds, damp places, and in the sea.

Monocotyledonous plants are grasses, palms, and others, having only one seed-lobe.

have swarmed for ages in the estuaries and shallow seas of the period, especially in the lias, a marine stratum of clay, the lowest of the oolite series. They gradually declined towards the end of the secondary fossiliferous epoch; but as a class they lived in all subsequent eras, and still exist in tropical countries, although the species are very different from their ancient congeners. Tortoises of various kinds were contemporary with the saurians, also a family that still exists. In the Stonefield slate, a stratum of the lower oolitic group, there are the remains of insects, and the bones of two small quadrupeds have been found there belonging to the marsupial tribe,[1] such as the opossum—a very remarkable circumstance, because that family of animals at the present time is confined to New Holland, South America, and as far north as Pennsylvania at least. The great changes in animal life during this period were indications of the successive alterations that had taken place on the earth's surface.

The cretaceous strata follow the oolite in ascending order, consisting of clay, green and iron sands, blue limestone, and chalk, probably formed of the decay of coral and shells, which predominates so much in England and other parts of Europe, that it has given the name and its peculiar feature to the whole group. It is, however, by no means universal; the chalk is wanting in many parts of the

[1] Marsupial animals have pouches in which their young are nourished till they are matured. The opossum and kangaroo are marsupial.

world where the other strata of this series prevail, and then their connexion with the group can only be ascertained by the identity of their fossil remains. With the exception of some beds of coal among the oolitic series, the Wealden clay, the lowest of the cretaceous group in England, is the only fresh-water formation, and the tropical character of its flora shows that the climate was still very warm. Plants allied to the zamias and cycades of our tropical regions, many ferns and pines of the genus araucaria, characterized its vegetation, and the upright stems of a fossil forest at Portland show that it had been covered with trees. It was inhabited by tortoises approaching to families now living in warm countries, and saurian reptiles of five different genera swarmed in the lakes and estuaries. This clay contains fresh-water shells and fish of the carp kind. The Wealden clay is one of the various instances of the subsidence of land which took place during this period.

The cretaceous strata above our Wealden clay are full of marine exuviæ. There are vast tracts of sand in Northern Europe, and many very extensive tracts of chalk; but in the southern part of the Continent the cretaceous rocks assume a different character. There and elsewhere extensive limestone rocks, filled with very peculiar shells,[1] show that, when the cretaceous strata were forming, an ocean extended from the Atlantic into Asia, which covered

[1] Shells called nummulites, from their round flat form, resembling a piece of money.

the south of France, all Southern Europe, part of Syria, the isles of the Ægean Sea, the coasts of Thrace and the Troad. The remains of turtles have been found in the cretaceous group, quantities of coral, and abundance of shells of extinct species; some of the older kinds still existed, new ones were introduced, and some of the most minute species of microscopic shells, which constitute a large portion of the chalk, are supposed to be the same with creatures now alive, the first instance of identity of species in the ancient and modern creation. An approximation to recent times is to be observed also in the arrangement of organized nature, since at this early period, and even in the Silurian and oolitic epochs, the marine fauna was divided, as now, into distinct geographical provinces. The great saurians were on the decline, and many of them were found no more, but a gigantic creature, intermediate between the monitor and iguana,[1] lived at this period. From the permian group to the chalk inclusive only two instances of fossil birds occur, one in a chalk deposit in the Swiss Alps, and the other a kind of albatross in the chalk in England; in North America, however, the foot-marks of a variety of birds have been found in the strata between the coal and lias, some of which are larger than those of the ostrich.

An immense geological cycle elapsed between the termination of the secondary fossiliferous strata and

[1] The monitor and iguana, creatures of the crocodile tribe, still existing.

the beginning of the tertiary. With the latter a new order of things commenced, approaching more closely to the actual state of the globe. During the tertiary formation the same causes under new circumstances produced an infinite variety in the order and kind of the strata, accompanied by a corresponding change in animal and vegetable life. The old creation, which had nothing in common with the existing order of things, had passed away and given place to one more nearly approaching to that which now prevails. Among the myriads of beings that inhabited the earth and the ocean during the secondary fossiliferous epoch scarcely one species is to be found in the tertiary. Two planets could hardly differ more in their natural productions. This break in the law of continuity is the more remarkable, as hitherto some of the newly-created animals were always introduced before the older were extinguished. The circumstances and climate suited to the one became more and more unfit for the other, which consequently perished gradually, while their successors increased. It is possible that, as observations become more extended, this hiatus may be filled up.

The series of rocks from the granite to the end of the secondary fossiliferous strata, taken as a whole, constitute the solid crust of the globe, and in that sense are universally diffused over the earth's surface. The tertiary strata occupy the hollows formed in this crust, whether by subterraneous movements, by lakes, or denudation by water as in the estuaries of rivers, and consequently occur in irregular tracts; often, however, of prodigious thickness and extent. Indeed, they seem to have been as widely developed as any other formation, though time has been wanting to bring them into view.

The innumerable basins and hollows with which the continents and larger islands had been indented for ages after the termination of the secondary fossiliferous series had sometimes been fresh-water lakes, and at other times inundated by the sea; consequently, the deposits which took place during these changes alternately contain the spoils of terrestrial and marine animals. The frequent intrusion of volcanic strata among the tertiary formations shows that, in Europe, the earth had been in a very disturbed state, and that these repeated vicissitudes had been occasioned by elevations and depressions of the soil, as well as by the action of water.

There are three distinct groups in these strata: the lowest tertiary or Eiocene group, so called by Sir Charles Lyell, because, among the myriads of fossil shell-fish it contains, very few are identical with those now living; the Meiocene, or middle group, has a greater number of the exuviæ of existing species of shells; and the Pleiocene, or upper tertiary group, still more. Though frequently heaved up to great elevations on the flanks of the mountain-chains, as, for example, on the Alps and Apennines, by far the greater part of the tertiary strata maintain their original horizontal position in the very places where they were formed. Immense insulated deposits of this kind are to be met with all over the world; Europe abounds with them, London, Paris, and Vienna stand on such basins, and they cover immense tracts both in North and South America.

The monstrous reptiles had mostly disappeared, and the mammalia now took possession of the earth, of forms scarcely less anomalous than their predecessors, though approaching more nearly to those now living.

Numerous species of extinct animals that lived during the earliest or Eiocene period have been found in various parts of the world, especially in the Paris basin, of the order of Pachydermata,[1] to the greater number of which we have nothing analogous; they were mostly herbivorous quadrupeds, which had frequented the borders of the rivers and lakes that covered the greater part of Europe at that time. This is the more extraordinary, as existing animals most similar to these, the tapirs for instance, are confined to the torrid zone. These creatures were widely diffused, and some of them were associated with genera still existing, though of totally different species; such as animals allied to the racoon and dormouse, the ox, bear, deer, the fox, the dog, and others. Although these quadrupeds differ so widely from those of the present day, the same proportion existed then as now between the carnivorous and herbivorous genera.

[1] Pachydermata, thick-skinned animals, as the rhinoceros and elephant.

The spoils of marine mammalia[1] of this period have also been found, sometimes at great elevations above the sea, all of extinct species, and some of these cetacea were of huge size. This marvellous change of the creative power was not confined to the earth and the ocean; the air also was now occupied by many extinct races of birds allied to the owl, buzzard, quail, curlew, &c. The climate must still have been warmer than at present, from the remains of land and sea plants found in high latitudes. Even in England bones of the opossum, monkey, and boa have been discovered, all animals of warm countries, besides fossil sword and saw fish, both of genera foreign to the British seas.

During the Meiocene period new amphibious quadrupeds were associated with the old, of which the deinotherium is the most characteristic and much the largest of the mammalia yet found, far surpassing the largest elephant in size, of a singular form, and unknown nature.

The palæotherium was of this period, and also the mastodon, both of large dimensions. Various families, and even genera, of quadrupeds now existing were associated with these extraordinary creatures, though of extinct species, such as the elephant, rhinoceros, hippopotamus, tapir, horse, bear, wolf, hyæna, weasel, beaver, ox, buffalo, deer, &c.; and also marine mammalia, as dolphins, sea-calves, walruses, and lamantines. Indeed, in the constant in-

[1] Marine mammalia, which suckle their young like land animals, are seals, whales, porpoises, &c.

crease of animal life manifested throughout the whole of the tertiary strata, the forms approach nearer to living species as their remains lie high in the series.

In the older Pleiocene period some of the large amphibious quadrupeds, and other genera of mammalia of the earlier tertiary periods, appear no more; but there were the mastodon, and the Elephas primigenius or mammoth, some species of which, of prodigious size, were associated with numerous quadrupeds of existing genera, but lost species. Extinct species of almost all the quadrupeds now alive seem to have inhabited the earth at that time; their bones have been discovered in caverns; they were embedded in the breccias and in most of the strata of that epoch—as the hippopotamus, rhinoceros, elephant, horse, bear, wolf, water-rat, hyæna, and various birds. It is remarkable that in the caverns of Australia the fossil bones all belong to extinct species of gigantic kangaroos and wombats, animals belonging to the marsupial family, which are so peculiarly the inhabitants of that country at the present day, but of diminished size. The newer Pleiocene strata show that the same analogy existed between the extinct and recent mammalia of South America, which, like their living congeners, as far as we know, belonged to that continent alone; for the fossil remains, quite different from those in the old world, are of animals of the same families with the sloths, anteaters, and armadilloes which now inhabit that country, but of vastly superior size and different species. In fact, there were giants in the land in those days. Were change of species possible, one might almost fancy that these countries had escaped the wreck of time, and that their inhabitants had pined and dwindled under the change of circumstances. The megatherium and Equus curvidens, or extinct horse, had so vast a range in America, that, while Sir Charles Lyell collected their bones in Georgia in 33° N. latitude, Mr. Darwin brought them from the corresponding latitude in South America. The Equus curvidens differed as much from the living horse as the quagga or zebra does, and the European fossil horse is also probably a distinct and lost species.

A comparison of the fossil remains with the living forms has shown the analogy between these beings of the ancient world and those that now people the earth; and the greatest triumph of the geologist is the certainty with which he can decide upon the nature of animals that have been extinct for thousands of years, from a few bones entombed on the earth's surface. Baron Cuvier will ever be celebrated as the founder of this branch of comparative anatomy, and which Professor Owen has brought to the highest perfection. Among many discoveries, he has found, by the most minute microscopic observation, that the structure of the tissue of which teeth are formed is different in different classes of animals, and that the species can in many instances be determined from the fragment of a tooth. A small portion of a bone enabled him to decide on the nature of an extinct race of birds, and the subsequent discovery of the whole skeleton confirmed the accuracy of this determination.

The greater part of the land in the northern hemisphere was elevated above the deep during the tertiary period, and such lands as already existed acquired additional height; consequently the climate, which had previously been tropical, became gradually colder, for an increase of land, which raises the temperature between the tropics, has exactly the contrary effect in higher latitudes. Hence excessive cold prevailed during the latter part of the Pleiocene period, and a great part of the European continent was covered by an ocean full of floating ice, not unlike that seen at this day off the north-eastern coast of America.[1]

During the latter part of the Pleiocene period, however, the bed of that glacial ocean rose partially, and after many vicissitudes the European continent assumed nearly the form it now bears. There is every reason to believe that the glacial sea extended also over great portions of the arctic lands of Asia and America. Old forms of animal and

[1] If a line be drawn from the north-eastern coast of North America within the limit of floating ice, and if it be continued across the southern half of Ireland and England, and prolonged eastward so as to strike against the Ural mountains, it will mark the boundary of the European portion of the Glacial Sea. It submerged part of Russia to the depth of 1000 feet.—Essay on the British Fauna and Flora, by Professor E. Forbes, in the 'Memoirs of the Geological Survey of Great Britain,' vol. i.

vegetable life were destroyed by these alterations in the surface of the earth, and the consequent change of temperature; and when, in the progress of the Pleiocene period, the mountain-tops appeared as islands above the water, they were clothed with the flora and peopled by the animals they still retain; and new forms were added as the land rose and became dry and fitted to receive and maintain the races of animals now alive, all of which had possession of the earth for ages prior to the historical or human period. Some of the extinct animals had long resisted the great vicissitudes of the times; of these the mammoth or Elephas primigenius, whose fossil remains are found all over Europe, Asia, and America, but especially in the gelid soil of Siberia, alone outlived its associates, the last remnant of a former world. In two or three instances this animal has been discovered entire, entombed in frozen mud, with its hair and its flesh so fresh that wolves and dogs fed upon it. The globe of the eye of one found by M. Middendorf at Tas, between the rivers Oby and Jenesei, was so perfect that it is now preserved in the museum at Moscow. It has been supposed that, as the Siberian rivers flow for hundreds of miles from the southern part of the country to the Arctic Ocean, these elephants might have been drowned by floods while browsing in the milder regions, and that their bodies were carried down by the rivers and embedded in mud, and frozen before they had time to decay. Mr. Darwin has suggested that, if the climate of Siberia has at any time been similar to that of the high latitudes of South America, where the line of perpetual snow in the Andes, and its sudden flexure in Southern Chili, come close to a nearly tropical vegetation, such a vegetation may have prevailed south of the frozen regions in Siberia, and, consequently, the bodies of animals entombed a few feet below the icy surface might be preserved for ages. On the other hand, although the congeners of this animal are now inhabitants of the torrid zone, they may have been able to endure the cold of a Siberian winter, for Baron Cuvier found that this animal differed as much from the living elephant as the horse does from the ass. Mr. Darwin has shown that the supply of food in summer was probably sufficient, since the quantity requisite for the maintenance of the larger animals is by no means in proportion to their bulk, or it may have migrated to a more genial climate in the colder months.

Shell-fish seem to have been more able to endure all the great geological changes than any of their organic associates, but they show a constant approximation to modern species during the progress of the tertiary period. The whole of these strata contain enormous quantities of shells of extinct species; in the oldest, three and a half per cent. of the shells are identical with species now existing, while on the uppermost strata of this geological period there are not less than from ninety to ninety-five in a hundred identical with those now alive.

Of all the fossil fishes, from the Silurian strata to the end of the tertiary, scarcely one is specifically the same with living forms: the Mallotus villosus, or captan, of the salmon family, is an exception, and perhaps a few others of the most recent of these periods. In the Eiocene strata one-third belong to extinct genera.

Under the vegetable mould in every country there is a stratum of loose sand, gravel, and mud, lying upon the subjacent rocks, often of great thickness, called alluvium, which in the high latitudes of North America and Europe is mixed with enormous fragments of rock, sometimes angular and sometimes rounded and water-worn, which have been transported hundreds of miles from their origin. It is there known as the Boulder formation, or Northern Drift, because, from the identity of the boulders with the rocks of the northern mountains, they evidently have come from them, and their size becomes less as the distance increases. In Russia there are blocks of great magnitude that have been carried 800 and even 1000 miles south-east from their origin in the Scandinavian range. There is much reason to believe that such masses, enormous as they are, have been transported by icebergs, and deposited when the northern parts of the continents were covered by the glacial sea, by which part of Russia was submerged to the depth of at least 1000 feet. The same process is now in progress in the high southern latitudes where icebergs have been met with covered with fragments of rock and boulders.[1]

[1] Sir James Ross and Captain Wilkes met with icebergs

The last manifestation of creative power, with few exceptions, differs specifically from all that preceded it; the recent strata contain only the exuviæ of animals now living, often mixed with the works of man.

The solid earth thus tells us of mountains washed down into the sea with their forests and inhabitants; of lands raised from the bottom of the ocean loaded with the accumulated spoils of centuries; of torrents of water and torrents of fire. In the ordinances of the heavens no voice declares a beginning, no sign points to an end; in the bosom of the earth however the dawn of life appears, the time is obscurely marked when first living things moved in the waters, when the first plants clothed the land. There we see that during ages of tranquillity the solid rock was forming at the bottom of the ocean, that during ages it was tossed and riven by fire and earthquake. What years must have gone by since that ocean flowed which has left its ripple-marks on the sand, now a solid mass on the mountain—since those unknown creatures left their foot-prints on the shore, now fixed by time on the rock for ever! time, which man measures by days and years, nature measures by thousands of centuries.

The thickness of the fossiliferous strata up to the end of the tertiary formation has been estimated at about seven or eight miles; so that the time requisite for their deposition must have been immense. Every

covered with mud and stones in the antarctic seas, and even in 66° 5′ lat. One block seen by Sir James Ross was estimated to weigh many tons.—Antarctic Voyages.

river carries down mud, sand, or gravel, to the sea: the Ganges brings more than 700,000 cubic feet of mud every hour, the Yellow River in China 2,000,000,[1] and the Mississippi still more; yet, notwithstanding these great deposits, the Italian hydrographer Manfredi has estimated that, if the sediment of all the rivers on the globe were spread equally over the bottom of the ocean, it would require 1000 years to raise its bed one foot, so that at that rate it would require 3,960,000 years to raise the bed of the ocean alone to a height nearly equal to the thickness of the fossiliferous strata, or seven miles and a half, not taking account of the waste of the coasts by the sea itself: but if the whole globe be considered, instead of the bottom of the sea only, the time would be nearly four times as great, even supposing as much alluvium to be deposited uniformly both with regard to time and place, which it never is. Besides, in various places the strata have been more than once carried to the bottom of the ocean, and again raised above its surface by subterranean fires after many ages, so that the whole period from the beginning of these primary fossiliferous strata to the present day must be great beyond calculation, and only bears comparison with the astronomical cycles, as might naturally be expected, the earth being without doubt of the same antiquity with the

[1] Account of the Ganges and Brahmapootra, by Major Rennell.—'Phil. Trans.,' 1781. Sir George Staunton's Embassy to China. Élie de Beaumont, Leçons de Géologie, 1 vol. 8vo. The latter work contains a very elaborate essay on alluvial deposits by rivers, &c.

other bodies of the solar system. What then shall we say if the time be included which the granitic, metamorphic, and recent series occupied in forming? These great periods of time correspond wonderfully with the gradual increase of animal life and the successive creation and extinction of numberless orders of being, and with the incredible quantity of organic remains buried in the crust of the earth in every country on the face of the globe.

Every great geological change in the nature of the strata was accompanied by the introduction of a new race of beings, and the gradual extinction of those that had previously existed, their structure and habits being no longer fitted for the new circumstances in which these changes had placed them. The change, however, never was abrupt; and it may be observed that there is no proof of progressive development of species by generation from a low to a high organization, for animals and plants of high organization appeared among the earliest of their kind, yet throughout the whole the gradual approach to living and more perfect forms is undoubted, not by change of species, but by increasing similarity of type.

The geographical distribution of animated beings was much more extensive in the ancient seas and land than in later times. In very remote ages the same animal inhabited the most distant parts of the sea; the corallines built from the equator to within ten or fifteen degrees of the pole; and previous to the formation of the carboniferous strata there appears to have been even a greater uniformity in the vegetable than in the animal world, though New Holland had formed even then a peculiar district, supposing the coal in that country to be of the same epoch as in Europe and America; but as the strata became more varied, species were less widely diffused. Some of the saurians were inhabitants of both the Old and New World, while others lived in the latter only. During the tertiary period the animals of Australia and America differed nearly as much from those of Europe as they do at the present day. The world was then, as now, divided into great physical regions, each inhabited by a peculiar race of animals; and even the different species of mollusca of the same sea were confined to certain shores. Of 405 species of shell-fish which inhabited the Atlantic Ocean during the early and middle parts of the tertiary period, only 12 were common to the American and European coasts. In fact, the divisions of the animal and vegetable creation into geographical districts had been in the latter periods contemporaneous with the rise of the land, each portion of which, as it rose above the deep, had been clothed with a vegetation and peopled with creatures suited to its position with regard to the equator, and to the existing circumstances of the globe; and the marine creatures had, no doubt, been divided into districts at the same periods, because the bed of the ocean had been subject to similar changes.

The quantity of fossil remains is so great that, with the exception of the metals and some of the primary rocks, probably not a particle of matter exists on the surface of the earth that has not at some time formed part of a living creature. Since the commencement of animated existence, zoophytes have built coral reefs extending hundreds of miles, and mountains of limestone are full of their remains all over the globe. Mines of shells are worked to make lime; ranges of hills and rocks, many hundred feet thick, are almost entirely composed of them, and they abound in every mountain-chain throughout the earth. The prodigious quantity of microscopic shells discovered by M. Ehrenberg is still more astonishing; shells not larger than a grain of sand form entire mountains; a great portion of the hills of San Casciano, in Tuscany, consist of chambered shells so minute that Signor Soldani collected 10,454 of them from one ounce of stone. Chalk is often almost entirely composed of them. Tripoli, a fine powder long in use for polishing metals, is also almost wholly composed of shells which owe their polishing property to their siliceous coats; and there are even hills of great extent consisting of this substance, the débris of an infinite variety of microscopic insects.

The facility with which many clays and slates are split is owing, in some instances, to layers of minute shells. Fossil fish are found in all parts of the world, and in all the fossiliferous strata with the exception of some of the lowest, but each great geological period had species of fish peculiar to itself.

The remains of the great saurians are innumerable; those of extinct quadrupeds are very numerous;

but there is no circumstance in the whole science of fossil geology more remarkable than the inexhaustible multitudes of fossil elephants that are found in Siberia. Their tusks have been an object of traffic in ivory for centuries, and in some places they have been in such prodigious quantities, that the ground is tainted with the smell of animal matter. Their huge skeletons are found from the frontier of Europe through all Northern Asia to its extreme eastern point, and from the foot of the Altaï mountains to the shores of the Frozen Ocean, a surface equal in extent to the whole of Europe. Some islands in the Arctic Sea, as, for instance, the first of the Lächow group, are chiefly composed of their remains, mixed with the bones of various other animals of living genera, but extinct species.[1]

Equally wonderful is the quantity of fossil plants that still remain, if it be considered that, from the frail nature of many vegetable substances, multitudes must have perished without leaving a trace behind. The vegetation that covered the terrestrial part of the globe previous to the formation of the carboniferous strata had far surpassed in exuberance the rankest tropical jungles. There are many coal-fields of great extent in various parts of the earth, especially in North America, where that of Pittsburg occupies an area of about 14,000 square miles, and that in the Illinois is not much inferior to the area of all England.

As coal is entirely a vegetable substance, some

[1] Lieut. Anjou's Polar Voyage.

idea may be formed of the richness of the ancient flora: in latter times it was less exuberant, and never has again been so luxuriant, probably on account of the decrease of temperature during the deposition of the tertiary strata, and in the glacial period which immediately preceded the creation of the present tribes of plants and animals. Even after their introduction the temperature must have been very low, but by subsequent changes in the distribution of the sea and land the cold was gradually mitigated, till at last the climate of the northern hemisphere became what it now is.

Such is the marvellous history laid open to us on the earth's surface. Surely it is not the heavens only that declare the glory of God—the earth also proclaims His handiwork![1]

[1] The author's geological information rests on the authority of those distinguished authors whose works are in the hands of every one, namely, Baron Cuvier, Sir Charles Lyell, Sir Roderick Murchison, Sir Henry de la Beche, Professor Owen, and the Memoirs of the Geological Society.

CHAPTER II.

Direction of the Forces that raised the Continents — Proportion of Land and Water — Size of the Continents and Islands — Outline of the Land — Extent of Coasts, and proportion they bear to the Areas of the Continents — Elevation of the Continents — Forms of Mountains — Forms of Rocks — Connexion between Physical Geography of Countries and their Geological Structure — Contemporaneous Upheaval of parallel Mountain Chains — Parallelism of Mineral Veins or Fissures — Mr. Hopkins's Theory of Fissures — Parallel Chains similar in Structure — Interruptions in Continents and Mountain Chains — Form of the Great Continent — The High Lands of the Great Continent — The Atlas, Spanish, French, and German Mountains — The Alps, Balkan, and Apennines — Glaciers — Geological Notice.

At the end of the tertiary period the earth was much in the same state as it is at present with regard to the distribution of land and water. The preponderance of land in the northern hemisphere indicates a prodigious accumulation of internal energy under these latitudes at a very remote geological period. The forces that raised the two great continents above the deep, when viewed on a wide scale, must evidently have acted at right angles to one another, nearly parallel to the equator in the old continent, and in the direction of the meridian in the new; yet the structure of the opposite coasts of the Atlantic points at some connexion between the two.

The mountains, from their rude and shattered condition, bear testimony to repeated violent convulsions similar to modern earthquakes; while the high table-lands, and that succession of terraces by which the continents sink down from their mountain-ranges to the plains, to the ocean, and even below it, show also that the land must have been heaved up occasionally by slow and gentle pressure, such as appears now to be gradually elevating the coast of Scandinavia and many other parts of the earth. The periods in which these majestic operations were effected must have been incalculable, since the dry land occupies an area of nearly 38,000,000 of square miles.

The ocean covers nearly three-fourths of the surface of the globe, but the distribution is very unequal, whether it be considered with regard to the northern and southern hemispheres, or the eastern and western. Independently of Victoria Land, whose extent is unknown, the quantity of land in the northern hemisphere is three times greater than in the southern. In the latter it occupies only one-sixteenth of the space between the Antarctic Circle and the thirtieth parallel of south latitude, while between the corresponding parallels in the northern hemisphere the extent of land and water is nearly equal. If the globe be divided into two hemispheres by a meridian passing through the island of Teneriffe, the land will be found to predominate greatly on the eastern side of that line, and the water on the western. In consequence of the very unequal arrangement of the solid and liquid portions of the surface of the earth, England is nearly in the centre of the greatest mass of land, and its antipode, the island of New Zealand, is in the centre of the greatest mass of water; so that a person raised above Falmouth, which is almost the central point, till he could perceive a complete hemisphere, would see the greatest possible expanse of land, while, were he elevated to the same height above New Zealand, he would see the greatest possible extent of ocean. In fact, only one twenty-seventh of the land has land directly opposite to it in the opposite hemisphere, and under the equator five-sixths of the circumference of the globe is water. It must however be observed that there is still an unexplored region within the Antarctic Circle more than twice the size of Europe, and of the north polar basin we know nothing. With regard to the land alone, the great continent has an area of about 24,000,000 square miles, while the extent of America is 11,000,000, and that of Australia with its islands scarcely 3,000,000. Africa is more than three times the size of Europe, and Asia is more than four times as large. The extent of the continents is twenty-three times greater than that of all the islands taken together.[1]

[1] The proportions of land to water referred to in the text were estimated by Mr. Gardner. According to his computation, the extent of land is about 37,673,000 square British miles, independently of Victoria Continent; and the sea occupies 110,849,000. Hence the land is to the sea as 1 to 4 nearly. The unexplored region within the Arctic Circle is about 7,620,000 square miles.

Of the polar lands little is known. Greenland probably is part of a continent, the domain of perpetual snow; and the recent discovery of so extensive a mass of high volcanic land near the south pole is an important event in the history of physical science, though the stern severity of the climate must for ever render it unfit for the abode of animated beings, or even for the support of vegetable life. It seems to form a counterpoise to the preponderance of dry land in the northern hemisphere. There is something sublime in the contemplation of these lofty and unapproachable regions—the awful realm of ever-during ice and perpetual fire, whose year consists of one day and one night. The strange and terrible symmetry in the nature of the lands within the polar circles, whose limits are to us a blank, where the antagonist principles of cold and heat meet in their utmost intensity, fills the mind with that awe which arises from the idea of the unknown and the indefinite.

The tendency of the land to assume a peninsular form is very remarkable, and it is still more so that almost all the peninsulas tend to the south—circumstances that depend on some unknown cause which seems to have acted very extensively. The continents of South America, Africa, and Greenland are peninsulas on a gigantic scale, all tending to the south; the Asiatic peninsula of India, the Indo-Chinese peninsula, those of Corea, Kamtchatka, of Florida, California, and Aliaska, in North America, as well as the European peninsulas of

Norway and Sweden, Spain and Portugal, Italy and Greece, take the same direction. All the latter have a rounded form except Italy, whereas most of the others terminate sharply, especially the continents of South America and Africa, India, and Greenland, which have the pointed form of wedges; while some are long and narrow, as California, Aliaska, and Malacca. Many of the peninsulas have an island or group of islands at their extremity, as South America, which terminates with the group of Tierra del Fuego: India has Ceylon; Malacca has Sumatra and Banca; the southern extremity of New Holland ends in Van Diemen's Land; a chain of islands run from the end of the peninsula of Aliaska; Greenland has a group of islands at its extremity; and Sicily lies close to the termination of Italy. It has been observed as another peculiarity in the structure of peninsulas that they generally terminate boldly, in bluffs, promontories, or mountains, which are often the last portions of the continental chains. South America terminates in Cape Horn, a high promontory, which is the visible termination of the Andes; Africa with the Cape of Good Hope; India with Cape Comorin, the last of the Ghauts; New Holland ends with South-East Cape in Van Diemen's Land; and Greenland's farthest point is the elevated bluff of Cape Farewell.[1]

[1] This very general view of the structure of the globe originated chiefly with the celebrated German geologist Von Buch, and has been much extended and developed by M. Elie de Beaumont, one of the most philosophical of modern geologists.

There is a strong analogy between South America and Africa in form and the unbroken mass which their surface presents, while North America resembles Europe, in being much indented by inland seas, gulfs, and bays. Eastern Asia is evidently continued in a subaqueous continent from the Indian Ocean across the Pacific nearly to the west coast of America, of which New Holland, the Indian Archipelago, the islands of the Asiatic coast and of Oceania are the great table-lands and summits of its mountain-chains. With the exception of a vast peninsula in Siberia between the mouths of the rivers Yeneseï and Khatanga and the unknown regions of Greenland, the two great continents terminate in a very broken line to the north; and as they sink beneath the Icy Ocean, the tops of their high lands and mountains rise above the waves and stud the coast with innumerable snow-clad rocks and islands. The 70th parallel is the average latitude of these northern shores, which have a great similarity on each side of Behring's Straits in form, direction, and in the adjacent islands.

The peninsular form of the continents adds greatly to the extent of their coasts, of such importance to civilization and commerce. All the shores of Europe are deeply indented and penetrated by the Atlantic Ocean, which has formed a number of inland seas of great magnitude, so that it has a greater line of maritime coast, compared with its size, than any other quarter of the world. The extent of coast from the Straits of Waigatz, in the

Polar Ocean, to the Strait of Caffa, at the entrance of the Sea of Azoff, is about 17,000 miles. The coast of Asia has been much worn by currents, and possibly also by the action of the ocean occasioned by the rotation of the earth from west to east. On the south and east especially it is indented by large seas, bays, and gulfs; and the eastern shores are rugged and encompassed by chains of islands which render navigation dangerous. Its maritime coast is about 33,000 miles in length.

The coast of Africa, 16,000 miles long, is very entire, except perhaps at the Gulf of Guinea and in the Mediterranean. The shores of North America have probably been much altered by the equatorial current and the Gulf-stream. There is little doubt that these currents, combined with volcanic action, have hollowed out the Gulf of Mexico, and separated the Antilles and Bahama Islands from the continent. The coast is less broken on the west, but in the Icy Ocean there is a labyrinth of gulfs, bays, and creeks. The shores of South America on both sides are very entire, except towards Southern Chili and Cape Horn, where the tremendous surge and currents of the ocean in those high latitudes have eaten into the mountains, and produced endless sounds and fiords which run far into the land. The whole continent of America has a sea-coast of 31,000 miles. Thus it appears that the ratio of the number of linear miles in the coast-line to the number of square miles in the extent of surface, in each of these great portions of the globe, is

164 for Europe, 376 for Asia, 530 for Africa, and 359 for America. Hence the proportion is most favourable to Europe, with regard to civilization and commerce; America comes next, then Asia, and last of all Africa, which has every natural obstacle to contend with, from the extent and nature of its coasts, the desert character of the country, and the insalubrity of its climate, on the Atlantic coast at least.

The continents had been raised from the deep by a powerful effort of the internal forces acting under widely-extended regions, and the stratified crust of the earth either remained level, rose in undulations, or sank into cavities, according to its intensity. Some thinner portion of the earth's surface, giving way to the internal forces, had been rent into deep fissures, and the mountain masses had been raised by violent concussions, perceptible in the convulsed state of their strata. The centres of maximum energy are marked by the pyrogenous rocks,[1] which generally form the nucleus or axis of the mountain masses, on whose flanks the stratified rocks are tilted at all angles to the horizon, whence, declining on every side, they sink to various depths, or stretch to various distances in the plains. Enormous as the mountain-chains and table-lands are, and prodigious as the forces that elevated them, they bear a very small proportion to the mass of the level continents and to the vast power which raised them even to

[1] Pyrogenous rocks are granite and others owing their origin to fire.

their inferior altitude. Both the high and the low lands had been elevated at successive periods; some of the very highest mountain-chains are but of recent geological date, and some chains that are now far inland once stood up as islands above the ocean, while marine strata filled their cavities and formed round their bases. The influence of mountain-chains on the extent and form of the continents is beyond a doubt.

Notwithstanding the various circumstances of their elevation, there is everywhere a certain regularity of form in mountain masses, however unsymmetrical they may appear at first, and rocks of the same kind have identical characters in every quarter of the globe. Plants and animals vary with climate, but a granite mountain has the same peculiarities in the southern as in the northern hemisphere—at the equator as near the poles. Single mountains, insulated on plains, are rare, except where they are volcanic; they generally appear in groups intersected by valleys in every direction, and more frequently in extensive chains symmetrically arranged in a series of parallel ridges, separated by narrow longitudinal valleys, the highest and most rugged of which occupy the centre: when the chain is broad and of the first order in point of magnitude, peak after peak arises in endless succession. The lateral ridges and valleys are constantly of less elevation, and are less bold, in proportion to their distance from the central mass, till at last the most remote ridges sink down into gentle undulations. Extensive and lofty branches diverge from the principal chains at various angles, and stretch far into the plains. They are often as high as the chains from which they spring, and it happens not unfrequently that these branches are united by transverse ridges, so that the country is often widely covered by a net-work of mountains, and, at the point where these offsets diverge, there is frequently a knot of mountains spreading over hundreds of square miles.

One side of a mountain-range is usually more precipitous than the other, but there is nothing in which the imagination misleads the judgment more than in estimating the steepness of a declivity. In the whole range of the Alps there is not a single rock which has 1600 feet of perpendicular height, or a vertical slope of 90°. The declivity of Mont Blanc towards the Allée Blanche, precipitous as it seems, does not amount to 45°; and the mean inclination of the Peak of Teneriffe, according to Baron Humboldt, is only 12° 30′. The Silla of Caraccas, which rises precipitously from the Caribbean Sea, at an angle of 53° 28′, to the height of between 6000 and 7000 feet, is a majestic instance of perhaps the nearest approach to perpendicularity of any great height yet known.

The circumstances of elevation are not the only causes of that variety observed in the summits of mountains. A difference in the composition and internal structure of a rock has a great influence upon its general form, and on the degree and manner in which it is worn by the weather. Thus dolomite assumes generally the form of peaks like saw-teeth; crystalline schists assume the form of needles, as in the Alps; slates and quartziferous schists take the form of triangular pyramids; calcareous rocks a rounded shape; serpentine and trachyte are often twisted and crumpled; phonolites assume a pyramidal form; dark walls like those in Greenland are of trap and basalt; and volcanoes are indicated by blunt cones and craters. Thus the mountain-peaks often indicate by their form their geological nature.

Viewing things on a broad scale, it appears that there is also a very striking connexion between the physical geography or external aspect of different countries and their geological structure. By a minute comparison of the different parts of the land, M. Boué has shown that a critical similarity of outward forms, while indicating similarity in the producing causes, must also to a large extent indicate identity of structure, and therefore from the external appearance of an unexplored country its geological structure may be inferred, at least to a certain extent. This he illustrates by pointing out a correspondence, even in their most minute details, between the leading features of Asia and Europe, and the identity of their geological structure. It has been justly observed, that when the windings of our continents and seas are narrowly examined, and the more essential peculiarities of their contours contemplated, it is evident that Nature has not wrought after an indefinite number of types or models, but that, on the contrary, her fundamental types are very few, and derived from the action of definite constructive forces on a primary base.[1] The whole of our land and sea, in fact, may be decomposed into a less or greater number of masses, either exhibiting all these fundamental forms or merely a portion of them.[2] The peninsular structure of the continents with their accompanying islands is a striking illustration of the truth of this remark, and many more might be adduced. It follows, as a consequence of that law in Nature's operations, that analogy of form and contour throws the greatest light on the constitution of countries far removed from each other. Even the picturesque descriptions of a traveller often afford information of which he may be little aware.

The determination of the contemporaneous upheaval of parallel mountain-chains, by a comparison of the ages of the inclined and horizontal strata resting on them, is one of the highest steps of generalization which has been attempted by geologists. It was first observed by the miners of the Freyberg school, and established as a law by

[1] M. Boué.

[2] The author avails herself with much pleasure of an opportunity of expressing her admiration of the accuracy, extent, and execution of Mr. Keith Johnston's Physical Atlas, and of the valuable information contained in the letterpress which accompanies it, which has afforded her the greatest assistance. As Mr. Johnston is publishing a small and cheap edition of his Atlas, well fitted to illustrate these volumes, the necessity of inserting in them any similar maps, which was at one time contemplated, is obviated.

Werner, that veins of the same nature in mines occur in parallel fissures opened at the same time, and probably filled with metal, also simultaneously, at a subsequent period; and that fissures differing in direction differ also in age. As these veins and fissures are rents through the solid strata, often of unfathomable depth and immense length, there is the strongest analogy between them and those enormous fissures in the solid mass of the globe through which the mountain-chains have been heaved up. Were the analogy perfect, it ought to follow that parallel mountain-chains have been raised simultaneously, that is, by forces acting during the same geological periods. By a careful examination of the relative ages of the strata resting on the flanks of many of the mountain systems, M. Elie de Beaumont has shown, if not proved, that all strata elevated simultaneously assume a parallel direction, or, that parallel strata are contemporaneous. Should this be confirmed, parallel chains in the most distant regions will no longer be regarded as insulated masses. They will indicate the course of enormous fissures that have simultaneously rent the solid globe and passed through the bed of the ocean from continent to continent, from island to island. M. Von Buch has found that four systems of mountains in Germany accord with this theory, and Mr. Sedgwick has observed the same in the Westmoreland system of mountains, believed to be the most ancient of which the globe can now furnish any traces. This theory of elevation of mountain-chains, which originated with M. Elie de Beaumont, has already led to the discovery of twelve different periods of fracture and elevation in the European continent alone.

Mr. Hopkins, of Cambridge, has taken a purely mathematical view of the subject, and has proved that, when an internal expansive force acts upwards upon a single point in the earth's crust, the splits or cracks must all diverge from that point like radii in a circle, which is exactly the case in many volcanic districts; that when the expansive force acts uniformly from below on a wide surface or area, it tends to stretch the surface, so that it would split or crack where the tension is greatest, that is, either in the direction of the length or breadth; and if the area yields in more places than one, he found that the fissures would necessarily be parallel to one another, which agrees with the law of arrangement of veins in mines. These results are greatly modified by the shape of the area, but the modification is according to a fixed law, which, instead of interfering with that of the parallelism of the fissures, actually arises from the same action which produces it. This investigation agrees in all its details with the fractures in the districts in England to which they were applied, so that theory comes to the aid of observation in this still unsettled question.[1]

It seems to bear on the subject, that parallel mountain-chains are similar in geological age, even when separated by seas. For instance, the moun-

[1] 'On the Parallel Lines of Simultaneous Elevation in the Weald of Kent and Sussex,' by —— Hopkins, Esq.

tains of Sweden and Finland are of the same structure, though the Gulf of Bothnia is between them; those of Cornwall, Brittany, and the north-west of Spain are similar; the Atlas and the Spanish mountains, the chains in California and those on the adjacent coast of America, and, lastly, those of New Guinea and the north-east of Australia, furnish examples. The same correspondence in geological epoch prevails in chains that are not parallel, but that are convergent from the form of the earth. This observation is also extensively exemplified in those that run east and west, as the Alps, the Balkan, Taurus, Paropamisus with its prolongation, the Hindoo Coosh, the Himalaya, and in America the mountains of Parima and the great chain of Venezuela.

Continents and mountain-chains are often interrupted by posterior geological changes, such as clefts and cavities formed by erosion, as evidently appears from the correspondence of the strata. The chalk cliffs on the opposite sides of the British Channel show that Britain once formed part of the continent; the formation of the Orkney Islands and Ireland is the same with that of the Highlands of Scotland; the formation is the same on each side of the Straits of Gibraltar; that of Turkey in Europe passes into Asia Minor, the Crimea into the Caucasus, a volcanic region bounds the Straits of Babelmandel, and Behring's Straits divide the ancient strata of a similar age. This is particularly the case with coast islands.[1]

[1] M. Boue.

Immediately connected with the mountains are the high table-lands which form so conspicuous a feature in the Asiatic and American continents. These perpetual storehouses of the waters send their streams to refresh the plains, and to afford a highway between the nations. Table-lands of less elevation, sinking in terraces of lower and lower level, constitute the links between the high ground and the low, the mountains and the plains, and thus maintain the continuity of the land. They frequently are of the richest soil, and enjoy the most genial climate, affording a delightful and picturesque abode to man, though the plains are his principal dwelling. Sloping imperceptibly from the base of the inferior table-lands, or from the last undulations of the mountains, to the ocean, they carry off the superfluous waters. Fruitfulness and sterility vary their aspect: immense tracts of the richest soil are favoured by climate and hardly require culture; a greater portion is only rendered productive by hard labour, compelling man to fulfil his destiny; while vast regions are doomed to perpetual barrenness, never gladdened by a shower.

The form of the great continent has been determined by an immense zone of mountains and table-lands, lying between the 30th and 40th or 45th parallels of north latitude, which stretches across it from W.S.W. to E.N.E., from the coasts of Barbary and Portugal, on the Atlantic Ocean, to the farthest extremity of Asia, at Behring's Straits, in the North Pacific. North of this lies a vast plain, extending almost from the Pyrenees to the utmost part of Asia, the greater portion of which is a dead level, or low undulations, uninterrupted except by the Scandinavian and British system on the north, and the Ural chain, which is of small elevation. The low lands south of the mountainous zone are much indented by the ocean, and of the most diversified aspect. By much the greater part of the flat country lying between the China Sea and the river Indus is of the most exuberant fertility, while that between the Persian Gulf and the foot of the Atlas is, with some happy exceptions, one of the most desolate tracts on the earth. The southern lowlands, too, are broken by a few mountain systems of considerable extent and height.

The Atlas and Spanish mountains form the western extremity of that great zone of high lands that girds the old continent almost throughout its extent: these two mountain systems were certainly at one time united, and from their geological formation, and also the parallelism of their mountain-chains, they must have been elevated by forces acting in the same direction; now, indeed, the Strait of Gibraltar, a sea-filled chasm 960 fathoms deep, divides them.[1]

A very elevated and continuous mountain region extends in a broad belt along the north-west of Africa, from the promontory of Gher, on the At-

[1] By the soundings of Captain Smyth, R.N., the Strait is 960 fathoms deep between Gibraltar and Ceuta, and varying from 160 to 500 in the narrowest part.

lantic, to the Gulf of Sidra, in the Mediterranean, enclosing all the high lands of Morocco, Algiers, and Tunis. It is bounded by the Atlantic and Mediterranean, and insulated from the rest of Africa by the desert of Sahara.

This mountain system consists of three parts. The chain of the Greater Atlas, which is farthest inland, extends from Cape Gher, on the Atlantic, to the Lesser Syrtis; and, in Morocco, forms a knot of mountains 15,000 feet high, covered with perpetual snow.

The Lesser Atlas begins at Cape Spartel (the ancient Cape Cotes) opposite to Gibraltar, and keeps parallel to the Mediterranean till it attains the Gharian range in Tripoli, the last and lowest of the Little Atlas, which runs due east in a uniformly diminishing line till it vanishes in the plain of the Great Syrtis. That long, rugged, but lower chain of parallel ridges and groups which forms the bold coasts of the Straits of Gibraltar and the Mediterranean, is only a portion of the Lesser Atlas, which rises above it majestically, covered with snow. The flanks of the mountains are generally clothed with forests, but their summit is one uninterrupted line of bare inaccessible rocks, and they are rent by fissures frequently not more than a few feet wide—a peculiar feature of the whole system.

The Middle Atlas, lying between the two great chains, consists of a table-land, rich in valleys and rivers, which rises in successive terraces to the foot of the Greater Atlas, separated by ridges of hills parallel to it. This wide and extensive region has a delightful climate, abounds in magnificent forests, and the valleys are full of vitality. The crest of the Atlas is of granite and crystalline strata; their flanks and lower ranges are sandstone and limestone, on which the tertiary strata rest.

The Spanish peninsula consists chiefly of a table-land traversed by parallel ranges of mountains, and is surrounded by the sea, except where it is separated from France by the Pyrenees, which extend from the Mediterranean to the Bay of Biscay, but are continued by the Cantabrian chain to Cape Finisterre on the Atlantic.

The Pyrenean chain is of moderate height at its extremities, but its summit maintains a waving line whose mean altitude is 7990 feet; it rises to a greater height on the east; its highest point is the Malahite or Nethou, 11,170 feet above the sea. The snow lies deep on these mountains during the greater part of the year, and is perpetual on the highest parts; but the glaciers, which are chiefly on the northern side, are neither so numerous nor so large as in the Alps.

The greatest breadth of this range is about 60 miles, and its length 270. It is so steep on the French side, so rugged and so notched, that from the plains below its summits look like the teeth of a saw, whence the term Sierra has been appropriated to mountains of this form. On the Spanish side, gigantic sloping offsets, separated by deep precipitous valleys, extend to the banks of the Ebro. All the Spanish mountains are torn by deep crevices, the beds of torrents and rivers.

The interior of Spain is a table-land with an area of 93,000 square miles, nearly equal to half of the peninsula. It dips to the Atlantic from its western side, where its altitude is about 2300 feet. There it is bounded by the Iberian mountains, which begin at the point where the Pyrenees take the name of the Cantabrian chain, and run in a tortuous south-easterly direction through all Spain, constituting the eastern boundary of Valencia and Murcia, and sending many branches through those provinces to the Mediterranean: its most elevated point is the Sierra Urbion.

Four nearly parallel ranges of mountains originate in this limiting chain, running from E.N.E. to W.S.W. diagonally across the peninsula to the Atlantic. Of these the high Castilian chain of the Guadarama and the Sierra de Toledo cross the table-land, the Sierra Morena, so called from the dingy colour of its forests of Hermes oak, on the southern edge; and lastly, the Sierra Nevada, though only 100 miles long and 50 broad, the finest range of mountains in Europe after the Alps, traverses the plains of Andalusia and Grenada. The table-land is monotonous and bare of trees; the plains of Old Castile are as naked as the Steppes of Siberia, and uncultivated, except along the banks of the rivers. Corn and wine are produced in abundance on the wide plains of New Castile and Estremadura: other places serve for pasture. The table-land becomes more fertile as it extends towards Portugal, which is altogether more productive than Spain, though the maritime provinces of the latter on the Mediterranean are luxuriant and beautiful, with a semi-tropical vegetation.

Granite, crystalline strata, and primary fossiliferous rocks prevail chiefly in the Spanish mountains, and give them their peculiar, bold, serrated aspect. The valleys between the parallel ranges, through which the great Spanish rivers flow to the Atlantic, appear to have been at one time the basins of lakes.

The mass of high land is continued through the south of France, at a much lower elevation, by chains of hills and table-lands, the most remarkable of which are the Montagnes Noires, and the great plateau of Auvergne, once the theatre of violent volcanic action. It continued from the beginning to the middle of the tertiary period, so that there are cones and craters of various ages and perfect form: some of the highest, as the Puy de Dôme, are trachytic domes of elevation; Mont d'Or, 6200 feet high, is a portion of an immense crater of elevation.[1] The volcanic mountains of Auvergne, and the Cévennes, which are a little lower, are the most remarkable of the French system; the offsets of the latter reach the right bank of the Rhone. In

[1] A crater of elevation is a mountain, generally dome-shaped, whose top has sunk into a crater or hollow, after the internal force which raised it was withdrawn, but from which no lava has issued. Dome-shaped mountains owe their form to internal pressure, probably from lava, but which have not sunk into a crater.

fact, the French mountains are the link between the more elevated masses of Western and Eastern Europe.

The eastern and highest part of the European portion of the mountain-zone begins to rise above the low lands about the 52nd parallel of north latitude, ascending by terraces, groups, and chains of mountains, through six or seven degrees of latitude, till it reaches its highest point in the great range of the Alps and Balkan. The descent on the south side of this lofty mass is much more rapid and abrupt, and the immediate offsets from the Alps shorter; but, taking a very general view, the Apennines and mountains of Northern Sicily, those of Greece and the southern part of Turkey in Europe, with all the islands of the adjacent coasts, are but outlying members of the general protuberance.

The principal chain of the Hyrcanian mountains, the Sudetes, and the Carpathian mountains, form the northern boundary of these high lands: the first, consisting of three parallel ridges, extends from the right bank of the Rhine to the centre of Germany, about 51° or 52° of N. lat., with a mean breadth of about 100 miles, and terminates in the knot of the Fichtelberge, covering an area of 9000 square miles, on the confines of Bavaria and Bohemia. The Sudetes begin on the east of this group, and, after a circuit of 300 miles round Bohemia, terminate at the small elevated plain of the Upper Oder, which connects them with the Carpathian mountains. No part of these limiting ranges attains the height of 5000 feet, except the Carpathians, some of which are very high. They consist of mountain-groups united by elevated plains, rather than of a single chain: the Tatra mountains, bisected by the 20th meridian, is their loftiest point. This range is high also in Transylvania, before it reaches the Danube, which divides it from a secondary branch of the Balkan. Spurs decline in undulations from these limiting chains on the great northern plain, and the country to the south, intervening between them and the Alps, is covered with an intricate network of mountains and plains of moderate elevation.

The higher Alps, which form the western crest of the elevated zone, may be said to begin at the Cape della Melle on the Gulf of Genoa, and bend round by the west and north to Mont Blanc; then turning E.N.E. they run through the Grisons and Tyrol to the Great Glockner, in 40° 7′ N. lat., and 12° 43′ E. long., where the higher Alps terminate a course 420 miles long. All this chain is lofty; much of it is above the line of perpetual congelation; the most elevated part lies between the Col de la Seigne, on the western shoulder of Mont Blanc, and the Simplon. The highest mountains in Europe are comprised within this space, not more than 60 miles long, where Mont Blanc, the highest of all, has an absolute elevation of 15,759·8 feet. The central ridge of the higher Alps is jagged with peaks, pyramids, and needles of bare and almost perpendicular rock, rising from fields of perpetual snow and rivers of ice to an elevation of 14,000 feet. Many parallel chains and groups, alike rugged and snowy, press on the principal crest, and send their flanks far into the lower grounds. Innumerable secondary branches, hardly lower than the main crest, diverge from it in various directions: of these the chain of the Bernese Alps is the highest and most extensive. It breaks off at the St. Gothard, in a line parallel to the principal chain, separates the Valais from the Canton of Berne, and with its ramifications forms one of the most remarkable groups of mountain scenery in Europe. Its endless maze of sharp ridges and bare peaks, mixed with gigantic masses of pure snow, fading coldly serene into the blue horizon, present a scene of sublime quiet and repose, unbroken but by the avalanche or the thunder.

At the Great Glockner the range of the Alps, hitherto undivided, splits into two branches, the Noric and Carnic Alps: the latter is the continuation of the chief stem. Never rising to the height of perpetual snow, it separates the Tyrol and Upper Carinthia from the Venetian States, and, taking the name of the Julian Alps at Mont Terglou, runs east till it joins the Eastern Alps, or Balkan, under the 18th meridian. Offsets from this chain cover all the neighbouring countries.

It is difficult to estimate the width of the Alpine chain: that of the higher Alps is about 100 miles; it increases to 150 east of the Grisons, and amounts to 200 between the 15th and 16th meridians, but is not more than 80 at its junction with the Balkan.

The Stelvio, 9174 feet above the sea, is the highest carriage-pass in these mountains. That of St. Gothard goes directly over the crest of the Alps. Passes very rarely go over the summit of a mountain; they generally cross the watershed, ascending by the valley of a torrent, and descending by a similar path on the other side.

The frequent occurrence of extensive deep lakes is a peculiar feature in European mountains, rarely to be met with in the Asiatic system, except in the Altaï and on the elevated plains.

With the exception of the Jura, whose pastoral summit is about 3000 feet above the sea, there are no elevated table-lands in the Alps; the tabular form, so eminently characteristic of the Asiatic high lands, begins in the Balkan. The Oriental peninsula rises by degrees from the Danube to Bosnia and Upper Macedonia, which are some hundred feet above the sea; and the Balkan extends 600 miles along this elevated mass, from the Julian Alps to Cape Eminec on the Black Sea. It begins by a table-land 70 miles long, traversed by low hills, ending, towards Albania and Myritida, in precipitous limestone rocks from 6000 to 7000 feet high. Rugged mountains, all but impassable, succeed to this, in which the domes and needles of the Schandach, or ancient Scamus, are covered with perpetual snow. Another table-land follows, whose marshy surface is bounded by mural precipices at Mount Arbelus, near the town of Sophia. There the Hemus, or Balkan properly so called, begins, and runs in parallel ridges, separated by longitudinal valleys, to the Black Sea, dividing the plains between the Lower Danube and the Propontis into nearly equal parts. The central ridge is passable in few places, and where there is no lateral ridge the precipices descend at once to the plains.

The Balkan is everywhere rent by terrific fissures across the chains and table-lands, so deep and narrow that daylight is almost excluded. These chasms afford the safest passes across the range; the others along the faces of the precipices are frightful.

The Mediterranean is the southern boundary of the elevated zone of Eastern Europe, whose last offsets rise in rocky islands along the coasts. The crystalline mountains of Sardinia and Corsica are outlying members of the Maritime Alps, while shorter offsets end in the plains of Lombardy, forming the magnificent scenery of the Italian lakes. Even the Apennines, whose elevation has given its form to the peninsula of Italy, are but secondary on a greater scale to the broad central band, as well as the mountains and high land in the north of Sicily, which form the continuation of the Calabrian chain.

The Apennines, beginning at the Maritime Alps, enclose the Gulf of Genoa, and run through the centre of Italy in parallel ranges to the middle of Calabria, where they split into two branches, one of which goes to Capo de Leuca, on the Gulf of

Torento, the other to Cape Spartivento, in the Straits of Messina. The whole length is about 800 miles. None of the Apennines come within the line of perpetual snow, though it lies nine months in the year on the Gran Sasso d'Italia, 9521 feet high, in Abruzza Ulteriore.

Offsets from the Julian and Eastern Alps render Dalmatia and Albania perhaps the most rugged tract in Europe; and the Pindus, which forms the watershed of Greece, diverges from the latter chain, and, running south 200 miles, separates Albania from Macedonia and Thessaly.

Greece is a country of mountains, and, although none are perpetually covered with snow, it lies nine months on several of their summits. The chains terminate in strongly projecting headlands, which reach far into the sea, and reappear in the numerous islands and rocks which stud that deeply indented coast. The Grecian mountains, like the Balkan, are torn by transverse fractures. The defile of Blatamana and the Gulf of Salonica are examples. The Adriatic, the Dardanelles, and the Sea of Marmora limit the secondaries of the southern part of the Balkan.

The valleys of the Alps are long and narrow; those among the mountains of Turkey in Europe and Greece are mostly caldron-shaped hollows, often enclosed by mural rocks. Many of these cavities of great size lie along the foot of the Balkan. In the Morea they are so encompassed by mountains that the water has no escape but through the porous soil.

They consist of tertiary strata, which had formed the bottom of lakes. Caldron-shaped valleys occur also in most volcanic countries, as Sicily, Italy, and central France.

The table-lands which constitute the tops of mountains or of mountain-chains are of a different character from those terraces by which the high lands slope to the low. The former are on a small scale in Europe, and of a forbidding aspect, with the exception of the Jura, which is pastoral, whereas the latter are almost always habitable and cultivated. The mass of high land in south-eastern Europe shelves on the north to the great plain of Bavaria, 3000 feet high; Bohemia, which slopes from 1500 to 900 feet; and Hungary, from 4000 above the sea to 300. The descent on the south of the Alps is six or seven times more rapid, because the distance from the axis of the chain is shorter.

It is scarcely possible to estimate the quantity of ice on the Alps; it is said, however, that, independent of the glaciers in the Grisons, there are 1500 square miles of ice in the Alpine range, from 80 to 600 feet thick. There are no glaciers east of the Great Glockner, except on the small group of Hallstadt. Thirty-four bound the snowy regions of Mont Blanc, and 95 square miles of snow and ice clothe that mountain. Some glaciers have been permanent and stationary in the Alps time immemorial, while others now occupy ground formerly bearing corn or covered with trees, which the irresistible force of the ice has swept away.

These ice-rivers, formed on the snow-clad summits of the mountains, fill the hollows and high valleys, hang on the declivities, or descend by their weight through the transverse valleys to the plains, where they are cut short by the increased temperature, and deposit those accumulations of rocks and rubbish, called moraines, which had fallen upon them from the heights above; but their motion is so slow, that six generations may pass before a stone fallen on the upper end of a long glacier can reach the moraine. In the Alps the glaciers move at the rate of from 12 to 25 feet annually, and, as in rivers, the motion is most rapid in the centre, and slower at the sides and bottom on account of friction. It is slower in winter, yet it does not cease, because the winter's cold penetrates the ice, as it does the ground, only to a limited depth. Glaciers are not of solid ice; they consist of a mixture of ice, snow, and water; so that they are in some degree flexible and viscous, but acquire more solidity as they descend to lower levels; evaporation goes on at their surface, but they are not consumed by it. The front is perpetually melting, but maintains a permanent form; it is steep and inaccessible, owing to the figure of the ground over which it tumbles in its icy cascade, sometimes 1000 feet high. The middle course is rather level, the higher part very steep, and the surface is uneven and rent by crevices into which the purest blue streams fall in rushing cascades while the sun is up, but they freeze at his setting, and then a death-like silence prevails. The rocks and stones that fall on them from the surrounding heights protect the ice below from the sun which melts it all around, so that at last they rest on elevated pinnacles till they fall off by their weight, and in this manner those numerous pyramids are formed with which the surface is bristled. Throughout much of the length of a glacier the winter's snow melts from its surface as completely as it does from the ground; it is fed from above, for in the upper part the snow never melts, but accumulates in a stratified form and is consolidated. In some of the largest glaciers, where there is a difference of 4000 feet in height between the origin and termination, the pressure is enormous and irresistible, carrying all before it; even the thickest forest is overwhelmed and crushed.

Glaciers advance or retreat according to the severity or mildness of the season; they have been advancing in Switzerland of late years, but they are subject to cycles of unknown duration. From the moraines, as well as the striæ engraven on the rocks over which they have passed, M. Agassiz has ascertained that the valley of Chamouni was at one time occupied by a glacier that had moved towards the Col de Balme. A moraine 2000 feet above the Rhone at St. Maurice would appear to indicate that, at a remote period, glaciers had covered Switzerland to the height of 2155 feet above the Lake of Geneva.

Their increase is now limited by various circumstances—as the mean temperature of the earth, which is always above the freezing-point in those latitudes; excessive evaporation; and blasts of hot air, which occur at all heights, in the night as well as in the day, from some unknown cause. They are not peculiar to the Alps, but have been observed also in the glaciers of the Andes. From the heat of the valley thawing the ice, the natural springs that rise under the glacier as they do elsewhere, the heat of the earth, the melting of the glacier itself, the rain that falls on its surface, which rushes down its crevices, a stream of turbid water is formed which works out an icy cavern at the termination of the glacier and flows through it into the lower ground. Thus a glacier "begins in the clouds, is formed by the mountains, and ends in the ocean."[1]

Granite no doubt forms the base of the mountain system of Eastern Europe, though it more rarely comes into view than might have been expected. Crystalline schists of various kinds are enormously developed, and generally form the most elevated pinnacles of the Alpine crest and its offsets, and also the principal chains in Greece and Turkey in Europe; but the secondary fossiliferous strata constitute the chief mass, and often rise to the highest summits; indeed, secondary limestones occupy a great portion of the high land of Eastern Europe. Calcareous rocks form two great mountain-zones on each side of the central chain of the Alps, and rise occasionally to altitudes of 10,000 or 12,000

[1] Professor Forbes on Glaciers.

feet. They constitute a great portion of the central range of the Apennines, and fill the greater part of Sicily. They are extensively developed in Turkey in Europe, where the plateau of Bosnia with its high lands on the south, part of Macedonia, and Albania with its islands, are principally composed of them.[1] Tertiary strata of great thickness rest on the flanks of the Alps, and rise in some places to a height of 5000 feet; zones of the older Pleiocene period flank the Apennines on each side, filled with organic remains; and half of Sicily is covered with the Pleiocene strata. It appears that the Atlas, the Sierra Morena and most of the Spanish mountains, the central chain of the Caucasus, and the Balkan were raised before the period of the erratic blocks.

From numerous dislocations in the strata, the Alps appear to have been heaved up by many violent and repeated convulsions, separated by intervals of repose, and different parts of the chain have been raised at different times; for example, the Maritime Alps and the south-western part of the Jura mountains were raised previously to the formation of the chalk: but the tertiary period appears to have been that of the greatest commotions; for nearly two-thirds of the lands of Europe have risen since the beginning of that epoch, and those that existed then acquired additional height, though some sank below their original level. During that time the Alps acquired an additional elevation of between 2000 and 3000

[1] Dr. Boué.

feet; Mont Blanc then attained its present altitude; the Apennines rose 1000 or 2000 feet higher; and the Carpathians seem to have gained an accession of height since the seas were inhabited by the existing species of animals.[1]

[1] Sir Charles Lyell.

CHAPTER III.

The High Lands of the Great Continent, *continued* — The Caucasus — The Western Asiatic Table-Land and its Mountains.

THE Dardanelles and the Sea of Marmora form but a small break in the mighty girdle of the old continent, which again appears in immense table-lands, passing through the centre of Asia, of such magnitude that they occupy nearly two-fifths of the continent. Here everything is on a much grander scale than in Europe: the table-lands rise above the mean height of the European mountains, and the mountains themselves that gird and traverse them surpass those of every other country in altitude. The most barren deserts are here to be met with, as well as the most luxuriant productions of animal and vegetable life. The earliest records of the human race are found in this cradle of civilization, and monuments still remain which show the skill and power of those nations which have passed away, but whose moral influence is still visible in their descendants. Customs, manners, and even prejudices, carry us back to times beyond the record of history, or even of tradition; while the magnitude with which the natural world is here developed evinces the tremendous forces that must have been in action at epochs immeasurably anterior to the existence of man.

The gigantic mass of high land which extends for 6000 miles between the Mediterranean and the Pacific is 2000 miles broad at its eastern extremity, 700 to 1000 in the middle, and somewhat less at its termination. Colossal mountains and elevated terraces form the edges of the lofty plains.

Between the 47th and 68th eastern meridians, where the low plains of Hindostan and Bokhara press upon the table-land and reduce its width to 700 or 1000 miles, it is divided into two parts by an enormous knot of mountains formed by the meeting of the Hindoo Coosh, the Himalaya, the Tsung-lin, and the transverse ranges of the Beloot Tagh, or Cloudy Mountains: these two parts differ in height, form, and magnitude.

The western portion, which is the table-land of Persia or plateau of Iran, is oblong, extending from the shores of Asia Minor to the Hindoo Coosh and the Solimaun range, which skirts the right bank of the Indus. It occupies an area of 1,700,000 square miles, generally about 4000 feet above the sea, and in some places 7000. The Oriental plateau or table-land of Tibet, much the largest, has an area of 7,600,000 square miles, a mean altitude of 14,000 feet, and in some parts of Tibet an absolute altitude of 17,000 feet.

As the table-lands extend from S.W. to N.E., so also do the principal mountain-chains, as well those which bound the high lands as those which traverse them. Remarkable exceptions to this equatorial direction of the Asiatic mass, however, occur in a series of meridional chains, whose axes extend from S.S.E. to N.N.W., between Cape Comorin, opposite to Ceylon, and the Arctic Ocean, under the names of the Western Ghauts, the Solimaun range (which forms the eastern boundary of the table-land of Persia), the Beloot Tagh, or Bolor (which is the western limit of the Oriental plateau), and the Ural Mountains. These chains, rich in gold, lie in different longitudes, and so alternate among themselves that each begins only in that latitude which has not yet been attained by the preceding one. The Khinghan, in China, also extends from south to north along the eastern slopes of the table-land, and forms its boundary at that end.[1]

The lofty range of the Caucasus, which extends 700 miles between the Black and Caspian Seas, is an outlying member of the Asiatic high lands. Offsets diverge like ribs from each side of the central crest, which penetrate the Russian Steppes on one hand and on the other cross the plains of Kara, or valley of the Kour and Rioni, and unite the Caucasus to the table-land. Some parts of these mountains are very high; the Elburz, on the western border of Georgia, is 17,796 feet. The central part of the chain is full of glaciers, and the limit of perpetual snow is at the altitude of 11,000 feet, which is higher than in any other chain of the old continent, except the Himalaya.

Anatolia, the most western part of the table-land of Iran, 3000 feet above the sea, is traversed

[1] Johnston's Physical Atlas.

by short chains and broken groups of mountains, separated by fertile valleys, which sink rapidly towards the Archipelago and end in promontories and islands along the shores of Asia Minor, which is a country abounding in vast, luxuriant, but solitary plains, watered by broad rivers—in Alpine platforms and mountain-ridges broken up by great valleys, opening seawards, with meandering streams. Single mountains of volcanic formation are conspicuous objects on the table-land of Anatolia, which is rich in pasture, though much of the soil is saline and covered with lakes and marshes. A triple range of limestone mountains, 6000 or 7000 feet high, divided by narrow but beautiful valleys, is the limit of the Anatolian table-land along the shores of the Black Sea. Two-thirds of their height are covered with forests, and broken by wooded glens, leaving a narrow coast, except near Trebizond, where it is broad and picturesque. The high land is bounded on the south by the serrated snowy range of the Taurus, which, beginning in Rhodes, Cos, and other islands in the Mediterranean, fills the south-western parts of Asia Minor with ramifications, and, after following the sinuosities of the iron-bound coast of Karamania in a single lofty range, extends at Samisat, where the Euphrates has pierced a way through this stony girdle.

About the 50th meridian the table-land is compressed to nearly half its width, and there the lofty mountainous regions of Armenia, Kourdistan, and Azerbijan tower higher and higher between the

Black Sea, the Caspian, and the Gulf of Scanderoon in the Mediterranean. Here the cold treeless plains of Armenia, the earliest abode of man, 7000 feet above the sea, bear no traces of the Garden of Eden; Mount Ararat, on which the Ark is said to have rested, stands a solitary majestic volcanic cone, 17,260 feet above the sea, shrouded in perpetual snow. Though high and cold, the soil of Armenia is richer than that of Anatolia, and is better cultivated. It shelves on the north in luxuriant and beautiful declivities to the low and undulating valley of Kara, south of the Caucasus; and on the other hand, the broad and lofty belt of the Kourdistan mountains, rising abruptly in many parallel ranges from the plains of Mesopotamia, form its southern limit, and spread their ramifications wide over its surface. They are rent by deep ravines, and in many places are so rugged that communication between the villages is always difficult, and in winter impracticable from the depth of snow. The line of perpetual congelation is decided and even along their summit; their flanks are wooded, and the valleys populous and fertile.

A thousand square miles of Kourdistan is occupied by the brackish lake Van, which is seldom frozen, though 5467 feet above the sea and surrounded by lofty mountains.

The Persian mountains, of which Elburz is the principal chain, extend along the northern brink of the plateau, from Armenia, almost parallel to the shores of the Caspian Sea, maintaining a considerable elevation up to the volcanic peak of Demavend, near Tehrân, their culminating point, which, though 90 miles inland, is a landmark to sailors on the Caspian. Elevated offsets of these mountains cover the volcanic table-land of Azerbijan, the fire-country of Zoroaster, and one of the most fertile provinces of Persia; there the Koh Salavan elevates its volcanic cone. Beautiful plains, pure streams, and peaceful glades, interspersed with villages, lie among the mountains, and the Vale of Khosran Shah, a picture of sylvan beauty, is celebrated as one of the five paradises of Persian poetry. The vegetation at the foot of these mountains on the shores of the Caspian has all the exuberance of a tropical jungle. The Elburz loses its height to the east of Demavend, and then joins the mountains of Khorasan and the Paropamisan range, which appear to be chains of mountains when viewed from the low plains of Khorasan and Balkh, but on the table-land of Persia they merely form a broad hilly country of rich soil, till they join the Hindoo Coosh.

The table-land of Iran is bounded for 1,000 miles along the Persian Gulf and Indian Ocean by a mountainous belt of from three to seven parallel ranges, having an average width of 200 miles, and extending from the extremity of the Kourdistan Mountains to the mouth of the Indus. The Lasistán Mountains, which form the northern part of this belt, and bound the vast level plain of the Tigris, rise from it in a succession of high table-lands divided by very rugged mountains, the last ridge of which, mostly covered with snow, abuts on the table-land of Persia. Oaks clothe their flanks; the valleys are of generous soil, verdant, and cultivated; and many rivers flow through them to swell the stream of the Tigris. Insulated hill forts, from 2000 to 5000 feet high, occur in this country, with flat cultivated tops some miles in extent, accessible only by ladders, or holes cut in their precipitous sides. These countries are full of ancient inscriptions and remains of antiquity. The moisture decreases more and more south from Shiraz, and then the parallel ridges, repulsive in aspect and difficult to pass, are separated by arid longitudinal valleys, which ascend like steps from the narrow shores of the Persian Gulf to the table-land. The coasts of the gulf are burning hot sandy solitudes, so completely barren, that the country from Bassora to the Indus, a distance of 1200 miles, is nearly a sterile waste. In the few favoured spots on the terraces where water occurs there is vegetation, and the beauty of these valleys is enhanced by surrounding sterility.[1]

With the exception of Mazenderan and the other provinces bordering upon the Caspian, and in the Paropamisan range, Persia is arid, possessing few perennial springs, and not one great river; in fact, three-tenths of the country is a desert, and the table-land is nearly a wide scene of desolation. A great salt-desert occupies 27,000 square miles between Irak and Khorasan, of which the soil is a stiff clay, covered with efflorescence of common salt and nitre, often an

[1] Sir John Malcolm on Persia, and Mr. Morier's Travels.

inch thick, varied only by a few saline plants and patches of verdure in the hollows. This dreary waste joins the large sandy and equally dreary desert of Kerman. Kelat, the capital of Belochistan, is 7000 feet above the level of the sea: round it there is cultivation, but the greater part of that country is a lifeless plain, over which the brick-red sand is drifted by the north wind into ridges like the waves of the sea, often 12 feet high, without a vestige of vegetation. The blast of the desert, whose hot and pestilential breath is fatal to man and animals, renders these dismal sands impassable at certain seasons.

Barren lands or bleak downs prevail at the foot of the Lukee and Solimaun ranges, formed of bare porphyry and sandstone, which skirt the eastern edge of the table-land, and dip to the plains of the Indus. In Afghanistan there is little cultivation except on the banks of the streams that flow into the Lake Zerrah, but vitality returns towards the north-east. The plains and valleys among the offsets from the Hindoo Coosh are of surpassing loveliness, and combine the richest peaceful beauty with the majesty of the snow-capped mountains by which they are encircled.

CHAPTER IV.

The High Lands of the Great Continent, *continued* — The Oriental Table-Land and its Mountains.

The Oriental plateau, or table-land of Tibet, is an irregular four-sided mass stretching from S.W. to N.E., enclosed and traversed by the highest mountains in the world. It is separated from the table-land of Persia by the Hindoo Coosh, which may be considered as the western prolongation of the Himalaya, occupying the terrestrial isthmus between the low lands of Hindostan and Bucharia.

The cold dreary plateau of Tibet is separated on the south from the glowing luxuriant plains of Hindostan by the Himalaya, which extends from the eastern extremity of the Hindoo Coosh in Cabulistan to about the 95th meridian, where it joins the immense mountain-knot which renders the south-western corner of the table-land and the Chinese province of Yun-nan one of the most elevated regions on the earth. On the west, the table-land has its limits in the chain of the Bolor or Beloot Tagh, the "Cloudy Mountains," the Tartash Tagh of the natives, a transverse range which detaches itself from the Hindoo Coosh nearly at a right angle about the 72nd degree of E. longitude, and, pursuing a northerly direction, forms magnificent mountain-knots with the diagonal chains of the table-land, and is the watershed between the valley of the Oxus and Chinese Tartary. It descends in a succession of tiers or terraces through the countries of Bokhara and Balkh to the deep cavity in which the Caspian Sea and the Sea of Azoff lie, and forms, with the Western Ghauts, the Solimaun range, and the Ural, a singular exception to the general parallelism of the Asiatic mountains. Two narrow difficult passes lead over the Beloot Tagh from the low plains of Bucharia and Independent Tourkistan to Kashgar and Yarkand, on the table-land in Chinese Tartary. The north-eastern edge of the table-land is bounded by the Khing-han Mountains, a serrated granitic chain running from south to north, which separates the plateau of Mongolia from the country of Mantchouria, and joins the Yablonoi branch of the Altaï at right angles about the 55th degree of north latitude. Little more is known of the south-eastern boundary of the table-land than that it is a mass of exceedingly high mountains. In fact, between the sources of the Brahmapootra and the Altaï chain, nearly 1,000,000 of square miles of the Chinese empire is covered with mountains.

The table-land itself is crossed longitudinally from west to east by two great chains. The Kuen-lun, or Chinese range, begins about 35° 30′ N. lat. at the mountain-knot of Tsung-lin, formed by the Hindoo Coosh and Himalaya, and, running eastward, it terminates about the 110th meridian, but probably covers a great part of the western provinces of China with its branches. The Thian-shan, or "Celestial Mountains," lie more to the north; they begin at the Bolor or Beloot Tagh, and, running along the 42nd parallel, sink to the desert of the Great Gobi about the centre of the plateau, but, rising again, they are continued under the name of Shan-Garjan, which runs to the north-east and ends on the shores of the Japan Sea. The Thian-shan is exceedingly volcanic, and, though so far inland, pours forth lava, and exhibits all the other phenomena of volcanic districts.

Tibet is enclosed between the Himalaya and the Kuen-lun; Tungut, or Chinese Tartary, lies between the latter chain and the Thian-shan, or Celestial Mountains; and Zungary, or Mongolia, between the Celestial range and the Altaï. The meridional chain of the Bolor encloses Chinese Tartary on the west; and Mongolia, which is entirely open on the west, is shut in on the east by the Khing-han range, also running from south to north. The Himalaya and Altaï ranges diverge in their easterly courses, so that the table-land, which is only from 700 to 1000 miles wide at its western extremity, is 2000 between the Chinese province of Yunnan and the country of the Mantchou Tonguses.[1]

Of all these vast chains of mountains the Himalaya, and its principal branch the Hindoo Coosh, are best known; though even of these a great part has never been explored, on account of their enormous

[1] Johnston's Physical Atlas.

height and the depth of snow, which make it impossible to approach the central ridge, exeept in a very few places.

The range consists of three parts: the Hindoo Coosh, or Indian Caucasus, which extends from the Paropamisan range in Afghanistan to Cashmere; the Himalaya, or Imaus of the ancients, which stretches from the valley of Cashmere to Bhotan; and, lastly, the mountains of Bhotan and Assam—the three making one magnificent unbroken chain.

The Hindoo Coosh, which has its name from a mountain of great height, north of the city of Cabul, is very broad to the west, extending over many degrees of latitude, and, together with the offsets of the Beloot Tagh, fills the countries of Kafferistan, Koonduz, and Budakshan. From the plains to the south it seems to consist of four distinct ranges running one above another, the last of which abuts on the table-land, and is so high that its snowy summits are visible at the distance of 150 miles. A ridge of stupendous height encloses the beautiful valley of Cashmere, to the east of which the chain takes the name of Himalaya, "the dwelling of snow." From the great mountain-knot of Tsung-lin, the Himalaya no longer maintains its direct easterly course, but makes a vast arch to the south of 300 miles, which extends to the Brahmapootra, varying in breadth from 250 to 350 miles, and occupying an area of 600,000 square miles.[1]

The general structure of the Himalaya is very

[1] Johnston's Physical Atlas.

regular: the first range of hills that rise above the plains of Hindostan is alluvial, north of which lies the Tariyani, a tract from 10 to 30 miles wide, 1000 feet above the sea, covered with dense pestilential jungle, and extending along the foot of the range. North of this region are rocky ridges 5000 or 6000 feet high. Between these and the higher ranges lie the peaceful and well-cultivated valleys of Nepaul, Bhotan, and Assam, of inexhaustible fertility, interspersed with picturesque and populous towns and villages. Though separated by mountain-groups, they form the principal terrace of the Himalaya between the Sutlej and Brahmapootra. Behind these are mountains from 10,000 to 12,000 feet high, flanked by magnificent forests; and, lastly, the snowy ranges rise in succession to the tableland.

The principal and most elevated chains are cut by narrow, gloomy ravines and transverse dusky gorges, through which the torrents of melted snow rush to swell the rivers of Hindostan. The character of the valleys becomes softer in the lower regions, till at last the luxuriance of vegetation and beauty cannot be surpassed. Transverse valleys, however, are more frequent in the Hindoo Coosh than in the Himalaya, where they consist chiefly of such chasms filled with wreck as the tributaries of the Indus and Ganges have made in bursting through the chain.

The mean height of the Himalaya is stupendous. Captain Gerard and his brother estimated that it could not be less than from 16,000 to 20,000 feet;

but, from the average elevation of the passes over these mountains, Baron Humboldt thinks it must be under 15,700 feet. Colonel Sabine estimates it to be only 11,510 feet, though the peaks exceeding that elevation are not to be numbered, especially at the sources of the Sutlej; indeed, from that river to the Kalee, the chain exhibits an endless succession of the loftiest mountains on earth; forty of them surpass the height of Chimborazo, one of the highest of the Andes, and several reach the height of 25,000 feet at least. So rugged is this part of the magnificent chain, that the military parade at Sabathoo, half a mile long and a quarter of a mile broad, is said to be the only level ground between it and the Tartar frontier on the north, or the valley of Nepaul on the east. Towards the fruitful valleys of Nepaul and Bhotan the Himalaya is equally lofty, some of the mountains being 28,000 feet high; but it is narrower, and the descent to the plains excessively rapid, especially in the territory of Bhotan, where the dip from the table-land is more than 10,000 feet in ten miles. The valleys are crevices so deep and narrow, and the mountains that hang over them in menacing cliffs are so lofty, that these abysses are shrouded in perpetual gloom, except where the rays of a vertical sun penetrate their depths. From the steepness of the descent the rivers shoot down with the swiftness of an arrow, filling the caverns with foam and the air with mist. At the very base of this wild region lies the elevated and peaceful valley of Bhotan, vividly green, and shaded by magnificent forests. Another rapid descent of 1000 feet leads to the plain of the Ganges.

The Himalaya still maintains great height along the north of Assam, and at the Brahmapootra the parent stem and its branches extend in breadth over two degrees of latitude, forming a vast mountain-knot of great elevation. Beyond this point nothing certain is known of the range, but it or some of its branches are supposed to cross the southern provinces of the Chinese empire and to end in the volcanic island of Formosa. Little more is known of the northern side of the mountains than that the passes are about 5000 feet above the plains of Tibet.

The passes over the Hindoo Coosh, though not the highest, are very formidable: there are six from Cabul to the plains of Turkistan; and so deep and so much enclosed are the defiles, that Sir Alexander Burnes never could obtain an observation of the pole-star in the whole journey from Barmeean till within thirty miles of Turkistan.

Most of the passes over the Himalaya are but little lower than the top of Mont Blanc; many are higher, especially near the Sutlej, where they are from 18,000 to 19,000 feet high; and that north-east of Khoonawur is 20,000 feet above the level of the sea—the highest that has been attempted. All are terrific, and the fatigue and suffering from the rarity of the air in the last 500 feet is not to be described. Animals are as much distressed as human beings, and many die; thousands of birds perish from the violence of the wind, the drifting snow is often fatal to travellers, and violent thunderstorms add to the horror of the journey. The Niti Pass, by which Mr. Moorcroft ascended to the sacred lake of Manasa, in Tibet, is tremendous; he and his guide had not only to walk barefooted, from the risk of slipping, but they were obliged to creep along the most frightful chasms, holding by twigs and tufts of grass, and sometimes they crossed deep and awful crevices on a branch of a tree, or on loose stones thrown across. Yet these are the thoroughfares for commerce in the Himalaya, never repaired nor susceptible of improvement from frequent landslips and torrents.

The loftiest peaks being bare of snow gives great variety of colour and beauty to the scenery, which in these passes is at all times magnificent. During the day, the stupendous size of the mountains, their interminable extent, the variety and sharpness of their forms, and, above all, the tender clearness of their distant outline melting into the pale blue sky contrasted with the deep azure above, is described as a scene of wild and wonderful beauty. At midnight, when myriads of stars sparkle in the black sky, and the pure blue of the mountains looks deeper still below the pale white gleam of the earth and snow-light, the effect is of unparalleled solemnity, and no language can describe the splendour of the sunbeams at daybreak streaming between the high peaks, and throwing their gigantic shadows on the mountains below. There, far above the habitation of man, no living thing exists, no sound is heard; the very echo of the traveller's footsteps startles him in the awful solitude and silence that reigns in these august dwellings of everlasting snow.

Nature has in mercy mitigated the intense rigour of the cold in these high lands in a degree unexampled in other mountainous regions. The climate is mild, the valleys are verdant and inhabited, corn and fruit ripen at elevations which in other countries—even under the equator—would be buried in permanent snow.

It is also a peculiarity in these mountains that the higher the range the higher likewise is the limit of snow and vegetation. On the southern slopes of the first range Mr. Gerard found cultivation 10,000 feet above the sea, though it was often necessary to reap the corn still green and unripe; while in Chinese Tartary good crops are raised 16,000 feet above the sea. Captain Gerard saw pasture and low bushes up to 17,009 feet; and corn as high as even 18,544 feet, which is 2784 feet higher than the top of Mont Blanc, and 1279 feet above the snow-line in the province of Quito under the equator. Birch-trees with tall stems grow at the elevation of 14,068 feet, and the vine and other fruits thrive in the valleys of these high plains. The temperature of the earth probably has some influence on the vegetation: as many hot springs exist in the Himalaya at great heights, there must be a source of heat below these mountains, which in some places comes near the surface, and possibly may be connected with the volcanic fires in the central chains of the table-land.

Hot springs abound in the valley of Jumnotra; and as it is well known that many plants thrive in very cold air if their roots are well protected, it may be the cause of pine-trees thriving at great elevations in that valley, and of the splendid forests of the deodar, a species of cypress that grows to gigantic size even in the snow.

According to Captain and Mr. Gerard, the line of perpetual congelation is at an elevation of only 12,981 feet on the southern slopes of the Himalaya; while on the northern side, or rather on the peaks which rise above the table-land, the limit is 16,620 feet; but the mean height of the table-land of Tibet, and the relative elevation of the line of perpetual snow on the two declivities of the Himalaya, require to be better investigated. The greater elevation of the snow-line on the northern side is the joint result of the serenity of the sky, the less frequent formation of snow in very cold dry air, and the radiation of heat from the neighbouring plains, which, being so near, have much greater effect on the temperature than the warmer but more distant plains on the south. There are fewer glaciers in the Asiatic mountains than might have been expected from the great mass of snow; they are chiefly on the Thibetian side of the Himalaya and on the Kuen-lun. There is a very large one at the source of the Indus, and another at the source of the Ganges, on the southern face of the Himalaya.

Various secondary chains of great length detach themselves from the eastern extremity of the Himalaya, or rather the vast knot of mountains, near the sources of the Brahmapootra, in the Chinese province of Yun-nan, which is a terra incognita; their origin, therefore, is unknown. But in Upper Assam they run cross to the equatorial system of Asiatic mountains, and, extending in a southerly but diverging direction, they spread like the spokes of a fan through the countries east of the Ganges and the Indo-Chinese peninsula, leaving large and fertile kingdoms between them. The Birmano-Siamese chain is the most extensive, reaching to Cape Romania, at the southern extremity of the Malay peninsula, the most southerly point of the Asiatic continent; it may be traced through the island of Sumatra parallel to the coast, and also in the islands of Banca and Biliton, where it ends.

Another range, called the Laos-Siamese chain, forms the eastern boundary of the kingdom of Siam, and the Annamatic chain, from the same origin, separates the empire of Annam from Tonquin and Cochin China.

These slightly diverging lines of mountains yield gold, silver, tin of the best quality and in great plenty, almost on the surface, and precious stones, as rubies and sapphires. Mountains in low latitudes have nothing of the severe character of those in less favoured climes. Magnificent forests reach their summit; spices, dyes of brilliant tints, medicinal and odoriferous plants, clothe their declivities; and in the low grounds the fruits of India and China grow in perfection, in a soil which yields three crops of grain in the year.

The crest of the Himalaya is of stratified crystalline rocks, especially gneiss, with large granitic veins, and beds of quartz of huge magnitude. The zone between 15,000 and 18,000 feet above the level of the sea is of Silurian strata; granite is most frequent at the base, and probably forms the foundation of the chain. Strata of comparatively modern date occur at great elevations. These sedimentary formations, prevailing also on the acclivities of the Alps and Apennines, show that the epochs of elevation in parts of the earth widely remote from one another, if not simultaneous, were at least not very different. There can be no doubt that very great geological changes have taken place at a comparatively recent period in the Himalaya, and through an extensive part of the Asiatic continent.

The Altaï mountains, which form the northern margin of the table-land, are unconnected with the Ural chain: they are separated from it by 400 miles of a low marshy country, part of the steppe of the Kirghiz, and by the Dalaï mountains, a low range never above 2000 feet high, which runs between the 64th meridian and the left bank of the Irtish. The Altaï chain rises on the right bank of that river, at the north-west angle of the table-land, and extends in a serpentine line to the Pacific, south of the Gulf of Okhotzk, dividing the high lands of Tartary and China from the wastes of Asiatic Siberia. Under various names, its branches skirt the north-west side of the Gulf of Okhotzk, and thence stretching to Behring's Straits, it ends at Eastern Cape, the most eastern extremity of the old continent, the whole length of the chain being 4500 miles. The breadth of this chain varies from 400 to 1000 miles, but towards the 105th meridian it is contracted to about 150 by a projection of the desert of the Great Gobi. Its height bears no proportion to its length and breadth. The Altaï, the only part of the chain properly so called, can only be regarded as a succession of terraces of a swelling outline, descending by steps from the table-land, and ending in the promontories of the Siberian plains. There are numerous large lakes on these terraces and in the valleys, as in the mountain systems of Europe. The general form of this part of the chain is monotonous from the prevalence of straight lines and smooth rounded outlines—long ridges with flattened summits, or small table-lands not more than 6000 feet high, which rarely attain the line of perpetual congelation: snow, however, is permanent on the Korgon table-land, 9900 feet above the sea, supposed to be the culminating point of this part of the chain. These table-lands bear a strong resemblance to those in the Scandinavian mountains in baldness and sterility, but their flanks are clothed with forests, verdant meadows, and pastoral valleys.

East of the 86th meridian this region of low mountains splits into three branches, enclosing longitudinal valleys for 450 miles. The Sayansk and Zongnou mountains, which are the northern and central branches, form a mountain-knot nearly as large as England, which projects like a huge promontory on the Siberian plains[1] west of Lake Baikal, and is celebrated for the richness of its mines. The third branch, which is the Ulangomula, lies south of Lake Oubsa. The principal part of the Baikal group is 500 miles long, from 10 to 60 wide, high and snow-capped, and said to be without glaciers. It flanks Lake Baikal on the north, the largest of Alpine lakes, so embedded in a knot of mountains, partly granitic, partly volcanic, that rocks and pillars of granite rise from its bed. The mountains south of the lake are but the face of the table-land; a traveller ascending them finds himself at once in the desert of Gobi, which stretches in unbroken sadness to the great wall of China.

The Daouria mountains, a volcanic portion of the Altaï, which borders the table-land on the north-east, follow the Baikal chain; and farther east, at the sources of the Aldan, the Altaï range takes the name of the Yablonnoi Khrebet, and stretches south of the Gulf of Okhotzk to the coast of the Pacific opposite to the island of Saghalian; while another part, 1000 miles broad, fills the space between the Gulf of Okhotzk and the river Lena, and then, bending to the north-east, ends in the peninsula of Kamtchatka. Between the western end of Lake Baikal and the Yablonnoi Khrebet the mountain-chains are parallel, and extend from the W.S.W. to the E.N.E., which is the general direction of the high lands in the most easterly regions of Asia.

[1] Johnston's Physical Atlas.

A great part of the Altaï chain is unknown to Europeans; the innumerable branches that penetrate the Chinese empire are completely so: those belonging to Russia abound in a great variety of precious and rare metals and minerals—silver, copper, and iron. In the Yablonnoi range and other parts there are whole mountains of porphyry, with red and green jasper; coal is also found; and in a branch of the Altaï between the rivers Obi and Yenissei there are mines of coal which, having been set on fire by lightning, have continued to burn for more than a century. The Siberian mountains far surpass the Andes in the richness of their gold mines. The eastern flank of the Ural chain, and some of the northern spurs of the Altaï, have furnished a vast quantity of gold, but a region as large as France has lately been discovered in Siberia covered with the richest gold alluvium, lying above rocks abounding in that precious metal. The mines of the Ural and Altaï are situated principally in metamorphic rocks, adjacent to the greenstones, syenites, and serpentines that have caused their change; and as the same formation prevails throughout the greater part of the Altaï and Aldan chains almost to Kamtchatka, there is every reason to believe that the whole of that vast region is auriferous: besides, as many of the northern offsets of the Altaï are particularly rich, it may be concluded that the southern branches in the Chinese empire are equally so. Thus Southern Siberia and Chinese Tartary form an auriferous district, probably greater in area than all Europe, which extends even to our dominions in Hindostan, where the formations containing gold are unexplored.[1]

The sedimentary deposits in this extensive mountain-range are more ancient than the granite, syenite, and porphyries: consequently these igneous rocks have not here formed part of the original crust of the globe. Rocks of the Palæozoic series occupy the greater part of the Altaï, and probably there are none more modern. There are no volcanic rocks properly speaking, ancient or modern, west of the Yenissei, but they abound to the east of that river, even to Kamtchatka, which is full of them.

The physical characters and the fossil remains of this extensive mountain system have little relation with the geological formations of Europe and America. Eastern Siberia seems even to form an insulated district by itself, and that part between the town of Yakoutzk and the mouth of the Lena appears to have been raised at a later period than the part of Siberia stretching westward to the Sayansk mountains; moreover, the elevation of the western part of the Altaï was probably contemporaneous with that of the Ural mountains.[2] On the whole, the chains in the direction of parallels of latitude in the

[1] Sir Roderick I. Murchison.

[2] From the observations of Sir Roderick Murchison, M. Middendorf, M. de Verneuil, and Count Keyserling, it appears also that the low land of Siberia has been extended since the existing species of shell-fish inhabited the northern seas; a circumstance that must have rendered the Siberian climate still more severe, and materially affected that of the northern parts of Europe and Asia.

Old Continent are much more numerous and extensive than those in the meridians; and as they lie chiefly towards the equator, the internal forces that raised them were probably modified by the rotation of the earth.

The table-land of Tibet is only 4000 feet above the sea towards the north, but it rises in Little Tibet to between 11,000 and 12,000 feet. The Kuen-lun, the most southerly of the two diagonal mountain-chains that cross the table-land, begins at the Hindoo Coosh, in latitude 35° 30′, being, in fact, a branch of that chain, and extends eastward in two branches, which surround the lake Tengri-Nor, and again unite in the K'han of eastern Tibet. The most southerly of the two branches known as the Ice Mountains, or Kara-Korum of the natives, maintains a curved course parallel to the Himalaya, and then bends north towards the Kuen-lun, which pursues a more direct line across the table-land. Chains more or less connected with these form an elevated mountain plain round Lake Koko-Nor, nearly in the centre of the table-land, from whence those immense mountain-ranges diverge which render the south-western provinces of China the most elevated region on earth. The country of Tibet lying between the Himalaya and the Kuen-lun consists of rocky mountainous ridges, extending from N.W. to S.E., separated by long valleys, in which flow the upper courses of the Brahmapootra, Sutlej, and Indus. According to Mr. Moorcroft, the sacred lake Manasa, in Great Tibet, and the surrounding country, is 17,000 feet above the sea, which is

1240 feet higher than Mont Blanc. In this elevated region wheat and barley grow, and many of the fruits of Southern Europe ripen. The city of H'Lassa, in eastern Tibet, the residence of the Grand Lama, is surrounded by vineyards, and is called by the Chinese the "Realm of Pleasure." There are some trees in this country; but the ground in cultivation bears a small proportion to the grassy steppes, which extend in endless monotony, grazed by thousands of the shawl-wool goats, sheep, and cattle. There are many lakes in the table-land: some in Ladak contain borax—a salt very useful in the arts, found only here, at Monte Cerboliti in Tuscany, and in one of the Lipari islands.

In summer the sun is powerful at mid-day, the air is of the purest transparency, and the azure of the sky so deep that it seems black as in the darkest night. The rising moon does not enlighten the atmosphere, no warning radiance announces her approach, till her limb touches the horizon, and the stars shine with the distinctness and brilliancy of suns. In southern Tibet the verdure is confined to favoured spots; the bleak mountains and high plains are sternly gloomy—a scene of barrenness not to be conceived. Solitude reigns in these dreary wastes, where there is not a tree, nor even a shrub to be seen of more than a few inches high. The scanty, short-lived verdure vanishes in October; the country then looks as if fire had passed over it, and cutting dry winds blow with irresistible fury, howling in the bare mountains, whirling the snow through the air, and freezing to death the unfortunate traveller benighted in their defiles.

Yarkand and Khotan, provinces of Chinese Tartary, which lie beyond the two diagonal chains, are less elevated and more fertile than Tibet; yet it is so cold in winter that the river Yarkiang is frozen for three months. They are watered by five rivers, and contain several large cities; Yarkand, the most considerable of these, is the emporium of commerce between Tibet, Turkistan, China, and Russia. Gold, rubies, silk, and other productions are exported.

The Tartar range of the Thian-Shan is very high; the Bogda Oola, or "Holy Mountain," near Lake Lob, its highest point, is always covered with snow, and it has two active volcanoes, one on each side. This range runs along the 42nd parallel of north latitude, forming at its western extremity a mountain-knot with the Beloot Tagh, in the centre of which lies the small table-land of Pamer, 15,600 feet high, called by the natives the "Roof of the World." Its remarkable elevation was first described by the celebrated Venetian traveller Marco Polo, six centuries ago. The Oxus originates in a glacier of the Pooshtee Khur, a peak of the Beloot Tagh near the plain of Pamer; the lake Sir-i-Kol is here the source of the river of Yarkand; and the Kokan also rises in the same plain, which is intensely cold in winter, and in summer is alive with flocks of sheep and goats. Snow lies deep on the Thian-Shan range in winter, yet little falls on the plains on account of the dryness of the air. There are only two or three showers annually on these mountains, for a very short time, and the drops are so minute as scarcely to wet the ground, yet the streams from them suffice for irrigation.

Zungary, or Mongolia, the country between the Thian-Shan and the Altaï, is hardly known, further than that its grassy steppes, intersected by many lakes and offsets from the Altaï, are the pasture-grounds of the wandering Kirghiz.

The remarkable feature of the table-land is the desert of the Great Gobi, which occupies an area of 300,000 square miles in its eastern extremity, interrupted only by a few spots of pasture and low bushes. Wide tracts are flat and covered with small stones or sand, and widely separated from one another are low hills destitute of wood and water; its general elevation is 4220 feet above the sea, but it is intersected from west to east by a depressed valley aptly named Shamo, or the "Sea of Sand," which is also mixed with salt. West from it lies the Han-Hai, the "Dry Sea," a barren plain of shifting sand blown into high ridges. Here, as in all deserts, the summer sun is scorching, no rain falls, and when thick fog occurs it is only the precursor of fierce winds. All the plains of Mongolia are intensely cold in winter, because the hills to the north are too low to screen them from the polar blast, and, being higher than the Siberian deserts, they are bitterly cold; no month in the year is free from frost and snow, yet it is not deep enough to prevent cattle from finding pasture. Sandy deserts like that of the Great Gobi occupy much of the country south of the Chinese branches of the Altaï.

Such is the stupendous zone of high land that girds the old continent throughout its whole length. In the extensive plains on each side of it several independent mountain systems rise, though much inferior to it in extent and height.

CHAPTER V.

Secondary Mountain Systems of the Great Continent — That of Scandinavia — Great Britain and Ireland — The Ural Mountains — The Great Northern Plain.

The great northern plain is broken by two masses of high land, in every respect inferior to those described; they are the Scandinavian system and the Ural mountains, the arbitrary limit between Europe and Asia.

The range of primary mountains which has given its form to the Scandinavian peninsula begins at Cape Lindesnaes, the most southerly point of Norway, and, after running along its western coast 1000 miles in a north easterly direction, ends at Cape Nord Kyn, on the Polar Ocean, the extremity of Europe. The highest elevation of this chain is not more than 8412 feet. It has been compared to a great wave or billow, rising gradually from the east, which, after having formed a crest, falls perpendicularly into the sea in the west. There are 3696 square miles of this peninsula above the line of perpetual snow.

The southern portion of the chain consists of ridges following the general direction of the range, 150 miles broad. At the distance of 360 miles from Cape Lindesnaes the mountains form a single elevated mass, terminated by a table-land which maintains an altitude of 4500 feet for 100 miles. It slopes towards the east, and plunges at once in high precipices into a deep sea on the west.

The surface is barren, marshy, and bristled with peaks; besides an area of 600 square leagues is occupied by the Snae Braen, the greatest mass of perpetual snow and glaciers on the continent of Europe. A prominent cluster of mountains follows, from whence a single chain, 25 miles broad, maintains an uninterrupted line to the island of Megaree, where it terminates its visible career in North Cape, a huge barren rock perpetually lashed by the surge of the Polar Ocean, but from the correspondence in geological structure it must be continued under the sea to where it reappears, according to M. Boué, in the schistose rocks of Spitzbergen. Offsets from these mountains cover Finland and the low rocky table-land of Lapland: the valleys and countries along the eastern side of the chain abound in forests and Alpine lakes.

The iron-bound coast of Norway is a continued series of rocky islands, capes, promontories, and precipitous cliffs, rent into chasms which penetrate miles into the heart of the mountains. These chasms, or fiords, are either partly or entirely filled by arms of the sea; in the former case the shores are fertile and inhabited, and the whole country abounds in the most picturesque scenery. Fiords are not peculiar to the coast of Norway; they are even more extensive in Greenland and Iceland, and of a more stern character, overhung by snow-clad rocks and glaciers.

As the Scandinavian mountains, those of Feroe, Britain, Ireland, and the north-eastern parts of Iceland have a similar character, and follow the same general directions, they must have been elevated by forces acting in parallel lines, and therefore may be regarded as belonging to the same system.

The Feroe islands, due west from Norway, rise at once in a table-land 2000 feet high, bounded by precipitous cliffs, which dip into the ocean.

The rocky islands of Zetland and those of Orkney form part of the mountain system of Scotland; the Orkney islands have evidently been separated from the mainland by the Pentland Firth, where the currents run with prodigious violence. The north-western part of Scotland is a table-land from 1000 to 2000 feet high, which ends abruptly in the sea, covered with heath, peat-mosses, and pasture. The general direction of the Scottish mountains, like those of Scandinavia, is from north-east to south-west, divided by a long line of lakes in the same direction, extending from the Moray Firth completely across the island to south of the island of Mull. Lakes of the most picturesque beauty abound among the Scottish mountains. The Grampian hills, with their offsets and some low ranges, fill the greater part of Scotland north of the Clyde and Forth. Ben Nevis, only 4374 feet above the sea, is the highest hill in the British islands.

The east coast of Scotland is generally bleak, though in many parts it is extremely fertile, and may be cited as a model of good cultivation; and the midland and southern counties are not inferior either in the quality of the soil or the excellence of the husbandry. To the west the country is wildly picturesque; the coast of the Atlantic, penetrated by the sea, which is covered with islands, bears a strong resemblance to that of Norway.

There cannot be a doubt that the Hebrides formed part of the mainland at some remote geological period, since they follow the direction of the mountain system in two parallel lines of rugged and imposing aspect, never exceeding the height of 3200 feet. The undulating country on the borders of Scotland becomes higher in the west of England and North Wales, where the hills are wild, but the valleys are cultivated like gardens, and the English lake scenery is of the most gentle beauty.

Evergreen Ireland is mostly a mountainous country, and opposes to the Atlantic storms an iron-bound coast of the wildest aspect; but it is rich in arable land and pasture, and possesses the most picturesque lake scenery: indeed, freshwater lakes in the mountain valleys, so peculiarly characteristic of the European system, are the great ornaments of the high lands of Britain.

Various parts of the British islands were dry land while most of the continent of Europe was yet below the ancient ocean. The high land of Lammermuir and the Grampian hills in Scotland, and those of Cumberland in England, were raised before the

Alps had begun to appear above the waves. In general all the highest parts of the British mountains are of granite and stratified crystalline rocks. The primary fossiliferous strata are of immense thickness in Cumberland and in the north of Wales, and the old red sandstone, many hundred feet thick, stretches from sea to sea along the flanks of the Grampians. The coal strata are developed on a great scale in the south of Scotland and the north of England; and examples of every formation, with the exception of the muschelkalk, are to be found in these islands. Volcanic fires had been very active in early times, and nowhere is the columnar structure more beautifully exhibited than in Fingal's Cave and the Storr of Skye, in the Hebrides: and in the north of Ireland a base of 800 square miles of mica-slate is covered with volcanic rocks, which end on the coast in the magnificent columns of the Giant's Causeway.

The Ural chain, the boundary between Europe and Asia, is the only interruption to the level of the great northern plain, and is altogether unconnected with and far separated from the Altaï mountains by salt lakes, marshes, and deserts. The central ridge may be traced from between the Lake of Aral and the Caspian Sea to the northern extremity of Nova Zemlia, a distance of more than 1700 miles; but as a chain it really begins on the right bank of the Ural river, at the steppes of the Kirghiz, about the 51st degree of north latitude, and runs due north in a long narrow ridge to the

Karskaïa Gulf, in the Polar Ocean, though it may be said to terminate in dreary rocks on the west side of Nova Zemlia. The Ural range is about the height of the mountains in the Black Forest or the Vosges; and, with few exceptions, it is wooded to the top, chiefly by the Pinus cembra. The immense mineral riches of these mountains — gold, platina, magnetic iron, and copper—lie on the Siberian side, and mostly between the 54th and 60th degrees of north latitude: the only part that is colonized, and one of the most industrious and civilized regions of the Russian empire. To the south the chain is pastoral, about 100 miles broad, consisting of longitudinal ridges, the highest of which does not exceed 3498 feet: in this part diamonds are found. To the north of the mining district the narrow mural mass is covered with impenetrable forests and deep morasses, altogether uninhabitable and unexplored. Throughout the Ural mountains there are neither precipices, transverse gorges, nor any of the characteristics of a high chain; the descent on both sides is so gentle that in many places it is difficult to know where the plain begins; and the road over the chain from Russia by Ekaterinburg is so low that it hardly seems to be a mountain-pass. The gentle descent and sluggishness of the streams produce extensive marshes along the Siberian base of the range. To the arduous and enterprising researches of Sir Roderick Murchison we are indebted for almost all we know of these mountains: he found them on the western side to be composed of Silurian, Devonian, and carboniferous rocks, more or less altered and crystallized; on the eastern declivity the mines are in metamorphic strata, mixed with rocks of igneous origin; and the central axis is of quartzose and chloritic rocks.

The great zone of high land which extends along the old continent from the Atlantic to the shores of the Pacific Ocean divides the low lands into two very unequal parts. That to the north, only broken by the Ural range and the Valdai table-land of still less elevation, stretches from the Thames or the British hills and the eastern bank of the Seine to Behring's Straits, including more than 190° of longitude, and occupying an area of at least 4,500,000 square geographical miles, which is a third more than all Europe. The greater part of it is perfectly level, with a few elevations and low hills, and in many places a dead level extends hundreds of miles. The country between the Carpathian and Ural mountains is a flat, on which there is scarcely a rise in 1500 miles; and in the steppes of southern Russia and Siberia the extent of level ground is immense. The mean absolute height of the flat provinces of France is 480 feet. Moscow, the highest point of the European plain, is also 480 feet high, from whence the land slopes imperceptibly to the sea both on the north and south, till it absolutely dips below its level. Holland, on one side, would be overflowed, were it not for its dykes, and towards Astrakan the plain sinks still lower. With the exception of the plateau of Ust-Urt, of no great elevation, situated between the Caspian and Aral, and which is the extreme southern ridge of the Ural chain, the whole of that extensive country north and east of the Caspian Sea and around the Lake of Aral forms a vast cavity of 18,000 square leagues, all considerably below the level of the ocean; and the surface of the Caspian Sea itself, the lowest point, has a depression of rather more than 83 feet.

The European part of the plain is highly cultivated and very productive in the more civilized countries in its western and middle regions and along the Baltic. The greatest amount of cultivated land lies to the north of the watershed which stretches from the Carpathians to the centre of the Ural chain, yet there are large heaths which extend from the extremity of Jutland through Lunebourg and Westphalia to Belgium. The land is of excellent quality to the south of it. Round Polkova and Moscow there is an extent of the finest vegetable mould, equal in size to France and the Spanish peninsula together, which forms part of the High Steppe, and is mostly in a state of nature.

A large portion of the great plain is pasture-land, and wide tracts are covered with natural forests, especially in Poland and Russia, where there are millions of acres of pine, fir, and deciduous trees.

The quantity of waste land in Europe is very great, and there are also many swamps. A morass as long as England extends from the 52nd parallel of latitude, following the course of the river Prepit, a branch of the Dnieper, which runs through its centre. There are swamps at the mouths of many of the sluggish rivers in Central Europe. They cover 1970 miles in Denmark, and mossy quagmires occur frequently in the more northerly parts.

Towards the eastern extremity of Europe the great plain assumes the peculiar character of desert called a *steppe*, a word supposed to be of Tartar origin, signifying a level waste destitute of trees: hence the steppes may vary according to the nature of the soil. They commence at the river Dnieper, and extend along the shores of the Black Sea. They include all the country north and east of the Caspian Lake and Independent Tartary; and, passing between the Ural and Altaï mountains, they may be said to occupy all the low lands of Siberia. Hundreds of leagues may be traversed east from the Dnieper without variation of scene. A dead level of thin but luxuriant pasture, bounded only by the horizon, day after day the same unbroken monotony fatigues the eye. Sometimes there is the appearance of a lake, which vanishes on approach, the phantom of atmospheric refraction. Horses and cattle beyond number give some animation to the scene, so long as the steppes are green; but winter comes in October, and then they become a trackless field of spotless snow. Fearful storms rage, and the dry snow is driven by the gale with a violence which neither man nor animal can resist, while the sky is clear and the sun shines cold and bright above the earthly turmoil. The contest between spring and winter is long and severe, for

> "Winter oft at once resumes the breeze,
> Chills the pale morn, and bids his driving sleets
> Deform the day, delightless."

Yet when gentler gales succeed, and the waters run off in torrents through the channels which they cut in the soft ground, the earth is again verdant. The scorching summer's sun is as severe in its consequences in these wild regions as the winter's cold. In June the steppes are parched, no shower falls, nor does a drop of dew refresh the thirsty and rent earth. The sun rises and sets like a globe of fire, and during the day he is obscured by a thick mist from the evaporation. In some seasons the drought is excessive: the air is filled with dust in impalpable powder, the springs become dry, and cattle perish in thousands. Death triumphs over animal and vegetable nature, and desolation tracks the scene to the utmost verge of the horizon, a hideous wreck.

Much of this country is covered by an excellent but thin soil, fit for corn, which grows luxuriantly wherever it has been tried; but a stiff cold clay at a small distance below the surface kills every herb that has deep roots, and no plants thrive but those which can resist the extreme vicissitudes of climate. A very wide range is hopelessly barren. The country from the Caucasus, along the shores of the Black and Caspian Seas—a dead flat, twice the size of the British islands—is a desert destitute of fresh water.

Saline efflorescences cover the surface like hoar-frost. Even the atmosphere and the dew are saline, and many salt lakes in the neighbourhood of Astrakan furnish great quantities of common salt and nitre. Saline plants, with patches of verdure few and far between, are the only signs of vegetable life, but about Astrakan there is soil and cultivation. Some low hills occur in the country between the Caspian and the Lake of Aral, but it is mostly an ocean of shifting sand, often driven by appalling whirlwinds.

Turkistan is a sandy desert, except on the banks of the Oxus and the Jaxartes, and as far on each side of them as canals convey the fertilising waters. To the north, barrenness gives place to verdure between the river Ural and the terraces and mountains of Central Asia, where the steppes of the Kirghiz afford pasture to thousands of camels and cattle belonging to these wandering hordes.

Siberia is either a dead level or undulating surface of more than 7,000,000 of square miles between the North Pacific and the Ural mountains, the Polar Sea and the Altaï range, whose terraces and offsets end in those plains, like headlands and promontories in the ocean. M. Middendorf, indeed, met with a chain of most desolate mountains on the shores of the Polar Ocean, in the country of the Samoides; and the almost inapproachable coast far to the east is unexplored. The mineral riches of the mountains have brought together a population who inhabit towns of considerable importance along the base of the Ural and Altaï chains, where the ground yields good crops and pasture; and there are forests on the undulations of the mountains and on the plains. There are many hundred square miles of rich black mould covered with trees and grass, uninhabited, between the river Tobal and the upper course of the Obi, within the limit where corn would grow; but even this valuable soil is studded with small lakes of salt and fresh water, a chain of which, 300 miles long, skirts the base of the Ural mountains.

North of the 62nd parallel of latitude corn does not ripen on account of the biting blasts from the Icy Ocean which sweep supreme over these unprotected wastes. In a higher latitude, even the interminable forests of gloomy fir are seen no more: all is a wide-spreading desolation of salt steppes, boundless swamps, and lakes of salt and fresh water. The cold is so intense there that the spongy soil is perpetually frozen to the depth of some hundred feet below the surface; and the surface itself, not thawed before the end of June, is again ice-bound by the middle of September, and deep snow covers the ground nine or ten months in the year. Happily gales of wind are not frequent during winter, but when they do occur no living thing ventures to face them. The Russian Admiral Wrangel, who travelled during the most intense cold from the mouth of the river Kolyma to Behring's Strait, gives an appalling account of these deserts. "Here endless snows and ice-covered rocks bound the horizon, nature lies shrouded in all but perpetual winter, life is a constant conflict with privation and with the terrors of cold and hunger—the grave of nature, which contains only the bones of another world. The people, and even the snow smokes, and this evaporation is instantly changed into millions of needles of ice, which make a noise in the air like the sound of torn satin or thick silk. The reindeer take to the forest, or crowd together for heat, and the raven alone, the dark bird of winter, still cleaves the icy air with slow and heavy wing, leaving behind him a long line of thin vapour, marking the track of his solitary flight. The trunks of the thickest trees are rent with a loud noise, masses of rock are torn from their sites, the ground in the valleys is rent into yawning fissures, from which the waters that are underneath rise, giving off a cloud of vapour, and immediately become ice. The atmosphere becomes dense, and the glistening stars are dimmed. The dogs outside the huts of the Siberians burrow in the snow, and their howling, at intervals of six or eight hours, interrupts the general silence of winter."[1] In many parts of Siberia, however, the sun, though long absent from these dismal regions, does not leave them to utter darkness. The extraordinary brilliancy of the stars, and the gleaming snowlight, produce a

[1] In 1820 Admiral (then Lieutenant) Wrangel travelled from the mouth of the Kolyma to Behring's Straits on sledges drawn by dogs, and made a bold but vain attempt to reach the North Pole. Lieutenant Anjou, at the same time, sailed from the mouth of the Jana river, reached 76½ degrees of north latitude, and passed round the group of the New Siberian Islands.

kind of twilight, which is augmented by the splendid coruscations of the aurora borealis.

The scorching heat of the summer's sun produces a change like magic on the southern provinces of the Siberian wilderness. The snow is scarcely gone before the ground is covered with verdure, and flowers of various hues blossom, bear their seed, and die in a few months, when Winter resumes his empire. A still shorter-lived vegetation scantily covers the plains in the far north, and, on the shores of the Icy Ocean, even reindeer-moss grows scantily.

The abundance of fur-bearing animals in the less rigorous parts of the Siberian deserts has tempted the Russians to colonize and build towns on these frozen plains. Yakutsk, on the river Lena, in 62° 1′ 30″ N. lat., is probably the coldest town on the earth. The ground is perpetually frozen to the depth of more than 400 feet, of which three feet only are thawed in summer, when Fahrenheit's thermometer is frequently 77° in the shade; and as there is in some seasons no frost for four months, larch forests cover the ground, and wheat and rye produce from fifteen to forty fold. In winter the cold is so intense that mercury is constantly frozen two months, and occasionally even three.

In the northern parts of Europe the Silurian, Devonian, and carboniferous strata are widely developed, and more to the south they are followed in ascending order by immense tracts of the higher series of secondary rocks, abounding in the huge monsters of a former world. Very large and interesting tertiary basins fill the ancient hollows in many parts of the plain, which are crowded with the remains of animals that no longer exist. Of these the most important are the London, Paris, Vienna, and Moscow basins, with many others in the north of Germany and Russia; and alluvial soil covers the greater part of the plain. In the east Sir Roderick Murchison has determined the boundary of a region twice as large as France, extending from the Polar Ocean to the southern steppes, and from beyond the Volga to the flanks of the Ural chain, which consists of a red deposit of sand and marl, full of copper in grains, belonging to the Permian system. This and the immense tract of black loam already mentioned are among the principal features of Eastern Europe.

CHAPTER VI.

The Southern Low Lands of the Great Continent, with their Secondary Table-Lands and Mountains.

THE low lands to the south of the great mountain girdle of the old continent are much broken by its offsets, by separate groups of mountains, and still more by the deep indentation of bays and large seas. Situate in lower latitudes, and sheltered by mountains from the cutting Siberian winds, these plains are of a more tropical character than those to the north; but they are strikingly contrasted in their different parts —either rich in all the exuberance that heat, moisture, and soil can produce, or covered by wastes of bare sand—in the most advanced state of cultivation, or in the wildest garb of nature.

The barren parts of the low lands lying between the eastern shores of China and the Indus bear a small proportion to the riches of a soil vivified by tropical warmth and watered by the periodical inundations of the mighty rivers that burst from the icy caverns of Tibet and the Himalaya. On the contrary, the favoured regions in that part of the low lands lying between the Persian Gulf, the Euphrates, and the Atlas mountains, are small when compared with the immense expanse of the Arabian and African deserts, scorched and calcined by an equatorial sun. The blessing of a mountain-zone, pouring out its everlasting treasures of moisture, the life-blood of the soil, is nowhere more strikingly exhibited than in the contrast formed by these two regions of the globe.

The Tartar country of Mandshur, watered by the river Amour, but little known to Europeans, lies immediately south of the Yablonnoi branch of the Altaï chain, and consequently partakes of the desert aspect of Siberia, and, in its northern parts, even of the Great Gobi. It is partly intersected by mountains, and covered by dense forests; nevertheless, oats grow in the plains, and even wheat in sheltered places. Towards Corea the country is more fertile; in that peninsula there are cultivated plains at the base of its central mountain-range.

China is the most productive country on the face of the earth; an alluvial plain of 210,000 square miles, formed by one of the most extensive river systems in the old world, occupies its eastern part. This plain, seven times the size of Lombardy, is no less fertile, and perfectly irrigated by canals. The Great Canal traverses the eastern part of the plain for 700 miles, of which 500 are in a straight line of considerable breadth, with a current in the greater part of it. Most part of the plain is in rice and garden ground, the whole cultivated with the spade. The tea-plant grows on a low range of hills between the 30th and 32nd parallels of north latitude, an offset from the Pe-ling chain. The cold in winter is much greater than in the corresponding European latitudes, and the heat in summer is proportionally excessive.

The Indo-Chinese peninsula, lying between China and the river Brahmapootra, has an area of 77,700 square miles, and projects 1500 miles into the ocean. The plains lying between the offsets descending from the east end of the Himalaya, and which divide it longitudinally, as before mentioned, are very extensive. The Birman empire alone, which occupies the valley of the Irrawaddy, is said to be as large as France, and not less fertile, especially its southern part, which is the granary of the empire. Magnificent rivers intersect the alluvial plains, whose soil they have brought down from the table-land of Tibet, and still continue to deposit in great quantities in the deltas at their mouths.

The plains of Hindostan extend 2000 miles along the southern slope of the Himalaya and Hindoo Coosh, between the Brahmapootra and the Indus, and terminate on the south in the Bay of Bengal, the table-land of the Deccan, and the Indian Ocean—a country embracing in its range every variety of climate from tropical heat and moisture to the genial temperature of southern Europe.

The valley of the Ganges is one of the richest on the globe, and contains a greater extent of vegetable mould, and of land under cultivation, than any other country in this continent, except perhaps the Chinese empire. In its upper part, Sirhind and Delhi, the seat of the ancient Mogul empire, still rich in splendid specimens of Indian art, are partly arid, although in the latter there is fertile soil. The country is beautiful where the Jumna and other streams unite to form the Ganges. These rivers are often hemmed in by rocks and high banks, which in a great measure prevent the periodical overflow of the waters; this, however, is compensated by the coolness and moisture of the climate. The land gradually improves towards the east, as it becomes more flat, till at last there is not a stone to be seen for hundreds of miles down to the Gulf of Bengal. Wheat and other European grain are produced in the upper part of this magnificent valley, while in the south every variety of Indian fruit, rice, cotton, indigo, opium, and sugar, are the staple commodities. The ascent of the plain of the Ganges from the Bay of Bengal is so gradual that Saharampore, nearly at the foot of the Himalaya, is only 1100 feet above the level of Calcutta; the consequence of which is that the Ganges and Brahmapootra, with their branches, in the rainy season between June and September, lay Bengal under water for hundreds of miles in every direction, like a great sea. When the water subsides, the plains are verdant with rice and other grain; but when harvest is over, and the heat is intense, the scene is changed—the country, divested of its beauty, becomes parched and dusty everywhere, except in the extensive jungles. It has been estimated that one-third of the British territory in India is covered with these rank marshy tracts. It was estimated by Lord Cornwallis, and confirmed by Mr. Colebrooke, that a third of the East India Company's territory is jungle.

The peninsula of Hindostan is occupied by the triangular-shaped table-land of the Deccan, which is much lower, and totally unconnected with the table-land of Tibet. It has the primary ranges of the Ghauts on the east and west, and the Vendhya mountains on the north, sloping by successive levels to the plains of Hindostan Proper. A trace of the general equatorial direction of the Asiatic high land is still perceptible in the Vendhya mountains, sometimes called the central chain of India, and in the Saulpoora range to the south, both being nearly parallel to the Himalaya.[1] The surface of the Deccan between 3000 and 4000 feet above the sea is a combination of plains, ridges of rock, and insulated flat-topped hills, which are numerous, especially in its north-eastern parts. These solitary and almost inaccessible heights rise abruptly from the plains, with all but perpendicular sides, which can only be scaled by steps cut in the rock, or by very dangerous paths. Many are fortified, and were the strongholds of the natives, but they never have withstood the determined intrepidity of British soldiers.

The peninsula terminates with the table-land of the Mysore, 7000 feet above the sea, surrounded by the Nilgherry or Blue Mountains, which rise 2941 feet higher.

The base of this plateau, and indeed of all the Deccan, is granite, and there are also many syenitic and trap rocks, with abundance of primary and secondary fossiliferous strata. Though possessing the diamond-mines of Golconda, the true riches of the

[1] Johnston's 'Physical Atlas.'

country consist in its vegetable mould, which in the Mysore is 100 feet thick, an inexhaustible source of fertility. The sea-coasts on the two sides of the peninsula are essentially different: that of Malabar on the western side is rocky, but in many parts well cultivated, and its mountains covered with forests form a continuous wall of very simple structure, 510 miles long, and rather more than 5000 feet high. On the coast of Coromandel the mountains are bare, lower, frequently interrupted, and the wide maritime plains are for the most part parched.

The island of Ceylon, nearly equal in extent to Ireland, is almost joined to the southern extremity of the peninsula by sandbanks and small islands, between which the water is only six feet deep in spring tides. The Sanscrit name of the "Resplendent" may convey some idea of this island, rich and fertile in soil, adorned by lofty mountains, numerous streams, and primeval forests; in addition to which it is rich in precious stones, and has the pearl oyster on its coast.

The Asiatic low lands are continued westward from the Indian peninsula by the Punjab and the great Indian desert. "The Punjab, or country of the five rivers," lies at the base of the Hindoo Coosh. Its most northern part consists of fertile terraces highly cultivated, and valleys at the foot of the mountains. It is very productive in the plain within the limits of the periodical inundations of the rivers, and where it is watered by canals; in other parts it is pastoral. Lahore occupies the chief part of the

Punjab, and the city of that name on the Indus, once the rival of Delhi, lies on the high road from Persia to India, and was made the capital of the kingdom by Runjeet Sing. The valley of the Indus throughout partakes of the character of the Punjab; it is fertile only where it is within reach of water; much of it is delta, which is occupied by rice-grounds; the rest is pasture, or sterile salt marshes.

South of the Punjab, and between the fertile plains of Hindostan and the left bank of the Indus, lies the great Indian desert, which is about 400 miles broad, and becomes more and more arid as it approaches the river. It consists of a hard clay, covered with shifting sand, driven into high waves by the wind, with some parts that are verdant after the rains. In the province of Cutch, south of the desert, a space of 7000 square miles, known as the Run of Cutch, is alternately a sandy desert and an inland sea. In April the waves of the sea are driven over it by the prevailing winds, leaving only a few grassy eminences, the resort of wild asses. The desert of Mekram, an equally barren tract, extends along the Gulf of Oman from the mouths of the Indus to the Persian Gulf: in some places, however, it produces the Indian palm and the aromatic shrubs of Arabia Felix. It was the line followed by Alexander the Great returning with his army from India.

The scathed shores of the Arabian Gulf, where not a blade of grass freshens the arid sands, and the uncultivated valleys of the Euphrates and Tigris, separate Asia from Arabia and Africa, the most desert regions in the old world.

The peninsula of Arabia, divided into two parts by the Tropic of Cancer, is about four times the size of France. No rivers, and few streams or springs nourish the thirsty land, whose barren sands are scorched by a fierce sun. The central part is a table-land of moderate height, which however is said to have an elevation of 8000 feet in the province of Haudramaut. To the south of the tropic it is an almost interminable ocean of drifting sand, wafted in clouds by the gale, and dreaded even by the wandering Bedouin. At wide intervals, long narrow depressions cheer the eye with brushwood and verdure. More to the north, mountains and hills cross the peninsula from S.E. to N.W., enclosing cultivated and fine pastoral valleys adorned by groves of the date-palm and aromatic shrubs. Desolation once more resumes its domain where the table-land sinks into the Syrian desert, and throughout the rest of its circumference it descends in terraces or parallel ranges of mountains and hills to a flat sandy coast from 30 to 100 miles wide, which surrounds the greater part of the peninsula, from the mouths of the Euphrates to the Isthmus of Suez. The hills come close to the beach in the province of Oman, which is traversed by chains, and broken into piles of arid mountains not more than 3500 feet high, with the exception of the Jebel Okkdar, which is 6000 feet above the sea, and is cleft by temporary streams and fertile valleys.

Here the ground is cultivated and covered with verdure, and still farther south there is a line of oases fed by subterraneous springs, where the fruits common to Persia, India, and Arabia are produced.

The south-eastern coast is scarcely known, except towards the provinces of Haudramaut and Yemen or Arabia Felix, where ranges of mountains, some above 5000 feet high, line the coast, and in many places project into the ocean, sometimes forming excellent harbours, as that of Aden, which is protected by projecting rocks. In the intervals there are towns and villages, cotton-plantations, date-groves, and cultivated ground.

On the northern side of these granite ranges, where the table-land is 8000 feet above the sea, and along the edge of the desert of El Aklaj in Haudramaut, there is a tract of land so loose and so very fine, that a plummet was sunk in it by Baron Wrede to the depth of 360 feet without reaching the bottom. There is a tradition in the country that the Sabæan army of King Suffi perished in attempting to cross this desert. Arabia Felix, which merits its name, is the only part of that country with permanent streams, though they are small. Here also the mountains and fertile ground run far inland, producing grain, pasture, coffee, odoriferous plants, and gums. High cliffs line the shores of the Indian Ocean and the Strait of Bab-el-man-deb—"the Gate of Tears." The fertile country is continued a considerable way along the coast of the Red Sea, but the character of barrenness is resumed by degrees, till at length the hills and intervening terraces, on which Mecca and Medina, the holy cities of the Mahomedans, stand, are sterile wastes whereever springs do not water them. The blast of the desert, loaded with burning sand, sweeps over these parched regions. Mountains skirt the table-land to the north; and the peninsula, between the Gulfs of Akabah and Suez on the Red Sea, the Eliath of Scripture, is filled by the mountain-group of Sinai and Horeb. Jebel Houra, Mount Sinai, on which Moses received the Ten Commandments, is 9000 feet high, surrounded by higher mountains, which are covered with snow in winter. The group of Sinai abounds in springs and verdure. At its northern extremity lies the desert of El-Teh, 70 miles long and 30 broad, in which the Israelites wandered forty years. It is covered with long ranges of high rocks, of most repulsive aspect, rent into deep clefts only a few feet wide, hemmed in by walls of rock sometimes 1000 feet high, like the deserted streets of a Cyclopean town. The journey from Sinai to Akabah, by the Wadee-el-Ain or Valley of the Spring, is perfectly magnificent, and the site of Petra itself is a tremendous confusion of black and brown mountains. It is a considerable basin closed in by rocks, with chasms and defiles in the precipices. The main street is 2 miles long, and not more than from 10 to 30 feet wide, enclosed between perpendicular rocks from 100 to 700 feet high, which so nearly meet as to leave only a strip of sky. A stream runs through the street which must once have been a considerable torrent, and the precipitous rocks are excavated into thousands of caverns once inhabited—into conduits, cisterns, flights of steps, theatres, and temples, forming altogether one of the most wonderful remains of antiquity. The whole of Arabia Petrea, Edom of the sacred writers, presents a scene of appalling desolation completely fulfilling the denunciation of prophecy.[1]

A sandy desert, crossed by low limestone ridges, separates the table-land of Arabia from the habitable part of Syria, which the mountains of Lebanon divide into two narrow plains. These mountains may almost be considered offsets from the Taurus chain; at least they are joined to it by the wooded range of Gawoor, the ancient Amanus, impassable except by two defiles, celebrated in history as the Amanic and Syrian Gates. The group of Lebanon begins with Mount Casius, which rises abruptly from the sea in a single peak to the height of 7000 feet, near the mouth of the Orontes. From thence the chain runs south, at a distance of about twenty miles from the shores of the Mediterranean, in a continuous line of peaks to the sources of the Jordan, where it splits into two nearly parallel naked branches, enclosing the wide and fertile plain of Beka or Ghor, the ancient Cœlo-Syria, in which are the ruins of Balbec.

The Lebanon branch terminates at the sea near

[1] From Miss Martineau's spirited and picturesque account of her journey to Egypt and Syria.

the mouth of the river Leontes, a few miles north of the city of Old Tyre; while the Anti-Libanus, which begins at Mount Hermon, 9000 feet high, runs west of the Jordan through Palestine in a winding line, till its last spurs, south of the Dead Sea, sink into rocky ridges on the desert of Sinai.

The tops of all these mountains, from Scanderoon to Jerusalem, are covered with snow in winter; it is permanent on Lebanon only, whose absolute elevation is 9300 feet. The precipices are terrific, the springs abundant, and the spurs of the mountains are studded with villages and convents; there are forests in the higher grounds, and lower down vineyards and gardens. Many offsets from the Anti-Libanus end in precipices on the coast between Tripoli and Beyrout, among which the scenery is superb.

The valleys and plains of Syria are full of rich vegetable mould, particularly the plain of Damascus, which is brilliantly verdant, though surrounded by deserts, the barren uniformity of which is relieved on the east by the broken columns and ruined temples of Palmyra (Tadmor). The Assyrian wilderness, however, is not everywhere absolutely barren. In the spring-time it is covered with a thin but vivid verdure, mixed with fragrant aromatic herbs, of very short duration. When these are burnt up, the unbounded plains resume their wonted dreariness. The country, high and low, becomes more barren towards the Holy Land, yet even here some of the mountains—as Carmel, Bashan, and Tabor—are luxuriantly wooded, and many of the valleys are fertile, especially the valley of the Jordan, which has the appearance of pleasure-grounds with groves of wood and aromatic plants, but almost in a state of nature. One side of the Lake of Tiberias in Galilee is savage; on the other there are gentle hills and wild romantic vales, adorned with palm-trees, olives, and sycamores—a scene of calm solitude and pastoral beauty. Jerusalem stands on a declivity encompassed by severe stony mountains, wild and desolate. The greater part of Syria is a desert compared with what it formerly was. Mussulman rule has blighted this fair region, once flowing with milk and honey—the Land of Promise.

Farther south desolation increases; the valleys become narrower, the hills more denuded and rugged, till, south of the Dead Sea, their dreary aspect announces the approach of the desert.

The valley of the Jordan affords the most remarkable instance known of the depression of the land below the general surface of the globe. This hollow, which extends from the Gulf of Akabah on the Red Sea to the bifurcation of Lebanon, is 620 feet below the Mediterranean at the Sea of Galilee, and the acrid waters of the Dead Sea have a depression of 1300 feet.[1] The lowness of the valley

[1] By the trigonometrical measurement of Major Anthony Symonds, confirmed by French authorities, and adopted by Baron Humboldt, the depression of the Dead Sea is, as stated in the text, 1300 feet; but MM. Bertou and Russiger made it out to be 1388 by the barometer. See Lieut. Molyneux's paper in the Journal of the Royal Geographical Society, 1848.

had been observed by the ancients, who gave it the descriptive name of Cœlo-Syria, "Hollow Syria." It is absolutely walled in by mountains between the Dead Sea and Lebanon, where it is from ten to fifteen miles wide.

A shrinking of the strata must have taken place along this coast of the Mediterranean, from a sudden change of temperature in the earth's crust, or perhaps in consequence of some of the internal props giving way, for the valley of the Jordan is not the only instance of a dip of the soil below the sea-level: the small bitter lakes on the Isthmus of Suez are cavities of the same kind, as well as the Natron lakes on the Libyan desert, west from the delta of the Nile.

CHAPTER VII.

Africa — Table-Land — Cape of Good Hope and Eastern Coast — Western Coast — Abyssinia — Senegambia — Low Lands and Deserts.

The continent of Africa is 5000 miles long from the Cape of Good Hope to its northern extremity, and as much between Cape Guardafuï, on the Indian Ocean, and Cape Verde, on the Atlantic; but from the irregularity of its figure it has an area of only 12,000,000 of square miles. It is divided in two by the equator, consequently the greater part of it lies under a tropical sun. The high and low lands of this portion of the old continent are so distinctly separated by the Mountains of the Moon, or rather of Komri, that, with the exception of the mountainous territory of the Atlas, and the small table-land of Barca, it may be said to consist of two parts only, a high country and a low.

An extensive, though not very elevated, table-land occupies all Southern Africa, and even reaches to six or seven degrees north of the equator. On three sides it shelves down in tiers of narrow parallel terraces to the ocean, separated by mountain-chains which rise in height as they recede from the coast; and there is reason to believe that the structure of the northern declivity is similar, though its extremities only are known—namely, Abyssinia on the east, and the high land of Senegambia on the west; both of which project farther to the north than the central part.

The borders of the table-land are very little known to Europeans, and still less its surface, which no white man has crossed north of the Tropic of Capricorn. A comparatively small part, north from the Cape of Good Hope, has been explored by European travellers. Mr. Truter and Mr. Somerville were the first white men whom the inhabitants of Litakoo had seen. Of an expedition that followed their track, a few years after, no one returned.

North of the Cape the land rises to 6000 feet above the sea; and the Orange River, or Gareep, with its tributaries, may be more aptly said to drain than to irrigate the arid country through which they flow; many of the tributaries, indeed, are only the channels through which torrents, from the periodical rains, are carried to the Orange River, and are destitute of water many months in the year. The "Dry River," the name of one of these periodical streams, is in that country no misnomer. Their margins are adorned with mimosas, and the sandy plains have furnished treasures to the botanist; and, indeed, zoology is no less indebted to the whole continent of Africa for the various animals it produces.

Dr. Smith crossed the Tropic of Capricorn in a journey from the Cape of Good Hope, where the country had still the same arid character. North from that there is a vast tract unexplored. In 1802 two native travelling merchants crossed the continent, which is 1590 miles wide, from Loando on the Atlantic to Zambeze on the Mozambique Channel. They found various mercantile nations, considerably advanced in civilization, who raise abundance of maize and millet, though the greater part of the country is in a state of nature. Ridges of low hills yielding copper, the staple commodity of this country, run from S.E. to N.W. to the west of the dominions of the Camleaze, a country full of rivers, morasses, and extensive salt marshes which supply this part of the continent with salt. The travellers crossed 102 rivers, most of them fordable. The leading feature of this country is Lake N'yassi, of great but unknown length, and comparatively narrow. It begins 200 miles north from the town of Tete, on the Zambeze, and extends from S.E. to N.W., flanked on the east by a range of mountains of the same name, running in the same direction, at the distance of 350 miles from the Mozambique Channel. This is all we know from actual observation of the table-land of South Africa, till about the 10th northern meridian, where Dr. Beke's Abyssinian journey terminated. It is evident, however, that there can be no very high mountains covered with perpetual snow on the table-land, for, if there were, Southern Africa would not be destitute of great rivers; nevertheless the height of the table-land, and of the mountains of Komri on its northern edge, must be considerable, to supply the perennial sources of the Nile, the Senegal, and the Niger.

The edges of the table-land are better known. At the Cape of Good Hope the African continent is about 700 miles broad, and ends in three narrow parallel ridges of mountains, the last of which is the highest, and abuts on the table-land. All are cleft by precipitous deep ravines, through which winter torrents flow to the ocean. The longitudinal valleys, or koroos, that separate them, are tiers, or steps, by which the plateau dips to the maritime plains. The descent is rapid, as both these plains and the mountain-ranges are very narrow. On the western side the mountains form a high group and end in steep promontories on the coast, where Table Mountain, at Cape Town, 3582 feet high, forms a conspicuous landmark for mariners.

Granite, which is the base of Southern Africa, rises to a considerable height in many places, and is generally surmounted by vast horizontal beds of sandstone, which give that character of flatness peculiar to the summits of many of the Cape mountains.

The koroos are arid deserts in the dry season, but soon after the rains they are covered with verdure and a splendid flora. The maritime plains partake of the same temporary aridity, though a large portion is rich in cereal productions, vineyards, fruits, and pasture.

The most inland of the parallel ranges, about the 20th meridian east, is 10,000 feet high, and, though it sinks to some groups of hills at its eastern extremity, it rises again, about the 27th meridian, in a truly alpine and continuous chain—the Quotlamba mountains, which follow the northerly direction of Natal, and are continued in the Lupata range of hills, 80 miles inland, through Zanguebar.

At Natal the coast is grassy, with clumps of trees, like an English park. The Zambeze, and other streams from the table-land, refresh the plains on the Mozambique Channel and Zanguebar, where, though some parts are marshy and covered with mangroves, groves of palm-trees adorn the plains, which yield prodigious quantities of grain, and noble forests cover the mountains; but from 4° N. latitude to Cape Guardafuï is a continued desert. There is also a barren tract at the southern end of the Lupata chain, where gold is found in masses and grains on the surface and in the watercourses, which tempted the Portuguese to make settlements on these unwholesome coasts.

The island of Madagascar, with its magnificent range of mountains, full of tremendous precipices, and covered with primeval forests, is parallel to the African coast, and only separated from it by the Mozambique Channel, 300 miles broad, so it may be presumed that it rose from the deep at the same time as the Lupata chain.

The contrast between the eastern and western coasts of South Africa is very great. The escarped bold mountains round the Cape of Good Hope, and its rocky coast, which extends a short way along the Atlantic to the north, are succeeded by ranges of sandstone of small elevation, which separate the internal sandy desert from the equally parched sandy shore. The terraced dip of the Atlantic coast for 900 miles, between the Orange River and Cape Negro, has not a drop of fresh water.

At Cape Negro, ranges of mountains, separated by long level tracts, begin, and make a semicircular bend into the interior, leaving plains along the coast 140 miles broad. In Benguela these plains are healthy and cultivated; farther north there are monotonous grassy savannahs, and forests of gigantic trees. The ground, in many places saturated with water, bears a tangled crop of mangroves and tall reeds, which even cover the shoals along the coast; hot pestilential vapours hang over them, never dissipated by a breeze.

The country of Calbongos is the highest land on the coast, where a magnificent group of mountains, covered almost to their tops with large timber, lie not far inland. The low plains of Biafra and Benin, west of them, and especially the delta of the Niger, consist entirely of swamps loaded with rank vegetation.

The angel of Death, brooding over these regions in noisome exhalations, guards the interior of that country from the aggressions of the European, and has hitherto baffled his attempts to form settlements on the banks of this magnificent river.

Many portions of North Guinea are so fertile that they might vie with the valley of the Nile in cereal riches, besides various other productions; and though the temperature is very high, the climate is not very unhealthy.

No European has yet seen the high mountains of Komri, generally known as the Mountains of the Moon, which are said to cross the continent along the northern edge of the great plateau, between the two projections or promontories of Abyssinia and Senegambia. This chain divides the semi-civilized states of Soudan, Bornou, and Begharmi from the barbarous nations on the table-land. It extends south of Abyssinia at one end, at the other it joins the high land of Senegambia, and is continued in the Kong range, which runs 1200 miles behind Dahomy and the Gold Coast, and ends in the promontory of Sierra Leone.

The vast alpine promontory of Abyssinia or Ethiopia, 700 miles wide, projects from the table-land for 300 miles into the low lands of North Africa. It dips to a low swampy region on the north, to the plains of Senaar and Kordofan on the west, and on the east sinks abruptly to the coast at a short distance from the Red Sea. It is there from 800 to 900 feet high, but declines to the westward, so that in the 15th parallel of N. latitude the eastern slope of the table-land towards the Red Sea is nearly twenty times greater than the counter-slope towards the Nile; the edge of the latter, however, is from 3000 to 4000 feet above the plains.[1] The character of Abyssinia is in that respect like the Deccan, or Southern India, where the Ghauts rise abruptly near the coast of Malabar, and the surface falls

[1] Estimated from N.E. to S.W., the proportion of the two slopes of the Abyssinian table-land is as 12·6 to 1.

gradually towards that of Coromandel. The table-land of Abyssinia is a succession of undulating plains, broken by higher insulated mountain-masses, which in Samien, Godjam, and in Kaffa more to the south, attain an absolute altitude of from 11,000 to 15,000 feet. The plains are intersected by numerous streams which form the Nile and its tributaries on the one hand, and the Hawásh and its affluents, which flow into the Indian Ocean, on the other. The edge of the table-land towards the Nile is steep; the streams run to the low lands through valleys from 3000 to 4000 feet deep, so that a traveller in ascending them might imagine that he is crossing a mountain-range, whereas, on coming to the top, he finds himself on a high plain. This elevated country has lakes, swamps, verdant meadows, and cultivated land, producing various grains, and occasionally coffee. The plain of the Dembia, the granary of the country, enjoys perpetual spring. Dr. Beke, to whom we are indebted for so much valuable information with regard to this part of Africa, travelled to within less than ten degrees of the equator, and, from the accounts he received, the country south of Abyssinia appears to be similar to those of Shoa and Godjam—extensive undulating plains, with occasional mountain-masses, and traversed by numerous streams; wide tracts must be 7000 or 8000 feet high, as they only produce barley: the country towards Kaffa and the sources of the Gojeb is still higher, and in some parts desert; but the caravan-road between Wallega and Kaffa passes through a vast forest impervious to the rays of the sun, which, according to the accounts of the merchants, is not seen for four or five days successively; and west of the Dedhesa there are immense grassy plains, the elephant-hunting grounds of the Galla tribes.

The geological structure of Abyssinia is similar to that of the Cape of Good Hope, the base being granite and the superstructure sandstone, occasionally limestone, schist, and breccia. The granite comes to the surface in the lower parts of Abyssinia, but sandstone predominates in the upper parts and assumes a tabular form, often lying on the tops of the mountains in enormous flat masses, only accessible by steps cut in the rocks or by ladders: such insulated spots are used as state prisons. Large tracts are of ancient volcanic rocks, especially in Shoa.

Senegambia, the appendage to the western extremity of the table-land, also projects far into the low lands, and is the watershed whence the streams flow on one side to the plains of Soudan, where they join the Joliba or Niger; and from the other side, the Gambia, Senegal, and other rivers run into the Atlantic over a rich cultivated plain, but unhealthy from the rankness of the vegetation.

The moisture that descends from the northern edge of the table-land of South Africa, under the fiery radiance of a tropical sun, fertilizes a tract of country stretching from sea to sea across the continent, the commencement of the African low lands.

A great part of this region, which contains many kingdoms and commercial cities, is a very productive country. The abundance of water, the industry of the natives in irrigating the ground, the periodical rains, and the tropical heat leave the soil no repose. Agriculture is in a rude state, but nature is so bountiful that rice and millet are raised in sufficient quantity to supply the wants of a numerous population. Gold is found in the river-courses, and there are elephants in the forests; but man is the staple of their commerce—a disgrace to the savage who sells his fellow-creature, but a far greater disgrace to the more savage purchaser who dares to assume the sacred name of Christian.

This long belt of never-failing vitality, which has its large lakes, poisonous swamps, deep forests of gigantic trees, and vast solitudes in which no white men ever trade, is of small width compared with its length. In receding from the mountains, the moisture becomes less and the soil gradually worse, sufficing only to produce grass for the flocks of the wandering Bedouin. At last a hideous barren waste begins, which extends northwards 800 miles in unvaried desolation to the grassy steppes at the foot of the Atlas; and for 1000 miles between the Atlantic and the Red Sea the nakedness of this blighted land is unbroken but by the valley of the Nile and a few oases.

In the west about 760,000 miles, an area equal to that of the Mediterranean Sea, and, in some parts, of a lower level, is covered by the trackless sands of the Sahara desert, which is even prolonged for miles into the Atlantic Ocean in the form of sand-banks. This desert is alternately scorched by heat and pinched by cold. The wind blows from the east nine months in the year; and at the equinoxes it rushes in a hurricane, driving the sand in clouds before it, producing the darkness of night at midday, and overwhelming caravans of men and animals in common destruction. Then the sand is heaped up in waves ever varying with the blast; even the atmosphere is of sand. The desolation of this dreary waste, boundless to the eye as the ocean, is terrific and sublime; the dry heated air is like a red vapour, the setting sun seems to be a volcanic fire, and at times the burning wind of the desert is the blast of death. There are many salt lakes to the north, and even the springs are of brine; thick incrustations of dazzling salt cover the ground, and the particles, carried aloft by whirlwinds, flash in the sun like diamonds.

Sand is not the only character of the desert; tracts of gravel and low bare rocks occur at times, not less barren and dreary; but on the eastern and northern borders of the Sahara fresh water rises near the surface, and produces an occasional oasis where barrenness and vitality meet. The oases are generally depressed below the level of the desert, with an arenaceous or calcareous border enclosing their emerald verdure like a frame. The smaller oases produce herbage, ferns, acacias, and some shrubs; forests of date-palms grow in the larger, which are the resort of lions, panthers, gazelles, reptiles, and a variety of birds.

In the Nubian and Libyan deserts, to the east of the Sahara, the continent shelves down towards the Mediterranean in a series of terraces, consisting of vast level sandy or gravelly deserts, lying east and west, separated by low rocky ridges. This shelving country, which is only 540 feet above the sea at the distance of 750 miles inland, is cut transversely by the Nile, and by a deep furrow parallel to it, in which there is a long line of oases. This furrow, the Nile, and the Red Sea, nearly parallel to both, are flanked by rocky eminences which run north from the table-land.

On the interminable sands and rocks of these deserts no animal—no insect—breaks the dread silence; not a tree nor a shrub is to be seen in this land without a shadow. In the glare of noon the air quivers with the heat reflected from the red sand, and in the night it is chilled under a clear sky sparkling with its host of stars. Strangely but beautifully contrasted with these scorched solitudes is the narrow valley of the Nile, threading the desert for 1000 miles in emerald green, with its blue waters foaming in rapids among wild rocks, or quietly spreading in a calm stream amidst fields of corn and the august monuments of past ages.

At the distance of a few days' journey west from the Nile, over a hideous flinty plain, lies the furrow already mentioned, trending to the north, and containing the oases of Darfour, Selime, the Great and

Little Oases, and the parallel valleys of the Natron Lakes, and Bahr-Belama or the "Dry River." The Great Oasis, or Oasis of Thebes, is 120 miles long and 4 or 5 broad; the Lesser Oasis, separated from it by 40 miles of desert, is of the same form. Both are rich in verdure and cultivation, with villages amid palm-groves and fruit-trees, mixed with the ruins of remote antiquity, offering scenes of peaceful and soft beauty contrasted with the surrounding gloom. The Natron Lakes are in the northern part of the Valley of Nitrùn, 35 miles west of the Nile; the southern part is a beautiful quiet spot, that became the retreat of Christian monks in the middle of the second century, and at one time contained 360 convents, of which 4 only remain; from these some very valuable manuscripts of old date have recently been obtained.

Another line of oases runs along the latitude of Cairo, with fresh-water lakes—consequently no less fertile than the preceding. The ruins of the Temple of Jupiter Ammon are in one of them.

Hundreds of miles on the northern edge of the desert, from the Atlantic along the southern foot of the Atlas to the Great Syrtis, are pasture-lands without a tree—an ocean of verdure. At the Great Syrtis the Sahara comes to the shores of the Mediterranean; and, indeed, for 1100 miles between the termination of the Atlas and the little table-land of Barca, the ground is so unprofitable that the population only amounts to about 30,000, and these are mostly wandering tribes who feed their flocks on the grassy steppes. Magnificent countries lie along the Mediterranean coast north of the Atlas, susceptible of cultivation. History, and the ruins of many great cities, attest their former splendour; even now there are many populous commercial cities, and much grain is raised, though a great part of these valuable kingdoms is badly cultivated or not cultivated at all.

The base of the sandy parts of North Africa is stiff clay; in Lower Nubia, between the parallels of Assouan and Esneh, red and white granite prevail, followed by argillaceous sandstone; Middle Egypt is calcareous; and lower down the alluvium of the Nile covers the surface.

It would appear that Southern Africa, though similar in its unbroken surface and peninsular shape to South America, bears no resemblance to it in other respects, but has a great analogy to the Deccan in its triangular form, its elevated platform, and in the position of its encompassing mountain-chains, if, as there is every reason to believe, from the fertile region to the north, either that South Africa descends in a succession of terraces to the low lands, or that the Komri mountains have a real existence, and run directly across the continent. From the connexion already mentioned between external appearance and internal structure, as well as from partial information, it is surmised that the mountains surrounding the two triangles in question are of corresponding constitution; that, if any secondary strata do exist in this part of Africa, they must be exterior to these chains, and neither on the summits of the high mountains nor in the interior; and that any tertiary strata on the table-land must, as in the Deccan, have formed the basins of fresh-water lakes.[1]

The prodigious extent of desert is one of the most extraordinary circumstances in the structure of the old continent. A zone of almost irretrievable desolation prevails from the Atlantic Ocean across Africa and through Central Asia almost to the Pacific Ocean, through at least 120 degrees of longitude. There are also many long districts of the same sterile nature in Europe; and if to these sandy plains the deserts of Siberia be added, together with all the barren and rocky mountain tracts, the unproductive land in the Old World is prodigious. The quantity of salt on the sandy plains is enormous, and proves that they have been part of the bed of the ocean or of inland seas at no very remote geological period. The low lands round the Black Sea and Caspian, and the Lake of Aral, seem to have been the most recently reclaimed, from the great proportion of shells in them identical with those now existing in these seas. The same may be said of the Sahara desert, where salt and recent shells are plentiful.

[1] Johnston's Physical Atlas.

CHAPTER VIII.

American Continent — The Mountains of South America — The Andes — The Mountains of the Parima and Brazil.

Some thinner portion of the crust of the globe under the meridians that traverse the continent of America from Cape Horn to the Arctic Ocean must have yielded to the expansive forces of the subterranean fires, or been rent by contraction of the strata in cooling. Through this the Andes had arisen, producing the greatest influence on the form of the continent, and the peculiar simplicity that prevails in its principal mountain systems, which, with very few exceptions, have a general tendency from north to south. The continent is 9000 miles long, and, its form being two great peninsulas joined by a long narrow isthmus, it is divided by nature into three parts, of South, Central, and North America; yet these three are connected by the mighty chain of the Andes, but little inferior in height to the Himalaya, running along the coast of the Pacific from within the Arctic nearly to the Antarctic circle. In this course every variety of climate is to be met with, from the rigour of polar congelation to the scorching heat of the torrid zone; while the mountains are so high that the same extremes of heat and cold may be experienced in the journey of a few hours from the burning plains of Peru to the snow-clad peaks above. In this long chain there are three distinct varieties of character, nearly, though not entirely, corresponding to the three natural divisions of the continent. The Andes of South America differ materially from those of Central America and Mexico, while both are dissimilar to the North American prolongation of the chain, generally known as the Chippewayan or Rocky Mountains.

The greatest length of South America from Cape Horn to the Isthmus of Panamá is about 4020 geographical miles. It is very narrow at its southern extremity, but increases in width northwards to the latitude of Cape Roque on the Atlantic, between which and Cape Blanco on the Pacific it attains its greatest breadth of nearly 2750 miles. It consists of three mountain systems, separated by the basins of three of the greatest rivers in the world. The Andes run along the western coast from Cape Horn to the Isthmus of Panamá, in a single chain of inconsiderable width but majestic height, dipping rapidly to the narrow maritime plains of the Pacific, but descending on the east in high valleys and occasional offsets to plains of vast extent, whose dead level is for hundreds of miles as unbroken as that of the ocean by which they are bounded. Nevertheless two detached mountain systems rise on these plains, one in Brazil between the Rio de la Plata and the river of the Amazons; the other is that of Parima and Guiana, lying between the river of the Amazons and the Orinoco.

The great chain of the Andes first raises its crest above the waves of the Antarctic Ocean in the majestic dark mass of Cape Horn, the southernmost point of the archipelago of Tierra del Fuego. This group of mountainous islands, equal in size to Britain, is cut off from the main land by the Straits of Magellan. The islands are penetrated in every direction by bays and narrow inlets of the sea, or fiords, ending often in glaciers fed by the snow on the summits of mountains 6000 feet high. Peat-mosses cover the higher declivities of these mountains, and their flanks are beset with densely entangled forests of brown beech, which never lose their dusky leaves, producing altogether a savage, dismal scene. The mountains which occupy the western side of this cluster of islands sink down to wide level plains to the east, like the continent itself, of which the archipelago is but the southern extremity.[1]

The Pacific washes the very base of the Patagonian Andes for about 1000 miles, from Cape Horn to the 40th parallel of south latitude. The whole coast is lined by a succession of archipelagos and islands, separated from the iron-bound shores by narrow arms of the sea, which, in the more southern part, are in fact profound longitudinal valleys of the Andes filled by the ocean, so that the chain of

[1] The Voyage of Captain King, R.N., Mr. Darwin's 'Journal of a Naturalist,' Dr. Pœppig's 'Travels in South America,' are the authorities for the account of Tierra del Fuego, Patagonia, and Chile; Baron Humboldt, Mr. Pentland, Drs. Pœppig and Meyer of Berlin, for Peru and the Andean Chain to the Isthmus of Panamá.

islands running parallel to the axes of the mountains is but the summits of an exterior range rising above the sea.

The coast itself for 650 miles is begirt by walls of rock, which sink into unfathomable depths, torn by long crevices or fiords, similar to those on the Norwegian shore, ending in tremendous glaciers, whose masses, falling with a crash like thunder, drive the sea in sweeping breakers through these chasms. The islands and the mainland are thickly clothed with forests, which are of a less sombre aspect as the latitude decreases.

Between the Pass of Chacabuco north of Santiago, the capital of Chile, and the archipelago of Chiloe, a chain of hills, composed in general of crystalline rocks, borders the coast; between which and the Andes exists a longitudinal valley, well watered by the rivers descending from the central chain, and which constitutes the most fertile portion, nay the garden of the Chilian republic—the rich provinces of Santiago, Colchagua, and Maule. This longitudinal depression may be considered as a prolongation of the strait that separates Chiloe from the mainland. Many peaks of the Andes enter within the limits of perpetual snow, between the 40th and 31st parallels; and some of which are active volcanos. In lat. 32° 39′ rises the giant of the American Andes, the Nevado of Aconcagua, which towers over the Chilian village of the same name, and is so clearly visible from Valparaiso. Although designated as a volcano, a term generally applied in Chile to every elevated and snowy peak, it offers no trace of modern igneous origin. It appears to be composed of a species of porphyry generally found in the centre of the Chilian chain. Its height, according to Captain Beechey's very accurate observations, exceeds 24,000 feet.[1]

About the latitude of Concepcion the dense forests of Araucarias and of other semi-tropical plants cease with the humid equable climate; and as no rain falls in central Chile for nine months in the year, the brown, purple, and tile-red hills and mountains are only dotted here and there with low trees and bushes; very soon, however, after the heavy showers have moistened the cracked ground, it is covered with a beautiful but transient flora. In some valleys it is more permanent and of a tropical character, mixed with alpine plants.[2] In southern Chile rain falls only once in two or three years, the consequence of which is sterility on the western precipitous and unbroken descent of the Andes; but on the east, two secondary branches leave the central Cordillera, which extend 300 or 400 miles into the plains, wooded to a great height. The Sierra de Cordova, the most southern of these, begins between the 33rd and 31st parallels, and extends in the direction of the Pampas; more to the north the Sierra di Salta and Juguy stretches from the valley of Catamarca and Tucuman towards

[1] This great height has been deduced, adopting the position of the Peak as fixed by Captain Fitz Roy, and employing the angles of elevation observed by Captain Beechey near Valparaiso.

[2] Dr. Pœppig's Travels.

the Rio Vermejo, one of the tributaries of the Rio de la Plata.

The chain takes the name of the Peruvian Andes about the 24th degree of south latitude, and is separated from the Pacific by a range of hills composed of crystalline rocks, and parallel to the sea coast, and of an intervening sandy desert, seldom above 60 miles broad, on which rain scarcely ever falls, where bare rocks pierce through the moving sand. The width of the coast is nearly the same to the Isthmus of Panamá, but damp luxuriant forests, full of orchideæ, begin about the latitude of Payta, and continue northwards.

From its southern extremity to the Nevado of Chorolque, in 21° 30′ S. lat., the Andes are merely one grand and continuous range of mountains, but north of that the chain intercepts a very elevated table-land, or wide longitudinal valley, in the direction of the chain, bounded on each side by a parallel range of high mountains, rising much above it. These parallel Cordilleras are united at various points by enormous transverse groups or mountain-knots, or by single ranges crossing between them like dykes, a structure that prevails to Pasto, 1° 13′ 6″ N. lat. The descent to the Pacific is very steep ; the dip is also very rapid to the east, whence offsets diverge to the level plains.

Unlike the table-lands of Asia of the same elevation, where cultivation is confined to the more sheltered spots, or those still lower in Europe, which are only fit for pasture, these lofty regions of the

Andes yield exuberant crops of every European grain, and have many populous cities enjoying the luxuries of life, with universities, libraries, civil and religious establishments, at altitudes equal to that of the Peak of Teneriffe, which is 12,170 feet above the sea-level. Villages are placed and mines are worked at heights as great and even greater than the top of Mont Blanc.[1] This state is not limited to the present times, since these table-lands were once the centre of civilization by a race of mankind which "bear the same relation to the Incas and the present inhabitants that the Etruscans bear to the ancient Romans and to the Italians of our own days."

The table-land or valley of Desaguadero, one of the most remarkable of these, has an absolute altitude of 12,900 feet, and a breadth varying from 30 to 60 miles: it stretches 400 miles between the two parallel chains of the Andes, and between the transverse mountain-group of Lipez, in 20° S. lat., and the enormous mountain-knot of Vilcañota, which, extending from east to west, shuts in the valley on the north-west, and occupying an area three times as large as Switzerland, some of the snowy peaks rising 8300 feet above the surface of the table-land, from which an idea may be formed of the gigantic scale of the Andes. This table-land or valley is bounded on each side by the two grand chains of the Bolivian Andes: that on the west is

[1] The celebrated silver mines of Potosi were formerly worked to the very summit of that metalliferous mountain, 16,150 feet above the sea level.

the Cordillera of the coast; the range on the east is the Bolivian Cordillera, properly speaking; and on its north-west prolongation the Cordillera Real.[1] These two rows of mountains lie so near the edge that the whole breadth of the table-land, including both, is only 226 miles. All the snowy peaks of the Cordilleras of the coast are either active volcanoes or of igneous origin, and are all situate near the maritime declivity of the chain; consequently, the descent is very abrupt. The eastern Cordillera, which begins at the metalliferous mountain of Potosi, is below the level of perpetual snow to the south, but its northern portion contains the three peaked mountains of Sorata, of Supäíwasi, and Illimani, and is one of the most magnificent portions of the Andes.[2] The snowy part begins with the gigantic mass of Illimani, whose serrated ridges are elongated in the direction of the axis of the chain. The lowest glacier on its southern slope does not descend below 16,500 feet, and the valley of Totoral, a mere gulf in which Vesuvius might stand, comes between Illimani and the Nevado of La Mesada, from whence the eastern Cordillera runs to the north-west in a continuous line of snow-clad peaks to the group of Vilcañota, where it unites with the Cordillera of the coast.

[1] Baron Humboldt and Mr. Pentland.

[2] The breadth of the table-land, and the two Cordilleras of the Bolivian Andes given in the text, was measured by Mr. Pentland; he also determined the heights of Illimani to be 21,150 feet; of Supäíwasi or Huayna Potosi, 20,260 feet; and of Ancohuma or the Nevado of Sorata, 21,290 feet.

The valley of the Desaguadero, occupying 150,000 square miles, has a considerable variety of surface; in the south, throughout the mining district, it is poor and cold. Potosi, the highest city in the world, stands at an absolute elevation of 13,330 feet, at the foot of a mountain celebrated for its silver-mines. Chiquisaca, the capital of Bolivia, containing 13,000 inhabitants, lies to the north-east of Potosi, in the midst of cultivated fields. The northern part of the valley is populous, and produces wheat, barley, and other grain; and the Lake of Titicaca, twenty times as large as the Lake of Geneva, fills the north-western portion of this great basin. The islands and shores of this lake still exhibit ruins of gigantic magnitude, monuments of a people more ancient than the Incas. The modern city of La Paz with 40,000 inhabitants, not far from its southern shores, stands in the most sublime situation that can be imagined, having in full view the vast Nevado of Illimani to the east-south-east at a distance of seven leagues.

Many offsets leave the eastern side of the Bolivian Cordillera which terminates in the great plain of Chiquitos and Paraguay; the most important is the Cordillera of Yuracaraës, which bounds the rich valley of Cochabamba on the north, and ends near the town of Santa Cruz de la Sierra.

There are some fertile valleys in the snow-capped group of Vilcañota and Cusco. The city of Cusco, which contains nearly 50,000 inhabitants, was the capital of the empire of the Incas: it still contains numerous ruins of that dynasty, among which the remains of the Temple of the Sun and its Cyclopean Fortress still mark its former splendour. Four ancient Peruvian roads led from Cusco to the different parts of the empire, little inferior in many respects to the old Roman ways: all crossing mountain-passes higher than the Peak of Teneriffe. On the northern prolongation of the chain, in lat. 11° S., encircled by the Andes, is the elevated plain of Bombon, near to the celebrated silver-mines of Pasco, at a height of 14,000 feet above the sea. In it is situated the Lake of Lauricocha, which may be considered, from its remoteness, as one of the sources of the Amazon. There are many small lakes on the table-lands and high valleys of the Andes, some even within the range of perpetual snow. They are very cold and deep, often of the purest sea-green colour; some of them may have been craters of extinct volcanos.

The chain of the Andes is divided into three ranges of mountains running from south to north in the transverse group or mountain-knot of Pasco and Huanuco, which shuts in the valley of Bombon between the 11th and 10th parallels of south latitude: that in the centre separates the wide fertile valley of the Upper Marañon from the still richer valley of the Huallaga, whilst the more eastern forms the barrier between the latter and the tropical valley of the Yucayali. The western chain alone reaches the limit of perpetual snow, and, if we except the Nevado of Huaylillas, in 7° 50′, no mountain north of this for nearly 400 miles to the Andes of Quito arrives at the snow-line.

In lat. 4° 50′ S. the Andes form the mountain-knot of Loxa, once celebrated for its forests, in which the cinchona or Peruvian bark was discovered. From this knot the chain divides into two great longitudinal ridges or cordilleras, in an extent of 350 miles, passing through the republic of the Equator to the mountain-group of Los Pastos in that of New Grenada. These ridges enclose a vast longitudinal valley, which, divided by the cross ridges of Assuay and Chisinche into three basins, form the valleys of Cuença, Tapia, and Quito. The plain of Cuença offers little interest; that of Tapia is magnificent; whilst the valley of Quito is one of extraordinary beauty: on either side rise a series of snow-capped peaks, celebrated in every way in the history of science, as the valley itself is in that of the aboriginal races of the New World. Here the energies of volcanic action have been studied with the greatest fruits; here, now one hundred years ago, took place that measurement of an arc of the meridian which afforded the most accurate data at the time towards the determination of the mass and form of our planet, and which has conferred eternal honour on the body with which it originated, the French Academy of Sciences; and celebrity on the names of Bouguier, La Condamine, and Godin, Don George Juan and Ulloa, who conducted it on the part of the crowns of France and of Spain.

The cordillera or ridge which hems in the valley of Quito on the east contains the snow-capped peaks of Antisana, Cotopaxi, one of the most beautiful of active volcanos, whose dazzling cone rises to a height of 18,775 feet, of Tungaragua and el-Altar, the latter once equal to Chimborazo in height, and Sangay. The western range includes the gigantic Chimborazo, which may be seen from the coast of the Pacific, the pyramidal peak of Illinissa, the wreck of an ancient volcano. The height of Illinissa was measured by the French Academicians, by very careful operations, directly above the level of the ocean, the latter being visible from it; and by its means the absolute elevation of the valley of Quito, and of the other peaks that encircle it, was deduced, as well as the first approximate value of the barometrical coefficient. North of Chimborazo and near it is the Carguäirazo, and close to the city of Quito rises the scarcely less celebrated volcano of Pichincha, whilst the Nevado of Cayambè, whose summit, elevated 19,535 feet, is traversed by the terrestrial equator, perhaps the greatest and most remarkable landmark on the surface of our planet, closes the north-east extremity of the valley.

The valley of Quito, one of the finest in the Andes, is 200 miles long and 30 wide, with a mean altitude of 10,000 feet, bounded by the most magnificent series of volcanos and mountains in the New World. A peculiar interest is attached to two of the many volcanos in the parallel Cordilleras that flank it on each side. The beautiful snow-clad cone of Cayambè Urcu, as already stated, traversed by the equator, the most remarkable division of the globe closes it on the north; and in the western Cordillera the cross still stands on the summit of Pichincha, 15,924 feet above the Pacific, which served for a signal to Bouguier and La Condamine in their memorable measurement of an arc of the meridian.[1]

Some parts of the plain of Quito to the south are sterile, but the soil generally is good, and perpetual spring clothes it with exuberant vegetation. The city of Quito, containing 70,000 inhabitants, on the side of Pichincha has an absolute height of 9540 feet. The city is well built and handsome; the churches are splendid; it possesses universities, the comforts and luxuries of civilized life, in a situation of unrivalled grandeur and beauty. Thus on the very summit of the Andes there is a world by itself, with its mountains and its valleys, its lakes and rivers, populous towns and cultivated fields. Many monuments of the Incas are still found in good preservation in these plains, where the scenery is most noble—eleven volcanic cones are visible from one spot. Although the Andes are inferior in height to the Himalaya, yet the domes of trachyte, the truncated cones of the active volcanos, and the serrated ruins of those that are extinct, mixed with the bold features of primary mountains, give an infinitely greater variety to the scene, while the smoke, and very often the flame, issuing from these regions of perpetual snow increase its sublimity. Stupendous

[1] Baron Humboldt.

as these mountains appear even from the plains of the table-land, they are merely the inequalities of the tops of the Andes, the serrated summit of that mighty chain.

Between the large group of Los Pastos, containing several active volcanos, and the group of Las Papas, in the second degree of north latitude, the bottom of the valley is only 6900 feet above the sea; and north of the latter mountain-knot the crest of the Andes splits into three Cordilleras, which diverge not again to unite. The most westerly of these, the chain of Choco, which may be considered the continuation of the great chain, divides the valley of the river Cauca from the Pacific; it is only 5000 feet high, and the lowest of the three. Though but 20 miles broad, it is so steep, and so difficult of access, that travellers cannot cross it on mules, but are carried on men's shoulders: it is rich in gold and platina. The central branch, or Cordillera of Quindiu, runs due north between the Magdalena and Cauca, rising to a great height in the volcanic Peak of Tolima. The two last chains are united by the mountain-knot of Antioquia, of which little more is known than that it forms two great masses, which, after separating the streams of the Magdalena, Cauca, and Atrato, trends to the N.W., greatly reduced in height, and with the chain of Choco forms the low mountains of the Isthmus of Panamá. The most easterly of the three Cordilleras, called the Sierra de la Summa Paz, spreads out on its western declivity into the table-lands of Bogota, Tunja, and others, the ancient Cundinamarca, which have an elevation of about 9000 feet; whilst on its eastern slope rise the rivers Guaviari and Meta, which form the head waters of the Orinoco. The tremendous crevice of Icononzo occurs in the path leading from the city of Santa Fé de Bogota to the banks of the Magdalena. It probably was formed by an earthquake, and is like an empty mineral vein, across which are two natural bridges: the lowest is composed of stones that have been jammed between the rocks in their fall.[1] This Cordillera comprises the Andes of Cundinamarca and Merida, and goes north-east through New Grenada to the 10th northern parallel, where it joins the coast-chain of Venezuela or Caraccas, which runs due east, and ends at Cape Paria in the Caribbean Sea, or rather at the eastern extremity of the island of Trinidad. This coast-chain is so majestic and beautiful that Baron Humboldt says it is like the Alps rising out of the sea without their snow. The insulated group of Santa Martha, 19,000 feet high, deeply covered with snow, stands on an extensive plain between the delta of the Magdalena and the sea-lake of Maracaybo, and is a landmark to mariners far off in the Caribbean Sea.

The passes over the Chilian Andes are numerous; that of the Portillo, leading from St. Jago to Mendoza, is the highest; it crosses two ridges, offering a valley between, a diminutive representation of the great Peru-Bolivian depression and of the valley of Quito; the most elevated is so high that vegetation

[1] Baron Humboldt.

ceases far below its summit. Those in Peru are higher, though very few reach the snow-line. In Bolivia the mean elevation of the passes in the western and eastern Cordillera is 14,892 and 14,422 feet respectively. That leading from Sorata to the auriferous valley of Tipuani is perhaps the highest in Bolivia. From the total absence of vegetation, and the intense cold, it is supposed to be 16,000 feet above the Pacific; those to the north are but little lower. The pass of Quindiu in Colombia, though not so high, is the most difficult of all across the Andes: but those crossing the mountain-knots from one table-land to another are the most dangerous; for example, that over the Paramo del Assuay, in the plain of Quito, where the road is nearly as high as Mont Blanc, and travellers not unfrequently perish from cold winds in attempting it.[1]

On the western side of the Andes little or no rain falls, except at their most southern extremity, and

[1] It appears by the measurements of Mr. Pentland in the Peru-Bolivian Andes, that many of their passes are higher than in the equatorial portion of the chain. The passes of Rumihuasi, on the high road from Cusco to Arequipa, of Toledo (between Arequipa and Puno), of Gualillas and Chullunquiani (between Arica and La Paz), all in the Western Cordillera, attain the respective elevations of 16,160, 15,790, 14,750, and 15,160 feet;—whilst in the Eastern or Bolivian Cordillera the passes of Challa (between Oruro and Cochabamba), of Pacuani (between La Paz and Coröico), of Pumapacheta (between the lake of Titicaca and the affluents to the Amazon), of Vilcañota (between the valley of the Collao and that of the river Yucay), rise to heights of 13,600, 15,350, 13,600, and 14.520 English feet.

scanty vegetation appears only on spots or in small valleys, watered by streams from the Andes. Excessive heat and moisture combine to cover the eastern side and its offsets with tangled forests of large trees and dense brushwood. This exuberance diminishes as the height increases, till at last the barren rocks are covered only by snow and glaciers. In the Andes near the equator glaciers descending below the snow-line are unknown. The steepness of the declivities and the dryness of the air, at such great elevations, prevent any accumulation of infiltrated water: the annual changes of temperature besides are small. Nothing can surpass the desolation of these regions, where nature has been shaken by terrific convulsions. The dazzling snow fatigues the eye; the huge masses of bold rock, the mural precipices, and the chasms yawning into dark unknown depths, strike the imagination; while the crash of the avalanche, or the rolling thunder of the volcano, startles the ear. In the dead of night, when the sky is clear and the wind hushed, the hollow moaning of the volcanic fire fills the Indian with superstitious dread in the deathlike stillness of these solitudes.

In the very elevated plains in the transverse groups, such as that of Bombon, however pure the sky, the landscape is lurid and colourless: the dark-blue shadows are sharply defined, and from the thinness of the air it is hardly possible to make a just estimate of distance. Changes of weather are sudden and violent; clouds of black vapour arise and are carried by fierce winds over the barren plains; snow and hail are driven with irresistible impetuosity; and thunder-storms come on, loud and awful, without warning. Notwithstanding the thinness of the air, the crash of the peals is quite appalling; while the lightning runs along the scorched grass, and, sometimes issuing from the ground, destroys a team of mules or a flock of sheep at one flash.[1]

Currents of warm air are occasionally met with on the crest of the Andes—an extraordinary phenomenon on such gelid heights, which is not yet accounted for: they generally occur two hours after sunset, are local and narrow, not exceeding a few fathoms in width, similar to the equally partial blasts of hot air in the Alps. A singular instance, probably, of earth-light occurs in crossing the Andes from Chile to Mendoza. On this rocky scene a peculiar brightness occasionally rests, a kind of undescribable reddish light, which vanishes during the winter rains, and is not perceptible on sunny days. Dr. Pœppig ascribes the phenomenon to the dryness of the air: he was confirmed in his opinion from afterwards observing a similar brightness on the coast of Peru, and it has also been seen in Egypt.

The Andes descend to the eastern plains by a series of cultivated levels, as those of Tucuman, Salta, and Jujuy, in the republic of La Plata, with many others. That of Tucuman is 2500 feet above the sea—the garden of the republic.

The low lands to the east of the Andes are divided

[1] Dr. Pœppig.

by the table-lands and mountains of Parima and Brazil into three parts of very different aspect—the deserts and pampas of Patagonia and Buenos Ayres, the Silvas or woody basin of the Amazons, and the Llanos or grassy steppes of the Orinoco. The eastern table-lands nowhere exceed 2500 feet of absolute height; the plains are so low and flat, especially at the foot of the Andes, that a rise of 1000 feet in the Atlantic Ocean would submerge more than half the continent of South America.

The system of Parima is a group of mountains scattered over a table-land not more than 2000 feet above the sea, which extends 600 or 700 miles from east to west, between the river Orinoco, the Rio Negro, the Amazons, and the Atlantic Ocean. It is quite unconnected with the Andes, being 80 leagues east from the mountains of New Grenada. It begins 60 or 70 miles from the coast of Venezuela, and ascends by four successive terraces to undulating plains, which come within one or two degrees of the equator, and is twice as long as it is broad.

Seven chains, besides groups of mountains, cross the table-land from west to east, of which the chief is the Sierra del Parima. Beginning at the mouth of the Meta, it crosses the plains of Esmeralda to the borders of Brazil. This chain is not more than 600 feet high, is everywhere escarped, and forms the watershed between the tributaries of the Amazons and those of the Orinoco. The Orinoco rises on the northern side of the Sierra del Parima, and in its circuitous course over the plains of Esmeralda it breaks through that chain and the parallel chain of the Maypures 36 miles to the south: dashing with violence against the transverse shelving rocks and dykes, it forms the magnificent series of rapids and cataracts of Maypures and Atures, from whence the Parima mountains have got the name of the Cordillera of the cataracts of the Orinoco. The chain is of granite, which forms the banks and fills the bed of the river, covered with luxuriant tropical vegetation, especially palm-forests. In the district of the Upper Orinoco, near Charichana, there is a granite rock which emits musical sounds at sunrise, like the notes of an organ, occasioned by the difference of temperature of the external air and that which fills the deep narrow crevices with which the rock is everywhere torn. Something of the same kind occurs at Mount Sinai.[1]

The other parallel chains that extend over the table-land in Venezuela and Guiana, though not of great height, are very rugged and often crowned with mural ridges; they are separated by flat savannahs, generally barren in the dry season, but after the rains covered with a carpet of emerald-green grass, often six feet high, mixed with flowers. The vegetation in these countries is beautiful beyond imagination: the regions of the Upper Orinoco and Rio Negro, and of almost all the mountains and banks of rivers in Guiana, are clothed with majestic and impenetrable forests, whose moist and hot recesses

[1] Baron Humboldt.

are the abode of the singular and beautiful race of the Orchideæ and tangled creepers of many kinds.

Although all the mountains of the system of Parima are wild and rugged, they are not high; the inaccessible peak of the Cerro Duida, which rises insulated 7155 feet above the plain of Esmeralda, is the culminating point, and one of the highest mountains in South America east of the Andes. The fine savannahs of the Rupununi were the country of romance in the days of Queen Elizabeth. South of Pacaraime, near an inlet of the river, the far-famed city of Manoa was supposed to stand, the object of the unfortunate expedition of Sir Walter Raleigh; about 11 miles south-west of which is situate the lake Amucu, "the Great Lake with golden banks,"—great only during the periodical floods.[1]

On the southern side of the basin of the river Amazons lies the table-land of Brazil, nowhere more than 2500 feet high, which occupies half that empire, together with part of the Argentine republic and Uruguay Orientale. Its form is a triangle, whose apex is at the confluence of the rivers Mamore and Beni, and its base extends, near the shore of the Atlantic, from the mouth of the Rio de la Plata to within three degrees of the equator. It is difficult to define the limits of this vast territory, but some idea may be formed of it by following the direction of the rapids and cataracts of the rivers descending from it to the plains around. Thus a line drawn from the fall of the river of the Tocantins, in

[1] Baron Humboldt's Personal Narrative.

3° 30′ S. latitude, to the cataracts of the Madeira, in the eighth degree of south latitude, will nearly mark its northern boundary; from thence the line would run S.W. to the junction of the Mamore and Beni; then turning to the S.E. along the ridges of mountains called the Cordillera Geral, and Sierra Parecis, it would proceed south to the cataract of the Paraná, called the Sete Quedas, in 24° 30′ S. lat.; and lastly from thence, by the great falls of the river Iguassu, to the Morro de Santa Martha, in lat. 28° 40′, south of the island of St. Catherine.

Chains of mountains, nearly parallel, extend from south-west to north-east, 700 miles along the base of the triangle, with a breadth of about 400 miles. Of these the Sierra do Mar, or the "coast-chain," reaches from the river Uruguay to Cape San Roque, never more distant than 20 miles from the Atlantic, except to the south of the bay of Santos, where it is 80. Offsets diverge to the right and left; the granitic peaks of the Corcovado and Tejuco, which form such picturesque objects in that most magnificent of panoramas the bay of Rio de Janeiro, are the ends of one. The parallel chain of Espenhaço, beginning near the town of San Paolo, and the continuous chains of the Serro Frio, and forming the western boundary of the basin of the Rio San Francisco, is the highest in Brazil, one of its mountains, Itambe, being 8426 feet above the sea. All the mountains in Brazil have a general tendency from S.W. to N.E., except the transverse chain of the Sierra dos Vertentes, which begins 60 miles south of

Villa Rica, and runs in a tortuous line to its termination near the junction of the Mamore and Beni. It forms the watershed of the tributaries of the San Francisco and Amazons on the north, and those of the Rio de la Plata on the south; its greatest height is 3500 feet above the sea: its western part, the Sierra Parecis, is merely a succession of detached hills. This chain, the coast-chain of Venezuela, and the mountains of Parima, are the only ranges in the continent of America that do not entirely, or in some degree, lie in the direction of the meridians.

Magnificent forests of tall trees, bound together by tangled creeping and parasitical plants, clothe the declivities of the mountains and line the borders of the Brazilian rivers, where the soil is rich and the verdure brilliant. Many of the plains on the table-land bear a coarse nutritious grass after the rains only, others forests of dwarf trees; but vast undulating tracts are always verdant with excellent pasture intermixed with fields of corn: some parts are bare sand and rolled quartz, and the Campos Parecis, north of the Sierra dos Vertentes, in the province of Matto Grosso, is a sandy desert of unknown extent, similar to the Great Gobi on the table-land of Tibet.

CHAPTER IX.

The Low Lands of South America — Desert of Patagonia — The Pampas of Buenos Ayres — The Silvas of the Amazons — The Llanos of the Orinoco and Venezuela — Geological Notice.

THE southern plains are the most barren of the three great tracts of American low lands; they stretch from Tierra del Fuego over 27 degrees of latitude, or 1900 miles, nearly to Tucuman and the mountains of Brazil. Palms grow at one end, deep snow covers the other many months in the year. This enormous plain, of 1,620,000 square miles, begins on the eastern part of Tierra del Fuego, which is a flat covered with trees, and therefore superior to its continuation on the continent through eastern Patagonia, which, for 800 miles from the land's end to beyond the Rio Colorado, is a desert of shingle.[1] It is occasionally diversified by huge boulders, tufts of brown grass, low bushes armed with spines, brine-lakes, incrustations of salt, white as snow, and by black basaltic platforms, like plains of iron, at the foot of the Andes, barren as the rest. Eastern Patagonia, however, is not one universal flat, but a succession of shingly horizontal plains at higher and higher levels, separated by long lines of cliffs or escarpments, the gable ends of the tiers or plains. The ascent is small, for even at the foot of the

[1] Captain King, R.N., and Mr. Darwin.

Andes the highest of these platforms is only 3000 feet above the ocean. The plains are here and there intersected by a ravine or a stream, the waters of which do not fertilize the blighted soil. The transition from intense heat to intense cold is rapid, and piercing winds often rush in hurricanes over these deserts, shunned even by the Indian, except when he crosses them to visit the tombs of his fathers. The shingle ends a few miles to the north of the Rio Colorado: there the red calcareous earth of the Pampas begins, monotonously covered with coarse tufted grass, without a tree or bush. This country, nearly as level as the sea and without a stone, extends almost to the table-land of Brazil, and for 1000 miles between the Atlantic and the Andes, interrupted only at vast distances by a solitary umbú, the only tree of this soil, rising like a great landmark. This wide space, though almost destitute of water, is not all of the same description. In the Pampas of Buenos Ayres there are four distinct regions. For 180 miles west from Buenos Ayres they are covered with thistles and lucern of the most vivid green so long as the moisture from the rain lasts. In spring the verdure fades, and a month afterwards the thistles shoot up 10 feet high, so dense and so protected by spines that they are impenetrable. During the summer the dried stalks are broken by the wind, and the lucern again spreads freshness over the ground. The Pampas for 430 miles west of this region is a thicket of long tufted luxuriant grass, intermixed with gaudy flowers, affording inexhaustible pasture to thousands of horses and cattle; this is followed by a tract of swamps and bogs, to which succeeds a region of ravines and stones, and, lastly, a zone, reaching to the Andes, of thorny bushes and dwarf trees in one dense thicket. The flat plains in Entre Rios in Uruguay, those of Santa Fé, and a great part of Cordova and Tucuman, are of sward, with cattle-farms. The banks of the Paraná, and other tributaries of the La Plata, are adorned with an infinite variety of tropical productions, especially the graceful tribe of palms; and the river islands are bright with orange-groves. A desert of sand, called Il Gran Chaco, exists west of the Paraguay, the vegetable produce of which is confined to a variety of the aloe and cactus tribes. Adjoining this desert are the Bolivian provinces of Chiquitos and Moxos, covered with forests and jungle, the scene of the most laborious and beneficent exertions of the Jesuit Missionaries towards the civilization of the aborigines of South America in the last century.

The Pampas of Buenos Ayres, 1000 feet above the sea, sink to a low level along the foot of the Andes, where the streams from the mountains collect in large lakes, swamps, lagoons of prodigious size, and wide-spreading salines. The swamp or lagoon of Ybera, of 1000 square miles, is entirely covered with aquatic plants. These swamps are swollen to thousands of square miles by the annual floods of the rivers, which also inundate the Pampas, leaving a fertilizing coat of mud. Multitudes of animals perish in the floods, and the drought that sometimes succeeds is more fatal. Between the years 1830 and 1832 two millions of cattle died from want of food. Millions of animals are sometimes destroyed by casual and dreadful conflagrations in these countries when covered with dry grass and thistles.[1]

The Silvas of the river of the Amazons, lying in the centre of the continent, form the second division of the South American low lands. This country is more uneven than the Pampas, and the vegetation is so dense that it can only be penetrated by sailing up the river or its tributaries. The forests not only cover the basin of the Amazons from the Cordillera of Chiquitos to the mountains of Parima, but also its limiting mountain-chains, the Sierra dos Vertentes and Parima, so that the whole forms an area of woodland more than six times the size of France, lying between the 18th parallel of south latitude and the 7th of north; consequently inter-tropical and traversed by the equator. There are some marshy savannahs between the 3rd and 4th degrees of north latitude, and some grassy steppes south of the Pacaraimo chain; but they are insignificant compared with the Silvas, which extend 1500 miles along the river, varying in breadth from 350 to 800 miles, and probably more. According to Baron Humboldt, the soil, enriched for ages by the spoils of the forest, consists of the richest mould. The heat is suffocating in the deep and dark recesses of these primeval woods, where not a breath of air

[1] Sir Woodbine Parish on Buenos Ayres, and Sir Francis Head's Journey over the Pampas.

penetrates, and where, after being drenched by the periodical rains, the damp is so excessive that a blue mist rises in the early morning among the huge stems of the trees, and envelops the entangled creepers stretching from bough to bough. A death-like stillness prevails from sunrise to sunset, then the thousands of animals that inhabit these forests join in one loud discordant roar, not continuous, but in bursts. The beasts seem to be periodically and unanimously roused by some unknown impulse, till the forest rings in universal uproar. Profound silence prevails at midnight, which is broken at the dawn of morning by another general roar of the wild chorus. Nightingales too have their fits of silence and song; after a pause they

> "—— all burst forth in choral minstrelsy,
> As if some sudden gale had swept at once
> A hundred airy harps." *Coleridge.*

The whole forest often resounds when the animals, startled from their sleep, scream in terror at the noise made by bands of its inhabitants flying from some night-prowling foe. Their anxiety and terror before a thunder-storm is excessive, and all nature seems to partake in the dread. The tops of the lofty trees rustle ominously, though not a breath of air agitates them; a hollow whistling in the high regions of the atmosphere comes as a warning from the black floating vapour; midnight darkness envelops the ancient forests, which soon after groan and creak with the blast of the hurricane. The gloom is rendered still more hideous by the vivid lightning and the stunning crash of thunder. Even fishes are affected with the general consternation; for in a few minutes the Amazons rages in waves like a stormy sea.

The Llanos of the Orinoco and Venezuela, covered with long grass, form the third department of South American low lands, and occupy 153,000 square miles between the deltas of the Orinoco and the river Coqueta, flat as the surface of the sea. It is possible to travel over these flat plains for 1100 miles from the delta of the Orinoco to the foot of the Andes of Pasto; frequently there is not an eminence a foot high in 270 square miles. They are twice as long as they are broad; and as the wind blows constantly from the east, the climate is the more ardent the farther west. These steppes for the most part are destitute of trees or bushes, yet in some places they are dotted with the mauritia and other palm-trees. Flat as these plains are, there are in some places two kinds of inequalities; one consists of banks or shoals of grit or compact limestone, five or six feet high, perfectly level for several leagues, and imperceptible except on their edges: the other inequality can only be detected by the barometer or levelling instruments; it is called a Mesa, and is an eminence rising imperceptibly to the height of some fathoms. Small as the elevation is, a mesa forms the watershed from S.W. to N.E., between the affluents of the Orinoco and the streams flowing to the northern coast of Terra Firma. In the wet season, from April to the end of October, the tropical rains pour down in torrents, and hundreds of square miles of the Llanos are inundated by the floods of the rivers. The water is sometimes 12 feet deep in the hollows, in which so many horses and other animals perish, that the ground smells of musk, an odour peculiar to many South American quadrupeds. From the flatness of the country too, the waters of some affluents of the Orinoco are driven backwards by the floods of that river, especially when aided by the wind, and form temporary lakes. When the waters subside, these steppes, manured by the sediment, are mantled with verdure, and produce ananas, with occasional groups of fan palm-trees, and mimosas skirt the rivers. When the dry weather returns, the grass is burnt to powder; the air is filled with dust raised by currents occasioned by difference of temperature, even where there is no wind. If by any accident a spark of fire falls on the scorched plains a conflagration spreads from river to river, destroying every animal, and leaves the clayey soil sterile for years, till vicissitudes of weather crumble the brick-like surface into earth.

The Llanos lie between the equator and the Tropic of Cancer; the mean annual temperature is about 84° of Fahrenheit. The heat is most intense during the rainy season, when tremendous thunder-storms are of common occurrence.

GEOLOGY OF SOUTH AMERICA.

The most remarkable circumstance in the geological features of the South American continent is the vast development of volcanic force, which is confined to the chain of the Andes, and where it has acquired a considerable breadth, as in the Peru-Bolivian portion, to the part nearest the sea-coast. It would be wrong, however, to say that there are no traces of modern volcanic action at a great distance from the sea:[1] it is one of those theories which recent discoveries in both continents have proved the fallacy of. The volcanic vents occur in the Andes in linear groups: the most southern of these is that of Chile, extending from the latitude of Chiloe to that

[1] Mr. Pentland found a very perfect volcanic crater, with well-marked currents of lava issuing from it—a rare occurrence in the higher craters of the Andes—near to San Pedro de Cacha, in the valley of the Yucay (lat. 14° 12′, long. 71° 15′ W., and at an elevation of 12,000 feet), near to the ruins of the Temple of the Inga Viracocha, a monument and a locality celebrated in Peruvian legend, the nearest point of the sea-coast being 175 miles distant. It is probable that many of the most celebrated mining districts of Alto Peru—Potosi, for instance, situated in a porphyry—have been upheaved at a very recent period. Modern volcanic rocks are not wanting in the valley of the Desaguadero; volcanic conglomerates exist in the deep ravines round the city of La Paz, lat. 16° 30′; and the mountain of Litanias, which furnishes the building-stone for that Bolivian city (lat. 16° 42′, long. 68° 19½′), is composed of a most perfect trachyte, and rises to a height of 14,500 feet above, and at a distance of 160 miles from the Pacific.

of Santiago, 42° to 33° S.: in this space exist five well-authenticated craters in ignition — the most southern is the volcano of Llanquihae or Osorno, observed by M. Gaye, and the most northern that of Maypu, the fires of which are sometimes seen from the capital of Chile. Between the 33rd parallel and the Bolivian frontier there does not appear to be a single volcanic vent, but in the province of Atacama rises the volcano of San Pedro of Atacama. The mountain of Isluga, in the province of Tarapaca, is said to be an active volcano, but the great centre of volcanic action in this part of the Western Cordillera extends from 18° 10′ to 16° 20′, where the Andes have changed their direction from being parallel to the meridian to one inclined nearly 45 degrees to that line. The trachytic giant domes of the Andes, Sahama, and the Nevado of Chuquibamba mark the N. and S. limits of this line of vents: the former, one of the most perfect trachytic pyramids in the Andes, rises to a height of 22,350 feet, in lat. 18° 7′ and long. 68° 54′ W.; near to it are the twin Nevados of Pomarape and Parinacota, one of which appears to emit smoke. The group of snowy peaks seen from Arica, the centre of which, the Nevado of Tacora, is in lat. 17° 43′, offers a broken-down crater, and an active solfaterra, on one of its sides. Between this point and the volcano of Arequipa no active volcano has been observed. It is well known that the latter has vomited flames and ashes, and spread desolation around, at a comparatively recent period; the crater of Uvinas, active in the 16th century, is now filled up and completely extinct. Between the latitude of Arequipa (16° 24′) and the Equatorial group of volcanos, the Andes do not present a single active crater. This Equatorial group extends over a meridional line of 3¼ degrees—between the Peak of Sangay and the volcano of Los Pastos. The most remarkable of these volcanic vents are the Sangay, Tunguragua, and Cotopaxi, all situated in the Cordillera most remote from the ocean. Pichincha burned as recently as 1831; and north of the Equator, Imbaburu, the volcanos of Chiles, of Cumbal, of Tuqueres or Los Pastos, of Sotara and Purace, mark the extension of actual volcanic action into our hemisphere.

Granite, which seems to be the base of the whole continent, is widely spread to the east and south: it appears in Tierra del Fuego and in the Patagonian Andes abundantly, and at great elevations, and in Chile and southern Peru forms the line of hills parallel to the Pacific, and where are situated the mineral riches of the former republic; but it comes into view so rarely in the northern parts of the chain, that Baron Humboldt says a person might travel years in the Andes of Peru and Quito without falling in with it. He never saw it at a greater height above the sea than 11,500 feet. Gneiss is here and there associated with the granite, but mica-schist is by much the most common of the crystalline rocks. Quartz rock, probably of the Devonian period, is much developed, generally mixed with mica, and rich in gold and specular iron. It sometimes extends several leagues in the western declivities of Peru 6000 feet thick. Red sandstone, with its gypseous and saliferous marls, of the age of our English red marl, of vast dimensions, occurs in the Andes, and on the table-land east of them, where in some places, as in Colombia, it spreads over thousands of square miles to the shores of the Atlantic. It is widely extended at altitudes of 10,000 and 12,000 feet—for example, on the plains of Tarqui and in the valley of Cuença. Coal is sometimes associated with it, and is found in the Andes of Pasco, in Peru, 14,750 feet above the sea.

Porphyry abounds all over the Andes, from Patagonia to Colombia, at every elevation, on the slopes and summits of the mountains, rising to the greatest elevation, but of very different ages and mineralogical characters. One variety which frequently occurs is rich in metals, and hence has been designated as *metalliferous:* in it are situated some of the most celebrated silver mines of Peru, those of Potosi, Oruro, Puno. The bare and precipitous porphyry-rocks give great variety to the colouring of the Andes, especially in Chile, where purple, tile-red, and brown are contrasted with the snow on the summit of the chain.[1]

Trachyte is almost as abundant as porphyry; many of the loftiest parts, and all the great dome-shaped mountains, are formed of it. Masses of this rock, from 14,000 to 18,000 feet thick, are seen on Chimborazo and Pichincha. Prodigious quantities of

[1] Dr. Pœppig.

volcanic products, lava, tufa, and obsidian, occur on the western face of the Andes, where volcanos are active. On the eastern side there are none. This is especially the case in that part of the chain lying between the equator and Chile. The Bolivian Cordilleras, which encircle the valley of Desaguadero, furnish a striking example. The Cordillera of the coast is composed of crystalline and stratified rocks at its base, and of trachytes, obsidian, and trachytic conglomerates at greater elevations, while the eastern Cordillera consists of stratified rocks of the Silurian system, with granites, quartziferous porphyries, and syenites injected, and of secondary rocks of the triassic period, and marls, containing gypsum, oolitic limestone, and rock-salt of the most beautiful colours. Towards Chile, and throughout the Chilian range, the case is different, because active volcanos are there in the centre of the chain.

Sea-shells of different geological periods are found at various elevations, which shows that many upheavings and subsidences have taken place in the chain of the Andes.[1] The whole range, after twice subsiding some thousand feet, was brought up by a slow movement in mass during the Eiocene period, after which it sank down once more several hundred feet, to be again uplifted to its present level by a slow and often interrupted motion. These vicissitudes

[1] Mr. Pentland found fossil shells of the Silurian period at a height of 17,500 feet, on the Bolivian Nevado of Antakäua, lat. 16° 21′, and those of the carboniferous limestone as high as 14,200 in several parts of Upper Peru.

are very perceptible, especially at its southern extremity. Stems of large trees, which Mr. Darwin found in a fossil state in the Uspallata range, on the eastern declivity of the Chilian Andes, now 700 miles distant from the Atlantic, exhibit a remarkable example of such vicissitudes. These trees, with the volcanic soil on which they had grown, had sunk from the beach to the bottom of a deep ocean, from which, after five alternations of sedimentary deposits and deluges of submarine lava of prodigious thickness, the whole mass was raised up, and now forms the Uspallata chain. Subsequently, by the wearing of streams, the embedded trunks have been brought into view in a silicified state, projecting from the soil in which they grew—now solid rock.

"Vast and scarcely comprehensible as such changes must ever appear, yet they have all occurred within a period recent when compared with the history of the Cordillera; and the Cordillera itself is absolutely modern compared with many of the fossiliferous strata of Europe and America."[1]

From the quantity of shingle and sand in the valleys in the lower ridges, as well as at altitudes from 7000 to 9000 feet above the present level of the sea, it appears that the whole area of the Chilian Andes has been rising for centuries by a gradual motion; and the coast is now rising by the same imperceptible degrees, though it is sometimes suddenly elevated by a succession of small upheavings of a few feet by earthquakes, similar to that which shook the con-

[1] Mr. Darwin's Journal of Travels in South America.

tinent for 1000 miles on the 20th of February, 1835.

On the eastern side of the Andes the land from Tierra del Fuego to the Rio de la Plata has been raised *en masse* by one great elevating force, acting equally and imperceptibly for 2000 miles, within the period of the shell-fish now existing, which, in many parts of these plains, even still retain their colours. The gradual upward movement was interrupted by at least eight long periods of rest, marked by the edges of the successive plains, which, extending from south to north, had formed so many lines of sea-coast, as they rose higher and higher between the Atlantic and the Andes. It appears, from the shingle and fossil shells found on both sides of the Cordillera, that the whole south-western extremity of the continent has been rising slowly for a long time, and indeed the whole Andean chain. The rise on the coast of Chile has been at the rate of several feet in a century; but it has diminished eastward, till, in the Patagonian plains and Pampas, it has been only a few inches in the same line.

The instability of the southern part of the continent is less astonishing, if it be considered that at the time of the earthquake of 1835 the volcanos in the Chilian Andes were in eruption contemporaneously for 720 miles in one direction and 400 in another, so that in all probability there was a subterranean lake of burning lava below this end of the continent twice as large as the Black Sea.[1]

[1] Mr. Darwin's Journal of Travels in South America.

The terraced plains of Patagonia, which extend hundreds of miles along the coast, are tertiary strata, not in basins, but in one great deposit, above which lies a thick stratum of a white pumaceous substance, extending at least 500 miles, a tenth part of which consists of marine infusoria. Over the whole lies the shingle already mentioned, spread over the coast for 700 miles in length, with a mean breadth of 200 miles, and 50 feet thick. These myriads of pebbles, chiefly of porphyry, have been torn from the rocks of the Andes, and water-worn, at a period subsequent to the deposition of the tertiary strata—a period of incalculable duration. All the plains of Tierra del Fuego and Patagonia, on both sides of the Andes, are strewed with huge boulders, which have been supposed to have been transported by icebergs which had descended to lower latitudes in ancient times than they do now—observations of great interest, which we owe to Mr. Darwin.

The stunted vegetation of these sterile plains was sufficient to nourish large animals of the pachydermata tribe, now extinct, even at a period when the present shell-fish of the Patagonian seas existed.

The Pampas of Buenos Ayres are entirely alluvial, the deposit of the Rio de la Plata. Granite prevails to the extent of 2000 miles along the coast of Brazil, and with syenite forms the base of the table-land. The superstructure of the latter consists of metamorphic and old igneous rocks, sandstone, clay-slate, limestone, in which are large caverns with bones of extinct animals, and alluvial soil. Gold is found in the alluvial soil on the banks of the rivers, and diamonds, so abundant in that country, in a ferruginous conglomerate of a very recent period.

The fertile soil of the Silvas has travelled from afar: washed down from the Andes, it has been gradually deposited, and manured by the decay of a thousand forests. Granite again appears, in more than its usual ruggedness, in the table-land and mountains of the Parima system. The sandstone of the Andes is found there also; and on the plains of Esmeralda it caps the granite of the solitary prism-shaped Duida, the culminating mountain of the Parima system. Limestone appears in the Brigantine or Cocollar, the most southern of the three ranges of the coast-chain of Venezuela; the other two are of granite, metamorphic rocks, and crystalline schists, torn by earthquakes and worn by the sea, which has deeply indented that coast. The chain of islands in the Spanish main is merely the wreck of a more northern ridge, broken up into detached masses by these irresistible powers.

CHAPTER X.

Central America — West Indian Islands — Geological Notice.

Taking the natural divisions of the continent alone into consideration, Central America may be regarded as lying between the Isthmus of Panamá and Darien and the Isthmus of Tehuantepec, and consequently in a tropical climate. This narrow tortuous strip of land, which unites the continents of North and South America, stretches from S.E. to N.W. about 1200 miles, varying in breadth from 20 to 300 or 400 miles.

As a regular chain, the Andes descend suddenly at the Isthmus of Panamá, but as a mass of high land they continue through Central America and Mexico, in an irregular mixture of table-lands and mountains. The mass of high land which forms the central ridge of the country, and the watershed between the two oceans, is very steep on its western side, and runs near the coast of the Pacific, where Central America is narrow; but to the north, where it becomes wider, the high land recedes to a greater distance from the shore than the Andes do in any other part between Cape Horn and Mexico.

This country consists of three distinct groups, divided by valleys which run from sea to sea, namely, Costarica, the group of Honduras and Nicaragua, and the group of Guatemala.[1]

[1] Johnston's Physical Atlas.

The plains of Panamá, very little raised above the sea, and in some parts studded with hills, follow the direction of the isthmus for 280 miles, and end at the Bay of Parita. From thence the forest-covered Cordillera of Veragua, supposed to be 9000 feet high, extends to the small but elevated table-land of Costarica, surrounded by volcanos, and terminates at the plain of Nicaragua, which, together with its lake, occupies an area of 30,000 square miles, and forms the second break in the great Andean chain. The lake is only 128 feet above the Pacific, from which it is separated by a line of active volcanos. The river San Juan de Nicaragua flows from its eastern end into the Caribbean Sea, and at its northern extremity it is connected with the smaller lake of Managua or Leon by the river Penaloya. By this water-line it has been projected to unite the two seas. The high land begins again, after an interval of 170 miles, with the Mosquito country and Honduras, which mostly consist of table-lands and high mountains, some of which are volcanos.

Guatemala is a table-land intersected by deep valleys, which lies between the plain of Comayagua and the Isthmus of Tehuantepec. It spreads to the east in the peninsula of Yucatan, which terminates at Cape Catoche, and encompasses the Bay of Honduras with terraces of high mountains. The table-land of Guatemala consists of undulating verdant plains of great extent, of the absolute height of 5000 feet, fragrant with flowers. In the southern part of the table-land the cities of Old and New

Guatemala are situate, 12 miles apart. The portion of the plain on which the new city stands is bounded on the west by the three volcanos of Pacayo, del Fuego, and de Agua; these, rising from 7000 to 10,000 feet above the plain, lie close to the new city on the west, and form a scene of wonderful boldness and beauty. The Volcano de Agua, at the foot of which Old Guatemala stands, is a perfect cone, verdant to its summit, which occasionally pours forth torrents of boiling water and stones. The old city has been twice destroyed by it, and is now nearly deserted on account of earthquakes. The Volcano del Fuego generally emits smoke from one of its peaks; and the Volcano de Pacayo is only occasionally active. The wide grassy plains are cut by deep valleys to the north, where the high land of Guatemala ends in parallel ridges of mountains, called the Cerro Pelado, which run from east to west along the 94th meridian, filling half the Isthmus of Tehuantepec, which is 140 miles broad, and unites the table-land of Guatemala with that of Mexico.

Though there are large savannahs on the high plains of Guatemala, there are also magnificent primeval forests, as the name of the country implies, Guatemala signifying, in the Mexican language, a place covered with trees. The banks of the Rio de la Papian, or Usumasinta, which rises in the alpine lake of Lacandon, and flows over the table-land to the Gulf of Mexico, are beautiful beyond description.

The coasts of Central America are generally narrow, and in some places the mountains and high lands come close to the water's edge. The sugar-cane is indigenous, and on the low lands of the eastern coast all the ordinary produce of the West Indian islands is raised, besides much that is peculiar to the country.

As the climate is cool on the high lands, the vegetation of the temperate zone is there in perfection. On the low lands, as in other countries where heat and moisture are in excess, and where nature is for the most part undisturbed, vegetation is vigorous to rankness: forests of gigantic timber seek the foul air above an impenetrable undergrowth, and the mouths of the rivers are dense masses of jungle with mangroves and reeds 100 feet high, yet delightful savannahs vary the scene, and wooded mountains dip into the water.

Nearly all the coast of the Pacific is skirted by an alluvial plain, of small width, and generally very different in character from that on the Atlantic side. In a line along the western side of the table-land and the mountains there is a continued succession of volcanos, at various distances from the shore, and at various heights, on the declivity of the table-land. It seems as if a great crack or fissure had been produced in the earth's surface, along the junction of the mountains and the shore, through which the internal fire had found a vent. There are more than 20 active volcanos in succession between the 10th and 20th parallels of north latitude; some higher than the mountains of the central ridge, and several subject to violent eruptions. Altogether there are 39 in Central America, 17 of which are in Guatemala—a greater number than in any other country, Java excepted.

The Colombian Archipelago, or West Indian Islands, which may be regarded as the wreck of a submerged part of the continent of South and Central America, consists of three distinct groups, namely, the Lesser Antillas or Caribbean Islands, the Greater Antillas, and the Bahama or Lucay Islands. Some of the Lesser Antillas are flat, but their general character is bold, with a single mountain or group of mountains in the centre, which slopes to the sea all around, more precipitously on the eastern side, which is exposed to the force of the Atlantic current. Trinidad is the most southerly of a line of magnificent islands, which form a semicircle, enclosing the Caribbean Sea, with its convexity facing the east. The row is single to the island of Guadaloupe, where it splits into two chains, known as the Windward and Leeward Islands. Trinidad, Tobago, St. Lucia, and Dominica are particularly mountainous, and the mountains are cut by deep narrow ravines, or gullies, covered by ancient forests. The volcanic islands, which are mostly in the single part of the chain, have conical mountains bristled with rocks of a still more rugged form; but almost all the islands of the Lesser Antillas have a large portion of excellent vegetable soil in a high state of cultivation. Most of them are surrounded by coral reefs, which render navigation dangerous, and there is little intercourse between these islands, and still less with the Greater Antillas, on account of the prevailing winds and currents, which make it difficult to return. The Lesser Antillas terminate with the group of the Virgin Islands, which are small and flat, some only a few feet above the sea, and most of them are mere coral rocks.

The four islands which form the group of the Greater Antillas are the largest and finest in the Archipelago. Porto Rico, Haiti or San Domingo, and Jamaica, separated from the Virgin Islands by a narrow channel, lie in a line parallel to the coast-chain of Venezuela, from east to west; while Cuba, by a serpentine bend, separates the Caribbean Sea, or Sea of the Antillas, from the Gulf of Mexico. Porto Rico is 90 miles long and 36 broad, with wooded mountains passing through its centre nearly from east to west, which furnish abundance of water. There are extensive savannahs in the interior, and very rich soil on the northern coast, but the climate near the sea is unhealthy.

Haiti or San Domingo, 340 miles long and 132 broad, has a chain of mountains in its centre, extending from east to west like all the mountains in the Greater Antillas, the highest point of which is 9000 feet above the sea. A branch diverges from the main stem to Cape Tiburon, so that Haiti contains a great proportion of high land. The mountains are susceptible of cultivation nearly to the summit, and are clothed with undisturbed tropical forests. The extensive plains are well watered, and the soil, though not deep, is productive.

Jamaica, the most valuable of the British possessions in the West Indies, has an area of 4256 square miles, of which 110,000 acres are cultivated, chiefly as sugar-plantations. The principal chain of the Blue Mountains lies in the centre of the island, from east to west, with so sharp a crest that in some places it is only four yards across. The offsets from it cover all the eastern part of the island; some of them are very high. The more elevated ridges are flanked by lower ranges, descending to verdant savannahs. The escarpments are wild, the declivities steep, and mingled with stately forests. The valleys are very narrow, and not more than a twentieth part of the island is level ground. There are many small rivers, and the coast-line is 500 miles long, with at least 30 good harbours. The mean summer-heat is 80° of Fahrenheit, and that of winter is 75°. The plains are often unhealthy, but the air in the mountains is salubrious; fever has never prevailed at the elevation of 2500 feet.

Cuba, the largest island in the Colombian Archipelago, has an area of 3615 square leagues, and 200 miles of coast, but so beset with coral reefs, sandbanks, and rocks, that only a third of it is accessible. Its mountains, which attain the height of 8000 feet, occupy the centre and fill the eastern part of the island, in a great longitudinal line. No island in these seas is more important with regard to situation and natural productions; and although much of the low ground is swampy and unhealthy, there are vast savannahs, and about a seventh part of the island is cultivated.

The Bahama Islands are the least valuable and least interesting part of the Archipelago. The group consists of about 500 islands, many of them mere rocks, lying east of Cuba and the coast of Florida. Twelve are rather large, and are cultivated; and though arid, they produce Campeche or log-wood and mahogany. The most intricate labyrinth of shoals and reefs, chiefly of corals, madrepores, and sand, encompass these islands; some of them rise to the surface, and are adorned with groves of palm-trees. The Great Bahama is the first part of the New World on which Columbus landed—the next was Haiti, where his ashes rest.

The geology of Central America is little known; nevertheless it appears, from the confused mixture of table-lands and mountain-chains in all directions, that the subterraneous forces must have acted more partially and irregularly than either in South or North America. Granite, gneiss, and mica-slate form the substrata of the country; but the abundance of igneous rocks bears witness to strong volcanic action, both in ancient and in modern times, which still maintains its activity in the volcanic groups of Guatemala and Mexico.

From the identity of the fossil remains of extinct quadrupeds, there is every reason to believe that the West Indian Archipelago was once part of South America, and that the rugged and tortuous isthmus of Central America, and the serpentine chain of islands winding from Cumana to the peninsula of Florida, are but the shattered remains of an unbroken continent. The powerful volcanic action in Central America and Mexico, the volcanic nature of many of the West Indian islands, and the still-existing fire in St. Vincent's, together with the tremendous earthquakes to which the whole region is subject, render it more than probable that the Caribbean Sea and the Gulf of Mexico are one great area of subsidence, which possibly has been increased by the erosion of the Gulf-stream and ground-swell—a temporary current of great impetuosity, common among the West Indian islands from October to May.

The subsidence of this extensive area must have been very great, since the water is of considerable depth between the islands, and it must have taken place after the destruction of the great quadrupeds, and consequently at a very recent geological period. The elevation of the table-land of Mexico may have been a contemporaneous event. In the Colombian Archipelago, volcanic action is confined to the smaller islands, which, forming a line in a meridional direction, extend from 12° to 18 N., and which may be designated as the Caribbean range: it commences with Grenada and ceases with St. Eustatius. St. Vincent, St. Lucia, Martinique, a great portion of Guadaloupe, Montserrat, Nevis, and St. Kitts are volcanic; most of them possess craters recently extinct, which have vomited ashes and lava within historical periods; whilst the less elevated of the Leeward and Windward Islands, Tobago, Barbadoes, Deseada, Antigua, Barbuda and St. Bartholomew's, with the Virgin Islands and Bahamas, are composed either of calcareous or coral rocks.

CHAPTER XI.

North America — Table-Land and Mountains of Mexico — The Rocky Mountains — The Maritime Chain and Mountains of Russian America.

According to the natural division of the continent, North America begins about the 20th degree of north latitude, and terminates in the Arctic Ocean. It is longer than South America, but the irregularity of its outline renders it impossible to estimate its area. Its greatest length is about 3100 miles, and its breadth, at the widest part, is 3500 miles.

The general structure of North America is still more simple than that of the southern part of the continent. The table-land of Mexico and the Rocky Mountains, which are the continuation of the high land of the Andes, run along the western side, but at so great a distance from the Pacific as to admit of another system of mountains along the coast. The immense plains to the east are divided longitudinally by the Alleghanny Mountains, which stretch from the Carolinas to the Gulf of St. Lawrence, parallel to the Atlantic, and at no great distance from it. Although the general direction of the mountains is from south to north, yet, as they maintain a degree of parallelism to the two coasts, they diverge towards the north—one inclining towards the north-west, and the other towards the north-east. The long narrow plain between the Atlantic and the Alleghannies is divided, throughout its length, by a line of cliffs not more than 200 or 300 feet above the Atlantic plain, the outcropping edge of the Second Terrace, or Atlantic Slope, whose rolling surface goes west to the foot of the mountains.

An enormous table-land occupies the greater part of Mexico or Anahuac. It begins at the Isthmus of Tehuantepec, and extends north-west to the 42nd parallel of north latitude, a distance of about 1600 miles, which is nearly equal to the distance from the north extremity of Scotland to Gibraltar. It is narrow towards the south, and expands towards the north-west till about the latitude of the city of Mexico, where it attains its greatest breadth of 360 miles, and there also it is highest. The most easterly part in that parallel is 7500 feet above the sea, from whence it rises towards the west to the height of 7430 feet at the city of Mexico, and then gradually diminishes to 4000 feet towards the Pacific.

Its height in California is not known, but it still bears the character of a table-land, and maintains an elevation of 6000 feet along the east side of the Sierra Madre, even to the 32nd degree of north latitude, where it sinks to a lower level before joining the Rocky Mountains. The descent from this plateau to the low lands is very steep on all sides; on the east, especially, it is so precipitous that, seen from a distance, it is like a range of high mountains. There are only two carriage-roads to it from the Mexican Gulf, by passes 500 miles asunder—one at

Xalapa, near Vera Cruz, the other at Santilla, west of Monterey. The descent to the shores of the Pacific is almost equally rapid, and that to the south no less so, where, for 300 miles between the plains of Tehuantepec and the Rio Yopez, it presses on the shores of the Pacific, and terminates in high mountains, leaving only a narrow margin of hilly maritime coast. Where the surface of the table-land is not traversed by mountains, it is as level as the ocean. There is a carriage-road over it for 1500 miles, without hills, from the city of Mexico to Santa Fé.

The southern part of the plateau is divided into four parts or distinct plains, surrounded by hills from 500 to 1000 feet high. In one of these, the plain of Tenochtitlan, surrounded by a wall of porphyritic mountains, stands the city of Mexico, once the capital of the empire of Montezuma, which must have far surpassed the modern city in extent and splendour, as many remains of its ancient glory testify. It is 7430 feet above the sea.

One of the singular crevices through which the internal fire finds a vent, stretches from the Gulf of Mexico to the Pacific, directly across the table-land, in a line about 16 miles south of the city of Mexico. A very remarkable row of active volcanos occurs along this parallel; Tuxtla, the most eastern of them, is in the 95th degree of west longitude, near the Mexican Gulf, in a low range of wooded hills. More to the west stands the snow-shrouded cone of Orizaba, with its ever-fiery crater, seen like a star in the darkness of the night, which has obtained it the name of Cittalapetl — the "Mountain of the Star." Popocatepetl, the loftiest mountain in Mexico, 17,884 feet above the sea, lies still farther west, and is in a state of constant eruption, which, with the peaks of Iztacihuatl and of Toluca, form a kind of volcanic circus in the midst of which the city of Mexico and its lake are situated. A chain of smaller volcanos unites the three. On a plain on the western slope of the table-land, and about 70 miles in a straight line from the Pacific, is the volcanic cone of Jorullo.[1] It suddenly appeared, and rose 1683 feet above the plain, on the night of the 29th of September, 1759, and is the highest of six mountains which have been thrown up on this part of the table-land since the middle of last century. The great cone of Colima, the last of this volcanic series, stands insulated in the plain of that name, between the western declivity of the table-land and the Pacific.

A high range of mountains extends along the eastern margin of the table-land to the Real de Catorce, and the surface of the plain is divided into two parts by the Sierra Madre, which begins at 21° of N. lat.; and, after running north about 60 miles, its continuity is broken into the insulated ridges of the Sierra Altamina, and the group containing the celebrated silver-mines of Fresnillo and Zacatecas: it soon after resumes its character of a regular chain, and, with a breadth of 100 miles, proceeds in parallel ridges

[1] Baron Humboldt.

and longitudinal valleys to New Mexico, where it skirts both banks of the Rio Bravo del Norte, and joins the Sierra Verde, the most southern part of the Rocky Mountains, in 40° of N. lat.

To the south, some points of the Sierra Madre are said to be 10,000 feet high and 4000 feet above their base; and between the parallels of 36° and 42°, where the chain is the watershed between the Rio Colorado and the Rio Bravo del Norte, they are still higher, and perpetually covered with snow. The mountains on the left bank of the last-mentioned river are the eastern ridges of the Sierra Madre, and contain the sources of the innumerable affluents of the Missouri and other rivers that flow into the Mississippi and Mexican Gulf.

Deep cavities, called Barancas, are a characteristic feature of the table-lands of Mexico: they are long rents, two or three miles in breadth, and many more in length, often descending 1000 feet below the surface of the plain, with a brook or the tributary of some river flowing through them. Their sides are precipitous and rugged, with overhanging rocks covered with large trees. The intense heat adds to the contrast between these hollows and the bare plains, where the air is more cool.

Vegetation varies with the elevation; consequently the splendour which adorns the low lands vanishes on the high plains, which, though producing much grain and pasture, are often saline, sterile, and treeless, except in some places where oaks grow to an enormous size, free of underwood.

The Rocky Mountains run 1500 miles in two parallel chains from the Sierra Verde to the mouth of the Mackenzie river in the Arctic Ocean, sometimes united by a transverse ridge. In some places the eastern range rises to the snow-line, and even far above it, as in Mounts Hooper and Brown; but the general elevation is only above the line of trees. The western range is not so high till north of the 55th parallel, where both ranges are of the same height, and frequently higher than the snow-line. They are generally barren, though the transverse valleys have fertile spots with grass, and sometimes trees. Their only offset in the south is the Saba and Ozark mountains, which run through Texas to the Mississippi. The long valley between the two rows of the Rocky Mountains, which is 100 miles wide, must have considerable elevation in the south, since the tributaries of the Colombia river descend from it in a series of rapids and cataracts for nearly 100 miles; and it is probably still higher towards the sources of the Peace river, where the mountains, only 1500 feet above it, are perpetually covered with snow. The Sierra Verde is 490 miles from the Pacific, but, as the coast trends due north to the Sound of Juan de Fuca, the western range of the Rocky Mountains maintains a distance of 380 miles from the ocean, from that point to the latitude of Behring's Sea, in 60° of N. lat.

The mountains on the west coast consist of two chains, one of which, beginning in Mexico, about the same latitude with the Sierra Madre, skirts the Gulf of California on the east, and maintains rather an inland course till north of the Oregon river, where it forms the Sea Alps of the coast; and then, increasing in breadth as it passes through Russian America, it ends at Nootka Sound.

The other chain, known as the Sea Alps of California, begins at the extremity of the peninsula, and, running northward with increasing height close to the Pacific, it passes through the island of Quadra and Vancouver, and, after joining the Alps of the north-west coast, it terminates at Mount St. Elias, which is 17,860 feet high. A range of very high snowy mountains, which begins at Cape Mendocino, goes directly across both of these coast-chains, and unites them to the Rocky Mountains. It forms the watershed between the Colorado, which goes to the Gulf of California, and the affluents of the Oregon or Colombia river, which flows into the Pacific, and is continued to the east of the Rocky Mountains, at a less elevation, under the name of the Black Mountains, which stretch to the Missouri. Prairies extend between this coast-chain and the Rocky Mountains from California to the north of the Oregon river. The Oregon coast, for 200 miles, is a mass of undisturbed forest-thickets and marshes; and north from it, with few exceptions, is a mountainous region of bold aspect, often reaching above the snow-line. A branch of the Sea Alps, which runs westward to Bristol Bay, has many active volcanos, and so has that which fills the promontory of Aliaska.

The archipelagos and islands along the coast, from

California to the promontory of Aliaska, have the same bold character as the mainland, and may be regarded as the tops of a submarine chain of table-lands and mountains which constitute the most westerly ridge of the maritime chains. Prince of Wales's Archipelago contains seven active volcanos.

The mountains on the coasts of the Pacific and the islands are in many places covered with colossal forests, but wide tracts in the south are sandy deserts.

CHAPTER XII.

North America, continued — The Great Central Plains, or Valley of the Mississippi — The Alleghanny Mountains — The Atlantic Slope — The Atlantic Plain — Geological Notice — The Mean Height of the Continents.

THE great central plain of North America, lying between the Rocky and Alleghanny Mountains, and reaching from the Gulf of Mexico to the Arctic Ocean, includes the valleys of the Mississippi, St. Lawrence, Nelson, Churchill, and most of those of the Missouri, Mackenzie, and Coppermine rivers. It has an area of 3,245,000 square miles, which is 245,000 square miles more than the central plain of South America, and about half the size of the great plain of the old continent, which is less fertile; for although the whole of America is not more than half the size of the old continent, it contains at least as much productive soil.

The plain, 5000 miles long, becomes wider towards the north, and has no elevations, except a low table-land which crosses it at the line of the Canadian lakes and the sources of the Mississippi, and is nowhere above 1500 feet high, and rarely more than 700: it is the watershed between the streams that go to the Arctic Ocean and those that flow to the Mississippi. The character of the plain is that of perfect uniformity, rising by a gentle regular ascent from the Gulf of Mexico to the sources of the Mississippi, which river is the great feature of the North American low lands. The ground rises in the same equable manner from the right bank of the Mississippi to the foot of the Rocky Mountains, but its ascent from the left bank to the Alleghannies is broken into hill and dale, containing the most fertile territory in the United States. Under so wide a range of latitude the plain embraces a great variety of soil, climate, and productions; but, being almost in a state of nature, it is characterized in its middle and southern parts by interminable grassy savannahs, or prairies, and enormous forests, and in the far north by deserts which rival those of Siberia in dreariness.

In the south a sandy desert, 400 or 500 miles wide, stretches along the base of the Rocky Mountains to the 41st degree of N. lat. The dry plains of Texas and the upper region of the Arkansas have all the characteristics of Asiatic table-lands; more to the north the bare treeless steppes on the high grounds of the far west are burnt up in summer, and frozen in winter by biting blasts from the Rocky Mountains; but the soil improves towards the Mississippi. At its mouth, indeed, there are marshes which cover 35,000 square miles, bearing a rank vegetation, and its delta is a labyrinth of streams and lakes, with dense brushwood. There are also large tracts of forest and saline ground, especially the Grand Saline between the rivers Arkansas and Neseikelongo, which is often covered two or three inches deep with salt like a fall of snow. All the cultivation on the right bank of the river is along the Gulf of Mexico and in the adjacent provinces, and is entirely tropical, consisting of sugar-cane, cotton, and indigo. The prairies, so characteristic of North America, then begin.

To the right of the Mississippi these savannahs are sometimes rolling, but oftener level, and interminable as the ocean, covered with long rank grass of tender green, blended with flowers chiefly of the liliaceous kind, which fill the air with their fragrance. In the southern districts they are sometimes interspersed with groups of magnolia, tulip, and cotton trees; and in the north with oak and black walnut. These are rare occurrences, as the prairies may be traversed for many days without finding a shrub, except on the banks of the streams, which are beautifully fringed with myrtles, azaleas, kalmias, andromedas, and rhododendrons. On the wide plains the only objects to be seen are countless herds of wild horses, bisons, and deer. The country assumes a more severe aspect in higher latitudes. It is still capable of producing rye and barley in the territories of the Assinaiboia Indians, and round Lake Winnepeg there are great forests; a low vegetation with grass follows, and towards the Icy Ocean the land is barren and covered with numerous lakes.

East of the Mississippi there is a magnificent undulating country about 300 miles broad, extending 1000 miles from south to north between that great river and the Alleghanny mountains, mostly covered with trees. When America was discovered, one uninterrupted forest spread over the country, from the Gulf of St. Lawrence and the Canadian lakes to the Gulf of Mexico, and from the Atlantic Ocean it crossed the Alleghanny mountains, descended into the valley of the Mississippi on the north, but on the south it crossed the main stream of that river altogether, forming an ocean of vegetation of more than 1,000,000 of square miles, of which the greater part still remains. Although forests occupy so much of the country, there are immense prairies on the east side of the river also. Pine barrens, stretching far into the interior, occupy the whole coast of the Mexican Gulf eastward from the Pearl river, through Alabama and a great part of Florida.

These vast monotonous tracts of sand, covered with forests of gigantic pine-trees, are as peculiarly a distinctive feature of the continent of North America as the prairies, and are not confined to this part of the United States; they occur to a great extent in North Carolina, Virginia, and elsewhere. Tenessee and Kentucky, though much cleared, still possess large forests, and the Ohio flows for hundreds of miles among magnificent trees, with an undergrowth of azaleas, rhododendrons, and other beautiful shrubs, matted together by creeping plants. There the American forests appear in all their glory: the gigantic deciduous cypress, and the tall tulip-tree, overtopping the forest by half its height, a variety of noble oaks, black walnuts, American plane, hickory, sugar-maple, and the lyreodendron, the most splendid of the magnolia tribe, the pride of the forest.

The Illinois waters a country of prairies ever fresh and green, and five new states are rising round the great lakes, whose territory of 280,000 square miles contains 180,000,000 of acres of land of excellent quality. These states, still mostly covered with wood, lie between the lakes and the Ohio, and they reach from the United States to the Upper Mississippi—a country twice as large as France, and six times the size of England.

The quantity of water in the north-eastern part of the central plain greatly preponderates over that of the land; the five principal lakes, Huron, Superior, Michigan, Erie, and Ontario, cover an area equal to Great Britain, without reckoning small lakes and rivers innumerable.

The Canadas contain millions of acres of good soil, covered with immense forests. Upper Canada is the most fertile, and in many respects is one of the most valuable of the British colonies in the west: every European grain, and every plant that requires a hot summer and can endure a cold winter, thrives there. The forest consists chiefly of black and white spruce, the Weymouth and other pines—trees which do not admit of undergrowth: they grow to great height, like bare spars, with a tufted crown, casting a deep gloom below. The fall of large trees from age is a common occurrence, and not without danger, as it often causes the destruction of those adjacent; and an ice-storm is awful.

After a heavy fall of snow, succeeded by rain and a partial thaw, a strong frost coats the trees and all their branches with transparent ice often an inch thick; the noblest trees bend under the load, icicles hang from every bough, which come down in showers with the least breath of wind. The hemlock-spruce especially, with its long drooping branches, is then like a solid mass. If the wind freshens, the smaller trees become like corn beaten down by the tempest, while the large ones swing heavily in the breeze. The forest at last gives way under its load, tree comes down after tree with sudden and terrific violence, crushing all before them, till the whole is one wild uproar, heard from afar like successive discharges of artillery. Nothing, however, can be imagined more brilliant and beautiful than the effect of sunshine in a calm day on the frozen boughs, where every particle of the icy crystals sparkles, and nature seems decked in diamonds.[1]

Although the subsoil is perpetually frozen at the depth of a few feet below the surface beyond the 56th degree of north latitude, yet trees grow in some places up to the 64th parallel. Farther north the gloomy and majestic forests cease, and are succeeded by a bleak, barren waste, which becomes progressively more dreary as it approaches the Arctic Ocean. Four-fifths of it are like the wilds of Siberia in surface and climate, covered many months in the year with deep snow. During the summer it is the resort of herds of rein-deer and bisons, which come

[1] Mr. Taylor.

from the south to browse on the tender short grass which then springs up along the streams and lakes.

The Alleghanny or Appalachian chain, which constitutes the second or subordinate system of North American mountains, separates the great central plain from that which lies along the Atlantic Ocean. Its base is a strip of table-land, from 1000 to 3000 feet high, lying between the sources of the rivers Alabama and Yazan, in the southern states of the Union, and New Brunswick, at the mouth of the river St. Lawrence. This high land is traversed throughout 1000 miles, between Alabama and Vermont, by from three to five parallel ridges of low mountains, rarely more than 3000 or 4000 feet high, and separated by fertile longitudinal valleys, which occupy more than two-thirds of its breadth of 100 miles. In Virginia and Pennsylvania, the only part of the chain to which the name of the Alleghanny mountains properly belongs, it is 150 miles broad, and the whole is computed to have an area of 2,000,000 of square miles. The parallelism of the ridges, and the uniform level of their summits, are the characteristics of this chain, which is lower and less wild than the Rocky Mountains. The uniformity of outline in the southern and middle parts of the chain is very remarkable, and results from their peculiar structure.[1] These mountains have no central axis, but consist of a series of convex and concave flexures, forming alternate hills and longitudinal valleys, running nearly parallel through-

[1] Sir Charles Lyell's Travels in North America.

out their length, and cut transversely by the rivers that flow to the Atlantic on one hand, and to the Mississippi on the other. The watershed nearly follows the windings of the coast from the point of Florida to the north-western extremity of the State of Maine.[1]

The picturesque and peaceful scenery of the Appalachian mountains is well known; they are generally clothed with a luxuriant vegetation, and their western slope is considered one of the finest countries in the United States. To the south they maintain a distance of 200 miles from the Atlantic, but approach close to the coast in the south-eastern part of the State of New York, from whence their general course is northerly to the river St. Lawrence. But the Blue Mountains, which form the most easterly ridge, are continued in the double range of the Green Mountains to Gaspé Point in the Gulf of St. Lawrence. They fill the Canadas, Maine, New Brunswick, and Nova Scotia with branches as high as the mean elevation of the principal chain, and extend

[1] A chain of mountains is assumed to be a three-sided horizontal prism, whose height is the mean elevation of the chain, and the base the mean length and breadth of the same, or the area on which the chain stands, and thus its mass may be computed approximately. It is evident that a table-land must have a greater effect on the mean height of a continent than a chain of mountains, for, supposing both to be of the same base and altitude, one would be exactly double the other; and even if the mountains be the higher of the two, their upper parts contain much less solid matter than their lower on account of the intervals and deep valleys between the peaks.

even to the dreary regions of Baffin's Bay. The chief Canadian branches are parallel to the river St. Lawrence. One goes N.E. from Quebec; and the Mealy Mountains, which are of much greater length, extend from Ottowa River to Sandwich Bay, and, though low, are always covered with snow. Little is known of the high lands within the Arctic Circle, except that they probably extend from S.E. to N.W.

The country between Hudson's Bay, the mouths of the Churchill and that of the Mackenzie river, is also an unknown region; on the east it descends steeply to the coast, but the western part, known as the Barren Ground, is low and destitute of wood, except on the banks of the streams. The whole is covered with low precipitous hills. Not only the deep forests, but vegetation in general, diminishes as the latitude increases, till on the arctic shores the soil becomes incapable of culture, and the majestic forest is superseded by the arctic birch, which creeps on the ground. Many of the islands along the north-eastern coasts, though little favoured by nature, produce flax and timber; and Newfoundland, as large as England and Wales, maintains a population of 70,000 souls by its fisheries: it is nearer to Britain than any part of America—the distance from the port of St. John to the harbour of Valentia in Ireland is only 1656 nautical miles.

The long and comparatively narrow plain which lies between the Appalachian mountains and the Atlantic extends from the Gulf of Mexico to the eastern coast of Massachusetts. At its southern extremity it joins the plain of the Mississippi, and gradually becomes narrower in its northern course to New England, where it merely includes the coast islands. It is divided throughout its length by a line of cliffs from 200 to 300 feet high, which begins in Alabama and ends on the coast of Massachusetts. This escarpment is the eastern edge of the terrace known as the Atlantic Slope, which rises above the Maritime or Atlantic Plain, and undulates westward to the foot of the Blue Mountains, the most eastern ridge of the Appalachian chain. It is narrow at its extremities in Alabama and New York, but in Virginia and the Carolinas it is 200 miles wide. The surface of the slope is of great uniformity; ridges of hills and long valleys run along it parallel to the mountains, close to which it is 600 feet high. It is rich in soil and cultivation, and has an immense water-power in the streams and rivers flowing from the mountains across it, which are precipitated over its rocky edge to the plains on the west. More than twenty-three rivers of considerable size fall in cascades down this ledge between New York and the Mississippi, affording scenes of great beauty.[1]

Both land and water assume a new aspect on the Atlantic Plain. The rivers, after dashing over the rocky barrier, run in tranquil streams to the ocean, and the plain itself is a monotonous level, not more

[1] The author is indebted to the 'Physical Geography of North America,' by H. D. Rogers, Esq., of the United States, for much valuable information.

than 100 feet above the surface of the sea. Along the coast it is scooped into valleys and ravines, with innumerable creeks.

The greater part of the magnificent countries east of the Alleghannies is in a high state of cultivation and commercial prosperity, with natural advantages not surpassed in any country. Nature, however, still maintains her sway in some parts, especially where pine-barrens and swamps prevail. The territory of the United States occupies 7,000,000 or 8,000,000 of square miles, the greater part of which is capable of producing everything that is useful to man, but not more than a twenty-sixth part of it has been cleared. The climate is generally healthy, the soil fertile, abounding in mineral treasures, and it possesses every advantage from navigable rivers and excellent harbours. The outposts of civilization have already advanced half-way to the Pacific, and the tide of white men is continually and irresistibly pressing onwards to the ultimate extinction of the original proprietors of the soil—a melancholy, but not a solitary, instance of the rapid extinction of a whole race.

Crystalline and Silurian rocks, rich in precious and other metals, form the substratum of Mexico, for the most part covered with plutonic and volcanic formations and secondary limestone; yet granite comes to the surface on the coast of Acapulco, and occasionally on the plains and mountains of the table-land. The Rocky Mountains are mostly Silurian, except the eastern ridge, which is of stratified crystalline rocks, amygdaloid and ancient volcanic productions. The coast-chain has the same character, with immense tracts of volcanic rocks, both ancient and modern, especially obsidian, which is nowhere developed on a greater scale, except in Mexico and the Andes.

In North America, as in the southern part of the continent, volcanic action is entirely confined to the coast and high land along the Pacific. The numerous vents in Mexico and California are often in great activity, and hot springs abound. Though a considerable interval occurs north of them, where the fire is dormant, the country is full of igneous productions, and it again finds vent in Prince of Wales's Archipelago, which has seven active volcanos. From Mount St. Elias westward through the whole southern coast of the peninsula of Russian America and the Aleutian Islands, which form a semicircle between Cape Aliaska, in America, and the peninsula of Kamtchatka, volcanic vents occur, and in the latter peninsula there are three of great height.

From the similar nature of the coasts and the identity of the fossil mammalia on each side of Behring's Strait, it is more than probable that the two continents were united, even since the sea was inhabited by the existing species of shell-fish. Some of the gigantic quadrupeds of the old continent are supposed to have crossed, either over the land or over the ice, to America; and to have wandered southward through the longitudinal valleys of the

Rocky Mountains, Mexico, and Central America, and to have spread over the vast plains of both continents, even to their utmost extremity.[1] An extinct species of horse, the mastodon, a species of elephant, three gigantic edentata, and a hollow-horned ruminating animal roamed over the prairies of North America—certainly since the sea was peopled by its present inhabitants, probably even since the existence of the Indians. The skeletons of these creatures are found in great numbers in the saline marshes on the prairies called the Licks, which are still the resort of the existing races.[2]

There were, however, various animals peculiar to America, as well as to each part of that continent, at least as far as yet known. South America still retains in many cases the type of its ancient inhabitants, though on a very reduced scale. But on the Patagonian plains, and on the Pampas, skeletons of creatures of gigantic size and anomalous forms have been found, one like an anteater of great magnitude, covered with a prodigious coat of mail similar to that of the armadillo; others like rats or mice, as large as the hippopotamus—all of which had lived on vegetables, and had existed at the same time with those already mentioned. These animals were not destroyed by the agency of man, since creatures not larger than a rat vanished from Brazil within the same period.

1 Dr. Richardson on the Fauna of the High Latitudes of North America.

2 Sir Charles Lyell.

The geological outline of the United States, the Canadas, and all the country of the Polar Ocean, though highly interesting in itself, becomes infinitely more so when viewed in connection with that of northern and middle Europe. A remarkable analogy exists in the structure of the land on each side of the North Atlantic basin. Gneiss, mica-schist, and occasional granite, prevail over wide areas in the Alleghannies, on the Atlantic Slope, and still more in the northern latitudes of the American continent; and they range also through the greater part of Scandinavia, Finland, and Lapland. In the latter countries, and in the more northern parts of America, Sir Charles Lyell has observed that the fossiliferous rocks belong either to the most ancient or to the newest formations[1], to the Silurian strata, or to such as contain shells of recent species only, no intermediate formation appearing through immense regions. Silurian strata extend over 2000 miles in the middle and high latitudes of North America; they occupy a tract nearly as great between the most westerly headlands of Norway and those that separate the White Sea from the Polar Ocean; and Sir Roderick Murchison has traced them through central and eastern Europe, and the Ural Mountains, even to Siberia. Throughout these vast regions, both in America and Europe, the Silurian strata are followed

[1] This remarkable analogy between the fossil remains of the Silurian systems in the Old and New World has been more particularly shown by the researches of Messrs. de Verneuil and Sharpe.

in ascending order by the Devonian and carboniferous formations, which are developed on a stupendous scale in the United States, chiefly in the Alleghanny mountains and on the Atlantic Slope. The Devonian and carboniferous strata together are a mile and a half thick in New York, and three times as much in Pennsylvania, where one single coal-field occupies 63,000 square miles between the northern limits of that state and Alabama. There are many others of great magnitude, both in the States and to the north of them, so that most valuable of all minerals is inexhaustible, which is not the least of the many advantages enjoyed by that flourishing country. The coal formation is also developed in New Brunswick, and traces of it are found on the shores and in the islands of the Polar Ocean, on the east coast of Greenland, and even in Spitzbergen.

Vast carboniferous basins exist in Belgium, above the Silurian strata; and a great portion of Britain is perfectly similar in structure to North America. The Silurian rocks in many instances are the same, and the coalfields of New England are precisely similar to those in Wales, 3000 miles off.

In all the more northern countries that have been mentioned, so very distant from one another, the general range of the rocks is from north-east to south-west; and in northern Europe, the British isles, and North America, great lakes are formed along the junction of the strata, the whole analogy affording a proof of the wide diffusion of the same geological conditions in the northern regions at a very remote period. At a later time those erratic blocks, which are now scattered over the higher latitudes of both continents, were, most likely, brought from the north by drift ice or currents, while the land was still covered by the deep. Volcanic agency has not been wanting to complete the analogy. The Silurian and overlying strata have been pierced in many places by trappean rocks on both continents, and they appear also in the islands of the North Atlantic and Polar Seas. Even now the volcanic fires are in great activity in the very centre of that basin in Iceland, and in the very distant and less-known island of Jan Meyen.

The average height of the continents above the level of the sea is the mean between the height of all the high lands and all the low. Baron Humboldt, by whom the computation was effected, found that the table-lands, with their slopes, on account of their great extent and mass, have a much greater influence upon the result than mountain-chains. For example, if the range of the Pyrenees were pulverized, and strewed equally over the whole of Europe, it would only raise the soil 6 feet; the Alps, which occupy an area four times as great as that on which the Pyrenees stand, would only raise it 22 feet; whereas the compact plateau of the Spanish peninsula, which has only 1920 feet of mean height, would elevate the soil of Europe 76 feet; so that the table-land of the Spanish peninsula would produce an effect four times as great as the whole system of the Alps.

A great extent of low land necessarily compensates for the high—at least it diminishes its effect. The mean elevation of France, including the Pyrenees, Juras, Vosges, and all the other French mountains, is 870 feet, while the mean height of the whole European continent, of 1,720,000 square miles, is only 670 feet, because the vast European plain, which is nine times as large as France, has a mean altitude of but 380 feet, although it has a few intumescences, which, however, are not much above 1000 feet high, so that it is 200 feet lower than the mean height of France.[1]

The great table-land of Eastern Asia, with its colossal mountain-chains, has a much less effect on the mean height of Asia than might have been expected, on account of the depression round the Caspian Sea; and still more from the very low level and the enormous extent of Siberia, which is a third larger than all Europe. The intumescences in these vast plains are insignificant in comparison with their vast area, for Tobolsk is only 115 feet above the level of the sea; and even on the Upper Angora, at a point nearer the Indian than the Arctic Sea, the elevation is only 830 feet, which is not half the height of the city of Munich, and the third part of Asia has

[1] According to M. Charpentier, the area of the base of the Pyrenees is 1720 square English miles. As the mean elevation of the passes gives the mean height of the mountains, Baron Humboldt estimated from the height of 23 passes over the Pyrenees that the mean crest of that chain is 7990 feet high, which is 300 feet higher than the mean height of the Alps, though the peaks in the Alps have a greater elevation than those of the Pyrenees in the ratio $1\frac{4}{10}$ to 1.

a mean height of only 255 feet. The effect of the Great Gobi, that part of the table-land lying between Lake Baikal and the wall of China, is diminished by a vast hollow 2560 feet deep, the dry basin of an ancient sea of considerable extent near Ergé, so that this great desert has a mean height of but 4220 feet, and consequently it only raises the centre of gravity of the Asiatic continent 128 feet, though it is twice as large as Germany. The table-land of Tibet, whose mean elevation, according to Baron Humboldt, is 11,600 feet, together with the chains of the Himalaya and Kuen-lun, which enclose it, only produces an effect of 358 feet. On the whole the mean level of Asia above the sea is 1150 feet.[1]

Notwithstanding the height and length of the Andes, their mass has little effect on the continent of South America on account of the extent of the eastern plains, which are exactly one-third larger than Europe. For if these mountains were reduced to powder, and strewn equally over them, it would not raise them above 518 feet; but when the minor mountain systems and the table-land of Brazil are added to the Andes, the mean height of the whole of South America is 1130 feet. North America, whose mountain-chains are far inferior to those in the

[1] The Russian Academicians MM. Fuss and Bunge found by barometrical measurement the mean height of that part of the Eastern Asiatic table-land lying between Lake Baikal and the Great Wall of China to be only about 6960 feet. The smallness of this mean is owing to hollows in the table-land, especially in the desert of the Great Gobi.

southern part of the continent, has its mean elevation increased by the table-land of Mexico, so that it has 750 feet of mean height.

The mean elevation of the whole of the New World is 930 feet, and the height of the centre of gravity of all the continental masses above the level of the sea, Africa excepted, is 1010 feet. Thus it appears that the internal action in ancient times has been most powerful under Asia, somewhat less under South America, considerably less under North America, and least of all under Europe. In the course of ages changes will take place in these results, on account both of the sudden and gradual rise of the land in some parts of the earth, and its depression in others. The continental masses of the north are the lowest portions of our hemisphere, since the mean heights of Europe and North America are 670 and 750 feet.[1]

[1] By the mensuration and computation of Baron Humboldt and Mr. Pentland, the elevation of the highest peaks, and the mean heights of the Himalaya, of the Equatorial and Bolivian Andes and the Alps, are as follows:—

	Peaks.	Mean Height.
Himalaya	25,700	15,670
Andes between 5° N. and 2° S. lat.	21,420	11,380
Eastern Cordillera (Between 18° and 15° S. lat.)	21,200	15,250
Western Cordillera (Between 18° and 15° S. lat.)	22,300	14,900
Alps	15,666	7,353

However, the Peak of Dhawalaghini is certainly 28,000 feet high. Captain Gerard gives 18,000 or 19,000 feet as the height of the snow-line on the mountains in the middle of the Asiatic table-land, and 30,000 feet as the absolute elevation of the Kuen-lun, but Colonel Sabine observes that these measures want confirmation.

So little is known of the bed of the ocean that no inference can be drawn with regard to its heights and hollows, and what relation its mean depth bears to the mean height of the land. From its small influence on the gravitating force, La Place assumed it to be about four miles. As the mean height of the continents is about 1000 feet, and their extent only about a fourth of that of the sea, they might be easily submerged, were it not that, in consequence of the sea being only one-fifth of the mean density of the earth, and the earth itself increasing in density towards its centre, La Place has proved that the stability of the equilibrium of the ocean can never be subverted by any physical cause: a general inundation from the mere instability of the ocean is therefore impossible.

CHAPTER XIII.

The Continent of Australia — Tasmania, or Van Diemen's Land — Islands — Continental Islands — Pelasgic Islands — New Zealand — New Guinea — Borneo — Atolls — Encircling Reefs — Coral Reefs — Barrier Reefs — Volcanic Islands — Areas of Subsidence and Elevation in the Bed of the Pacific — Active Volcanos — Earthquakes — Secular Changes in the Level of the Land.

THE continent of New Holland, situate in the Eastern Pacific Ocean, is so destitute of large navigable rivers that probably no very high land exists in its interior, which, as far as it has been explored, seems to be singularly flat and low, but it is still so little known that no idea can be formed of its mean elevation. It is 2400 miles from east to west, and 1700 from north to south, and is divided into two unequal parts by the Tropic of Capricorn; consequently it has both a temperate and a tropical climate. New Guinea, separated from New Holland by Torres Straits, and traversed by the same chain of mountains with New Holland and Van Diemen's Land, is so perfectly similar in structure, that it forms but a detached member of the adjacent continent.

The coasts of New Holland are indented by very large bays, and by harbours that might give shelter to all the navies in Europe. The most distinguishing feature of the eastern side, which is chiefly occupied by the British colony of New South Wales, is a long chain of mountains which never retires far from the coast, and, with the exception of some short deviations in its southern part, maintains a meridional direction through 35 degrees of latitude. It is continued at one extremity from Torres Straits, at the north of the Gulf of Carpentaria, far into the interior of New Guinea; and at the other it traverses the whole of Van Diemen's Land. It is low in the northern parts of New Holland, being in some places merely a high land; but about the 30th degree of south latitude it assumes the form of a regular mountain-chain, and, running in a very tortuous line from N.E. to S.W., terminates its visible course at Wilson's Promontory, the southern extremity of the continent. It is continued, however, by a chain of mountainous islands across Bass's Straits to Cape Portland, in Van Diemen's Land; from thence the range proceeds in a zigzag line of high and picturesque mountains to South Cape, where it ends, having, in its course of 1500 miles, separated the drainage of both countries into eastern and western waters.

The distance of the chain from the sea in New South Wales is from 50 to 100 miles, but at the 32nd parallel it recedes to 150, yet soon returns, and forms the wild group of the Corecudgy Peaks, from whence, under the names of the Blue Mountains and Australian Alps, its highest part, it proceeds in a general westerly direction to the land's end.

The average height of these mountains is only from 2400 to 4700 feet above the level of the sea, and even Mount Kosciusko, the loftiest of the Australian Alps, is not more than 6500 feet high; yet its position is so favourable, that the view from its snowy and craggy top sweeps over an area of 7000 square miles. The rugged and savage character of these mountains far exceeds what might be expected from their height: in some places, it is true, their tops are rounded and covered with forests; but by far the greater part of the chain, though wooded along the flanks, is crowned by naked needles, tooth-formed peaks, and flat crests of granite or porphyry, mingled with patches of snow. The spurs give a terrific character to these mountains, and in many places render them altogether inaccessible, both in New South Wales and Van Diemen's Land. These shoot right and left from the ridgy axis of the main range, equal to it in height, and separated from it, and from one another, by dark and almost subterraneous gullies, like rents in the bosom of the earth, iron-bound by impracticable precipices, and streams flowing through them in black silent eddies or foaming torrents. The intricate character of these ravines, the danger of descending into them, and the difficulty of getting out again, render this mountain-chain, in New South Wales at least, almost a complete barrier between the country on the coast and that in the interior—a circumstance very unfavourable to the latter.[1]

In New South Wales the country slopes westward from these mountains to a low, flat, unbroken plain.

[1] Memoirs of Count Strzelecki.

On the east side, darkly verdant and round-topped hills and ridges are promiscuously grouped together, leading to a richly-wooded undulating country, which gradually descends to the coast, and forms the valuable lands of the British colony. Discovered by Cook in the year 1770, it was not colonized till 1788. It has become a prosperous country; and although new settlers in the more remote parts suffer the privations and difficulties incident to their position, yet there is educated society in the towns, with the comforts and luxuries of civilized life.

The coast-belt on the western side of New Holland is generally of inferior land, with richer tracts interspersed near the rivers, and bounded on the east by a range of primary mountains from 3000 to 4000 feet high, in which granite occasionally appears. Beyond this the country is level, and the land better, though nowhere very productive except in grass.

None of the rivers of New Holland are navigable to any great distance from their mouths. The want of water is severely felt in the interior, which, as far as it is known, is a treeless desert of sand, swamps, and jungle; yet a belief prevails that there is a large sea or fresh-water lake in its centre; and this opinion is founded partly on the nature of the soil, and also because all the rivers that flow into the sea on the northern coast, between the Gulfs of Van Diemen and Carpentaria, converge towards their sources, as if they served for drains to some large body of water.

However unpropitious the centre of the continent may be—and the shores generally have the same barren character—there is abundance of fine country inland from the coast. On the north all tropical productions might be raised, and in so large a continent there must be extensive tracts of arable land, though its peculiar character is pastoral. There are large forests on the mountains and elsewhere, yet that moisture is wanting which clothes other countries in the same latitudes with rank vegetation. In the colonies, the clearing of a great extent of land has modified in some degree the mean annual temperature, so that the climate has become hotter and drier, and not thereby improved.

Van Diemen's Land, of triangular form, has an area of 27,200 square miles, and is very mountainous. No country has a greater number of deep, commodious harbours; and as most of the rivers, though not navigable to any distance, end in arms of the sea, they afford secure anchorage for ships of any size. The mountain-chain that traverses the colony of New South Wales and the islands in Bass's Straits, rises again from Cape Portland, and, winding through Van Diemen's Land in the form of the letter Z, separates it into two nearly equal parts, with a mean height of 3750 feet, and at an average distance of 40 miles from the sea. It encloses the basins of the Derwent and Heron rivers, and, after sending a branch betwen them to Hobart Town, ends at South Cape. The offsets which shoot in all directions are as savage and full of impassable chasms as it is itself. There are cultivable plains and valleys along the numerous rivers and large lakes by which the country is well watered; so that Van Diemen's Land is more agricultural and fertile than the adjacent continent, but its climate is wet and cold. The uncleared soil of both countries, however, is far inferior to that in the greater part of North or South America.[1]

Granite constitutes the entire floor of the western portion of New South Wales, and extends far into the interior of the continent, bearing a striking resemblance in character to a similar portion of the Altaï chain described by Baron Humboldt. The central axis of the mountain-range, in New South Wales and in Van Diemen's Land, is of granite, syenite, and quartz rock; but in early times there had been great invasions of volcanic substances, as many parts of the main chain, and most of its offsets, are of the older igneous rocks. The fossiliferous strata of the two colonies are mostly of the Palæozoic period, but their fossil fauna is poor in species. Some are identical with, and others are representatives of, the species of other countries, even of England. It appears from their coal-measures that the flora of these countries was as distinct in appearance from that of the northern hemisphere, previous to the carboniferous period, as it is at the present day.

Though the innumerable islands that are scattered through the ocean and seas differ much in size, form, and character, they have been grouped by M. Von Buch into the two distinct classes of Continental and

[1] Count Strzelecki.

Pelasgic islands, most of the latter being either of volcanic or coral formation. Continental islands are long in proportion to their breadth, and follow each other in succession along the margin of the continents, as if they had been formed during the elevation of the mainland, or had subsequently been separated from it by the action of the sea, and still mark its ancient boundary. These islands, which follow one another in their elongated dimensions, generally run parallel to the maritime chains of mountains, and are mostly of the same structure, so that they suggest the idea of a submarine portion of the maritime range that has not yet completely emerged from the deep—or, if sinking, has not yet disappeared below the waves.

America offers numerous examples of this kind of island. On the north-western coast there is a long chain of them, beginning with the New Norfolk group, and ending with Vancouver's Island, all similar and parallel to the maritime chain. Another range of Continental islands occurs at the southern extremity of America, extending from Chiloe to Cape Horn, evidently an exterior range of the Patagonian Andes, and the southern prolongation of the granitic or coast chain of Chile; in the Gulf of Mexico, the ancient margin of the mainland is marked by the curved group of Porto Rico, San Domingo, Jamaica, and Cuba, which nearly joins the peninsula of Yucatan. The various islands along the American coast of the Polar Ocean are the shattered fragments of the continent.

The old continent also affords innumerable examples; along the whole coast of Norway, from North Cape southwards, there is a continuous chain of rocky islands similar and parallel to the great range of the Scandinavian Alps; Great Britain itself, with the Hebrides, Orkney, and Zetland islands, are remarkable instances of Continental islands. It would be superfluous to mention the various instances which occur in the Mediterranean, where many of the islands are merely the prolongations of the mountain-chains of the mainland rising above the sea, as Corsica and Sardinia, which are a continuation of the Maritime Alps.

The great central chain of Madagascar and its elongated form, parallel to the Lupata Mountains, show that the island once formed part of the African continent. Asia, also, abounds in instances, as Sumatra, Java, and the Moluccas, and another vast chain extends along the western coast of Asia from Formosa to Kamtchatka.

Pelasgic islands have risen from the bed of the ocean, independently of the continents, and generally far from land. They are mostly volcanic, altogether or in part; often very lofty; sometimes single, and frequently in groups, and each group has, or formerly has had, a centre of volcanic action in one or more of the islands, round which the others have been formed. Many have craters of elevation, that is to say, they have been raised up in great hollow domes by the internal elastic vapours, and have either remained so, have become rent at the surface into gigantic fissures, or have collapsed into hollow cups, in which craters have formed, by the eruption of loose incoherent matter, or of lava currents, when the pressure from below was removed:[1] a considerable number have active vents.

The small islands and groups scattered at enormous distances from one another, within the Antarctic Circle, are all of volcanic formation, though none are active. In the Atlantic, Tristan da Cunha, St. Helena, Ascension, and Madeira are volcanic, though not now actively so; whereas the Cape de Verde, Canaries, and Azores have each volcanic vents: the peak of Teyda, in Teneriffe, is one of the most magnificent volcanic cones in the world.

The labyrinth of islands scattered over the Pacific Ocean for more than 30 degrees on each side of the equator, and from the 130th eastern meridian to Sumatra, which all but unites this enormous archipelago to the continent of Asia, has the group of New Zealand or Tasmania, and the continent of Australia, with its appendage, Van Diemen's Land, on the south, and altogether forms a region which, from the unstable nature of the surface of the earth, is partly the wreck of a continent that has been engulfed by the ocean, and partly the summits of a new one rising above the waves. This extensive portion of the globe is in many parts terra incognita; the Indian Archipelago has been little explored, and, with the exception of our colonies in New Holland and New Zealand, is little known.

[1] M. Von Buch.

M. Von Buch conceives that the enormous circuit, beginning with New Zealand and extending through Norfolk Island, New Caledonia, New Hebrides, Solomon's Island, New Britain, New Hanover, New Ireland, Louisiade, and New Guinea, once formed the western and northern boundary of the Australian continent.

New Zealand, divided into three islands by rocky and dangerous channels, is superior to Australia in richness of soil, fertility, and beauty; it abounds in a variety of vegetable and mineral productions. High mountains, of volcanic origin, run through the islands, which, in the most northerly, rise 14,000 feet above the stormy ocean around, buried two-thirds of their height in permanent snow and glaciers, exhibiting on the grandest scale all the alpine characters, with the addition of active volcanos on the eastern and western coasts: that of Tangarara pours forth deluges of boiling water, which deposit vast quantities of siliceous sinter like the Geysers in Iceland; and such is the vitality of the vegetation that plants grow richly on the banks, and even in water too hot to be endured.[1] The coast is a broken country, overspread with a most luxuriant but dark and gloomy vegetation. There are undulating tracts and table-lands of great extent without a tree, over-run by ferns and a low kind of myrtle; but the mountain-ridges are clothed with dense and gigantic forests. There is much good land and many lakes, with navigable rivers, the best of harbours, and a mild

[1] — Mansel, Esq.

climate; so that no country is better suited for a prosperous and flourishing colony. It may be considered, even at this early period of its colonial existence, as the Great Britain of the southern hemisphere.

A very different scene from the stormy seas of New Zealand presents itself to the north of Australia. There, vivified by the glowing sun of the equator, the islands of the Indian Archipelago are of matchless beauty, crowned by lofty mountains, loaded with aromatic verdure, that shelve to the shore, or dip into a transparent glassy sea. Their coasts are cut by deep inlets, and watered by the purest streams, which descend in cascades rushing through wild crevices. The whole is so densely covered with palms and other beautiful forms of tropical vegetation that they seem to realize a terrestrial paradise.

Papua or New Guinea, the largest island in the Pacific after New Holland, is 1100 miles long and 400 in width, with mountains rising above mountains, till in the west they attain the height of 16,000 feet, capped with snow, and two volcanos burn on its northern shores. From its position so near the equator it is probable that New Guinea has the same vegetation with the Spice Islands to the east, and, from the little that is known of it, must be one of the finest countries in existence.

Borneo, next in size to New Guinea, is a noble island, divided into two nearly equal parts by the equator, and traversed through its whole length by magnificent chains of mountains, which end in three branches at the Java Sea. Beautiful rivers flow from them to the plains, and several of these spring from a spacious lake on the table-land in the interior, among the peaks of Keni-Balu, the highest point of the island. Diamonds, gold, and antimony are among its minerals; gums, gutta percha, precious woods, and all kinds of spices and tropical fruits are among its vegetable productions.

Situate in the centre of a vast archipelago, and in the direct line of an extensive and valuable commerce, it will in the course of time become the seat of a great nation, whose civilization and prosperity will hand down to posterity the name of the enterprising, philanthropic Sir James Brooke, Rajah of Sarawak, with the highest honour to which man can aspire. The climate is healthy, tempered by sea-breezes, and in some parts even European; and its appendage, the small island of Labuan, rich in coal, is happily situate in the route of steam-vessels between India and China.

A volume might be written on the beauty and riches of the Indian Archipelago. Many of the islands are hardly known; the interior of the greater number has never been explored, so that they offer a wide field of discovery to the enterprising traveller, and they are now of easier access since the seas have been cleared of pirates by the exertions of the Honourable Captain Keppel, and other officers of Her Majesty's Navy.

They have become of much importance since our relations with China have been extended, on which account surveys of their coasts have been already made, and are going on, under the able direction of the Hydrographer of the Navy, Sir F. Beaufort. The great intertropical islands of the Pacific, likewise other large islands, as Ceylon and Madagascar, in the Indian Seas, which by the way do not differ in character from the preceding, are really continents in miniature, with their mountains and plains, their lakes and rivers; and in climate they vary, like the main land, with the latitude, only that continental climates are more extreme both as to heat and cold.

It is a singular circumstance, arising from the instability of the crust of the earth, that all the smaller tropical pelasgic islands in the Pacific and Indian Oceans are either volcanic or coralline, except New Caledonia and the Seychelles; and it is a startling fact, that in most cases where there are volcanos the land is rising by slow and almost imperceptible degrees above the ocean, whereas there is every reason to believe that those vast spaces, studded with coral islands or atolls, are actually sinking below it, and have been for ages.[1]

There are four different kinds of coral formations in the Pacific and Indian Oceans, all entirely produced by the growth of organic beings, and their detritus, namely, lagoon islands or atolls, encircling reefs, barrier reefs, and coral fringes. They are all nearly confined to the tropical regions; the atolls to the Pacific and Indian Oceans alone.

An atoll or lagoon island consists of a chaplet or

[1] Mr. Darwin on Coral Reefs.

ring of coral, enclosing a lagoon or portion of the ocean in its centre. The average breadth of the part of the ring above the surface of the sea is about a quarter of a mile, oftener less, and it seldom rises higher than from 6 to 10 or 12 feet above the waves. Hence the lagoon islands are not discernible, even at a very small distance, unless when they are covered with the cocoa-nut, palm, or the pandanus, which is frequently the case. On the outer side this ring or circlet shelves down to the distance of 100 or 200 yards from its edge, so that the sea gradually deepens to 25 fathoms, beyond which the sides plunge at once into the unfathomable depths of the ocean, with a more rapid descent than the cone of any volcano. Even at the small distance of some hundred yards no bottom has been found with a sounding-line a mile and a half long. All the coral at a moderate depth below water is alive—all above is dead, being the detritus of the living part, washed up by the surf, which is so tremendous on the windward side of the tropical islands of the Pacific and Indian Oceans, that it is often heard miles off, and is frequently the first warning to seamen of their approach to an atoll.

On the lagoon side, where the water is calm, the bounding ring or reef shelves into it by a succession of ledges, also of living coral, though not of the same species with those which build the exterior wall and the foundations of the whole ring. The perpetual change of water brought into contact with the external coral by the breakers probably supplies them with more food than they could obtain in a quieter sea, which may account for their more luxuriant growth. At the same time, they deprive the whole of the coral in the interior of the most nourishing part of their food, because the still water in the lagoon, being supplied from the exterior by openings in the ring, ceases to produce the hardier corals; and species of more delicate forms, and of much slower growth, take their place.[1] The depth of the lagoon varies, in different atolls, from 20 to 50 fathoms, the bottom being partly detritus and partly live coral. By the growth of the coral, some few of the lagoons have been filled up; but the process is very slow from the causes assigned, and also because there are marine animals that feed on the living coral, and prevent its indefinite growth. In all departments of nature, the exuberant increase of any one class is checked and limited by others. The coral is of the most varied and delicate structure, and of the most beautiful tints: dark brown, vivid green, rich purple, pink, deep blue, peach-colour, yellow, with dazzling white, contrasted with deep shadows, shine through the limpid water; while fish of the most gorgeous hues swim among the branching coral, which are of many different kinds, though all combine in the structure of these singular islands. Lagoon islands are sometimes circular, but more frequently oval or irregular in their form. Sometimes they are solitary or in groups, but

[1] Supplement to the Observations on the Temple of Serapis, by Charles Babbage, Esq.

they occur most frequently in elongated archipelagos, with the atolls elongated in the same direction. The grouping of atolls bears a perfect analogy to the grouping of the archipelagos of ordinary islands.

The size of these fairy-rings of the ocean varies from 2 to 90 miles in diameter, and islets are frequently formed on the coral rings by the washing up of the detritus, for they are so low that the waves break over them in high tides or storms. They have openings or channels in their circuit, generally on the leeward side, where the tide enters, and by these ships may sail into the lagoons, which are excellent harbours, and even on the surface of the circlet or reef itself there are occasionally boat-channels between the islets.

Dangerous Archipelago, lying east of the Society Islands, is one of the most remarkable assemblages of atolls in the Pacific Ocean. There are 80 of them, generally in a circular form, surrounding very deep lagoons, and separated from each other by profound depths. The reefs or rings are about half a mile wide, and seldom rise more than 10 feet above the edge of the surf, which beats upon them with such violence that it may be heard at the distance of 8 miles; and yet on that side the coral insects build more vigorously, and vegetation thrives better, than on the other. Many of the islets are inhabited.

The Caroline Archipelago, the largest of all, lies north of the equator, and extends its atolls in 60 groups over 1000 miles. Many are of great size, and all are beat by a tempestuous sea and occasional hurricanes. The atolls in the Pacific Ocean and China Sea are beyond enumeration. Though less frequent in the Indian Ocean, none are more interesting, or afford more perfect specimens of this peculiar formation, than the Maldive and Laccadive archipelagos, both nearly parallel to the coast of Malabar, and elongated in that direction. The former is 470 miles long and about 50 miles broad, with atolls arranged in a double row, separated by an unfathomable sea, into which their sides descend with more than ordinary rapidity. The largest atoll is 88 miles long, and somewhat less than 20 broad; Suadiva, the next in size, is 44 miles by 23, with a large lagoon in its centre, to which there is access by 42 openings. There are inhabited islets on most of the chaplets or rings not higher than 20 feet, while the reefs themselves are nowhere more than 6 feet above the surge.

The Laccadives run to the north of this archipelago in a double line of nearly circular atolls, on which are low inhabited islets.

Encircling reefs differ in no respect from atoll-reefs, except that they have one or more islands in their lagoon. They commonly form a ring round mountainous islands, at a distance of two or three miles from the shore, rising on the outside from a very deep ocean, and separated from the land by a lagoon or channel 200 or 300 feet deep. These reefs surround the submarine base of the island, and, rising by a steep ascent to the surface, they encircle the island itself. The Caroline Archipelago exhibits good examples of this structure in the encircled islands of Hogoleu and Siniavin; the narrow ring or encircling reef of the former is 135 miles in its very irregular circuit, on which are a vast number of islets: six or eight islands rise to a considerable height from its lagoon, which is so deep, and the opening to it so large, that a frigate might sail into it. The encircling reef of Siniavin is narrow and irregular, and its lagoon is so nearly filled by a lofty island, that it leaves only a strip of water round it from 2 to 5 miles wide and 30 fathoms deep.

Otaheite, the largest of the Society group, is another instance of an encircled island of the most beautiful kind; it rises in mountains 7000 feet high, with only a narrow plain along the shore, and, except where cleared for cultivation, it is covered with forests of cocoa-nut, palms, bananas, bread-fruit, and other productions of a tropical climate. The lagoon, which encompasses it like an enormous moat, is 30 fathoms deep, and is hemmed in from the ocean by a coral band of the usual kind, at a distance varying from half a mile to three miles.

Barrier-reefs are of precisely the same structure as the two preceding classes, from which they only differ in their position with regard to the land. A barrier reef off the north-east coast of the continent of Australia is the grandest coral formation existing. Rising at once from an unfathomable ocean, it extends 1000 miles along the coast, with a breadth varying from 200 yards to a mile, and at an average distance of from 20 to 30 miles from the shore, increasing in some places to 60 and even 70 miles. The great arm of the sea included between it and the land is nowhere less than 10, occasionally 60 fathoms deep, and is safely navigable throughout its whole length, with a few transverse openings by which ships can enter. The reef is really 1200 miles long, because it stretches nearly across Torres Straits. It is interrupted off the southern coast of New Guinea by muddy water, which destroys the coral animals, probably from some great river on that island. There are also extensive barrier-reefs on the islands of Louisiade and New Caledonia, which are exactly opposite to the great Australian reef; and as atolls stud that part of the Pacific which lies between them, it is called the Coralline Sea. The rolling of the billows along the great Australian reef has been admirably described. "The long ocean-swell, being suddenly impeded by this barrier, lifted itself in one great continuous ridge of deep blue water, which, curling over, fell on the edge of the reef in an unbroken cataract of dazzling white foam. Each line of breaker ran often one or two miles in length with not a perceptible gap in its continuity. There was a simple grandeur and display of power and beauty in this scene that rose even to sublimity. The unbroken roar of the surf, with its regular pulsation of thunder, as each succeeding swell fell first on the outer edge of the reef, was almost deafening, yet so deep toned as not to interfere with the slightest nearer and sharper sound. . . . . . Both the sound and sight were such as to impress the spectator with the consciousness of standing in the presence of an overwhelming majesty and power." [1]

Coral-reefs are distinct from all the foregoing; they are merely fringes of coral along the margin of a shore, and, as they line the shore itself, they have no lagoons. A vast extent of coast, both on the continents and islands, is fringed by these reefs, and, as they frequently surround shoals, they are very dangerous.

Lagoon islands are the work of various species of coral animals; but those particular polypi which build the external wall, the foundation and support of the whole ring or reef, are most vigorous when most exposed to the breakers; they cannot exist at a greater depth than 25 or 30 fathoms at most, and die immediately when left dry; yet the coral wall descends precipitously to unfathomable depths; and although the whole of it is not the work of these animals, yet the perpendicular thickness of the coral is known to be very great, extending hundreds of feet below the depth at which these polypi cease to live. From an extensive survey of the Coralline Seas of the tropics, Mr. Darwin has found an explanation of these singular phenomena in the instability of the crust of the earth.

Since there are certain proofs that large areas of the dry land are gradually rising, and others sinking

[1] By Mr. Jukes, Naturalist to the Surveying Voyage of Captain Blackwood, R.N., in Torres Straits.

down, so the bottom of the ocean is not exempt from the general change that is slowly bringing about a new state of things; and as there is evidence, on multitudes of the volcanic islands in the Pacific, of a rise in certain parts of the basis of the ocean, so the lagoon islands indicate a subsidence in others—changes arising from the expansion and contraction of the strata under the bed of the ocean.

There are strong reasons for believing that a continent once occupied a great part of the tropical Pacific, some part of which subsided by slow and imperceptible degrees. As portions of it gradually sank down below the surface of the deep, the tops of mountains and table-lands would remain as islands of different magnitude and elevation, and would form archipelagos elongated in the direction of the mountain-chains. Now, the coral-animal, which constructs the outward wall and mass of the reefs, never builds laterally, and cannot exist at a greater depth than 25 or 30 fathoms. Hence, if it began to lay the foundation of its reef on the submerged flanks of an island, it would be obliged to build its wall upwards in proportion as the island sank down, so that at length a lagoon would be formed between it and the land. As the subsidence continued, the lagoon would increase, the island would diminish, and the base of the coral-reef would sink deeper and deeper, while the animal would always keep its top just below the surface of the ocean, till at length the island would entirely disappear, and a perfect atoll would be left. If the island were mountainous, each peak would form a separate island in the lagoon, and the encircled islands would have different forms, which the reefs would follow continuously. This theory perfectly explains the appearances of the lagoon islands and barrier-reefs, the continuity of the reef, the islands in the middle of the lagoons, the different distances of the reefs from them, and the forms of the archipelago, so exactly similar to the archipelagos of ordinary islands, all of which are but the tops of submerged mountain-chains, and generally partake of their elongated forms.[1]

Every intermediate form between an atoll and an encircling reef exists: New Caledonia is a link between them. A reef runs along the north-western coast of that island 400 miles, and for many leagues never approaches within 8 miles of its shore, and the distance increases to 16 miles near the southern extremity. At the other end the reefs are continued on each side 150 miles beyond the sub-

[1] Another theory relative to the formation of the lagoon islands is, that the coral circuit is but the edge of a submarine elevation crater, on which the coral animals have raised their edifice. This view, which has been adopted by Von Buch and Captain Beechey, to whom we are indebted more than to any other navigator for positive information and admirable surveys of the coral islands of the Pacific, receives corroboration from the perfect conformity in shape between many of the lagoon islands of the Gambier group and the known elevation craters, and from the circumstance of a lagoon island having been seen to rise in 1825, in lat. 30° 14′, accompanied with smoke, and communicating so high a temperature to the surrounding sea as rendered it impossible to land.—See Beechey's Voyages, and Pœppig's Reise.

marine prolongation of the land, marking the former extent of the island. In the lagoon of Keeling Atoll, situate in the Indian Ocean, 600 miles south of Sumatra, many fallen trees and a ruined storehouse show that it has subsided: these movements take place during the earthquakes at Sumatra, which are also felt in this atoll. Violent earthquakes have lately been felt at Vanikora (celebrated for the wreck of La Pérouse), a lofty island of the Queen Charlotte group, with an encircling reef in the western part of the South Pacific, and on which there are marks of recent subsidence. Other proofs are not wanting of this great movement in the beds of the Pacific and Indian Oceans.

The extent of the atoll formations, including under this name the encircling reefs, is enormous. In the Pacific, from the southern end of Low Archipelago to the northern extremity of Marshall or Radick Archipelago, a distance of 4500 miles, and many degrees of latitude in breadth, atolls alone rise above the ocean. The same may be said of the space in the Indian Ocean between Saya de Matha and the end of the Laccadives, which includes 25 degrees of latitude—such are the enormous areas that have been, and probably still are, slowly subsiding. Other spaces of great extent may also be mentioned, as the large archipelago of the Carolinas, that in the Coralline Sea of the northwest coast of Australia, and an extensive one in the China Sea.

Though the volcanic islands in the Pacific are so numerous, there is not one within the areas mentioned, and there is not an active volcano within several hundred miles of an archipelago, or even group of atolls. This is the more interesting, as recent shells and fringes of dead coral, found at various heights on their surfaces, show that the volcanic islands have been rising more and more above the surface of the ocean for a very long time.

The volcanic islands also occupy particular zones in the Pacific, and it is found from extensive observation that all the points of eruption fall on the areas of elevation.[1]

One of the most terribly active of these zones begins with the Banda group of islands, and extends through the Sunda group of Timor, Sumbawa, Bali, Java, and Sumatra, separated only by narrow channels, and altogether forming a gently curved line 2000 miles long; but as the volcanic zone is continued through Barren Island and Narcondam in the Bay of Bengal, northward through the islands along the coast of Aracan, the entire length of this volcanic range is a great deal more. During the last hundred years all the islands and rocks for 100 miles along the coast of Aracan have been gradually rising. The greatest elevation of 22 feet has taken place about the centre of the line of upheaval, in the north-west end of the island of

[1] Few books have more interest than Mr. Darwin's on Coral Reefs and Volcanic Islands, to which the author is much indebted. Consult also Captain Beechey's Voyages, and his beautiful charts of the Coral Islands in the Pacific.

Cheduba, containing two mud volcanos, and is continued through Foul Island and the Terribles.[1]

The little island of Gonung-Api, belonging to the Banda group, contains a volcano of great activity; and such is the elevating pressure of the submarine fire in that part of the ocean, that a mass of black basalt rose up, of such magnitude as to fill a bay 60 fathoms deep, so quietly that the inhabitants were not aware of what was going on till it was nearly done. Timor and the other adjacent islands also bear marks of recent elevation.

There is not a spot of its size on the face of the earth that contains so many volcanos as the island of Java.[2] A range of volcanic mountains, from 5000 to 13,000 feet high, forms the central crest of the island, and ends to the east in a series of 38 separate volcanos with broad bases, rising gradually into cones. They all stand on a plain but little elevated above the sea, and each individual mountain seems to have been formed independently of the rest. Most of them are of great antiquity, and are covered with thick vegetation. Some are extinct, or only emit smoke; from others sulphureous vapours issue with prodigious violence; one has a large crater filled with boiling water; and a few have had fierce eruptions of late years. The island is covered with volcanic spurs from the main ridge, united by cross chains, together with other chains of less magnitude, but no less fury.

[1] By the Nautical Survey in 1848.

[2] Sir Stamford Raffles on Java.

In 1772 the greater part of one of the largest volcanic mountains was swallowed up after a short but severe combustion; a luminous cloud enveloped the mountain on the 11th of August, and soon after the huge mass actually disappeared under the earth with tremendous noise, carrying with it about 90 square miles of the surrounding country, 40 villages, and 2957 of their inhabitants.

The northern coast of Java is flat and swampy, but the southern provinces are beautiful and romantic; yet in the lovely peaceful valleys the stillness of night is disturbed by the deep roaring of the volcanos, many of which are perpetually burning with slow but terrific action.

Separated by narrow channels of the sea, Bali and Sumbawa are but a continuation of Java, the same in nature and structure, but on a smaller scale, their mountains being little more than 8000 feet high.

The intensity of the volcanic force under this part of the Pacific may be imagined from the eruption of Tomboro in Sumbawa in 1815, which continued from the 5th of April till July. The explosions were heard at the distance of 970 miles; and in Java, at the distance of 300 miles, the darkness during the day was like that of deep midnight, from the quantity of ashes that filled the air: they were carried to Bencoolen, a distance of 1100 miles, which, with regard to distance, is as if the ashes of Vesuvius had fallen at Birmingham. The country round was ruined, and the town of Tomboro was submerged by heavy rollers from the ocean.

In Sumatra the extensive granitic formations of Eastern Asia join the volcanic series which occupies so large a portion of the Pacific. This most beautiful of islands presents the boldest aspect; it is indented by arms of the most transparent sea, and watered by innumerable streams; it displays in its vegetation all the bright colouring of the tropics. Here the submarine fire finds vent in three volcanos on the southern, and one on the northern side of the island. A few atolls, many hundreds of miles to the south, show that this volcanic zone alternates with an area of subsidence.

More to the north, and nearly parallel to the preceding zone, another line of volcanic islands begins to the north of New Guinea, and passes through New Britain, New Ireland, Solomon Islands, and the New Hebrides, containing many open vents. This range or area of elevation separates the Coralline Sea from the great chain of atolls on the north between Ellice's group and the Caroline Islands, so that it lies between two areas of subsidence.

The third and greatest of all the zones of volcanic islands includes Gilolo, one of the Molucca group, which is bristled with volcanic cones; and from thence it may be traced northwards through the Philippine Islands and Formosa: bending thence to the north-east, it passes through Loo-Choo, the Japan Archipelago, and is continued by the Kurile Islands to the peninsula of Kamtchatka, where there are several volcanos of great elevation.

The Philippine Islands and Formosa form the volcanic separation between the atoll region in the China Sea, and that of the Caroline and Pellew groups.

There are six islands east of Jephoon in the Japan Archipelago which are subject to eruptions, and the internal fire breaks through the Kurile Islands in 18 vents, besides having raised two new islands in the beginning of this century, one 4 miles round, and the other 3000 feet high, though the sea there is so deep that the bottom has not been reached with a line 200 fathoms long.

Thus some long rent in the earth had extended from the tropics to the gelid seas of Okhotsk, probably connected with the peninsula of Kamtchatka: a new one begins to the east of the latter in the Aleutian Islands, which are of the most barren and desolate aspect, perpetually beaten by the surge of a restless ocean, and bristled by the cones of 24 volcanos; they sweep in a half-moon round Behring's Sea till they join the volcanic peninsula of Russian America.

The line of volcanic agency has been followed far beyond the limits of the coral-working animals, which extend but a short way on each side of the tropics; but it has been shown that in the equatorial regions immense areas of elevation alternate with as great areas of subsidence: north of New Holland they are so mixed that it indicates a point of convergence.[1]

On the other side of the Pacific the whole chain of the Andes, and the adjacent islands of Juan

[1] Mr. Darwin on Volcanic Islands.

Fernandez and the Galapagos, form a vast volcanic area, which is actually now rising; and though there are few volcanic islands north of the zone of atolls, yet those that be indicate great internal activity, especially in the Sandwich Islands, where the volcanos of Owhyhee are inferior to none in awful sublimity. That of Kirawah is on the flanks of Mowna Roa, which is itself a volcano. It was seen in high activity by Mr. Douglas in 1834; he describes it as a deep sunken pit, occupying five square miles, covered with masses of lava which had been in a state of recent fusion. In the midst of these were two lakes of liquid lava: in both there was a vast caldron in furious ebullition, occasionally spouting to the height of from 20 to 70 feet, whence streams of lava, hurrying along in fiery waves, were finally precipitated down an ignited arch, where the force of the lava was partly arrested by the escape of gases, which threw back huge blocks, and literally spun them into threads of glass, which were carried by the wind like the refuse of a flax-mill. He says the noise could hardly be described—that of all the steam-engines in the world would be a whisper to it; and the heat was so overpowering, and the dryness of the air so intense, that the very eyelids felt scorched and dried up.[1]

It may be observed that, where there are coral fringes, the land is either rising or stationary; for,

[1] Mr. Douglas's Voyage to the Sandwich Islands in 1833-4. — Journal of the Royal Geographical Society of London.

were it subsiding, lagoons would be formed. On the contrary, there are many fringing reefs on the shores of volcanic islands along the coasts of the Red Sea, the Persian Gulf, and the West Indian islands, all of which are rising. Indeed, this occurrence, in numberless instances, coincides with the existence of upraised organic remains on the land.

As the only coral formations in the Atlantic are fringing reefs, and as there is not one in its central expanse, except in Bermuda, it may be concluded that the bed of the ocean is not sinking; and with the exception of the Leeward Islands, the Canaries, the Azores, and the Cape de Verde groups, there are no active volcanos on the islands or on the coasts of that ocean.

At present the great continent has few centres of volcanic action in comparison with what it once had. The Mediterranean is still undermined by fire, which occasionally finds vent in Vesuvius and the stately cone of Etna. Though Stromboli constantly pours forth inexhaustible showers of incandescent matter, and a temporary island now and then starts up from the sea, the volcanic action is diminished, and Italy has become comparatively more tranquil.

The table-land of Western Asia, especially Azerbijan, had once been the seat of intense commotion, now spent, as the Seiban Dagh and Ararat, or only smoking from the snowy cone of Demavend. The table-land of Eastern Asia furnishes the solitary instance of igneous explosion at a distance of 1500 miles from the sea, in the volcanic chain of the Thean-Tchan.

Besides the two active volcanos of the Pe-shan and Ho-tcheou in the chain itself, at the distance of 670 miles from each other, with a solfatara between them, it is the centre of a most extensive volcanic district, extending northward to the Altaï Mountains, in which there are many points of connexion between the interior of the earth and the atmosphere, not by volcanos, but by solfataras, hot springs, and vapours. In the range of Targatabai, in the country of the Kirghiz, there is a mount said to emit smoke and even flame, which produces sulphur and sal-ammoniac in abundance. It is not ascertained that there are any mountains in China that eject lava, but there are many fire-hills and fire-springs; the latter are real Artesian wells five or six inches wide, and from 1500 to 3000 feet deep: from some of these water rises containing a great quantity of common salt; from others gases issue; and when a flame is applied, fire rushes out with great violence, rising 20 or 30 feet high, with a noise like thunder. The gas, conducted in tubes of bamboo cane, is used in the evaporation of salt water from the neighbouring springs.

There are altogether about 270 active volcanos, of which 190 are on the shores and islands of the Pacific. They are generally disposed in lines or groups. The chain of the Andes furnishes a magnificent example of linear volcanos. The peak of Teneriffe, encompassed by the volcanic islands of Palma and

Lancerote, is an equally good specimen of a central group. Eruptions are much more frequent in low than in high volcanos: that in the island of Stromboli is in perpetual activity; whereas Cotopaxi, 18,775 feet high, and Tungaragua in the Andes, have only been active once in a hundred years. On account of the force requisite to raise lava to such great elevations, it rarely flows from very elevated cones. Antisana is the only instance to the contrary among all the lofty volcanos in Quito. In Etna also the pressure is so great that the lava forces its way through the sides of the mountain or at the base of the cone.

An explosion begins by a dense volume of smoke issuing from the crater, mixed with aqueous vapour and gases; then masses of rock and molten matter in a half-fluid state are ejected with tremendous explosion and violence; after which lava begins to flow, and the whole terminates by a shower of ashes from the crater—often the most formidable part of the phenomenon, as was experienced at the destruction of Pompeii. There are several volcanos which eject only streams of boiling water, as the Volcano de Agua in Guatemala; others pour forth boiling mud, as in the islands of Trinidad, Java, and Cheduba in the Bay of Bengal. A more feeble effort of the volcanic force appears in the numerous solfataras. Hot springs show that the volcanic fire is not extinguished, though not otherwise apparent. To these may be added acidulous springs, those of naphtha, petroleum, and various kinds of gas, as carbonic acid gas, the food of plants—and, when breathed, the destruction of animals, as is fearfully seen in the Guero Upas, or "Valley of Death," in Java: it is half a mile in circumference and about 35 feet deep, with a few large stones and not a vestige of vegetation on the bottom, which is covered with the skeletons of human beings and the bones of animals and birds blanched white as ivory. On approaching the edge of the valley, which is situate on the top of a hill, a nauseous sickening sensation is felt; and nothing that has life can enter its precincts without being immediately suffocated.[1]

The seat of activity has been perpetually changing, but there always has been volcanic action, possibly more intense in former times, but even at present it extends from pole to pole.

Notwithstanding the numerous volcanic vents in the globe, many places are subject to violent earthquakes, which ruin the works of man, and often change the configuration of the country. The most extensive district of earthquakes comprises the Mediterranean and the adjacent countries, Asia Minor, the Caspian Sea, Caucasus, and the Persian mountains. It joins a vast volcanic district in Central Asia, whose chief focus seems to be the Thean-Tchan, which includes Lake Baikal and the neighbouring regions. A great part of the continent of Asia is more or less subject to shocks; but, with the exception of the shores of the Red Sea and the northern

[1] Letter from Alex. Loudon, Esq., in the Journal of the Geographical Society of London.

parts of Barbary, Africa is entirely free from these tremendous scourges; and it is singular that, notwithstanding the terrible earthquakes which shake the countries west of the Andes, the Andean chain itself, and all the countries round the Gulf of Mexico and the Caribbean Sea, they are extremely rare in the great eastern plains of South America. For the most part the shocks are transmitted in the line of the primary mountain-chains, and seem often to be limited by them in the other direction.

There must be some singular volcanic action underneath part of Great Britain, which has occasioned 255 slight shocks of earthquake, of which 139 took place in Scotland: the most violent of them have been felt at Comre, in Stratherne; of the rest 14 took place on the borders of Yorkshire and Derbyshire, 30 in Wales, and 31 on the south coast of England: they were preceded by singular phenomena, as a sudden fall of the barometer, fogs, and unusual sultriness; the two latter are said to indicate these convulsions about Siena, and in the Maremma of Tuscany, where they have of late years been attended with very disastrous effects.

Earthquakes are probably produced by fractures and sudden heavings and subsidences in the elastic crust of the globe, from the pressure of the liquid fire, vapour, and gases in its interior, which there find vent, relieve the tension which the strata acquire during their slow refrigeration, and restore equilibrium. But whether the initial impulse be eruptive, or a sudden pressure upwards, the shock originating in that point is propagated through the elastic surface of the earth in a series of circular or oval undulations, similar to those produced by dropping a stone into a pool, and like them they become broader and lower as the distance increases, till they gradually subside; in this manner the shock travels through the land, becoming weaker and weaker till it terminates. When the impulse begins in the interior of a continent, the elastic wave is propagated through the solid crust of the earth, as well as in sound through the air, and is transmitted from the former to the ocean, where it is finally spent and lost, or, if very powerful, is continued in the opposite land. Almost all the great earthquakes, however, have their origin in the bed of the ocean, far from land, whence the shocks travel in undulations to the surrounding shores.

No doubt many of small intensity are imperceptible: it is only the violent efforts of the internal forces that can overcome the pressure of the ocean's bed, and that of the superincumbent water. The internal pressure is supposed to find relief most readily in a belt of great breadth that surrounds the land at a considerable distance from the coast, and, being formed of the débris, the internal temperature is in a perpetual state of fluctuation, which would seem to give rise to sudden flexures and submarine eruptions.

When the original impulse is a fracture or eruption of lava in the bed of the deep ocean, two kinds of waves or undulations are produced and propagated simultaneously—one through the bed of the ocean, which is the true earthquake shock, and coincident with this a wave is formed and propagated on the surface of the ocean, which rolls to the shore, and reaches it in time to complete the destruction long after the shock or wave through the solid ocean-bed has arrived and spent itself on the land. The sea rose 50 feet at Lisbon and 60 at Cadiz after the great earthquake; it rose and fell 18 times at Tangier on the coast of Africa, and 15 times at Funchal in Madeira. At Kinsale in Ireland a body of water rushed into the harbour, and the water in Loch Lomond in Scotland rose two feet four inches —so extensive was the oceanic wave.[1] The height to which the surface of the ground is elevated, or the vertical height of the shock-wave, varies from one inch to two or three feet. This earth-wave, on passing under deep water, is imperceptible, but when it comes to soundings it carries with it to the land a long, flat, aqueous wave; on arriving at the beach, the water drops in arrear from the superior velocity of the shock, so that at that moment the sea seems to recede before the great ocean-wave arrives.

It is the small forced wave that gives the shock to ships, and not the great wave; but when ships are struck in very deep water, the centre of disturbance is either immediately under, or very nearly under, the vessel.

Three other series of undulations are formed simul-

[1] Mitchell on the Causes of Earthquakes, in Philosophical Transactions for 1760.

taneously with the preceding, by which the sound of the explosion is conveyed through the earth, the ocean, and the air, with different velocities. That through the earth travels at the rate of from 7000 to 10,000 feet in a second in hard rock, and somewhat less in looser materials, and arrives at the coast a short time before, or at the same moment with, the shock, and produces the hollow sounds that are the harbingers of ruin; then follows a continuous succession of sounds, like the rolling of distant thunder, formed, first, by the wave that is propagated through the water of the sea, which travels at the rate of 4700 feet in a second, and, lastly, by that passing through the air, which only takes place when the origin of the earthquake is a submarine explosion, and travels with a velocity of 1123 feet in a second. The rolling sounds precede the arrival of the great wave on the coasts, and are continued after the terrific catastrophe when the eruption is extensive.

When there is a succession of shocks all the phenomena are repeated. Sounds sometimes occur when there is no earthquake: they were heard on the plains of the Rio Apure, in Caraccas, at the moment the volcano in St. Vincent's, 700 miles off, discharged a stream of lava. The bellowings of Guanaxuato afford a singular instance: these subterraneous noises have been heard for a month uninterruptedly when there was no earthquake felt on the table-land of Mexico, nor in the rich silver-mines 1600 feet below its surface.

The velocity of the great oceanic wave varies as the square root of the depth ; it consequently has a rapid progress through deep water, and less when it comes to soundings. That raised during the earthquake at Lisbon travelled to Barbadoes at the rate of 7·8 miles in a minute, and to Portsmouth at the rate of a little more than two miles in a minute. The velocity of the shock varies with the elasticity of the strata it passes through. The undulations of the earth are subject to the same laws as those of light and sound ; hence, when the shock or earth-wave passes through strata of different elasticity, it will partly be reflected, and a wave will be sent back, producing a shock in a contrary direction, and partly refracted, or its course changed, so that shocks will occur both upwards and downwards, to the right or to the left of the original line of transit. Hence most damage is done at the junction of deep alluvial plains with the hard strata of the mountains, as in the great earthquake in Calabria in the year 1783.

When the height of the undulations is small, the earthquake will be a horizontal motion, which is the least destructive; when the height is great, the central and horizontal motions are combined, and the effect is terrible. The concussion was upwards in the earthquake which took place at Riobamba in 1797. Baron Humboldt mentions that some of the inhabitants were thrown across a river, several hundred feet in height, on a neighbouring mountain. The worst of all is a verticose or twisting motion, which nothing can resist; it is occasioned by the crossing of two waves of horizontal vibration, which unite at their point of intersection and form a rotatory movement. This, and the interferences of shocks arriving at the same point from different origins or routes of different lengths, account for the repose in some places, and those extraordinary phenomena that took place during the earthquake of 1783 in Calabria, where the shock diverged on all sides from a centre through a highly elastic base covered with alluvial soil, which was tossed about in every direction. The dynamics of earthquakes are ably discussed by Mr. Mallet in a very interesting paper in the 'Transactions of the Royal Irish Academy.'

There are few places where the earth is long at rest, for, independently of those secular elevations and subsidences that are in progress over such extensive tracts of country, small earthquake-shocks must be much more frequent than we imagine, though imperceptible to our senses, and only to be detected by means of instruments. The shock of an earthquake at Lyons in February, 1822, was not generally perceptible at Paris, yet the wave reached and passed under that city, and was detected by the swinging of the large declination needle at the Observatory, which had previously been at rest.

The undulations of some of the great earthquakes have spread to an enormous extent. The earthquake that happened in 1842 in Guadaloupe was felt over an extent of 3000 miles in length; and that which destroyed Lisbon had its origin in the bed of the Atlantic, from whence the shock extended over an area of about 700,000 square miles, or a twelfth part of the circumference of the globe; the West Indian islands, and the lakes in Scotland, Norway, and Sweden were agitated by it. In linear distance the effects of that earthquake extended through 300 miles, the shocks were felt through a line of 2700 miles, and the vibrations or tremors were perceptible in water through 4000 miles. It began without warning, and in five minutes the city was a heap of ruins.

The earthquake of 1783, in Calabria, which completely changed the face of the country, only lasted two minutes; but it was not very extensive, yet all the towns and villages for 22 miles round the small town of Oppido were utterly ruined. The destruction is generally accomplished in a fearfully short time; the earthquake at Caraccas, in March 1812, consisted of three shocks, which lasted three or four seconds, separated by such short intervals that in 50 seconds 10,000 people perished. Baron Humboldt's works are full of interesting details on this subject, especially with regard to the tremendous convulsions in South America.

Sometimes a shock has been perceived underground which was not felt at the surface, as in the year 1802, in the silver-mine of Marienberg, in the Hartz. In some instances miners have been insensible to shocks felt on the surface above, which happened at Fahlun, in Sweden, in 1823—circumstances in both instances depending on the elasticity of the strata, the depth of the impulses, or obstacles that may have changed the course of the terrestrial undulation. During earthquakes dislocations of strata take place, the course of rivers is changed, and in some instances they have been permanently dried up, rocks are hurled down, masses raised up, and the configuration of the country altered; but if there be no fracture at the point of original impulse, there will be no noise.

The power of the earthquake in raising and depressing the land has long been well known, but the gradual and almost imperceptible change of level through immense tracts of the globe is altogether a recent discovery; it has been ascribed to the expansion of rocks by heat, and subsequent contraction by the retreat of the melted matter from below them. It is not at all improbable that there may be motions, like tides, ebbing and flowing in the internal lava, for the changes are by no means confined to those enormous elevations and subsidences that appear to be in progress in the basin of the Pacific and its coasts, nor to the Andes and the great plains east of them—countries for the most part subject to earthquakes; they take place, to a vast extent, in regions where these convulsions are unknown. There seems to be an extraordinary flexibility in the crust of the globe from the 54th or 55th parallel of north latitude to the Arctic Ocean. There is a line crossing Sweden from east to west in the parallel of 56° 3′ N. lat., along which the ground is perfectly stable, and has been so for centuries. To the north of it for 1000 miles, between Gottenburg and North Cape, the ground is rising, the maximum elevation, which takes place at North Cape, being at the rate of five feet in a century, from whence it gradually diminishes to three inches in a century at Stockholm. South of the line of stability, on the contrary, the land is sinking through part of Christianstad and Malmo, for the village of Stassten in Scania is now 380 feet nearer to the Baltic than it was in the time of Linnæus, by whom it was measured 87 years ago. The coast of Denmark on the Sound, the island of Saltholm, opposite to Copenhagen, and that of Bornholm are rising, the latter at the rate of a foot in a century. The coast of Memel on the Baltic has actually risen a foot and four inches within the last 30 years, while the coast of Pillau has sunk down an inch and a half in the same period. The west coast of Denmark, part of the Feroe Islands, and the west coast of Greenland are all being depressed below their former level. In Greenland, the encroachment of the sea, in consequence of the change of level, has submerged ancient buildings on the low rocky islands, and on the main land. The Greenlander never builds near the sea on that account, and the Moravian settlers have had to move inland the poles to which they moor their boats. It has been in progress for four centuries, and extends through 600 miles from Igalito Firth to Disco Bay.[1] Mr. Robert Chambers has shown that in our own country the land has been for ages on the

[1] Captain Graah's Survey in 1823-4, and Dr. Pingel, 1830-2.

rise, and that the parallel roads in Glen Roy, which have so long afforded matter of discussion, are merely margins left by the retreat of the water, as the land alternately rose and remained stationary. In the present day the elevation is going on in many places, especially on the Murray Firth and in the Channel islands. The notice of this curious subject of the gradual changes of level on the land has been chiefly revived by Sir Charles Lyell, in whose admirable works on geology all the details will be found.[1]

1 Lyell's Principles of Geology, in 8vo. See also Mr. Darwin's observations on the same subject, in the voyage of the Adventure and Beagle.

CHAPTER XIV.

Arctic Lands — Greenland — Spitzbergen — Iceland — Its Volcanic Phenomena and Geysers — Jan Mayen's Land — New Siberian Islands — Antarctic Lands — Victoria Continent.

Greenland, the most extensive of the Arctic lands, begins with the lofty promontory of Cape Farewell, the southern extremity of a group of rocky islands, which are separated by a channel five miles wide from a table-land of appalling aspect, narrow to the south, but increasing in breadth northward to a distance of which only 1300 miles are known. This table-land is bounded by mountains rising from the deep in mural precipices, which terminate in needles and pyramids, or in parallel terraces, of alternate snow and bare rock, occasionally leaving a narrow shore. The coating of ice is so continuous and thick that the surface of the table-land may be regarded as one enormous glacier, which overlaps the rocky edges and dips between the mountain-peaks into the sea.

The coasts are beset with rocky islands, and cloven by fiords, which in some instances wind like rivers for 100 miles into the interior. These deep inlets of the sea, now sparkling in sunshine, now shaded in gloom, are hemmed in by walls of rock often 2000 feet high, whose summits are hid in the clouds. They generally terminate in glaciers, which are sometimes forced on by the pressure of the upper ice-plains till they fill the fiord, and even project far into the sea like bold headlands, when, undermined by the surge, huge masses of ice fall from them with a crash like thunder, making the sea boil. These icebergs, carried by currents, are stranded on the Arctic coast, or are drawn into lower latitudes. The ice is very transparent and compact in the Arctic regions; its prevailing tints are blue, green, and orange, which, contrasted with the dazzling whiteness of the snow and the gloomy hue of the rocks, produce a striking effect.

A great fiord in the 68th parallel of latitude is supposed to extend completely across the table-land, dividing the country into south and north Greenland, which last extends indefinitely towards the pole; but it is altogether inaccessible from the frozen sea and the iron-bound shore, so that, excepting a very small portion of the coast, it is an unknown region.

In some sheltered spots in south Greenland, especially along the borders of the fiords, there are meadows where the service-tree bears fruit, beech and willow trees grow by the streams, but not taller than a man; still farther north the willow and juniper scarcely rise above the surface; yet this country has a flora peculiar to itself. South of the island of Disco on the west coast, Danish colonies and missionaries have made settlements on some of the islands and at the mouths of fiords; the Esquimaux inhabit the coasts even to the extremity of Baffin's Bay.

The pelasgic islands in the Arctic Ocean are highly volcanic, with the exception of Spitzbergen. In the island of Spitzbergen the mountains spring sharp and grand from the margin of the sea in dark gloomy masses, mixed with pure snow and enormous glaciers, presenting a sublime spectacle. Seven valleys filled by glaciers ending at the sea form a remarkable object on the east coast. One of the largest masses of ice seen by Captain Scoresby on the island was north of Horn Sound: it extended 11 miles along the shore, with a sea-face in one part more than 2000 feet high, from which he saw a huge fragment hurled into the sea, which it lashed into vapour, as it broke into a thousand pieces. The sun is not seen for several months in the year, when the intensity of the cold splits rocks, and makes the sea reek like a boiling caldron. Many have perished in the attempt to winter in this island, yet a colony of Russian hunters and fishermen lead a miserable existence there, within 10° of the pole, the most northern inhabited spot on the globe.

Although the direct rays of the sun are powerful in sheltered spots within the Arctic Circle, the thermometer does not rise above 45° of Fahrenheit. July is the only month in which snow does not fall, and in the end of August the sea at night is covered with a thin coating of ice, and a summer often passes without one day that can be called warm. The snow-blink, the aurora, the stars, and the moon, which appears ten or twelve days without intermission in her northern declination, furnish the greatest light the inhabitants enjoy in their long winter.

Iceland is 200 miles east from Greenland, and lies south of the Arctic Circle, which its most northern part touches. Though a fifth part larger than Ireland, not more than 4000 square miles are habitable, all beside being a chaos of volcanos and ice.

The peculiar feature of Iceland lies in a trachytic region which seems to rest on an ocean of fire. It consists of two vast parallel table-lands covered with ice-clad mountains, stretching from N.E. to S.W. through the very centre of the island, separated by a longitudinal valley nearly 100 miles wide, which reaches from sea to sea. These mountains assume rounded forms, with long level summits or domes with sloping declivities, as in the trachytic mountains of the Andes and elsewhere; but such huge masses of tufa and conglomerate project from their sides in perpendicular or overhanging precipices, separated by deep ravines, that the regularity of their structure can only be perceived from a distance; they conceal under a cold and tranquil coating of ice the fiery germs of terrific convulsions, sometimes bursting into dreadful activity, sometimes quiescent for ages. The most extensive of the two parallel ranges of Jockuls or Ice Mountains runs along the eastern side of the valley, and contains Ordefa, the highest point in Iceland, seen like a white cloud from a great distance at sea: the western high land passes through the centre of the island.

Glaciers cover many thousand square miles in Iceland, descending from the mountains, and pushing far into the low lands. This tendency of the ice to encroach has very materially diminished the quantity of habitable ground, and the progress of the glaciers is facilitated by the influence of the ocean of subterranean fire, which heats the superincumbent ground, and loosens the ice.

The longitudinal space between the mountainous table-lands is a low valley 100 miles wide, extending from sea to sea, where a substratum of trachyte is covered with lava, sand, and ashes, studded with low volcanic cones. It is a tremendous desert, never approached without dread even by the natives—a scene of perpetual conflict between the antagonist powers of fire and frost, without a drop of water or a blade of grass; no living creature is to be seen—not a bird, nor even an insect. The surface is a confused mass of streams of lava rent by crevices; and rocks piled on rocks, and occasional glaciers, complete the scene of desolation. As herds of reindeer are seen browsing on the Iceland moss that grows plentifully at its edges, it is presumed that some unknown parts may be less barren. The extremities of the valley are more especially the theatres of perpetual volcanic activity. At the southern end, which opens to the sea in a wide plain, there are many volcanos, of which Heckla is most known, from its insulated position, its vicinity to the coast, and its tremendous eruptions. Between the years 1004 and 1766 twenty-three violent eruptions have taken place, one of which continued six years, spreading devastation over a country once the abode of a thriving colony, now covered with lava, scoria, and ashes: in the year 1846 it was in full activity. The eruption of the Skaptar Jockul, which broke out on the 8th of May, 1783, and continued till August, is one of the most dreadful recorded. The volcanic fire must have been in fearful commotion under Europe, for a tremendous earthquake ruined a wide extent of Calabria that year, and a submarine volcano had been burning fiercely for many weeks in the ocean, 30 miles from the south-west cape of Iceland. Its fires suddenly ceased, the island was shaken by earthquakes, when, at the distance of 150 miles, they burst forth with almost unexampled fury in Skaptar. The sun was hid many months by dense clouds of vapour, which extended to England and Holland, and clouds of ashes were carried many hundreds of miles to sea. The quantity of matter thrown out in this eruption was computed at fifty or sixty thousand millions of cubic yards. The lava flowed in a stream in some places from 20 to 30 miles broad, and of enormous thickness, which filled the beds of rivers, poured into the sea nearly 50 miles from the places of its eruption, and destroyed the fishing on the coast. Some rivers were heated to ebullition, others dried up; the condensed vapour fell in snow and torrents of rain; the country was laid waste; famine and disease ensued; and in the course of the two succeeding years 1300 people and 150,000 sheep and horses perished. The scene of horror was closed by a dreadful earthquake. Previous to the explosion an ominous mildness of temperature indicated the approach of the volcanic fire towards the surface of the earth; similar warnings had been observed before in the eruptions of Heckla.

A semicircle of volcanic mountains on the eastern side of the lake Myvatr is the focus of the igneous phenomena at the northern end of the great central valley. Leirhnukr and Krabla, on the N.E. of the lake, have been equally formidable. After years of quiescence they suddenly burst into violent eruption, and poured such a quantity of lava into the lake Myvatr, which is 20 miles in circumference, that the water boiled many days. There are other volcanos in this district no less formidable. Various caldrons of boiling mineral pitch, the shattered craters of ancient volcanos, occur at the base of this semicircle of mountains, and also on the flanks of Mount Krabla: these caldrons throw up jets of the dark matter, enveloped in clouds of steam, at regular intervals, with loud explosion. That which issues from the crater of Krabla must, by Mr. Henderson's description, be one of the most terrific objects in nature.

The eruptive boiling springs of Iceland are perhaps the most extraordinary phenomena in this singular country. All the great aqueous eruptions occur in the trachytic formation; they are characterised by their high temperature, by holding siliceous matter in solution, which they deposit in the form of siliceous sinter, and by the discharge of sulphuretted hydrogen gas. Numerous instances of spouting springs occur at the extremities of the great central valley, especially at its southern end, where more than fifty have been counted in the space of a few acres—some constant, others periodical—some merely agitated, or stagnant. The Great Geyser and Strokr, 35 miles north-west from Heckla, are the most magnificent; at regular intervals they project large columns of boiling water 100 feet high, enveloped in clouds of steam, with tremendous noise. The tube of the Great Geyser whence the jet issues is about 10 feet in diameter and 75 feet deep; it opens into the centre of a basin 4 feet deep and between 46 and 50 feet in diameter: as soon as the basin is filled by the boiling water that rises through the tube, explosions are heard, the ground trembles, the water is thrown to the height of 100 or 150 feet, followed by large volumes of steam. No farther explosion takes place till the empty basin and tube are again replenished.

MM. Descloiseaux and Bunsen, who visited Iceland in 1846, found the temperature of the Great Geyser, at the depth of 72 feet, before a great eruption, to be $260\frac{1}{2}°$ of Fahrenheit, and after the eruption $251\frac{1}{2}°$; an interval of 28 hours passed without any eruption. The Strokr (from stroka, to agitate), 140 yards from the Great Geyser, is a circular well, a little more than 44 feet deep, with an orifice of 8 feet, which diminishes to little more than 10 inches at a depth of 27 feet. The surface of the water is in constant ebullition, while at the bottom the temperature exceeds that of boiling water by about 24°. By the experiments of M. Donny of Ghent, water long boiled becomes more and more free from air, by which the cohesion of the particles is so much increased that when it is exposed to a heat sufficient to overcome the force of cohesion, the production of steam is so instantaneous and so considerable as to cause explosion. To this cause he ascribes the eruptions of the Geysers, which are in constant ebullition for many hours, and become so purified from air, that the strong heat at the bottom at last overcomes the cohesion of the particles, and an explosion takes place. The boiling spring of Tunquhaer, in the valley of Reikholt, is remarkable from having two jets, which play alternately for about four minutes each. Some springs emit gas only, or gas with a small quantity of water. Such fountains are not confined to the land or fields of ice; they occur also in the sea, and many issue from the crevices in the lava-bed of Lake Myvatr, and rise in jets above the surface of the water.

A region of the same character with the mountains of the Icelandic desert extends due west from it to the extremity of the long narrow promontory of the Sneefield Syssel, ending in the snow-clad cone of the Sneefield Jockul, 5000 feet high, one of the most conspicuous mountains in Iceland.

With the exception of the purely volcanic districts described, trap-rocks cover a great part of Iceland, which have been formed by streams of lava at very ancient epochs, occasionally 4000 feet deep.

The dismal coasts are torn in every direction by fiords, penetrating many miles into the interior, and splitting into endless branches. In these fissures the sea is still, dark, and deep, between walls of rock 1000 feet high. The fiords, however, do not here, as in Greenland, terminate in glaciers, but are prolonged in narrow valleys, through which streams and rivers run to the sea. In these valleys the inhabitants have their abode, or in meadows which have a transient verdure along some of the fiords, where the sea is so deep that ships find safe anchorage.

In the valleys on the northern coast, near as they approach to the Arctic Circle, the soil is wonderfully good, and there is more vegetation than in any other part of Iceland, with the exception of the eastern shore, which is the most favoured portion of this desolate land. Rivers abounding in fish are much more frequent there than elsewhere; willows and juniper adorn the valleys, and birch-trees, 20 feet high, grow in the vale of Lagerflest, the only place which produces them large enough for house-building, and the verdure is fine on the banks of those streams which are heated by volcanic fires.

The climate of Iceland is much less rigorous than that of Greenland, and it would be still milder were not the air chilled by the immense fields of ice from the Polar Sea which beset its shores.

The inhabitants are supplied with fuel by the Gulf Stream, which brings drift-wood in great quantities from Mexico, the Carolinas, Virginia, the river St. Lawrence, and some even from the Pacific Ocean is drifted by currents round by the northern shores of Siberia. The mean temperature in the south of the island is about 39° of Fahrenheit, that of the central districts 36°, and in the north it is rarely above the freezing point. The cold is most intense when the sky is clear, but that is a rare occurrence, as the wind from the sea covers mountain and valley with thick fog. Hurricanes are frequent and furious; and although thunder is seldom heard in high latitudes, Iceland is an exception, for tremendous thunder-storms are not uncommon there—a circumstance no doubt owing to the volcanic nature of that island, as lightning accompanies volcanic eruptions everywhere. At the northern end of the island the sun is always above the horizon in the middle of summer, and under it in mid-winter, yet there is no absolute darkness.

The island of Jan Mayen lies midway between Iceland and Spitzbergen; it is the most northern volcanic country known. Its principal feature is the volcano of Beerenberg, 6870 feet high, whose lofty snow-capped cone, apparently inaccessible, has been seen to emit fire and smoke. It is flanked by enormous glaciers, like frozen cataracts, which occupy three hollows in an almost perpendicular cliff, which descends from the base of the mountain to the sea.

The group of New Siberian Islands, which lie north of the province of Yakutsk, and in about 78° of N. lat., have so rude a climate that they have no permanent inhabitants; they are remarkable for the vast quantity of fossil bones they contain: the elephants' tusks found there have for years been an article of commerce.

The south polar lands are equally volcanic, and as deeply ice-bound, as those to the north. Victoria Land, which from its extent seems to form part of a continent, was discovered by Sir James Ross, who commanded the expedition sent by the British government in 1839 to ascertain the position of the south magnetic pole. This extensive tract lies under the meridian of New Zealand; Cape North, its most northern point, is situate in 70° 31′ S. lat., and 165° 28′ E. long. To the west of that cape the northern coast of this new land terminates in perpendicular ice-cliffs, from 200 to 500 feet high, stretching as far as the eye can reach, with a chain of grounded icebergs extending for miles from the base of the cliffs, all of tabular form, and varying in size from one to nine or ten miles in circumference. A lofty range of peaked mountains rises in the interior at Cape North, covered with unbroken snow, only relieved from uniform whiteness by shadows produced by the undulations of the surface. The indentations of the coast are filled with ice many hundreds of feet thick, which makes it impossible to land. To the east of Cape North the coast trends first to S.E. by E. and then in a southerly direction to 78¼° of S. lat., at which point it suddenly bends to the east, and extends in one continuous vertical ice-cliff to an unknown distance in that direction. The first view of Victoria Land is described as most magnificent. "On the 11th of January, 1841, in about latitude 71° S. and longitude 171° E., the Antarctic continent was first seen, the general outline of which at once indicated its volcanic character, rising steeply from the ocean in a stupendous mountain-range, peak above peak enveloped in perpetual snow, and clustered together in countless groups resembling a vast mass of crystallisation, which, as the sun's rays were reflected on it, exhibited a scene of such unequalled magnificence and splendour as would baffle all power of language to portray, or give the faintest conception of. One very remarkable peak, in shape like a huge crystal of quartz, rose to the height of 7867 feet, another to 9096, and a third to 8444 feet above the level of the sea. From these peaks ridges descended to the coast, terminating abruptly in bold capes and promontories, whose steep escarpments, affording shelter to neither ice nor snow, alone showed the jet black lava or basalt, which reposed beneath the mantle of eternal frost." . . . . "On the 28th, in lat. 77° 31′ and long. 167° 1′, the burning volcano, Mount Erebus, was discovered, covered with ice and snow from its base to its summit, from which a dense column of black smoke towered high above the other numerous lofty cones and crateriferous peaks with which this extraordinary land is studded from the 72nd to the 78th degree of latitude. Its height above the sea is 12,367 feet, and Mount Terror, an extinct crater near to it, which has doubtless once given vent to fires beneath, attains an altitude little inferior, being 10,884 feet in height, and ending in a cape, from which a vast barrier of ice extended in an easterly direction, checking all farther progress south. This continuous perpendicular wall of ice, varying in height from 200 to 100 feet, its summit presenting an almost unvarying level outline, we traced for 300 miles, when the pack-ice obstructed all farther progress."[1]

The vertical cliff in question forms a completely solid mass of ice about 1000 feet thick, the greater part of which is below the surface of the sea; there is not the smallest appearance of a fissure throughout its whole extent, and the intensely blue sky beyond indicated plainly the great distance to which the ice-plains reach southward. Gigantic icicles hang from every projecting point of the icy cliff, showing that it sometimes thaws in these latitudes, although in the month of February, which corresponds with August in England, Fahrenheit's thermometer did not rise above 14° at noon. In the North Polar Ocean, on the contrary, streams of water flow from every ice-berg during the summer. The whole of this country is beyond the pale of vegetation; no moss, not even a lichen, covers the barren soil where everlasting winter reigns. Parry's Mountains, a lofty range, stretching south from Mount Terror to the 79th parallel, is the most southern land yet discovered. The South Magnetic Pole, one of the objects of the expedition, is situate in Victoria Land, in 75° 5′ S. lat., and 154° 8′ E. long., according to Sir James C. Ross's observations.

Various tracts of land have been discovered near

[1] Remarks on the Antarctic Continent and Southern Islands, by Robert MacCormick, Esq., Surgeon of H.M.S. Erebus.

the Antarctic Circle, and within it, though none in so high a latitude as Victoria Land. Whether they form part of one large continent remains to be ascertained. Discovery ships sent by the Russian, French, and American governments have increased our knowledge of these remote regions, and the spirited adventures of British merchants and captains of whalers have contributed quite as much.[1] The land within the Antarctic Circle is generally volcanic, at least the coast-line, which is all that is yet known, and that, being covered with snow and ice, is destitute of vegetation.

[1] Captain Cook discovered Sandwich Land in 1772-5.—Captain Smith, of the brig William, discovered New South Shetland in 1819.—Captain Billingshausen discovered Peter's Island, and the coast of Alexander the First.—Captain Weddel discovered the Southern Orcades.—Captain Bisco discovered Enderby's Land and Graham's Land in 1832, Admiral d'Urville La Terre d'Adelie in 1841, and Sir James Ross Victoria Land in the same year.

CHAPTER XV.

Nature and Character of Mineral Veins — Metalliferous Deposits — Mines — Their Drainage and Ventilation — Their Depth — Diffusion of the Metals — Gold — Silver — Lead — British Mines — Quicksilver — Copper — Tin — Cornish Mines — Coal — Iron — Most abundant in the Temperate Zones, especially in the Northern — European and British Iron and Coal — American Iron and Coal — Arsenic and other Metals — Salt — Sulphur — Diffusion of the Gems.

The tumultuous and sudden action of the volcano and the earthquake on the great masses of the earth is in strong contrast with the calm, silent operations on the minute atoms of matter by which Nature seems to have filled the fissures in the rocks with her precious gifts of metals and minerals, sought for by man from the earliest ages to the present day. Tubal-cain was "the instructor of every artificer in brass and iron." Gold was among the first luxuries, and even in our own country, from time immemorial, strangers came from afar to carry off the produce of the Cornish mines.[1]

[1] The author owes much information on British mines to two publications on the Mining District of the North of England, by J. Sopwith, Esq., Civil Engineer, and Mr. Leithart, Mine Agent. On the Cornish mines she has derived much information from the writings of John Taylor, Esq., and Sir Charles Lemon, Bart.; from a store of valuable materials contained in the 'Progress of the Nation,' by G. R.

The ancients scarcely were acquainted with a third of the thirty-five metals now known, and the metallic bases of the alkalis only date from the time of Sir Humphry Davy, having formed a remarkable part of his brilliant discoveries.[1]

Minerals are deposited in veins or fissures of rocks, in masses, in beds, and sometimes in gravel and sand, the detritus of water. Most of the metals are found in veins; a few, as gold and tin, iron and copper, are disseminated through the rocks, though rarely. Veins are cracks or fissures in rocks, seldom in a straight line, yet they maintain a general direction, though in a zigzag form, striking downwards at a very high angle, seldom deviating from the perpendicular by so much as forty-five degrees, and extending to an unfathomable depth. They are for the most part accompanied by a subsidence of the strata

Porter, Esq.; from the Statistical Journal; and on the general distribution of minerals over the globe, from the 'Penny Cyclopædia,' and various other sources.

[1] The metals are gold, silver, platinum, copper, lead, tin, iron, zinc, arsenic, bismuth, antimony, nickel, quicksilver, manganese, cadmium, cerium, cobalt, iridium, uranium, chrome, lantanium, molybdenum, columbium, osmium, palladium, pelapium, tantalum, tellurium, rhodium, titanium, vanadium, tungsten, dydynium, ferbium, erbium. The three last are little known.

Sir Humphry Davy discovered that lime, magnesia, alumine, and other similar substances, are metals combined with oxygen. There are thirteen of these metalloids, namely—calcium, magnesium, aluminum, glucinum, thorium, yttrium, zirconium, strontium, barium, lithium, natrium, potassium, and silicium.

on one side of their course, and by an elevation on the other; the throw, or perpendicular distance between the corresponding strata on the opposite sides of a vein, varies from a few inches to thirty, forty, even a hundred fathoms. The beginning or end of a vein is scarcely ever known; but, when explored, they are found to begin abruptly, and, after continuing entire to a greater or less distance, they branch into small veins or strings.

In the downward zigzag course of a vein, the bending of the strata upwards on one side and downwards on the other, and the chemical changes almost always observed on the adjacent rocks, veins bear a strong analogy to the course and effects of a very powerful electrical discharge.

Veins have been filled with substances foreign to them, which have probably been disseminated in atoms in the adjacent rocks or by sublimation. Nothing can be more certain than that the minute particles of matter are constantly in motion from the action of heat, mutual attraction, and electricity. Prismatic crystals of salts of zinc are changed in a few seconds into crystals of a totally different form by the heat of the sun: casts of shells are found in rocks, from which the animal matter has been removed, and its place supplied by mineral matter; and the excavations made in rocks diminish sensibly in size in a short time if the rock be soft, and in a longer time when it is hard—circumstances which show an intestine motion of the particles, not only in their relative positions, but in space, which there is every reason to believe is owing to electricity—a power which, if not the sole agent, must at least have co-operated essentially in the formation and filling of mineral veins.[1]

The magnetism of the earth is presumed to be owing to electrical currents circulating through its surface in a direction at right angles to the magnetic meridians. Mr. Fox, so well known in the scientific world, has long since shown, from observations in the Cornish mines, that such currents do flow through all metallic veins. Now, as the different substances of which the earth is composed are in different states of electro-magnetism, and are often interrupted by non-conducting rocks, the electric currents, being stopped in their course, act chemically on all the liquids and substances they meet with. Hence Mr. Fox has come to the conclusion that not only the nature of the deposits must have been determined by their relative electrical conditions, but that the direction of the metallic veins themselves must have been influenced by the direction of the magnetic meridians; and, in fact, almost all the metallic deposits in the world are in parallel veins or fissures tending from east to west, or from north-east to south-west. Veins at right angles to

[1] This subject is ably discussed by Mr. Leithart in his work, already mentioned, on the formation and filling of metallic veins. Mr. Leithart is an instance of the intelligence that prevails among miners, notwithstanding the scanty opportunities of acquiring that knowledge which they are generally so eager to obtain. He was a working miner, whose only education was at a Sunday-school.

these are generally non-metalliferous, and, if they do contain metallic ores, they are of a different kind. In some few cases both contain the same ore, but in very different quantities, as in the silver-mine at Pasco, in the Andes, and both veins are richer near the point of crossing than elsewhere.

Sir Henry de la Beche conceives that the continued expansion and elevation of an intensely heated mass from below would occasion numerous vertical fissures through the superincumbent strata, within which some mineral matters may have been drawn up by sublimation, and others deposited in them when held in solution by ascending and descending streams of water; but even on this hypothesis the direction of the rents and the deposition of the minerals would be influenced by the electrical currents. But if veins were filled from below, the richest veins would be lowest, which is not the case in Cornwall, Mexico, or Peru[1]. The primum mobile of the whole probably lies far beyond our globe: we must look to the sun's heat, if not as the sole cause of electrical currents, at least as combined with the earth's rotation in their evolution.[2]

[1] Mineral veins are generally richer near the surface than at great depths: this is particularly the case in the mines of the precious metals in America, where the greatest quantities of ore have been found near the surface—a fact that may be explained by supposing the mineral substances brought by sublimation from the interior of the earth, and deposited where the temperature was lowest at or near the surface in the rocks among which they are situated.

[2] Rotation alone produces electrical currents in the earth.—'Connexion of the Physical Sciences,' page 364, 7th edition.

When veins cross one another, the traversed veins are presumed to be of prior formation to those traversing, because the latter are dislocated and often heaved out of their course at the point of meeting; and such is the case with the metalliferous veins, which are therefore the most recent. Veins are rarely filled in every part with ore; they contain sparry and stony matter, called its matrix, with here and there irregular masses of the metallic ores, often of great size and value. Solitary veins are generally unproductive, and veins are richer when near one another. The prevalence and richness of mineral veins are intimately connected with the proximity or junction of dissimilar rocks, where the electro-molecular and electro-chemical actions are most energetic. Granite, porphyry, and the plutonic rocks are often eminently metalliferous; but mineral deposits are also abundant in rocks of sedimentary origin, especially in and near situations where these two classes of rocks are in contact with one another, or where the metamorphic structure has been induced upon the sedimentary. This is remarkably the case in Cornwall, the north of England, in the Ural, and all the great mining districts.

The metalliferous deposits are peculiar to particular rocks: gold and tin are most plentiful in granite and the rocks lying immediately above it; copper is deposited in various slate formations resting on the preceding, and in the trias; lead is found in the mountain-limestone system, and is rare where iron and copper abound; iron abounds in the coal and oolitic strata, and in a state of oxidule and carbonate in the older rocks; and silver is found in almost all of these formations; its ores being frequently combined with those of other metals, especially of lead and copper. There is such a connexion between the contents of a vein and the nature of the rock in which the fissure is, that, when in the oldest rocks the same vein intersects clay-slate and granite, the contents of the parts enclosed in one rock differ very much from what is found in the other. It is believed that in the strata lying above the coal-measures none of the more precious metals have been found in England in such plenty as to defray the expense of raising them, although such a rule does not extend to the continent of Europe or to South America, where copper and silver ores abound in our new red sandstone series. In Great Britain no metal is raised in any stratum newer than the magnesian limestone. Metals exist chiefly in the primary and early secondary strata, especially near the junction of the granite and slates; and it is a fact that rich veins of lead, copper, tin, &c., abound only in and near the districts which have been greatly shaken by subterraneous movements. In other countries, as Auvergne and the Pyrenees, the presence of igneous rocks may have caused mineral veins to appear in more recent strata than those which contain them in Great Britain.

When a mine is opened, a shaft like a well is sunk perpendicularly from the surface of the ground, and from it horizontal galleries are dug at different levels according to the direction of the metallic veins, and gunpowder is used to blast the rocks when too hard for the pickaxe. When mines extend very far in a horizontal direction, it becomes necessary to sink more shafts, for ventilation as well as for facility in raising the ore. Such is the perfection of underground surveying in England, that the work can be carried on at the same time from above and below so exactly as to meet; and in order to accelerate the operation, the shaft is worked simultaneously from the different galleries or levels of the mine. In this manner a perpendicular shaft was sunk 204 fathoms deep, about nineteen years ago, in the Consolidated mines in Cornwall; it was finished in twelve months, having been worked in fifteen different points at once. In that mine there are ninety-five shafts, besides other perpendicular communications underground from level to level: the depth of the whole of these shafts added together amounts to about 25 miles; the galleries and levels extend horizontally about 43 miles, and 2500 people are employed in it: yet this is but one of many mines now in operation in the mining district of Cornwall alone.[1]

The infiltration of the rain and surface-water, together with subterranean springs and pools, would soon inundate a mine and put a stop to the work, were not adequate means employed to remove it. The steam-engine is often the only way of accomplishing what in many cases would otherwise be impossible, and the produce of mines has been in

[1] J. Taylor, Esq., on Cornish Mines.

proportion to the successive improvements in that machine. In the Consolidated mines already mentioned there are nine steam-engines constantly pumping out the water; four of these, which are the largest ever made, together lift from thirty to fifty hogsheads of water per minute, from an average depth of 230 fathoms. The power of the steam-engines in draining the Cornish mines is equal to 44,000 horses — one-sixth of a bushel of coals performing the work of a horse. The largest engine is between 300 and 350 horse-power; but as horses must rest, and the engine works incessantly, it would require 1000 horses to do its work.[1]

Mines in high ground are sometimes drained to a certain depth by an adit or gallery dug from the bottom of a shaft in a sloping direction to a neighbouring valley. One of these adits extends through the large mining district of Gwennap, in Cornwall; it begins in a valley near the sea, and very little above its level, and goes through all the neighbouring mines, which it drains to that depth, and with all its ramifications is 30 miles long. Nent Force Level, in the north of England, forms a similar drain to the mines in Alston Moor: it is a stupendous aqueduct 9 feet broad, and in some places from 16 to 20 feet high; it passes for more than 3 miles under the course of the river Nent to Nentsbury engine-shaft, and is navigated underground by long narrow

[1] The total amount of steam-power in Great Britain in 1833 was equal to that of 2,000,000 of men.—J. Taylor, Esq., on Cornish Mines.

boats. Daylight at its mouth is seen like a star at the distance of a mile in the interior. Most of the adits admit of the passage of men and horses, with rails at the sides for waggons.

The ventilation of mines is accomplished by burning fires in some of the shafts, which are in communication with the others, so that currents of air flow up one and down the others. In some cases fresh air is carried into the mines by streams that are made to flow down some of the shafts. Were this not done, the heat, which increases with the depth, would be insupportable; ventilation diminishes the danger from the fire-damp, for, even where Sir Humphry Davy's safety-lamp is used, accidents happen from the carelessness of the miners.[1]

The access to deep mines, as in Cornwall, is by a series of perpendicular or slightly-inclined ladders, sometimes uninterrupted, but generally broken at intervals by resting-places. It is computed that one-third of a miner's physical strength was exhausted in ascending and descending a deep mine: they are now drawn up by the steam-engine.

[1] The splendid discovery of Sir Humphry Davy, that flame does not pass through fine wire-gauze, prevents the fatal explosion of inflammable air in the mines, by which thousands of lives have been lost. By means of a light enclosed in a wire-gauze lantern, a miner now works with safety surrounded by fire-damp. To the honour of the illustrious author of this discovery, be it observed that it was not, like that of gunpowder and others, the unforeseen result of chance by new combinations of matter, but the solution of a question based on scientific experiment and induction, which it required the genius of a philosophic mind like his to arrive at.

The greatest depth to which man has excavated is nothing when compared with the radius of the earth. The Eselschacht mine at Kuttenberg in Bohemia, now inaccessible, which is 3778 feet below the surface, is deeper than any other mine. Its depth is only 150 feet less than the height of Vesuvius, and it is eight times greater than the height of the pyramid of Cheops, or the cathedral of Strasburg. The Monkwearmouth coal-mine near Sunderland descends to 1500 feet below the level of the sea, so that the barometer stands there at 31·80, which is higher than anywhere on the earth's surface.[1] The salt-works of New Saltzwerk in Prussia are 2231 feet deep, and 1993 feet below the level of the sea; and various other mines, such as the Liege coal-mine of Esperance, and that of Mont Massi, in the Maremma of Tuscany, do the same. Mines on high ground may be very deep without extending to the sea-level: that of Valenciana, near Guanaxuato in Mexico, is 1686 feet deep, yet its bottom is 5960 feet above the surface of the sea; and the mines in the higher Andes must be much more. For the same reason the rich mine of Joachimsthal in Bohemia, 2120 feet deep, has not yet reached that level. The fire-springs at Tseu-lieu-tsing in China are 3197 feet deep, but their relative depth is unknown.[2] How insignificant

[1] Supposing the barometer to be 30 inches on the level of the sea.

[2] Note to the English translation of Kosmos, by Colonel Sabine, on the depths below the surface of the earth, attained by man.

are all the works of man compared with nature!—A line 27,600 feet long did not reach the bottom of the Atlantic Ocean.

The metals are very profusely diffused over the earth. Few countries of any extent do not contain some of them. A small number occur pure, but in general they are found in the form of ores, in which the metal is chemically combined with other substances, and the ore is often so mixed with earthy matter and rock that it is necessary to reduce it to a coarse powder in order to separate the ore, which is rarely more than a third or fourth part of the mass brought above ground.

Gold is found in almost every country, but in such minute quantities that it is often not worth the expense of working. It is almost always in a native state, and in the form of crystals, grains, or rolled masses. Sometimes it is combined with silver. It is exhausted in several parts of Europe where it was formerly found. The united produce of the mines in Transylvania, Hungary, the north-western districts of Austria, and the bed of the Danube, is nearly 60,000 ounces annually. Gold is found in small quantities in Spain, in the lead-hills in Scotland, and the Wicklow mountains in Ireland.

Gold abounds in Asia, especially in Siberia. The deposits at the foot of the Ural mountains are very rich. In 1826 a piece of pure gold weighing 23 pounds was found there, along with others weighing three or four pounds each, together with the bones of elephants. All the diluvium there is ferruginous; and more to the east, as already mentioned, a region as large as France has lately been discovered with a soil rich in gold-dust, resting on rocks filled with it. In 1834 the treasures in that part of the Altaï chain called the Gold Mountains were discovered, forming a mountain-knot nearly as large as England, from which a great quantity of gold has been extracted. Gold is found in Tibet, in the Chinese province of Yun-nan, and abundantly in the mountains of the Indo-Chinese peninsula, in Japan, and Borneo. In the latter island it occurs near the surface in six different places.

Africa has long furnished a large supply to Europe. That part of the Kong Mountains west of the meridian of Greenwich is one of the most auriferous regions in the world. The gold stratum lies from 20 to 25 feet below the surface, and increases in richness with the depth. It is found in particles and pieces in a reddish sand. Most of the streams from the table-land bring down gold, as well those that descend to the low ground to the north, as those that flow to the Atlantic. On the shores of the Red Sea it was found in sufficient quantity to induce the Portuguese to form a settlement there.

In South America, the western Cordillera is poor in metals except in New Grenada, where the most westerly of the three chains of the Andes is rich in gold and platinum — a metal found only there, in Brazil, and on the European side of the Ural mountains — in alluvial deposits. The largest piece of platinum that has been found weighed 21 ounces. Gold is found in sand and gravel on the high plains of the Andes, on the low lands to the east of them, and in almost all the rivers that flow on that side. The whole country between Jaen de Bracamores and the Guaviare is celebrated for its metallic riches. Almost all the Brazilian rivers bring down gold; and the mine of Gongo Socco, near Rio de Janeiro, is said to yield several varieties of gold-ore. Central America, Mexico, and California are auriferous countries. The quantity of gold recently found near the surface in California is very great. A considerable quantity is found in Tenessee, the mountains of Georgia, and on 1000 square miles of North Carolina it occurs in grains and masses.

A great deal of silver is raised in Europe. The mines of Hungary are the most productive, especially those in the mountains of Chemnitz. The metalliferous mountains of the Erzgebirge are also very rich, as also the mines near Christiania in Sweden. Silver is also found in Saxony, Transylvania, and Austria. In no part of the old continent is silver in greater abundance than in the Ural and Altaï mountains, especially in the district of Kolywan. There are silver-mines in Armenia, Anatolia, Tibet, China, Cochin-China, and Japan.

The richness of the Andes in silver can hardly be conceived, but the mines are frequently on such high ground that the profits are diminished by the difficulty of carriage, the expense of living in a barren country, sometimes destitute of water, where the miners suffer from the cold and snow, and especially the want of fuel. This is particularly the case at the silver-mines of Copiapo in Chile, where the country is utterly barren, and not a drop of water is to be found in a circuit of nine miles. These mines were discovered by a poor man in 1832, who hit upon a mass of silver in rooting out a tree. They extend over 150 square leagues. Sixteen veins of silver were found in the first four days, and, before three weeks elapsed, forty more, not reckoning smaller ramifications, were discovered. The rolled pieces which lay on the surface produced a large quantity of pure silver. A single mass weighed 5000 pounds.[1]

In Peru there are silver-mines along the whole range of the Andes, from Caxamarea to the confines of the desert of Atacama. The richest at present are those of Pasco, which were discovered by an Indian in 1630. They have been worked without interruption since the beginning of the seventeenth century, and seem to be still inexhaustible. The soil under the town of Pasco is metalliferous, the ores probably forming a series of beds contemporaneous with the strata. The richness of these beds is not everywhere the same, but the nests of ore are numerous. The mines of Potosi, 16,150 feet above the sea-level, are celebrated for riches, but the owners have to contend with all the difficulties which such a situation imposes. The small depth at which the silver lies on the high plains of the Andes, and the

[1] Dr. Pœppig's 'Travels in Chile and Peru.'

quantity of it on the surface, is probably owing, as has been already stated, to the greater deposition of the sublimed mineral from refrigeration near the surface. The ore in the mines at Chota is near the surface over an extent of half a square league, and the filaments of silver are sometimes even entwined with the roots of the grass. This mine is 13,300 feet above the level of the sea, and even in summer the thermometer is below the freezing-point in the night. In the district of Huantajaya, not far from the borders of the Pacific, there are mines where masses of pure silver are found, of which one weighed 800 pounds.[1]

According to Baron Humboldt, the quantity of the precious metals brought to Europe between the discovery of America and the year 1803 was worth 1257 millions sterling; and the silver alone taken from the mines during that period would form a ball 89 feet in diameter. The disturbed state of the South American republics has interfered with the working of the mines.

Lead-ore is very often combined with silver, and is then called Argentiferous Galena. It is one of the principal productions of the British mines, especially in the northern mining district, which occupies 400 square miles at the junction of Northumberland, Cumberland, Westmoreland, Durham, and Yorkshire. It comprises Alston Moor, the mountain-ridge of Cross-fell, and the dales of Derwent, East and West Allen, the Wear, and Tees. There are other extensive mining

[1] Dr. Pœppig.

tracts separated from this by cultivated ground. The principal products of this rich district are lead and copper. The lead-mines lie chiefly in the upper dales of the Tyne, Wear, and Tees, and all of it contains more or less silver, though not always enough to indemnify the expense of refining or separating the silver. The deleterious vapours resulting from this process are conveyed in a tube along the surface of the ground for 14 miles; and instead of being, as formerly, a dead loss to the proprietor, they are condensed in their passage, and in one instance yield metal to the annual value of 10,000*l.*[1] The Hudgillburn lead-mine in that district has yielded treasures almost unexampled in the annals of mining. The veins, from ten to twelve, and in some places even twenty feet wide, were filled with ore which is entirely obtained with the pickaxe, without blasting. In 1821 the galena of this mine yielded 32,000 ounces of silver.

Lead-mines are in operation in France, but not to any great amount: those of the south of Spain furnish large quantities of this metal: also in Saxony, Bohemia, and Carinthia, where they are very rich. Lead is not very frequently found in Siberia, though it does occur in the Nerchinsk mining district, in the basin of the river Amur. It is also a production of China, of the peninsula beyond the Ganges, and of America. It is also found in Lower Peru, Mexico, and in California, where the richest argentiferous lead is worked.

[1] Constructed under the direction of Thomas Sopwith, Esq.

Quicksilver—a metal so important in separating silver from its ores, and in other arts as well as in medicine—occurs either liquid in the native state, or combined with sulphur in that of cinnabar. It is found in the mines of Idria and some other places in the Austrian empire, in the Palatinate on the left bank of the Rhine, and in Spain. The richest quicksilver mines of Europe, at the present day, are those of Almaden, where the quicksilver is found in the state of sulphuret chiefly. These mines were worked 700 years before the Christian era, and as many as 1200 tons of the metal are extracted annually. It occurs in China, Japan, and Ceylon, at San Onofro in Mexico, and in Peru, at Guancavelica, the mines of which, now almost deserted, produced, up to the beginning of the present century, the enormous quantity of 54,000 tons of quicksilver.

Copper is of such common occurrence that it would be vain to enumerate the localities where it is found. It is produced in Africa and America, in Persia, India, China, and Japan. The Siberian mines are very productive both in ore and native copper. Malachite is the most beautiful of the ores, and the choicest specimens come from Siberia. Almost every country in Europe yields copper. The mines in Sweden, Norway, and Germany are very productive; and it forms a principal part of our own mineral wealth. It is raised in all the principal mining districts in England and Wales. In Cornwall it is very plentiful, and is often associated with tin. The period at which the Cornish mines were first worked goes far beyond history, or even tradition: certain, however, it is that the Phœnicians came to Britain for tin. Probably copper was also worked very early in small quantities, for its exportation was forbidden in the time of Henry VIII. It was only in the beginning of the eighteenth century that the Cornish copper-mines were worked with success, in consequence of the invention of an improved machine for draining them.[1]

In Cornwall clay-slate rests upon granite, and is traversed by porphyritic dykes. The veins which contain copper or tin, or both, run east and west, and penetrate both the granite and the clay-slate. The non-metalliferous veins run north and south; and if veins in that direction do contain any metal, it never is tin or copper, but lead, silver, cobalt, or antimony, which with little exception are believed to be always in the clay-slate. No miner in Cornwall has ever seen the end or bottom of a vein; their width varies from the thickness of a sheet of paper to 30 feet; the average is from one to three feet. It rarely happens that either tin or copper is found nearer the surface than 80 or 100 feet. If tin be first discovered, it sometimes disappears after sinking the mine 100 feet deeper, when copper is found, and in some instances tin is found 1000 feet deep without a trace of copper; but if copper is first discovered, it is very rarely succeeded by tin. Tin is found in rolled pieces, in horizontal beds of sand and gravel, and is called stream-tin. The most valuable tin-mines on the continent of Europe are

[1] Sir Charles Lemon, Bart.

those in Saxony; it also occurs in France, Bohemia, and Spain. One of the richest deposits of tin known is in the province of Tenasserim, on the east side of the gulf of Martaban, in the Malayan peninsula. These deposits occur in several parts of that country; the richest is a layer eight or ten feet thick of sand and gravel, in which masses of oxide of tin are sometimes the size of a pigeon's egg. The best of all comes from the island of Banca, at the extremity of the Malacca peninsula; a large portion of it is imported into Britain, and much goes to China. It is found in the alluvial tracts through every part of the island, rarely more than 25 feet below the surface. Great deposits occur also in the Siberian mining district of Nertshinsk, near the desert of the Great Gobi, and in Bolivia, near Oruro.

There are comparatively few coal-mines worked within the tropics; they are mostly in the temperate zones, especially between the Arctic Circle and the Tropic of Cancer; and as iron, the most useful of metals, is chiefly found in the carboniferous strata, it follows the same distribution. In fact, the most productive iron-mines yet known are in the temperate zones. In the eastern mining district of Siberia, in the valley of the river Vilui, the ores are very rich, and very abundant in many parts of the Altaï and Ural. In the latter the mountain of Blagod, at 1534 feet above the sea, is one mass of magnetic iron-ore.[1] Coal and iron are worked in so many parts of Northern China, Japan, India, and

[1] M. Erman's 'Travels in Siberia.'

Eastern Asia, that it would be tedious to enumerate them.

In Europe the richest mines of iron, like those of coal, lie chiefly north of the Alps. Sweden, Norway, Russia, Germany, Styria, Belgium, and France, all contain it plentifully. In Britain many of the coal-fields contain subordinate beds of a rich argillaceous iron-ore, interstratified with coal, worked at the same time and in the same manner; besides, there is a substratum of limestone, which serves as a flux for melting the metal. The mines lie near Birmingham, on the north-east frontier of the great coal-basin of South Wales, near Pontypool and Merthyr Tydvil. There are extensive iron-mines in Staffordshire, Shropshire, North and South Wales, Yorkshire, Derbyshire, and Scotland. Altogether there are about 220 mines, which yield iron sufficient for our own enormous consumption and for exportation. These productive mines would have been of no avail had it not been for the abundance of fuel with which the greater part of them in the north of England, Scotland, and Wales are associated — the great source of our national wealth, more precious than mines of gold. Most of the coal-mines would have been inaccessible but for the means which their produce affords of draining them at a small expense. A bushel of coals, which costs only a few pence, in the furnace of a steam-engine generates a power which in a few minutes will raise 20,000 gallons of water from a depth of 360 feet—an effect which could not be accomplished in a shorter time than a whole day by the continuous labour of twenty men working with the common pump. Yet this circumstance, so far from lessening the demand for human labour, has caused a greater number of men to be employed in the mines.[1]

The coal strata lie in basins, dipping from the sides towards the centre, which is often at a vast depth below the surface of the ground. The centre of the Liege coal-basin is 21,358 feet, or 3½ geographical miles deep, which is easily estimated from the dip, or inclination, of the strata at the edges, and the extent of the basin. The coal lies in strata of small thickness and great extent. It varies in thickness from 3 to 9 feet, though in some instances several layers come together, and then it is 20 and even 30 feet thick; but these layers are interrupted by frequent dislocations, which raise the coal-seam towards the surface. These fissures, which divide the coalfield into insulated masses, are filled with clay, so that an accumulation of water takes place, which must be pumped up.

There are three immense coalfields in England. The first lies north of the Trent, and occupies an area of 360 square miles; and although the quantity of coal annually raised in Northumberland and Durham amounts to a million and a half of tons, there is enough to last 1000 years. London is chiefly supplied from it. The second or central coalfield, which includes Leicester, Worcester, Stafford, and Shropshire, has an area of 1495 square miles, and

[1] In 1841 there were 196,921 persons employed in the mines of Great Britain and Ireland.

supplies the manufactories round it, and the midland counties south and east of Derbyshire. The third or western coalfield includes South Wales, Gloucestershire, and Somersetshire. The coalfield of South Wales alone is 100 miles long, and 18 or 20 broad. The Workington and Whitehaven coal-mines go a mile under the sea; several shafts in the latter are 100 fathoms deep; and it is one of the finest in England for extent and thickness of strata, some of the seams being nine feet thick.

The Scotch coal-measures occupy the great central low land of Scotland, lying between the southern high lands and the Highland mountains; the whole of that rude tract is occupied by them, besides which there are other coalfields of less extent. Coal has been found in seventeen counties in Ireland, but the island contains only four principal coal districts—Leinster, Munster, Connaught, and Ulster. Thus there is coal enough in the British islands to last some thousands of years; and were it exhausted, our friends across the Atlantic have enough to supply the world for ages uncountable. Moreover, if science continues to advance at the rate it has lately done, a substitute for coal will probably be discovered before our own mines are worked out.[1]

[1] In the year 1829 the value of the mineral produce of Europe, including Asiatic Russia, but exclusive of manganese, amounted to—

Gold and Silver . .	£1,943,000
Other metals . . .	28,519,000
Salts	7,640,000
Combustibles . . .	18,050,000
Total . . .	£56,148,000

England

The carboniferous strata are enormously developed in the States of North America. The Appalachian coalfield extends, without interruption, 720 miles,

England contributed more than half this amount, namely,—

Silver	£ 28,500
Copper	1,369,000
Iron	11,292,000
Lead	760,000
Tin	536,000
Salts	756,250
Vitriol	33,600
Alum	33,000
Coal	13,000,000
Total	£28,716,750

—nearly £29,000,000 sterling.—John Taylor, Esq., on the Cornish Mines.

At present there are 34,000,000 of tons of coals consumed in Great Britain annually, besides the quantity exported to our colonies and to foreign countries, amounting to nearly 2,000,000 of tons. 8,000,000 of tons are consumed in our iron-foundries alone. Between 500,000 and 600,000 tons are used in making gas.

The iron made in Britain in 1844 amounted to 1,400,000 tons. Iron is now applied to many uses instead of timber, especially in ship-building: between the years 1830 and 1847, 150 iron vessels were launched in Britain. 25 of the steam-ships of the East India Company are of iron.

The produce of our copper-mines has increased threefold within the last 60 years. The quantity of tin has also increased from our own mines, and also from the extensive importation of that metal from Banca, where the country yielding stream-tin extends from 7° N. lat. to 3° S. lat. The yearly produce amounts to 300 tons of pure metal.—'Progress of the Nation, in its Social and Commercial Relations, since the Beginning of the Nineteenth Century,' by G. R. Porter, Esq., 2nd edition.

In France there are 62 coal-mines, which yielded 3,410,200 tons with a maximum breadth of 280 miles, from the northern border of Pennsylvania to near Huntsville, in Alabama, occupying an area of 63,000 square miles. It is intersected by three great navigable rivers—the Monogahela, the Alleghanny, and the Ohio—which expose to view the seams of coal on their banks. The Pittsburg seam, 10 feet thick, exposed on the banks of the Monogahela, extends, horizontally, 225 miles in length and 100 in breadth, and covers an area of 14,000 square miles, so that this seam of coal may be worked for ages almost on the surface, and in many places literally so. Indeed, the facility is so great, that it is more profitable to convey the coal by water to New Orleans, 1100 miles distant, than to cut down the trees with which the country is covered for fuel, and which may be had for the expense of felling. The coal is bituminous, similar to the greater part of the British coal; forty miles to the east, however, among the ridges of the Appalachian chain, there is an extensive outlying

tons in 1841, and in 1838 the 12 iron districts in that country yielded to the value of 4,975,424*l.*

The British coal and metal imported into France amounted to 1,222,228*l.*—Progress of the Nation.

Belgium is next to Britain as a European coal country. In Britain the coalfields occupy one-twentieth part of the area of the country—in Belgium one twenty-second part—in France one two hundred and tenth part of its area.

The quantity of coal raised in one year is, according to 'The Statistics of Germany,' by R. Valpy, Esq.—

In Britain . . .	347,000,000 tons
Belgium . . .	4,000,000
France . . .	3,783,000
Germany . . .	3,000,000

member of the great coalfield, which yields anthracite, a species of coal which has the advantage of burning without smoke.

In the western States the Illinois coalfield, which occupies part of Illinois, Indiana, and Kentucky, is as large as England, and consists of horizontal strata, with numerous seams of rich bituminous coal. There is a vast coalfield also in Michigan. Large areas in New Brunswick and Nova Scotia abound in coal. Iron is worked in many parts of the States, from Connecticut to South Carolina.[1]

The tropical regions of the globe have been so little explored that no idea can be formed of the quantity of coal or iron they contain; but as iron is so universal, it is probable that coal is not wanting. It is found in Formosa. Both abound in Borneo, and in various parts of tropical Africa and America. There is comparatively so little land in the southern temperate zone, that the mineral produce must be more limited than in the northern, yet New Holland, Van Diemen's Land, and New Zealand are rich in coal and iron.

Arsenic, used in the arts and manufactures, is generally found combined with other metals in many countries as well as our own. Manganese, zinc, bismuth, and antimony are raised to a considerable amount. As the qualities of the greater part of the more rare metals are little known, they have hitherto been interesting chiefly to the mineralogist.

The mines of rock-salt in Cheshire seem to be in-

[1] Sir Charles Lyell's 'Travels in the United States of North America.'

exhaustible. Enormous deposits of salt extend 600 miles on each side of the Carpathian mountains, and throughout wide districts in Austria, Gallicia, and Spain. It would not be easy to enumerate the places in Asia where rock-salt has been found. Armenia, Syria, and extensive tracts in the Punjab abound in it, also China and the Ural district; and the Andes contain vast deposits of rock-salt, some at great heights.

Volcanic countries in both continents yield sulphur. Sicily, where it is found in the tertiary marine strata, unconnected with the volcanic district, is the magazine which supplies the greater part of the manufactures of Europe. It is often found beautifully crystallized. Asphalt, nitre, alum, and naphtha are found in various parts of Europe and Asia, and natron is procured from small lakes in an oasis on the west of the Valley of the Nile.

The diffusion of precious stones is very limited. Diamonds are mostly found in a soil of sand and gravel, and in the beds of rivers. Brazil furnishes most of the diamonds in commerce; they are the produce of tracts on each side of the Sierra Espenhaço, and of a district watered by some of the affluents of the Rio San Francesco. During the century ending in 1822, diamonds were collected in Brazil to the value of three millions sterling, one of which weighed 138½ carats. The celebrated mines of Golconda have produced many splendid diamonds; they are also found in Borneo, which produced one weighing 367 carats, valued at 269,378*l*. The eastern parts of the Thian-Tchan, on the great platform of

Asia, and a wide district of the Ural Mountains, yield diamonds.

The ruby and sapphire have the same crystalline form, and are nearly allied to corundum; both are found in Ceylon, in the gravel of streams. The rubies at Gharan, on the verge of the river Oxus, are found imbedded in limestone. The gravel of rivulets in the Birman empire contains the oriental, star, and opalescent rubies. The spinelle also occurs in that country in a district five days' journey from Ava. The Hungarian rubies are of inferior value. The blue, green, yellow, and white sapphires are the produce of the Birman empire, and the spinelle is not uncommon in Brazil.

The finest emeralds come from veins of clay-slate in the valley of Musa, in New Grenada. Beryls are found in Brazil, and in the old mines in Mount Zabarah, in Upper Egypt. Those of Hungary and of the Heubach Valley, near Saltzburg, are very inferior in colour and quality.

Hungary and Bohemia yield the finest opals; the most esteemed are opaque, of a pale brown, and shine with the most brilliant iridescence; some are white, transparent, or semi-transparent, and radiant in colours: the precious opal is found in Hungary and in Mexico. The most beautiful garnets come from Bohemia and Hungary; they are found in the Hartz mountains, Ceylon, and many other localities. The turquoise is a Persian gem, and supposed to be the fossilized enamel of the tooth of a fossil mastodon; it is also found in Tibet and in the Belat-Tagh in Badakshan, which is the country of the lapis lazuli, mined by heating the rock, and then throwing cold water upon it. This beautiful mineral is also found in several places of the Hindoo Coosh, in the hills of Istalif north of Cabool, in Tibet, and in the Baïkal mountains in Siberia.

The cat's-eye is peculiar to Ceylon; the king of Kandy had one two inches broad. Topaz, beryl, and amethyst are of very common occurrence, especially in Brazil, Siberia, and other places. They are little valued, and scarcely accounted gems. Agates are so beautiful on the table-land of Tibet, and in some parts of the desert of the Great Gobi, that they form a considerable article of commerce in China; and some are brought to Rome, where they are cut into cameos and intaglios. But the greater part of the agates, cornelians, and chalcedonies used in Europe are found in the trap-rocks of Oberstein, in the Palatinate.

Thus, by her unseen ministers, electricity and reciprocal action, the great artificer Nature has adorned the depths of the earth and the heart of the mountains with her most admirable works, filling the veins with metals, and building the atoms of matter, with the most elegant and delicate symmetry, into innumerable crystalline forms of inimitable grace and beauty. The calm and still exterior of the earth gives no indication of the activity that prevails in its bosom, where treasures are preparing to enrich future generations of man. Gold will still be sought for in the deep mine, and the diamond will be gathered among the débris of the mountains, while time endures.

CHAPTER XVI.

The Ocean — its Size, Colour, Pressure, and Saltness — Tides — Waves — their Height and Force — Currents — their Effect on Voyages — Temperature — The Stratum of Constant Temperature — Line of Maximum Temperature — North and South Polar Ice — Inland Seas.

THE ocean, which fills a deep cavity in the globe, and covers three-fourths of its surface, is so unequally distributed that there is three times more land in the northern than in the southern hemisphere. The torrid zone is chiefly occupied by sea, and only one twenty-seventh part of the land on one side of the earth has land opposite to it on the other. The form assumed by this immense mass of water is that of a spheroid, flattened at the poles; and as its mean level is nearly the same, for anything we know to the contrary, it serves as a base to which all heights of land are referred.

The bed of the ocean, like that of the land, of which it is the continuation, is diversified by plains and mountains, table-lands and valleys, sometimes barren, sometimes covered with marine vegetation, and teeming with life. Now it sinks into depths which the sounding-line has never fathomed, now it appears in chains of islands, or rises near to the surface in hidden reefs and shoals, perilous to the mariner. Springs of fresh water rise from the bottom, volcanos eject their lavas and scoriæ, and earthquakes trouble the deep waters.

The ocean is continually receiving the spoils of the land, and from that cause would constantly be decreasing in depth, and, as the quantity of water is always the same, its superficial extent would increase. There are, however, counteracting causes to check this tendency: the secular elevation of the land over extensive tracts in many parts of the world is one of the most important. Volcanos, coral islands, and barrier-reefs show that great changes of level are constantly taking place in the bed of the ocean itself —that symmetrical bands of subsidence and elevation extend alternately over an area equal to a hemisphere, from which it may be concluded that the balance is always maintained between the sea and land, although the distribution may vary in the lapse of time.

The Pacific, or Great Ocean, exceeds in superficies all the dry land on the globe. It has an area of 50 millions of square miles; including the Indian Ocean, its area is nearly 70 millions; and its breadth from Peru to the coast of Africa is 16,000 miles. Its length is less than the Atlantic, as it only communicates with the Arctic Ocean by Behring's Straits, whereas the Atlantic, as far as we know, stretches from pole to pole.

The continent of Australia occupies a comparatively small portion of the Pacific, while innumerable islands stud its surface many degrees on either side of the equator, of which a great number are volcanic, showing that its bed has been, and indeed actually is, the theatre of violent igneous eruptions. So great is its depth, that a line five miles long has not reached the bottom in many places; yet as the whole mass of the ocean counts for little in the total amount of terrestrial gravitation, its mean depth is but a small fraction of the radius of the globe.

The bed of the Atlantic is a long deep valley, with few mountains, or at least but few that raise their summits as islands above its surface. Its greatest breadth, including the Gulf of Mexico, is 5000 miles, and its superficial extent is about 25 millions of square miles. This sea is exceedingly deep: in 27° 26′ S. latitude and 17° 29′ W. longitude Sir James Ross found the depth to be 14,550 feet; about 450 miles west from the Cape of Good Hope it was 16,062 feet, or 332 feet more than the height of Mont Blanc; and 900 miles west from St. Helena a line of 27,600 feet did not reach the bottom, a depth which is equal to the height of some of the most elevated peaks of the Himalaya; but there is reason to believe that many parts of the ocean are still deeper. A great part of the German Ocean is only 93 feet deep, though on the Norwegian side, where the coast is bold, the depth is 190 fathoms.

Immense sandbanks often project from the land, which rise from great depths to within a few fathoms of the surface. Of these, the Aghullas Banks, off the Cape of Good Hope, are amongst the most remarkable; those of Newfoundland are still greater in extent: they consist of a double sandbank, which is supposed to reach to the north of Scotland. The Dogger Bank, in the North Sea, and many others, are well known. According to Mr. Stevenson, one-fifth of the German Ocean is occupied by sandbanks, whose average height is 78 feet, an area equal to about one-third of Great Britain. Currents are sometimes deflected from their course by sandbanks whose tops do not come within 50 or even 100 feet of the surface. Some on the coast of Norway are surrounded by such deep water that they must be submarine table-lands. All are the resort of fish.

The pressure at great depths is enormous. In the Arctic Ocean, where the specific gravity of the water is lessened, on account of the greater proportion of fresh water produced by the melting of the ice, the pressure at the depth of a mile and a quarter is 2809 pounds on a square inch of surface; this was confirmed by Captain Scoresby, who says, in his 'Arctic Voyages,' that the wood of a boat suddenly dragged to a great depth by a whale was found, when drawn up, so saturated with water forced into its pores, that it sank in water like a stone for a year afterwards. Even sea-water is reduced in bulk from 20 to 19 solid inches at the depth of 20 miles. The compression that a whale can endure is wonderful. Many species of fish are capable of sustaining great pressure, as well as sudden changes of pressure. Divers in the pearl-fisheries exert great muscular strength, but man cannot bear the increased pressure at great depths, because his lungs are full of air, nor can he endure the diminution of it at great altitudes above the earth.

The depth to which the sun's light penetrates the ocean depends upon the transparency of the water, and cannot be less than twice the depth to which a person can see from the surface. In parts of the Arctic Ocean shells are distinctly seen at the depth of 80 fathoms; and among the West India islands, in 80 fathoms water, the bed of the sea is as clear as if seen in air; shells, corals, and sea-weeds of every hue display the tints of the rainbow.

The purest spring is not more limpid than the water of the ocean; it absorbs all the prismatic colours, except that of ultramarine, which, being reflected in every direction, imparts a hue approaching the azure of the sky. The colour of the sea varies with every gleam of sunshine or passing cloud, although its true tint is always the same when seen sheltered from atmospheric influence. The reflection of a boat on the shady side is often of the clearest blue, while the surface of the water exposed to the sun is bright as burnished gold. The waters of the ocean also derive their colour from animalcules of the infusorial kind, vegetable substances, and minute particles of matter. It is white in the Gulf of Guinea, black round the Maldives; off California the Vermilion Sea is so called on account of the red colour of the infusoria it contains; the same red colour was observed by Magellan near the mouth of the river Plate. The Persian Gulf is called the Green Sea by eastern geographers, and there is a trail of green water off the Arabian coast so distinct that a ship has been seen in green and blue water at the same time. Rapid transitions take place in the Arctic Sea, from ultramarine to olive-green, from purity to opacity. These appearances are not delusive, but constant as to place and colour; the green is produced by myriads of minute insects, which devour one another and are a prey to the whale. The colour of clear shallow water depends upon that of its bed; over chalk or white sand it is apple-green, over yellow sand dark-green, brown or black over dark ground, and grey over mud.

The sea is supposed to have acquired its saline principle when the globe was in the act of subsiding from a gaseous state. The density of sea-water depends upon the quantity of saline matter it contains: the proportion is generally a little above 3 per cent., though it varies in different places; the ocean contains more salt in the southern than in the northern hemisphere, the Atlantic more than the Pacific. The greatest proportion of salt in the Pacific is in the parallels of 22° N. lat. and 17° S. lat.; near the equator it is less, and in the Polar Seas it is least, from the melting of the ice. The saltness varies with the seasons in these regions, and the fresh water, being lightest, is uppermost. Rain makes the surface of the sea fresher than the interior parts, and the influx of rivers renders the ocean less salt at their estuaries; the Atlantic is brackish 300 miles from the mouth of the Amazons. Deep seas are more saline than those that are shallow, and inland seas communicating with the ocean are less salt, from the rivers that flow into them; to this, however, the Mediterranean is an exception, occasioned by the great evaporation, and the influx of salt currents from the Atlantic. The water in the Straits of Gibraltar at the depth of 670 fathoms is four times as salt as that at the surface.

Fresh water freezes at the temperature of 32° of Fahrenheit; the point of congelation of salt water is much lower. As the specific gravity of the water of the Greenland Sea is about 1·02664, it does not freeze till its temperature is reduced to $28\frac{1}{2}°$ of Fahrenheit, so that the saline principle preserves the sea in a liquid state to a much higher latitude than if it had been fresh, while it is better suited for navigation by its greater buoyancy. The healthfulness of the sea is ascribed to the mixing of the water by tides and currents which prevents the accumulation of putrescent matter.

Besides its saline ingredients, the sea contains bromine and sodine in very minute quantities, and, no doubt, portions of other substances too small to be detected by chemical analysis, since it has constantly received the débris of the land and all its organised matter.

Raised by the moon and modified by the sun, the area of the ocean is elevated into great tidal waves which keep time with the attractions of these luminaries at each return to the upper and lower meridian. The water under the moon is drawn from the earth by her attraction, at the same time that she draws the earth from the water diametrically opposite to her, in both cases producing a tide of nearly equal height. The height to which the tides rise depends upon the relative positions of the sun and moon, upon their declination and distance from the earth, but much more upon local circumstances. The spring-tides happen at new and full moon, consequently, twice in a month, because in both cases the sun and moon are in the same meridian; for when the moon is new they are in conjunction, and when she is full they are in opposition, and in each of these positions their attraction is combined to raise the water to its greatest height; while, on the contrary, the neap or lowest tides happen when the moon is in quadrature, or 90° distant from the sun, for then they counteract each other's attraction to a certain degree.

The tides ordinarily happen twice in 24 hours, because the rotation of the globe brings the same point of the ocean twice under the meridian of the moon; but peculiar local circumstances sometimes affect the tides, so as to produce only one tide in 24 hours, while on the other hand there have been known three and even four tides in the same space of time.

As the earth revolves, a succession of tides follow one another, and are diffused over the Pacific, Indian, and Atlantic Oceans, giving birth to the tides which wash the shores of the vast continents and islands which rise above their surfaces; but in what manner these marginal tides branch off from the parent wave, science has not yet determined: we know only their course along each shore, but are unable to connect these curves with the great ridge of the tidal wave.

In the Atlantic the marginal wave travels towards the north, and impinges upon the coasts of North America and of Europe. In the Indian Ocean it also pursues a northerly course, and finally washes the shores of Hindostan, the Bay of Bengal, and the Arabian Gulf: while in the Pacific, on the contrary, the waves diverge from the equator towards the poles—but in all they partake also of the westerly course of the moon.

Although such are the directions in which the tides unquestionably proceed along *the shores* of those seas, yet observations at islands in the open sea and towards the centres of the oceans contradict the idea of corresponding progressive waves throughout the entire area of those seas.

Upon the coasts of Britain and New Brunswick the tides are high, from the local circumstances of the coast and bottom of the sea; while in the centre of the ocean, where they are due to the action of the sun and moon only, they are remarkably small. The spring-tides rise more than 40 feet at Bristol, and in the Bay of Fundy, in Nova Scotia, they rise upwards of 50 feet; the general height in the North Atlantic is 10 or 12 feet, but in the open and deep sea they are less; and at St. Helena they are not more than 3 feet, whilst among the islands in the Pacific they are scarcely perceptible.

The mean height of the tides will be increased by a very small quantity for ages to come, in consequence of the decrease in the mean distance of the moon from the earth; the contrary effect will take place after that period has elapsed, and the moon's mean distance begins to increase again, which it will continue to do for many ages. Thus, the mean distance of the moon, and the consequent minute increase in the height of the tides, will oscillate between fixed limits for ever.[1]

The tidal wave extends to the bottom of the ocean, and moves uniformly and with great speed in very deep water, variably and slow in shallow water; the time of propagation depends on the depth of the water as well as on the nature and form of the shores. Its velocity varies inversely as the square of the depth—a law which theoretically affords the means of ascertaining the proportionate depth of the sea in different parts; it is one of the great constants of nature, and is to fluids what the pendulum is to solids—a connecting link between time and force.

The great oceanic wave that twice a-day brings the tides to our shores, has occupied a day and a half in travelling from the place where it was generated. The wave first impinges on the west coast of Ireland and England, and then passes round the north of Scotland, up the North Sea, and enters the Thames, having made the tour of Great Britain in about 18 hours.

At the equator the tide-wave follows the moon at the rate of 1000 miles an hour; it moves very slowly

[1] For the reason of this secular variation in the Moon's distance, see page 42 of 'The Connexion of the Physical Sciences.'

in the northern seas on account of the shallowness of the water; but the tides are so retarded by the form of the coasts and irregularities of the bottom of the sea, that a tide is sometimes impeded by an obstacle till a second tide reaches the same point by a different course, and the water rises to double the height it would otherwise have attained. A complete extinction of the tide takes place when a high-water interferes in the same manner with a low-water, as in the centre of the German Ocean—a circumstance predicted by theory, and confirmed by Captain Hewett, who was not aware that such an interference existed. When two unequal tides of contrary phases meet, the greater overpowers the lesser, and the resulting height is equal to their difference; such varieties occur chiefly in channels among islands and at the estuaries of rivers. When the tide flows suddenly up a river encumbered with shoals, it checks the descent of the stream; the water spreads over the sands, and a high crested wave, called a bore, is driven with force up the channel. This occurs in the Ganges; in the Amazon, at the equinoxes, where, during three successive days, five of these destructive waves, from 12 to 15 feet high, follow one another up that river daily; and in a lesser degree in some of our own rivers.

There may be some small flow of *stream* with the oceanic tide; but that does not necessarily follow, since the tide in the open ocean is merely an alternate rise and fall of the surface: so that the wave, not the stream, follows the moon. A bird resting on the sea is not carried forward as the waves rise and fall; indeed, if so heavy a body as water were to move at the rate of 1000 miles in an hour, it would cause universal destruction, since in the most violent hurricanes the velocity of the wind hardly exceeds 100 miles an hour.

During the passage of the great tidal wave in deep water, the particles of the fluid glide for the moment over each other into a new arrangement, and then retire to their places; but this motion is extremely limited and momentary. Over shallows, however, and near the land, both the water and the waves advance during the flow of the tide, and roll on the beach.[1]

The friction of the wind combines with the tides in agitating the surface of the ocean, and, according to the theory of undulations, each produces its effect independently of the other; wind, however, not only raises waves, but causes a transfer of superficial water also. Attraction between the particles of air and water, as well as the pressure of the atmosphere, brings its lower stratum into adhesive contact with the surface of the sea. If the motion of the wind be parallel to the surface, there will still be friction, but the water will be smooth as a mirror; but if it be inclined, in however small a

[1] Every undulating motion consists of two distinct things—an advancing form and a molecular movement. The motion of each particle is in an ellipse lying wholly in the vertical plane, so that, after the momentary disturbance during the passage of the wave, they return to their places again.—'Theory of Waves,' by J. Scott Russell, Esq.

degree, a ripple will appear. The friction raises a minute wave, whose elevation protects the water beyond it from the wind, which consequently impinges on the surface at a small distance beyond; thus, each impulse, combining with the other, produces an undulation which continually advances.

Those beautiful silvery streaks on the surface of a tranquil sea, called cats'-paws by sailors, are owing to a partial deviation of the wind from a horizontal direction. The resistance of the water increases with the strength and inclination of the wind. The agitation at first extends little below the surface, but in long-continued gales even the deep water is troubled: the billows rise higher and higher, and, as the surface of the sea is driven before the wind, their "monstrous heads," impelled beyond the perpendicular, fall in wreaths of foam. Sometimes several waves overtake one another, and form a sublime and awful sea. The highest waves known are those which occur during a north-west gale off the Cape of Good Hope, aptly called by the ancient Portuguese navigators the Cape of Storms: Cape Horn also seems to be the abode of the tempest. The sublimity of the scene, united to the threatened danger, naturally leads to an over estimate of the magnitude of the waves, which appear to rise mountains high, as they are proverbially said to do: there is, however, reason to doubt if the highest waves off the Cape of Good Hope exceed 40 feet from the hollow trough to the summit. The waves are short and abrupt in small shallow seas, and on that account are more dangerous than the long rolling billows of the wide ocean.

"The sea-shore after a storm presents a scene of infinite grandeur. It exhibits the expenditure of gigantic force, which impresses the mind with the presence of elemental power as sublime as the waterfall or the thunder. Long before the waves reach the shore they may be said to feel the bottom as the water becomes shallower, for they increase in height, but diminish in length. Finally the wave becomes higher, more pointed, assumes a form of unstable equilibrium, totters, becomes crested with foam, breaks with great violence, and, continuing to break, is gradually lessened in bulk till it ends in a fringed margin."[1]

The waves raised by the wind are altogether independent of the tidal waves; each maintains its undisturbed course; and as the inequalities of the coasts reflect them in all directions, they modify those they encounter and offer new resistance to the wind, so that there may be three or four systems or series of coexisting waves, all going in different directions, while the individual waves of each maintain their parallelism.

The undulation called a ground-swell, occasioned by the continuance of a heavy gale, is totally different from the tossing of the billows, which is confined to the area vexed by the wind; whereas the ground-swell is rapidly transmitted through the ocean to regions far beyond the direct influence of

[1] J. Scott Russell, Esq., on Waves.

the gale that raised it, and it continues to heave the smooth and glassy surface of the deep long after the wind and the billows are at rest. In the South Pacific, billows which must have travelled 1000 miles against the trade-wind from the seat of the storm, expend their fury on the lee side of the many coral islands which bedeck that sunny sea.[1] A swell sometimes comes from a quarter in direct opposition to the wind, and occasionally from various points of the compass at the same time, producing a vast commotion even in a dead calm, without ruffling the surface. They are the heralds that point out to the mariner the distant region where the tempest has howled, and not unfrequently they are the harbingers of its approach. At the margin of the polar ice, in addition to other dangers, there is generally a swell which would be very formidable to the mariner in thick weather, did not the loud grinding noise of the ice warn him of his approach.

Heavy swells are propagated through the ocean till they gradually subside from the friction of the water, or till the undulation is checked by the resistance of land, when they roll in surf to the shore, or dash in spray and foam over the rocks. The rollers at the Cape de Verde Islands are seen at a great distance approaching like mountains. When a gale is added to a ground-swell the commotion is great and the force of the surge tremendous, tossing huge masses of rock and shaking the cliffs to their foundations. During heavy gales on the coast of

[1] Beechey's Voyage to the Pacific.

Madras the surf breaks in nine fathoms water at the distance of four and even four and a half miles from the shore. The violence of the tempest is sometimes so intense as to quell the billows and scatter its surface in a heavy shower called by sailors spoon-drift. On such occasions saline particles have impregnated the air to the distance of 50 miles inland.

The force of the waves in gales of wind is tremendous; from experiments made by Mr. Stevenson, civil engineer, on the west coast of Scotland, exposed to the whole fury of the Atlantic, it appears that the average pressure of the waves during the summer months was equal to 611 pounds weight on a square foot of surface, while in winter it was 2086 pounds, or three times as great. During the storm that took place on the 9th of March, 1845, it amounted to 6083 pounds. Now as the pressure of a wave 20 feet high not in motion is only about half a ton on a square foot, it shows how much of their force waves owe to their velocity. The rolling breakers on the cliffs on the west coast of Ireland are magnificent: Lord Adair measured some that were 50 and even 150 feet high.

In the Isle of Man a block which weighed about 10 stone was lifted from its place and carried inland during a north-westerly gale; and in the Hebrides a block of 42 tons weight was moved several feet by the force of the waves. The Bell Rock lighthouse in the German Ocean, though 112 feet high, is literally buried in foam and spray to the very top during ground-swells when there is no wind. On the 20th of November, 1827, the spray rose 117 feet, so that the pressure was computed by Mr. Stevenson to be nearly three tons on a square foot.

The effect of a gale descends to a comparatively small distance below the surface; the sea is probably tranquil at the depth of 200 or 300 feet; were it not so, the water would be turbid and shellfish would be destroyed. Anything that diminishes the friction of the wind smooths the surface of the sea—for example, oil or a small stream of packed ice, which suppresses even a swell. When the air is moist, its attraction for water is diminished, and consequently so is the friction; hence the sea is not so rough in rainy as in dry weather.

Currents of various extent, magnitude, and velocity disturb the tranquillity of the ocean; some of them depend upon circumstances permanent as the globe itself, others on ever-varying causes. Constant currents are produced by the combined action of the rotation of the earth, the heat of the sun, and the trade-winds; periodical currents are occasioned by tides, monsoons, and other long-continued winds; temporary currents arise from the tides, melting ice, and from every gale of some duration. A perpetual circulation is kept up in the waters of the main by these vast marine streams; they are sometimes superficial and sometimes submarine, according as their density is greater or less than that of the surrounding sea.

The exchange of water between the poles and the equator affects the great currents of the ocean.

Although these depend upon the same causes as the trade-winds, they differ essentially in this respect—that whereas the atmosphere is heated from below by its contact with the earth, and transmits the heat to the strata above, the sea is heated at its surface by the direct rays of the sun, which diminish the specific gravity of the upper strata, especially between the tropics, and also occasion strong and rapid evaporation, both of which causes disturb the equilibrium of the ocean. The rotation of the earth also gives the water a tendency to take an oblique direction in its flow towards the equatorial regions, as, in order to restore the equilibrium, deranged by so many circumstances, great streams perpetually descend from either pole. When these currents leave the poles they flow towards the equator; but, before proceeding far, their motion is deflected by the diurnal rotation of the earth. At the poles they have no rotatory motion; and although they gain it more and more in their progress to the equator, which revolves at the rate of 1000 miles an hour, they arrive at the tropics before they have acquired the same velocity of rotation with the intertropical ocean. On that account they are left behind, and consequently seem to flow in a direction contrary to the diurnal rotation of the earth. For that reason the whole surface of the ocean, for 30 degrees on each side of the equator, has an apparent tendency from east to west, which produces all the effects of a great current or stream flowing in that direction. The trade-winds, which blow constantly in one direction, combine to give this current a mean velocity of 10 or 11 miles in 24 hours.

It has been supposed that the primary currents, as well as those derived from them, are subject to periodical variations of intensity occasioned by the melting of the ice at each pole alternately.

In consequence of the uninterrupted expanse of ocean in the southern hemisphere, the prevalence of westerly winds, and the tendency of the polar water towards the equator, a great oceanic current is originated in the Antarctic Sea. Driven by the prevailing winds, the waters take an easterly direction inclining to the northward, and one part sets upon the American coast, where it is divided. A small part doubles Cape Horn, while the main cold stream flows down the American shore; then turning suddenly to the west, it loses itself in the great equatorial current of the Pacific, which crosses that ocean between the parallels of 26° S. and 24° N. in a vast stream nearly 3500 miles broad. In the north this stream is interrupted by the coast of China, the Eastern Peninsula, and the islands of the Indian Archipelago; but a part forces its way between the islands, and joins the great equatorial current of the Indian Ocean, which, impelled by the S.E. trade-wind, maintains a westerly course between the 10th and 20th parallels of south latitude; as it approaches the Island of Madagascar the stream is divided; one part runs to the north-west, bends round the northern end of Madagascar, flows through the Mosambique Channel, and, being joined by the other branch, it doubles the Cape of Good Hope outside of the Agullhas Bank, and, under the name of the South Atlantic Current, it runs along the west coast of Africa to the parallel of St. Helena. There it is deflected by the coast of Guinea, and forms the Great Atlantic Equatorial Current, which flows westward and divides upon Cape St. Roque in Brazil. One branch of the stream setting southward along the continent of South America, becomes insensible before it reaches the Straits of Magellan; but an offset from it stretches directly across the Atlantic to the Cape of Good Hope, having made the circuit of the South Atlantic Ocean, and keeping 150 miles outside of the Cape or Agullhas current, which runs in the opposite direction, it pursues its course into the Indian Ocean, where traces of it are met with 2000 miles from the Cape.

The principal branch of the great equatorial current takes a northerly course from off Cape St. Roque, and rushes along the coast of Brazil with such force and depth that it suffers only a temporary deflection by the powerful streams of the river Amazon and of the Orinoco. Though much weakened in passing among the West Indian islands, it acquires new strength in the Caribbean Sea. From thence, after sweeping round the Gulf of Mexico with the high temperature of 88° 52′ of Fahrenheit, it flows through the Straits of Florida, and along the North American coast to Newfoundland under the name of the

Gulf-stream: it is there deflected eastward by the form of the land and the prevalent wind, and after passing Newfoundland by a current from Baffin's Bay. From the Azores it bends southward, and aided by the north-east trade rejoins the equatorial current, having made a circuit of 3800 miles with various velocity, leaving a vast loop or space of water nearly stagnant in its centre, which is thickly covered with sea-weed. The bodies of men, animals, and plants of unknown appearance, brought to the Azores by this stream, suggested to Columbus the idea of land beyond the Western Ocean, and thus led to the discovery of America. The Gulf-stream is more salt, warmer, and of a deeper blue than the rest of the ocean, till it reaches Newfoundland, where it becomes turbid from the shallowness of that part of the sea. Its greatest velocity is 78 miles a-day soon after leaving the Florida Strait; and its breadth increases with its distance from the strait until the warm water spreads over a large surface of the ocean. An important branch leaves the current near Newfoundland, setting towards Britain and Norway; which is again subdivided into many branches, whose origin is recognised by their greater warmth, even at the edge of perpetual ice in the Polar Ocean; and in consequence of some of these branches the Spitzbergen Sea is 6° or 7° warmer at the depth of 200 fathoms than at its surface. Though the warmth of the Gulf-stream diminishes as it goes north, Lieutenant Murray says "that the quantity of heat which it spreads over the Atlantic in a winter's day would be sufficient to raise the whole atmosphere that covers France and Great Britain from the freezing point to summer heat; and it really is the cause of the mildness and of the damp of Ireland and the south of England.

These oceanic streams exceed all the rivers in the world in breadth and depth as well as length. The equatorial current in the Atlantic is 160 miles broad off the coast of Africa, and towards its mid-course across the Atlantic its width becomes nearly equal to the length of Great Britain: but as it then sends off a branch to the N.W., it is diminished to 200 miles before reaching the coast of Brazil. The depth of this great stream is unknown; but the Brazilian branch must be very profound, since it is not deflected by the river La Plata, which crosses it with so strong a current that its fresh muddy waters are perceptible 500 miles from its mouth. When currents pass over banks and shoals, the colder water rises to the surface and gives warning of the danger.

In summer, the great north polar current coming along the coasts of Greenland and Labrador, together with the current from Davis's Straits, brings icebergs to the margin of the Gulf-Stream. The difference between the temperatures of these two oceanic streams brought into contact is the cause of the dense fogs that brood over the banks of Newfoundland. The north polar current runs inside of the Gulf-Stream, along the coast of North America to Florida, and beyond it—since it sends an under-current into the Caribbean Sea. Counter-currents on the surface are of such frequent occurrence that there is scarcely a strait joining two seas that does not furnish an example — a current running in along one shore, and a counter-current running out along the other. One of the most remarkable occurs in the Atlantic: it begins off the coast of France, and, after sending a mass of water into the Mediterranean, it holds a southerly direction at some distance from the continent of Africa; till, after passing Cape Mesurada, it flows rapidly for 1000 miles due east to the Bight of Biafra in immediate contact with the equatorial current, running with great velocity in the opposite direction, and seems to merge in it at last.

Periodical currents are frequent in the eastern seas: one flows into the Red Sea from October to May, and out of it from May to October. In the Persian Gulf this order is reversed; in the Indian Ocean and China Sea the waters are driven alternately backwards and forwards by the monsoons. It is the south-westerly monsoon that causes inundations in the Ganges, and a tremendous surf on the coast of Coromandel. The tides also produce periodical currents on the coasts and in straits, the water running in one direction during the flood, and the contrary way in the ebb. The Roost of Sumburgh, at the southern promontory of Shetland, runs at the rate of 15 miles an hour; indeed, the strongest tidal currents known are among the Orkney and Shetland islands; their great velocity arises from local circumstances. Currents in the wide ocean move at the rate of from one to three miles an hour, but the velocity is less at the margin and bottom of the stream from friction.

Whirlpools are produced by opposing winds and tides; the whirlpool of Maelstrom, on the coast of Norway, is occasioned by the meeting of tidal currents round the islands of Lofoden and Mosköe; it is a mile and a half in diameter, and so violent that its roar is heard at the distance of several leagues.

Although with winds, tides, and currents, it might seem that the ocean is ever in motion, yet in the equatorial regions, far from land, dead calms prevail; the sea is of the most perfect stillness day after day; partaking of the universal quiet, and heaving its low flat waves in noiseless and regular periods as if nature were asleep.

The safety and length of a voyage depends upon the skill with which a seaman avails himself of the set of the different currents, and the direction of the permanent and periodical winds; it is frequently shortened by following a very circuitous track to take advantage of them if favourable, or to avoid them if unfavourable. From Acapulco, in Mexico, across the Pacific to Manilla or Canton, the trade-wind and the equatorial current are so favourable that the voyage is accomplished in 50 or 60 days; whereas, in returning, 90 or 100 are required. Within the Antillas navigation is so difficult from winds and currents, that a vessel, going from Jamaica to the lesser Antillas, cannot sail directly across the Caribbean Sea, but must go round about through the windward passage between Cuba and Haiti to the ocean; nearly as many weeks are requisite to accomplish this voyage as it takes days to return. On account of the prevalence of westerly winds in the North Atlantic, the voyage from Europe to the United States is longer than that from the latter to Europe; but the Gulf-stream is avoided in the outward voyage, because it would lengthen the time by a fortnight. Ships going to the West Indies, Central or South America, from Europe, generally make the Canary Islands in order to fall in with the N.E. trade-winds.

The passage to the Cape of Good Hope from the British Channel may be undertaken at any season, and is accomplished in 50 or 60 days; but it is necessary to regulate the voyage from the Cape to India and China according to the seasons of the monsoons. There are various courses adopted for that purpose, but all of them pass through the very focus of the hurricane district, which includes the islands of Rodriguez, the Mauritius, and Bourbon, and extends from Madagascar to the island of Timor.

The extensive deposits of coal discovered in the Bay of Talcahuano, in Chile, in Australia, New Zealand, in the British settlement at Labuan, and in Borneo, will be the means of increasing the steam navigation of the Pacific, and shortening the voyages upon that ocean.

Sea-water is a bad conducter of heat, therefore the temperature of the ocean is less liable to sudden changes than the atmosphere; the influence of the seasons is imperceptible at the depth of 300 feet; and as light probably does not penetrate lower than 700 feet, the heat of the sun cannot affect the bottom of a deep sea. It has been established beyond a doubt that in all parts of the ocean the water has a constant temperature of about 39°·5 of Fahrenheit, at a certain depth, depending on the latitude. At the equator the stratum of water at that temperature is at the depth of 7200 feet; from thence it gr dually rises till it comes to the surface in S. lat. 56° 26′, where the water has the temperature of 39°·5 at all depths; it then gradually descends till S. lat. 70°, where it is 4500 feet below the surface. In going north from the equator the same law is observed. Hence, with regard to temperature, there are three regions in the ocean: one equatorial and two polar. In the equatorial region the temperature of the water at the surface of the ocean is 80° of Fahrenheit, therefore higher than that of the stratum of 39°·5; while in the polar regions it is lower. Thus the surface of the stratum of constant temperature is a curve which begins at the depth of 4500 feet in the southern basin, from whence it gradually rises to the surface in S. lat. 56° 26′; it then sweeps down to 7200 feet at the equator, and rises up again to the surface in the corresponding northern latitude, from whence it descends again to a depth of 4500 feet in the northern basin.

The temperature of the surface of the ocean decreases from the equator to the poles. For 10 degrees on each side of the line the maximum is 80° of Fahrenheit, and remarkably stable; from thence to each tropic the decrease does not exceed 3°·7. The tropical temperature would be greater were it not for the currents, because the surface reflects much fewer of the sun's rays which fall on it directly, than in higher latitudes where they fall obliquely. In the torrid zone the surface of the sea is about 3°·5 of Fahrenheit warmer than the air above it; because the polar winds, and the great evaporation which absorbs the heat, prevent equilibrium; and as a great mass of water is slow in following the changes in the atmosphere, the vicissitude of day and night has little influence, whereas in the temperate zones it is perceptible.

The line of maximum temperature, or that which passes through all the points of greatest heat in the ocean, is very irregular, and does not coincide with the terrestrial equator; six-tenths of its extent lies on an average 5° to the north of it, and the remainder runs at a mean distance of 3° on its southern side. It cuts the terrestrial equator in the middle of the Pacific Ocean in 21° E. longitude in passing from the northern to the southern hemisphere, and again between Sumatra and the peninsula of Malacca in returning from the southern to the northern. Its maximum temperature in the Pacific is 88°·5 of Fahrenheit on the northern shores of New Guinea, where it touches the terrestrial equator, and its highest temperature in the Atlantic, which is exactly the same, lies in the Gulf of Mexico, which furnishes the warm water of the Gulf-stream.

The superficial water of the Pacific is much cooled on the east by the Antarctic current; it sends a cold stream along the coasts of Chili and Peru, which has great influence on the climate of both countries; it was first observed by Baron Humboldt, and is known as Humboldt's current. It is more than 14° colder than the adjacent ocean, and renders the air 11° cooler than the surrounding atmosphere.

In the Indian Ocean the highest temperature of the surface-water (87°·4) is in the Arabian Sea, between the Strait of Bab-el-Mandeb and the coast of Hindostan; it decreases regularly from south to north in the Red Sea.

The superficial temperature diminishes from the tropics with the increase of the latitude more rapidly in the southern than in the northern hemisphere, till towards the poles the sea is never free from ice. In the Arctic Ocean the surface is at the freezing point even in summer; and during the eight winter months a continuous body of ice extends in every direction from the pole, filling the area of a circle of between 3000 and 4000 miles in diameter. The outline of this circle, though subject to partial variations, is found to be nearly similar at the same season of each succeeding year, yet there are periodical changes in the polar ice which are renewed after a series of years. The freezing process itself is a bar to the unlimited increase of the oceanic ice. Fresh water congeals at the temperature of 32° of Fahrenheit, but sea-water must be reduced to 28°·5 before it deposits its salt and begins to freeze: the salt thus set free, and the heat given out, retard the process of congelation more and more below.

The ice from the north pole comes so far south in winter as to render the coast of Newfoundland inaccessible: it envelops Greenland, sometimes even Iceland, and always invests Spitzbergen and Nova Zembla. As the sun comes north the ice breaks up into enormous masses of what is called packed ice. In the year 1806 Captain Scoresby forced his ship through 250 miles of packed ice, in imminent danger, until he reached the parallel of 81° 50′, his nearest approach to the pole: the Frozen Ocean is rarely navigable so far.

In the year 1827 Sir Edward Parry arrived at the latitude of 82° 45′, which he accomplished by dragging a boat over fields of ice, but he was obliged to abandon the bold and hazardous attempt to reach the pole, because the current drifted the ice southward more rapidly than he could travel over it to the north.

The following considerations have induced some persons to believe that there is sea instead of land at the north pole. The average latitude of the northern shores of the continent is 70°, so that the Arctic Ocean is a circle whose diameter is 2400 geographical miles, and its circumference 7200. On the Asiatic side of this sea are Nova Zembla and the New

Siberian islands, each extending to about 76° N. latitude. On the European and American sides are Spitzbergen, extending to 80°, and a part of Old Greenland, whose northern termination is unknown. Facing America is a large island—Melville Island—with some others not extending so far north as those mentioned; consequently all of them may be considered continental islands. As there are no large islands very far from land in the other great oceans, there is reason to presume that the same structure may prevail here also, and consequently it may be open sea at the north pole. Possibly also it may be free from ice, for Admiral Wrangel found a wide and open sea, free from ice and navigable, beginning 16 miles north of the island of Kotelnoi, and extending to the meridian of Cape Jackan. In fine summers the ice suddenly clears away and leaves an open channel of sea along the western coast of Spitzbergen from 60 to 150 miles wide, reaching to 80° or even to 80½° N. latitude, probably owing to warm currents from low latitudes. It was through this channel that Captain Scoresby made his nearest approach to the pole. A direct course from the Thames, across the pole to Behring's Straits, is 3570 geographical miles, while by Lancaster Sound it is 4660 miles. The Russians would be saved a voyage of 18,800 geographical miles could they go across the pole and through Behring's Straits to their North American settlements, instead of going by Cape Horn.

Floating fields of ice, 20 or 30 miles in diameter, are frequent in the Arctic Ocean: sometimes they extend 100 miles, so closely packed together that no opening is left between them; their thickness, which varies from 10 to 40 feet, is not seen, as there is at least two-thirds of the mass below water. Sometimes these fields, many thousand millions of tons in weight, acquire a rotatory motion of great velocity, dashing against one another with a tremendous collision. Packed ice always has a tendency to drift southwards, even in the calmest weather; and in their progress the ice-fields are rent in pieces by the swell of the sea. It is computed that 20,000 square miles of drift-ice are annually brought by the current along the coast of Greenland to Cape Farewell. In stormy weather the fields and streams of ice are covered with haze and spray from constant tremendous concussions; yet our seamen, undismayed by the appalling danger, boldly steer their ships amidst this hideous and discordant tumult.

Huge icebergs and masses detached from the glaciers, which extend from the Arctic lands into the sea, especially in Baffin's Bay, are drifted southwards 2000 miles from their origin to melt in the Atlantic, where they cool the water sensibly for 30 or 40 miles around, and the air to a much greater distance. They vary from a few yards to miles in circumference, and rise hundreds of feet above the surface. Seven hundred such masses have been seen at once in the polar basin. When there is a swell the loose ice dashing against them raises the spray to their very summits; and as they waste away they occasionally lose equilibrium and roll over, causing a swell which breaks up the neighbouring field-ice; the commotion spreads far and wide, and the uproar resounds like thunder.

Icebergs have the appearance of chalk-cliffs with a glittering surface and emerald-green fractures: pools of water of azure-blue lie on their surface or fall in cascades into the sea. The field-ice also, and the masses that are heaped up on its surface, are extremely beautiful from the vividness and contrast of their colouring. A peculiar blackness in the atmosphere around a bright haze at the horizon indicates their position in a fog, and their place and character are shown at night by the reflection of the snow-light on the horizon. An experienced seaman can readily distinguish by the blink, as it is termed, whether the ice is newly formed, heavy, compact, or open. The blink or snow-light of field-ice is the most lucid, and is tinged yellow; of packed ice it is pure white: ice newly formed has a greyish blink, and a deep yellow tint indicates snow on land.

Icebergs come to a lower latitude by 10° from the south pole than from the north, and appear to be larger; they have been seen near the Cape of Good Hope, and are often of great size; one observed by Captain D'Urville was 13 miles long, with perpendicular sides 100 feet high: they are less varied than those on the northern seas, a tabular form is the most prevalent. The discovery ships under the command of Sir James Ross met with multitudes with flat surfaces, bounded by perpendicular cliffs on every side, from 100 to 180 feet high, sometimes several miles in circumference. On one occasion they fell in with a chain of stupendous bergs close to one another, extending farther than the eye could reach even from the mast-head. Packed ice too is often in immense quantities: these ships forced their way through a pack 1000 miles broad, often under the most appalling circumstances. It generally consists of smaller pieces than the packs in the comparatively tranquil North Polar seas, where they are often several miles in diameter, and where fields of ice extend beyond the reach of vision. The Antarctic Ocean, on the contrary, is almost always agitated; there is a perpetual swell, and terrific storms are common, which break up the ice and render navigation perilous. The floe pieces are rarely a quarter of a mile in circumference, and generally much smaller.

A more dreadful situation can hardly be imagined than that of ships beset during a tempest in a dense pack of ice in a dark night, thick fog, and drifting snow, with the spray beating perpetually over the decks, and freezing instantaneously. Sir James Ross's own words can alone give an idea of the terrors of one of the many gales which the two ships under his command encountered:—"Soon after midnight our ships were involved in an ocean of rolling fragments of ice, hard as floating rocks of granite, which were dashed against them by the waves with so much violence, that their masts quivered as if they would fall at every successive blow; and the destruction of the ships seemed inevitable from the tremendous shocks they received. In the early part of the storm the rudder of the Erebus was so much damaged as to be no longer of any use; and about the same time I was informed by signal that the Terror's was completely destroyed and nearly torn away from the stern-post. Hour passed away after hour without the least mitigation of the awful circumstances in which we were placed. The loud crashing noise of the straining and working of the timbers and decks, as they were driven against some of the heavier pieces of ice, which all the exertions of our people could not prevent, was sufficient to fill the stoutest heart, that was not supported by trust in Him who controls all events, with dismay; and I should commit an act of injustice to my companions if I did not express my admiration of their conduct on this trying occasion. Throughout a period of 28 hours, during any one of which there appeared to be very little hope that we should live to see another, the coolness, steady obedience, and untiring exertions of each individual, were every way worthy of British seamen.

"The storm gained its height at 2 P. M., when the barometer stood at 28·40 inches, and after that time began to rise. Although we had been forced many miles deeper into the pack, we could not perceive that the swell had at all subsided, our ships still rolling and groaning amidst the heavy fragments of crushing bergs, over which the ocean rolled its mountainous waves, throwing huge masses upon one another, and then again burying them deep beneath its foaming waters, dashing and grinding them together with fearful violence." For three successive years were these dangers encountered during this bold and hazardous enterprise.

The ocean is one mass of water, which, entering into the interior of the continents, has formed seas and gulfs of great magnitude, which afford easy and rapid means of communication, while they temper the climates of the widely expanding continents.

The inland seas communicating with the Atlantic are larger, and penetrate more deeply into the continents, than those connected with the great ocean; a circumstance which gives a coast of 48,000 miles to the former, while that of the great ocean is only 44,000. Most of these internal seas have extensive river domains, so that by inland navigation the Atlantic virtually enters into the deepest recesses of the land, brings remote regions into contact, and improves the condition of the less cultivated races of mankind by commercial intercourse with those that are more civilized.

The Baltic, which occupies 125,000 square miles in the centre of northern Europe, is one of the most important of the inland seas connected with the Atlantic, and, although inferior to the others in size, the drainage of more than a fifth of Europe flows into it. Only about a fourth part of the boundary of its enormous basin of 900,000 square miles is mountainous; and so many navigable rivers flow into it from the watershed of the great European plain, that its waters are one-fifth less salt than those of the Atlantic: it receives at least 250 streams. Its depth nowhere exceeds 167 fathoms,[1] and generally it is not more than 40 or 50. From that cause, together with its freshness and northern latitude, the Baltic is frozen five months in the year. From the flatness of the greater part of the adjacent country, the climate of the Baltic is subject to influences coming from regions far beyond the limits of its river-basin. The winds from the Atlantic bring warmth and moisture, which, condensed by the cold blasts from the Arctic plains, falls in rain in summer, and deep snow in winter, which also makes the sea more fresh. The tides are imperceptible; but the waters of the Baltic occasionally rise more than three feet above their usual level from some unknown cause—possibly from oscillations in its bed, or from changes of atmospheric pressure.

The Black Sea, which penetrates most deeply into the continent of all the seas in question, has, together with the Sea of Azov, an area of 190,000 square miles: it must at a remote period have been united with the Caspian Lake, and must have covered all the Steppe of Astracan. It receives some of the largest European rivers, and drains about 950,000 square miles, consequently its waters are brackish and freeze on its northern shores in winter. It is very deep, no bottom having been reached with a line of 140 fathoms: on the melting

[1] By Captain Albrecht's soundings.

of the snow such a body of water is poured into it by the great European rivers that a rapid current is produced, which sets along the western shore from the mouth of the Dnieper to the channel of Constantinople.

Of all the branches of the Atlantic that enter deeply into the bosom of the land, the Mediterranean is the largest and most beautiful, covering with its dark blue waters more than 760,000 square miles. Situate in a comparatively low latitude, exposed to the heat of the African deserts on the south, and sheltered on the north by the Alps, the evaporation is excessive; on that account the water of the Mediterranean is salter than that of the ocean, and for the same reason the temperature at its surface is $3\frac{1}{2}°$ of Fahrenheit higher than that of the Atlantic: it does not decrease so rapidly downwards as in tropical seas, and it becomes constant at depths of from 340 to 1000 fathoms, according to the situations. Although its own river domain is only 250,000 square miles, the constant current that sets in through the Dardanelles brings a great part of the drainage of the Black Sea, so that it is really fed by the melted snow and rivers from the Caucasus, Asia Minor, Abyssinia, the Atlas, and the Alps. Yet the quantity of water that flows into the Mediterranean from the Atlantic, by the central current in the Straits of Gibraltar, exceeds that which goes out by the lateral currents.

Near Alexandria the surface of this sea is 26 feet 6 inches lower than the level of the Red Sea at

Suez at low water, and about 30 feet lower at high water.[1]

On the shore of Cephalonia there is a cavity in the rocks, into which the sea has been flowing for ages.[2]

The Mediterranean is divided into two basins by a shallow that runs from Cape Bon on the African coast to the Strait of Messina, on each side of which the water is exceedingly deep, and said to be unfathomable in some parts. M. Bérard has sounded to the depth of more than 1000 fathoms in several places without reaching the bottom. At Nice, within a few yards of the shore, it is nearly 700 fathoms deep; and Captain Smyth, R.N., ascertained the depth to be 960 fathoms between Gibraltar and Ceuta. This sea is not absolutely without tides; in the Gulf of Venice they rise three feet, and at the Great Syrte to five feet at new and full moon, but in most other places they are scarcely perceptible. The surface is traversed by various currents, two of which, opposing one another, occasion the celebrated whirlpool of Charybdis, whose terrors were much diminished by the earthquake of 1783. Its bed is subject to violent volcanic paroxysms, and its surface is studded with islands of all sizes, from the magnificent kingdom of Sicily to mere barren rocks—some actively volcanic, others of volcanic formation, and many of the secondary geological period.

[1] By the measurement of M. Lepère in the French expedition to Egypt.—'Annales du Bureau de Longitude,' 1836.

[2] Proceedings of the Royal Geological Society, vol. ii. p. 210.

Various parts of its coasts are in a state of great instability; in some places they have sunk down and risen again more than once within the historical period.

Far to the north the Atlantic penetrates the American continent by Davis's Straits, and spreads out into Baffin's Bay, twice the size of the Baltic, very deep, and subject to all the rigours of an arctic winter —the very storehouse of icebergs—the abode of the walrus and the whale. Hudson's Bay, though without the Arctic Circle, is but little less dreary.

Very different is the character of those vast seas where the Atlantic comes "cranking in" between the northern and southern continents of America. The surface of the sea in Baffin's Bay is seldom above the freezing point; here, on the contrary, it is always 88°·5 of Fahrenheit, while the Atlantic Ocean in the same latitude is not above 77° or 78°. Of that huge mass of water, partially separated from the Atlantic by a long line of islands and banks, the Caribbean Sea is the largest; it is as long from east to west as the distance between Great Britain and Newfoundland, and occupies a million of square miles. Its depth in many places is very great, and its water is limpid. The Gulf of Mexico, fed by the Mississippi, one of the greatest of rivers, is more than half its size, or about 625,000 square miles, so that the whole forms a sea of great magnitude. Its shores, and the shores of the numerous islands, are dangerous from shoals and coral-reefs, but the interior of these seas is not. The trade-winds prevail there; they are subject to severe northern gales, and some parts are occasionally visited by tremendous hurricanes.

By the levelling across the peninsula of Panama by Mr. Lloyd, in 1828, the mean height of the Pacific above that of the Atlantic was found to be three feet six inches.

The Pacific does not penetrate the land in the same manner that the Atlantic does the continent of Europe. The Red Sea and Persian Gulf are joined to it by very narrow straits; but almost all the internal seas on the eastern coast of Asia, except the Yellow Sea, are great gulfs shut in by islands, like the Caribbean Sea and the Gulf of Mexico, to which the China Sea, the Sea of Japan, and that of Okhotsk are perfectly analogous.

The set of the great oceanic currents has scooped out and indented the southern and eastern coasts of the Asiatic continent into enormous bays and gulfs, and has separated large portions of the land, which now remain as islands—a process which probably has been increased by the submarine fires extending along the eastern coast from the equator nearly to the Arctic Circle.

The perpetual agitation of the ocean by winds, tides, and currents is continually, but slowly, changing the form and position of the land—steadily producing those vicissitudes on the surface of the earth to which it has been subject for ages, and to which it will assuredly be liable in all time to come.

CHAPTER XVII.

Springs — Basins of the Ocean — Origin, Course, and Heads of Rivers — Hydraulic Systems of Europe — African Rivers — the Nile, Niger, &c.

The vapour which rises invisibly from the land and water ascends in the atmosphere till it is condensed by the cold into clouds, which restore it again to the earth in the form of rain, hail, and snow; hence there is probably not a drop of water on the globe that has not been borne on the wings of the wind. Part of this moisture restored to the earth is re-absorbed by the air, part supplies the wants of animal and vegetable life, a portion is carried off by the streams, and the remaining part penetrates through porous soils till it arrives at a stratum impervious to water, where it accumulates in subterranean lakes often of great extent. The mountains receive the greatest portion of the aërial moisture, and, from the many alternations of permeable and impermeable strata they contain, a complete system of reservoirs is formed in them, which, continually overflowing, form perennial springs at different elevations, which unite and run down their sides in incipient rivers. A great portion of the water at these high levels penetrates the earth till it comes to an impermeable stratum below the plains, where it collects in a sheet, and is forced by hydraulic pressure to rise in springs, through cracks in the ground, to the surface. In this manner the water which falls on hills and mountains is carried through highly-inclined strata to great depths, and even below the bed of the ocean, in many parts of which there are springs of fresh water. In boring Artesian wells the water often rushes up with such impetuosity by the hydrostatic pressure as to form jets 40 or 50 feet high. In this operation several successive reservoirs have been met with; at St. Ouen, near Paris, five sheets of water were found; the water in the first four not being good, the operation was continued to a greater depth; it consists merely in boring a hole of small diameter, and lining it with a tube. It rarely happens that water may not be procured in this way; and as the substratum in many parts of deserts is an argillaceous marl, it is probable that Artesian wells might be bored with success.

A spring will be intermittent when it issues from an opening in the side of a reservoir fed from above, if the supply be not equal to the waste, for the water will sink below the opening, and the spring will stop till the reservoir is replenished. Few springs give the same quantity of water at all times; they also vary much in the quantity of foreign matter they contain. Mountain-springs are generally very pure, the carbonic acid gas almost always found in them escapes into the atmosphere, and their earthy matter is deposited as they run along, so that river-water from such sources is soft, while wells and springs in the plains are hard, and more or less mineral.

The water of springs takes its temperature from that of the strata through which it passes: mountain-springs are cold, but, if the water has penetrated deep into the earth, it acquires a temperature depending on that circumstance.

The temperature of the surface of the earth varies with the seasons to a certain depth, where it becomes permanent and equal to the mean annual temperature of the air above. It is evident that the depth at which this stratum of invariable temperature lies must vary with the latitude. At the equator the effect of the seasons is imperceptible at the depth of a foot below the surface: between the parallels of 40° and 52° the temperature of the ground in Europe is constant at the depth of from 55 to 60 feet: and in the high Arctic regions the soil is perpetually frozen a foot below the surface. Now, in every part of the world where experiments have been made, the temperature of the earth increases with the depth below the constant stratum at the rate of 1° of Fahrenheit for every 50 or 60 feet of perpendicular depth; hence, should the increase continue to follow the same ratio, even granite must be in fusion at little more than five miles below the surface. In Siberia the stratum of frozen earth is some hundred feet thick, but below that the increase of heat with the depth is three times as rapid as in Europe. The temperature of springs must therefore depend on the depth to which the water has penetrated before it has been forced to the surface, either by the hydraulic pressure of water at higher levels or by steam. If it never goes below the stratum of invariable temperature, the heat of the spring will vary with the seasons, more or less, according to the depth below the surface: should the water come from the constant stratum itself, its temperture will be invariable; and if from below it, the heat will be in proportion to the depth to which it has penetrated. Thus, there may be hot and even boiling springs hundreds of miles distant from volcanic action and volcanic strata, of which there are many examples, though they are more frequent in volcanic countries and those subject to earthquakes. The temperature of hot springs is very constant, and that of boiling springs has remained unchanged for ages; shocks of earthquakes sometimes affect the temperature, and have even stopped them altogether. Jets of steam of high tension are frequent in volcanic countries, as in Iceland.

Both hot and cold water dissolves and combines with many of the mineral substances it meets with in the earth, and comes to the surface from great depths as medicinal springs, containing various ingredients. So numerous are they that in the Austrian dominions alone there are 1500; and few countries of any extent are destitute of them. They contain hydrosulphuric and carbonic acids, sulphur, iron, magnesia, and other substances. Boiling springs deposit silex, as in Iceland and in the Azores; and others of lower temperature deposit carbonate of lime in great quantities all over the world. Springs of pure brine are rare; those in Cheshire are rich in salt, and have flowed unchanged 1000 years, a proof of the tranquil state of that part of the globe. Many substances that lie beyond our reach are brought to the surface by springs, as naphtha, petroleum, and boracic acid: petroleum is particularly abundant in Persia, and numberless springs and lakes of it surround some parts of the Caspian Sea. It is found in immense quantities in various parts of the world.

RIVERS.

Rivers have had a greater influence on the location and fortunes of the human race than almost any other physical cause, and, since their velocity has been overcome by steam navigation, they have become the highway of the nations.

They frequently rise in lakes, which they unite with the sea; in other instances they spring from small elevations in the plains, from perennial sources in the mountains, alpine lakes, melted snow and glaciers; but the everlasting storehouses of the mightiest floods are the ice-clad mountains of table-lands.

Rivers are constantly increased, in descending the mountains and traversing the plains, by tributaries, till at last they flow into the ocean, their ultimate destination and remote origin. "All rivers run into the sea, yet the sea is not full," because it gives in evaporation an equivalent for what it receives.

The Atlantic, the Arctic, and the Pacific Oceans are directly or indirectly the recipients of all the rivers, therefore their basins are bounded by the principal watersheds of the continents; for the basin of a sea or ocean does not mean only the bed actually occupied by the water, but comprehends also all the land drained by the rivers which fall into it, and is bounded by an imaginary line passing through all their sources. These lines generally run through the elevated parts of a country that divide the streams which flow in one direction from those that flow in another. But the watershed does not coincide in all cases with mountain-crests of great elevation, as the mere convexity of a plain is often sufficient to throw the streams into different directions.

From the peculiar structure of the high land and mountain-chains, by far the greater number of important rivers on the globe flow into the ocean in an easterly direction, those which flow to the south and north being the next in size, while those that flow in a westerly direction are small and unimportant.

The course of all rivers is changed when they pass from one geological formation to another, or by dislocations of the strata: the sudden deviations in their directions are generally owing to these circumstances.

None of the European rivers flowing directly into the Atlantic exceed the fourth or fifth magnitude, except the Rhine; the rest of the principal streams come to it indirectly through the Baltic, the Black Sea, and the Mediterranean. It nevertheless receives nearly half the waters of the old continent, and almost all the new, because the Andes and Rocky Mountains, which form the watershed of the American continent, lie along its western side, and the rivers which rise on the western slope of the Alleghannies are tributaries to the Mississippi, which comes indirectly into the Atlantic by the Gulf of Mexico.

The Arctic Ocean drains the high northern latitudes of America, and receives those magnificent Siberian rivers that originate in the Altaï range from the Steppe of the Kerghis to the extremity of Kamtchatka, as well as the very inferior streams of North European Russia. The running waters of the rest of the world flow into the Pacific. The Caspian and Lake Aral are mere salt-water lakes, which receive rivers but emit none. However, nearly one-half of all the running water in Europe falls into the Black Sea and the Caspian.

Mountain-torrents gradually lose velocity in their descent to the low lands by friction, and when they enter the plains their course becomes still more gentle, and their depth greater. A slope of one foot in 200 prevents a river from being navigable, and a greater inclination forms a rapid or cataract. The speed, however, does not depend entirely upon the slope, but also upon the height of the source of the river, and the pressure of the body of water in the upper part of its course; consequently, under the same circumstances, large rivers run faster than small, but in each individual stream the velocity is perpetually varying with the form of the banks, the winding of the course, and the changes in the width of the channel. The Rhone, one of the most rapid European rivers, has a declivity of one foot in 2620, and flows at the rate of 120 feet in a minute; the sluggish rivers in Flanders have only one-half that velocity. The Danube, the Tigris, and the Indus are among the most rapid of the large rivers. In flat countries rivers are generally more meandering, and thus they afford a greater amount of irrigation; the windings of the Vistula are nearly equal to nine-tenths of its direct course from its source to its mouth.

When one river falls into another, the depth and velocity are increased, but not always proportionally to the width of the channel, which sometimes even becomes less, as at the junction of the Ohio with the Mississippi. When the angle of junction is very obtuse, and the velocity of the tributary stream great, it sometimes forces the water of its primary to recede a short distance. The Arve, swollen by a freshet, occasionally drives the water of the Rhone back into the Lake of Geneva; and it once happened that the force was so great as to make the mill-wheels revolve in a contrary direction.

Streams sometimes suddenly vanish, and after flowing underground to some distance reappear at the surface, as in Derbyshire. Instances have occurred of rivers suddenly stopping in their course for some hours, and leaving their channels dry. On the 26th of November, 1838, the water failed so completely in the Clyde, Nith, and Teviot, that the mills were stopped eight hours in the lower part of their streams. The cause was the coincidence of a gale of wind and a strong frost, which congealed the water near their sources. Exactly the contrary happens in the Siberian rivers, which flow from south to north over so many hundreds of miles; the upper parts are thawed, while the lower are still frozen, and the water, not finding an outlet, inundates the country.

The alluvial soil carried down by streams is gradually deposited as their velocity diminishes; and if they are subject to inundations, and the coast flat, it forms deltas at their mouths; there they generally divide into branches, which often join again, or are united by transverse channels, so that a labyrinth of streams and islands is formed. Deltas are sometimes found in the interior of the continents at the junction of rivers, exactly similar to those on the ocean, though less extensive: deltas are said to be maritime, lacustrine, or fluviatile, according as the stream that forms them falls into the sea, a lake, or another river.

Tides flow up rivers to a great distance, and to a height far above the level of the sea: the tide is perceptible in the river of the Amazons 576 miles from its mouth, and it ascends 255 miles in the Orinoco.

In the temperate zones rivers are subject to floods from autumnal rains, and the melting of the snow, especially on mountain-ranges. The Po, for example, spreads desolation far and wide over the plains of Lombardy; but these torrents are as variable in their recurrence and extent as the climate which produces them. The inundations of the rivers in the torrid zone, on the contrary, occur with a regularity peculiar to a region in which meteoric phenomena are uniform in all their changes. These floods are due to the periodical rains, which, in tropical countries, follow the cessation of the trade-winds after the vernal equinox and at the turn of the monsoons, and are thus dependent on the declination of the sun, the immediate cause of all these variations. The melting of the snow no doubt adds greatly to the floods of the tropical rivers which rise in high mountain-chains, but it is only an accessary circumstance; for although the snow-water from the Himalaya swells the streams considerably before the rains begin, yet the principal effect is owing to the latter, as the southern face of the Himalaya is not beyond the influence of the monsoon, and the consequent periodical rains, which besides prevail all over the plains of India traversed by the great rivers and their tributaries.

Under like circumstances, the floods of rivers, whose sources have the same latitude, take place at the same season; but the periods of the inundations of rivers on one side of the equator are exactly the contrary of what they are in rivers on the other side of it, on account of the declination of the sun. The flood in the Orinoco is at its greatest height in the month of August, while that of the river of the Amazons, south of the equinoctial line, is at its greatest elevation in March.[1] The commencement and end of the annual inundations in each river depend upon the mean time of the beginning, and on the duration of the rains in the latitudes traversed by its affluents. The periods of the floods in such rivers as run towards the equator are different from those flowing in an opposite direction; and as the rise requires time to travel, it happens at regular but different periods in various parts of the same river, if very long. The height to which the water rises in the annual floods depends upon the nature of the country, but it is wonderfully constant in each individual river where the course is long; for the inequality in the quantity of rain in a district drained by any of its affluents is imperceptible in the general flood, and thus the quantity of water carried down is a measure of the mean humidity of the whole country comprised in its basin from year to year. By the admirable arrangement of these periodical inundations the fresh soil of the mountains, borne down by the water, enriches countries far remote from their source. The waters from the high lands designated as the Mountains of the Moon, and of Abyssinia, have fertilized the banks of the Nile through a distance of 2500 miles for thousands of years.

When rivers rise in mountains, water communication between them in the upper parts of their course is impossible; but when they descend to the plains, or rise in the low lands, the boundaries between the countries drained by them become low, and the

[1] Baron Humboldt's Personal Narrative.

different systems may be united by canals. It sometimes happens in extensive and very level plains, that the tributaries of the principal streams either unite or are connected by a natural canal by which a communication is formed between the two basins—a circumstance advantageous to the navigation and commerce of both, especially where the junction takes place far inland, as on the Orinoco and Amazons in the interior of South America. The Rio Negro, one of the largest affluents of the latter, is united to the Upper Orinoco in the plains of Esmeralda by the Cassiquiare—a stream as large as the Rhine, with a velocity of 12 feet in a second. Baron Humboldt observes that the Orinoco, sending a branch to the Amazons, is, with regard to distance, as if the Rhine should send one to the Seine or Loire. At some future period this junction will be of great importance. These bifurcations are frequent in the deltas of rivers, but very rare in the interior of continents. The Mahamuddy and Godavery, in Hindostan, seem to have something of the kind; and there are several instances in the great rivers of the Indo-Chinese peninsula.

The hydraulic system of Europe is eminently favourable to inland navigation, small as the rivers are in comparison with those in other parts of the world; but the flatness of the great plain, and the lowness of its watershed, are very favourable to the construction of canals. In the west, however, the Alps and German mountains divide the waters that flow to the Atlantic on one side, and to the Mediterranean and Black Sea on the other; but in the eastern parts of Europe the division of the waters is merely a more elevated ridge of the plain itself, for in all plains such undulations exist, though often imperceptible to the eye. This watershed begins on the northern declivity of the Carpathian Mountains about the 23rd meridian, in a low range of hills running between the sources of the Dnieper and the tributaries of the Vistula, from whence it winds in a tortuous course along the plain to the Valdai table-land, which is its highest point, 1200 feet above the sea; it then declines northward towards Onega, about the 60th parallel, and lastly turns in a very serpentine line to the sources of the Kama in the Ural mountains near the 62nd degree of north latitude. The waters north of this line run into the Baltic and White Sea, and, on the south of it, into the Black Sea and the Caspian.

Thus Europe is divided into two principal hydraulic systems; but since the basin of a river comprehends all the plains and valleys drained by it and its tributaries from its source to the sea, each country is subdivided into as many natural divisions or basins as it has primary rivers, and these generally comprise all the rich and habitable parts of the earth, and are the principal centres of civilization, or are capable of becoming so.

The streams to the north of the general watershed are very numerous; those to the south are of greater magnitude. The systems of the Volga and Danube are the most extensive in Europe; the former has a basin comprising 640,000 square miles, and is navigable throughout the greater part of its course of 1900 miles. It rises in a small lake on the slopes of the Valdai table-land, 550 feet above the level of the ocean, and falls into the Caspian, which is 83 feet 7 inches below the level of the Black Sea, so that it has a fall of 633 feet in a course of more than 2400 miles. It carries to the Caspian one-seventh of all the river-water of Europe.

The Danube drains 300,000 square miles, and receives 60 navigable tributaries. Its quantity of water is nearly as much as that of all the rivers that empty themselves into the Black Sea taken together. Its direct course is 900 miles, its meandering line is 2400. It rises in the Black Forest at an elevation of 2850 feet above the level of the sea, so that it has considerable velocity, which, as well as rocks and rapids, impedes its navigation in many places, but it is navigable downwards, through Austria, for 600 miles, to New Orsova, from whence it flows in a gentle current to the Black Sea. The commercial importance of these two rivers is much increased by their flowing into inland seas. By canals between the Volga and the rivers north of the watershed, the Baltic and White Seas are connected with the Black Sea and the Caspian; and the Baltic and Black Sea are also connected by a canal between the Don and the Dnieper. Altogether the water system of Russia is the most extensive in Europe.

The whole of Holland is a collection of deltoid islands, formed by the Rhine, the Meuse, and the

Scheldt—a structure very favourable to commerce, and which has facilitated an extensive internal navigation. The Mediterranean is already connected with the North Sea by the canal which runs from the Rhone to the Rhine; and this noble system, extended over the whole of France by 7591 miles of inland navigation, has conduced mainly to the improved state of that great country.

Many navigable streams rise in the Spanish mountains; of these the Tagus has depth enough for the largest ships as high as Lisbon. Its actual course is 480 miles, but its direct line much less. In point of magnitude, however, the Spanish rivers are of inferior order, but canals have rendered them beneficial to the country. Italy is less favoured in her rivers, which only admit vessels of small burthen; those on the north are by much the most important, especially the Po and its tributaries, which by canals connect Venice and Milan with various fertile provinces of Northern Italy; but whatever advantages nature has afforded to the Italian states have been improved by able engineers, both in ancient and modern times.

The application of the science of hydraulics to rivers took its rise in Northern Italy, which has been carried to such perfection in some points, that China is the only country which can vie with it in the practice of irrigation. The lock on canals was in use in Lombardy as early as the 13th century, and in the end of the 15th it was applied to two canals which unite the Ticino to the Adda, by that great artist and philosopher Leonardo da Vinci: about the same time he introduced the use of the lock into France.[1]

Various circumstances combine to make the British rivers more useful than many others of greater magnitude. The larger streams are not encumbered with rocks or rapids; they all run into branches of the Atlantic; the tides flow up their channels to a considerable distance; and above all, though short in their course, they end in wide estuaries and sounds, capable of containing whole navies—a circumstance that gives an importance to streams otherwise insignificant, when compared with the great rivers of either the old or new continent.

The Thames, whose basin is only 5027 square miles, and whose length is but 240 miles, of which, however, 204 are navigable, spreads its influence over the remotest parts of the earth; its depth is sufficient to admit large vessels even up to London, and throughout its navigable course a continued forest of masts display the flags of every nation: its banks, which are in a state of perfect cultivation, are the seat of the highest civilization, moral and political. Local circumstances have undoubtedly been favourable to this superior development, but the earnest and

[1] Leonardo da Vinci was appointed Director of Hydraulic Operations in Lombardy by the Duke of Milan, and during the time he was painting the "Last Supper" he completed the Canal of Martesana, extending from the Adda to Milan, and improved the course of the latter river from where it emerges from the Lake of Como to the Po. By means of the Naviglio Grande, the Martesana canal establishes a water communication between the Adda and the Ticino, the Lakes of Como and Maggiore.

energetic temperament of the Saxon races has rendered the advantages of their position available. The same may be said of other rivers in the British islands, where commercial enterprise and activity vie with that on the Thames. There are 2790 miles of canal in Britain, and, including rivers, 5430 miles of inland navigation, which, in comparison with the size of the country, is very great; it is even said that no part of England is more than 15 miles distant from water communication.

On the whole, Europe is fortunate with regard to its water systems, and its inhabitants are for the most part alive to the bounties which Providence has bestowed.

AFRICAN RIVERS.

In Africa the tropical climate and the extremes of aridity and moisture give a totally different character to its rivers. The most southerly part is comparatively destitute of them, and those that do exist are of inferior size, except the Gariep, or Orange River, which has a long course on the table-land, but is nowhere navigable. From the eastern edge of the table-land of South Africa, which is very abrupt, rise all those rivers which flow across the plains of Mozambique and Zanguebar to the Indian Ocean. Of these the Zambesi, or Quillimane, is probably the largest: it is said to have a course of 900 miles, and to be navigable during the rains for 200 or 300 miles from its mouth. The Ozay, not far south of the equator, is also believed to be of great extent, and the Juba, more to the north; all these streams have little water at their mouths during the dry season, but in the rainy season they are navigable. Some of those still farther north do not reach the sea at all times of the year, but end in lakes and marshes, as the Haines and Hawash. The first, after coming to within a small distance of the Indian Ocean, runs southward parallel to the coast, and falls into a very large and deep lake about a degree north of the equator. Between the Hawash and the Straits of Bàb-el-Mandeb there is no river of any note. In many parts of the coast, near the rivers, grain ripens all the year, yielding from 80 to 150 fold, and every eastern vegetable production might be raised. The Hawash runs through a low desert country inhabited by the Dankali Beduins: that river is the recipient of the waters which come from the eastern declivity of the table-land of Abyssinia, while the Nile receives those of the counter slope.

The part of the table-land between the 18th parallel of south latitude and the equator is the origin from whence the waters flow to the Atlantic on one hand, and to the Mediterranean on the other. Those which go to the Atlantic rise south of Lake N'yassi, chiefly in a ridge of no great elevation which runs from S.W. to N.E. to the west of the dominions of the Cambeze, and, after falling in cascades and rapids through the chains that border the table-land on the west, fertilize the luxuriant maritime plains of Benguela, Congo, Angola, and Loando. The Zaire, or

Congo, by much the largest of these, is navigable for 140 miles, where the ascent of the tide is stopped by cataracts. The lower course of this river is 5 or 6 miles broad, full of islands, and 160 fathoms deep at its mouth. Its upper course, like that of most of these rivers, is unknown; the greater number are fordable on the table-land, but, from the abrupt descent of the high country to the maritime plains, none of them afford access to the interior of South Africa.

The mountainous edge of the table-land, with its terminal projections, Senegambia and Abyssinia, which separate the northern from the southern deserts, are the principal source of running water in Africa. Various rivers have their origin in these mountainous regions, of which the Nile and the Niger yield in size only to some of the great Asiatic and American rivers. In importance and historical interest the Nile is inferior to none.

Two large rivers unite their streams to form the Nile—the Bahr-el-Abiad, or White Nile, and the Bahr-el-Azrek, or Blue Nile; but the latter is so far inferior to the Bahr-el-Abiad that it may almost be regarded as a tributary. The main stream has never been ascended by any traveller above 4° 42′ 42″ north latitude, where a ledge of gneiss crossing it arrested the progress of the second expedition sent by the Viceroy of Egypt to discover its source. Bahr-el-Abiad, or the true Nile, is supposed, from the report of the natives, to rise, under the name of the Tubiri, at a comparatively small distance from the sea, in the country of Mono Moézi, which is a continuation of the high plateau of Abyssinia, situate to the north of the great Lake Zambéze, or N'yassi. The natives say that it flows from the lake itself; at all events it seems to be pretty certain that its origin is in the mountainous or hilly country of Mono Moezi, a word which in all the languages of that part of Africa signifies the Moon: hence the Nile has been said, since the days of Ptolemy, to rise in the Mountains of the Moon. Amidst many windings it takes a general direction towards the N.E. to the 14th northern parallel, whence it follows the same course till its junction near Khartum with the Blue Nile in the plains of Sennaar.

The Shoaberri and Godjeb, the chief affluents of the White Nile, come from the east; the former makes a great circuit round the country of Berri before it falls into the Nile, and the Godjeb, which has its origin in the great forest already mentioned, in the Galla country, south of Abyssinia, makes a similar spiral détour round Kaffa, and under the name of Subat joins the Nile, which it enlarges to nearly double its size.

The Abyssinian branch of the Nile, known as the Bahr-el-Azrek, or Blue River, rises under the name of the Dedhesa in the Galla country, south of Abyssinia, about 73 miles west of Sokka, the capital of Enarea. It springs from a swampy meadow in the same elevated plains where the Godjeb and other affluents of the White Nile originate, and after a completely spiral course, in which it separates the kingdoms of Guma and Enarea, it maintains a general north-westerly direction till it joins the White Nile at Khartum. Of the many tributaries to the Blue River, the Abái, the Nile of Bruce, is the greatest and most celebrated. Its sources are in a swampy meadow near Mount Giesk, in the district of Sákkata, from whence it takes a circular direction round the peninsula of Gojam, passing through Lake Dembea, and receiving many affluents from the mountain-chain that forms the cone of the peninsula, and at last falls into the Dedhesa or Bahr-el-Azrek, in about 11° N. latitude. From that point no stream of any consequence joins either the Blue River, or the united streams of the Blue and White Rivers, till 160 miles below their confluence, where the Atbarah, or Takkazie, falls into it. This river, which is the principal tributary of the Nile, is formed by two branches. The Takkazie rises in the mountains of Lasta, near Lalíbata, one of the most celebrated places in Abyssinia, remarkable for its churches hewn out of the living rock, and the Tselari, which springs from Mount Biála, the northern extremity of the high land of Lasta, which divides the head waters of the two branches. The united stream, after winding like the other rivers of this country, joins the Nile in 18° N. latitude, the northern limit of the tropical rains.

The Abyssinian rivers in the early part of their course are little more than muddy brooks in the dry season, but during the rains they inundate the plains. They break from the table-lands through fissures in the rocky surface, which are at first only a few yards wide, but gradually increase to several miles; the streams form cataracts from 80 to more than 100 feet high, and then continue to descend by a succession of falls and rapids, which decrease in height as they go northwards to join the main stream. The Takkazie takes its name of "The Terrible" from the impetuosity with which it rushes through the chasms and over the precipices of the mountains.

A peculiarity of most of the principal affluents of the Nile is their spiral course, so that, after having formed a curve of greater or less extent, generally round insulated mountain masses, they return upon themselves at a short distance from their sources. It is by no means improbable that the head stream of the Nile itself takes a spiral course round a lofty mountain mass, similar to the snow-clad mountains of Sámien and Káffa.[1]

From the Takkazie down to the Mediterranean, a distance of 1200 miles, the Nile does not receive a single brook. The first part of that course is interrupted by cataracts, from the geological structure of the Nubian desert, which consists of a succession of broad sterile terraces, separated by ranges of rocks running east and west. Over these the Nile falls in nine or ten cataracts, the last of which is at Es-Souan (Syene), where it enters Egypt. Most of them are only rapids, where each successive fall of water is not a foot high. That they were higher at a former period has recently been ascertained by Dr. Lepsius, the very intelligent traveller sent by

[1] Dr. Beke on the Nile and its Affluents.

the King of Prussia at the head of a mission to explore that country. He found a series of inscriptions on the rocks at Sennaar, marking the height of the Nile at different periods; and it appears from these, that in that country the bed of the river had been 30 feet higher than it is now.

Fifteen miles below Cairo, and at 90 miles from the sea, the Nile is divided into two branches, of which one, running in a northerly direction, enters the Mediterranean below Rosetta; the other, cutting Lower Egypt into two nearly equal parts, enters the sea above Damietta, so that the delta between these two places has a sea-coast of 187 miles. The fall from the great cataract to the sea is two inches in a mile.

The basin of the Nile, occupying an area of 500,000 square miles, has an uncommon form: it is wide in Ethiopia and Nubia, but for the greater part of a winding course of 2750 miles it is merely a verdant line of the softest beauty, suddenly and strongly contrasted with the dreary waste of the Red Desert. Extending from the equatorial far into the temperate zone, its aspect is less varied than might have been expected on account of the parched and showerless country it passes through. Nevertheless, from the great elevation of the origin of the river, the upper part has a perpetual spring, though within a few degrees of the equator. At the foot of the table-land of Abyssinia the country is covered with dense tropical jungles, while the rest of the valley is rich soil, the detritus of the mountains for thousands of years.

As the mean velocity of the Nile, when not in flood, is about two miles and a half an hour, a particle of water would take twenty-two days and a half to descend from the junction of the Takkazie to the sea; hence the retardation of the annual inundations of the Nile in its course is a peculiarity of this river, owing to some unknown cause towards its origin which affects the whole stream. In Abyssinia and Sennaar the river begins to swell in April, yet the flood is not sensible at Cairo till towards the summer solstice; it then continues to rise about a hundred days, and remains at its greatest height till the middle of October, when it begins to subside, and arrives at its lowest point in April and May. The height of the flood in Upper Egypt varies from 30 to 35 feet; at Cairo it is 23, and in the northern part of the delta only 4 feet.

Anubis, or Sirius, the Dog-star, was worshipped by the Egyptians, from its supposed influence on the rising of the Nile. According to Champollion, their calendar commenced when the heliacal rising of that star coincided with the summer solstice—the time at which the Nile began to swell at Cairo. Now this coincidence made the nearest approach to accuracy 3291 years before the Christian era; and as the rising of the river still takes place precisely at the same time and in the same manner, it follows that the heat and periodical rains in Upper Ethiopia have not varied for 5000 years. In the time of Hipparchus the summer solstice was in the sign of

Leo, and probably about that period the flowing of the fountains from the mouths of lions of basalt and granite was adopted as emblematical of the pouring forth of the floods of the Nile. The emblem is still common in Rome, though its origin is probably forgotten, and the signs of the Zodiac have moved backwards more than 30°.

The two greatest African rivers, the Nile and the Niger, are dissimilar in almost every circumstance; the Nile, discharging for ages into a sea, the centre of commerce and civilization, has been renowned by the earliest historians, sacred and profane, for the exuberant fertility of its banks, and for the learning and wisdom of their inhabitants, who have left magnificent and imperishable monuments of their genius and power. Egypt was for ages the seat of science, and by the Red Sea it had intercourse with the most highly cultivated nations of the east from time immemorial. The Niger, on the contrary, though its rival in magnitude, and running through a country glowing with all the brilliancy of tropical vegetation, has ever been inhabited by barbarous or semi-barbarous nations; and its course till lately was little known, as its source still is. In early ages, before the Pillars of Hercules had been passed, and indeed long afterwards, the Atlantic coast of Africa was an unknown region, and thus the flowing of the Niger into that lonely ocean kept the natives in their original rude state. Such are the effects of local circumstances on the intellectual advancement of man.

The sources of the Niger, Joliba, or Quorra, are supposed to be on the northern side of the Kong Mountains, in the country of Bambarra, more than 1600 feet above the level of the sea. From thence it runs north, and, after passing through Lake Debo, makes a wide circuit in the plains of Soudan to Timbuctoo through eight or nine degrees of latitude: then bending round, it again approaches the Kong Mountains, at the distance of 1000 miles in a straight line from its source; and having threaded them, it flows across the low lands into the Gulf of Guinea, a course of 2300 miles. In the plains of Soudan it receives many very large affluents from the high land of Senegambia on the west, and the Tchadda on the east—a navigable river larger than itself, probably the outlet of the great lake Tchad, which drains the high land of Komri, designated by the ancients as the Mountains of the Moon, and falls into it a little below Fundah, after a course of some hundred miles: thus the Niger probably affords an uninterrupted water-communication from the Atlantic to the heart of Africa.[1] Long before leaving the plains of Soudan it becomes a noble river with a smooth stream, gliding at the rate of from 5 to 8 miles an hour, varying in breadth from 1 to 8 miles. Its banks are studded with densely populous towns and villages, groves of palm-trees, and cultivated fields.

This great river divides into three branches near the head of a delta which is equal in area to Ireland,

[1] Captain W. Allen, R.N.

intersected by navigable branches of the principal stream in every direction. The soil is rich mould, and the vegetation so rank that the trees seem to grow out of the water. The Nun, which is the principal or central branch, flows into the sea near Cape Formosa, and is that which the brothers Lander descended. There are, however, six rivers which run into the Bight of Benin, all communicating with the Niger, and with one another. The old Calabar is the most eastern; it rises in the high land of Calbongos, and is united to the Niger by a natural canal. The Niger, throughout its long winding course, lies entirely within the tropic of Cancer, and is consequently subject to periodical inundations, which reach their greatest height in August, about 40 or 50 days after the summer solstice. The plains of Soudan are then covered with water and crowded by boats. These fertile regions are inaccessible to Europeans from the pernicious climate, and dangerous from the savage condition of many of the tribes.

The coast of Guinea, west from the Niger, is watered by many streams, of no great magnitude, from the Kong Mountains. The table-land of Senegambia is the origin of the Rio Grande, the Gambia, the Senegal, and others of great size; and also of many of an inferior order that fertilize the luxuriant maritime plains on the Atlantic. Their navigable course is cut short by a semicircular chain of mountains which forms the boundary of the high land, through which they thread their way in rapids and cataracts. The Gambia rises in Foula Toro, and after a course of about 600 miles enters the Atlantic by many branches connected by natural channels, supposed at one time to be separate rivers. The Senegal, the largest river in this part of Africa, is 850 miles long. It receives many tributaries in the upper part of its course, and the lower is full of islands. It drains two lakes, has several tributaries, and is united to the basin of the Gambia by the river Neriko.

CHAPTER XVIII.

Asiatic Rivers — Euphrates and Tigris — River Systems South of the Himalaya — Chinese Rivers — Siberian Rivers.

THE only river system of importance in Western Asia is that of the Euphrates and Tigris. In the basin of these celebrated streams, containing an area of 230,000 square miles, immense mounds of earth, in a desolate plain, point out the sites of some of the most celebrated cities of antiquity—of Nineveh and Babylon. Innumerable remains and inscriptions, the records of times very remote, have been discovered by adventurous travellers, and bear testimony to the truth of some of the most interesting pages of history. The Euphrates, and its affluent the Merad-Chaï (supposed to be the stream forded, as the Euphrates, by the Ten Thousand in their retreat), rise in the heart of Armenia, and, after running 1800 miles on the table-land to 38° 41′ of north latitude, they join the northern branch of the Euphrates, which rises in the Gheul Mountains, near Erzeroum. The whole river then descends in rapids through the Taurus chain, north of Romkala, to the plains of Mesopotamia.

The Tigris rises in the mountains to the N. and W. of Dyar-bekir, and after receiving several tributaries from the high lands of Kurdistan, it pierces the Taurus range about 100 miles above Mosul, from whence it descends in a tortuous course through the plain of ancient Assyria, receiving many streams from the Tyari mountains, inhabited by the Nestorian Christians, and, farther south, from those of Luristan. The country through which it flows is rich in corn-fields, date-groves, and forest-trees.[1] Near to the city of Bagdad the Tigris and Euphrates approach to within 12 miles, where they were once connected by two great canals. From this point they run nearly parallel for more than 100 miles, encircling the plain of Babylon or Southern Mesopotamia—the modern Irak-Arabi. The two rivers unite at Korna, and form one stream, which, under the name of Shat el Arab, runs for 150 miles before it falls into the Persian Gulf. The banks of the

[1] It is in the space comprised between two of the eastern tributaries of the Tigris, the Khaus and the Great Zab, or Abou Selman of the Arabs, that the extensive ruins of Koyunjik, Khorsabad, and especially of Nimroud, are situated, the last of which have been so satisfactorily identified with the capital of Assyria—the ancient Nineveh—by our enterprising and talented countryman Mr. Layard, to whose exertions, under circumstances of peculiar difficulty, surrounded by every privation, our national Museum is indebted for that magnificent collection of Assyrian monuments which at this moment forms the admiration of the British public. It is to be hoped that our Government will follow up the researches commenced by Mr. Layard, and that several of the gigantic sculptures removed by him, with such perseverance and labour, to Bussorah, will ere long be added to the riches of the British Museum.

See Mr. Layard's work on 'Nineveh and its Remains,' 2 vols. 8vo., and his illustrated work in folio—the former one of the most interesting narratives ever published on the antiquities of Central Asia.

Tigris and Euphrates, once the seat of an extensive population, and of art, civilization, and industry, are now nearly deserted, covered with brushwood and grass, dependent on the rains alone for that luxuriant vegetation which, under an admirable system of irrigation, formerly covered them. Excepting the large centres of population, Bagdad and Mosul, the inhabitants consist of nomade Kurdish tribes. What remains of civilization has taken refuge in the mountains, where the few traces of primitive and most ancient Christianity, under the misapplied denomination of Nestorian Christians, are to be found in the Tyari range. The floods of the rivers are very regular in their period; beginning in March, they attain their greatest height in June.

The Persian Gulf may be navigated by steam all the year, the Euphrates only eight months; it might, however, afford easy intercourse with eastern Asia, as it did in former times. The distance from Aleppo to Bombay by the Euphrates is 2870 miles, of which 2700, from Bir to Bombay, are by water; in the time of Queen Elizabeth this was the common route to India, and a fleet was then kept at Bir, expressly for that navigation.

Six rivers of the first magnitude descend from the southern side of the table-land of eastern Asia and its mountain barriers, all different in origin, direction, and character, while they convey to the ocean a greater volume of water than all the rivers of the rest of the continent conjointly. Of these, the Indus, the double system of the Ganges, and Brahmapootra, and the three parallel rivers in the Indo-Chinese peninsula, water the plains of southern Asia; the great system of rivers that descend from the eastern terraces of the table-land irrigates the fertile lands of China; and lastly the Siberian rivers, not inferior to any in magnitude, carry the waters of the Altaï and northern slope of the table-land to the Arctic Ocean.

The hard-fought battles and splendid victories recently achieved by British valour over a bold and well-disciplined foe have added to the historical interest of the Indus and its tributary streams, now the boundaries of our Asiatic territories.

The sources of the Indus were only ascertained in 1812; the Ladak, the largest branch of the Indus, has its origin in the snowy mountains of Karakorum; and the Shyook, which is the smaller stream, rises in the Kentese or Gangri range, a ridge parallel to the Himalaya, which extends along the table-land of Tibet, north and west of the sacred lake of Mánasarowar. These two streams join north-west of Ladak and form the Indus; the Sutlej, its principal tributary, springs from the lake of Rakas Tal, which communicates with that of Mánasarowar, both situated in a valley between the Himalaya and Gangri chain at the great elevation of 15,200 feet. These rivers, fed by streams of melted snow from the northern side of the Himalaya, both flow westward along the extensive longitudinal valley of western Tibet. The Sutlej breaks through the Himalaya about the 75th meridian, and traverses the whole breadth of the chain, in frightful chasms and clefts in the rocks, to the plains of the Punjab; the Indus, after continuing its course on the table-land through several degrees of longitude farther, descends near the junction of the Himalaya and the Hindoo Coosh, west of the valley of Cashmere, to the same plain. Three tributaries—the Jelum or Hydaspes, the Chenab or Acescines, and the Ravee or Hydraötes, all superior to the Rhone in size—flow from the southern face of the Himalaya, and with the Sutlej (the ancient Hyphasis) join the Indus before it reaches Mittun; hence the name Punjab, "the plain of the five rivers," now one of the most valuable countries in the East. From Mittun to the ocean, the Indus, like the Nile, does not receive a single accessary, from the same cause—the sterility of the country through which it passes. The Cabul river, which rises near Guzni, and is joined by a larger affluent from the southern declivities of the Hindoo Coosh, flows through picturesque and dangerous defiles, and joins the Indus at the town of Attock, and is the only tributary of any magnitude that comes from the west.

The Indus is not favourable to navigation: for 70 miles after it leaves the mountains the descent in a boat is dangerous, and it is only navigable for steam-vessels of small draught of water; yet, from the fertility of the Punjab, and the near approach of its basin to that of the Ganges at the foot of the mountains, it must ultimately be a valuable acquisition, and the more especially because it commands the principal roads between Persia and India, one through Cabul and Peshawer, and the other from Herat through Candahar. The delta of the Indus, formerly celebrated for its civilization, has long been a desert; but from the luxuriance of the soil, and the change of political circumstances, it may again resume its pristine aspect. It is 60 miles long, and presents a face of 120 miles to the sea at the Gulf of Oman, where the river empties itself by many mouths, of which only three or four are navigable: one only can be entered by vessels of 50 tons, and all are liable to change. The tide ascends them with extraordinary rapidity for 75 miles, and so great is the quantity of mud carried by it, and the absorbing violence of the eddies, that a vessel wrecked on the coast was buried in sand and mud in two tides. The annual floods begin with the melting of the snow in the Himalaya in the end of April, come to their height in July, and end in September. The length of this river is 1500 miles, and it drains an area of 400,000 square miles.

The second group of South Indian rivers, and one of the greatest, is the double system of the Ganges and Brahmapootra. These two rivers, though wide apart at their courses, have their sources little removed from each other, on opposite sides of the central ridge of the Himalaya, and which, converging to a common delta, constitute one of the most important groups on the globe.

Mr. Alexander Elliot, of the Body Guard in Bengal, son of Admiral Elliot, with his friends, are the first who have accomplished the arduous expedition to the sources of the Ganges. The river flows at once in a very rapid stream not less than 40 yards across, from a huge cave in a perpendicular wall of ice at the distance of about three marches from the Temple of Gungootree, to which the pilgrims resort. Mr. Elliot says, "The view from the glacier was perfectly amazing; beautiful or magnificent is no word for it,—it was really quite astonishing. If you could fancy a bird's-eye of all the mountains in the world in one cluster, and every one of them covered with snow, it would hardly give you an idea of the sight which presented itself."

Many streams from the southern face of the Himalaya unite at Hurdwar to form the great body of the river. It flows from thence in a south-easterly direction through the plains of Bengal, receiving in its course the tribute of 19 or 20 rivers, of which 12 are larger than the Rhine. About 220 miles in a direct line from the Bay of Bengal, into which the Ganges flows, the innumerable channels and branches into which it splits form an intricate maze over a delta twice as large as that of the Nile.

The Brahmapootra, a river equal in the volume of its waters to the Ganges, may be considered as the continuation of the Dzangho Tchou or river of Lassa, which rises near the sources of the Sutlej and the Indus, in long. 82° E. After watering the great longitudinal valley of eastern Tibet, it makes a sudden bend to the south in long. 90° E., cutting through the Himalaya chain, as the Indus does at its opposite extremity between Iskasdo and Attock;

after which it receives several tributaries from the northern mountains of the Birman empire; but very little is known of this part of its basin. The upper part of the Brahmapootra is parallel to the Himalaya chain, until it enters Upper Assam, where, passing through the sacred pool of Brahma-Koond, it receives the name which it bears in the lower part of its course—Brahmapootra, the "offspring of Brahma:" the natives call it the Lahit, Sanscrit for the "Red River." In Upper Assam, through which it winds 500 miles and forms some extensive channel islands, it receives six very considerable accessories, of which the origin is unknown, though some are supposed to come from the table-land of Tibet. They are only navigable in the plains, but vessels of considerable burthen ascend the parent stream as far as Sundiva. Before it enters the plains of Bengal, below Goyalpara, the Brahmapootra runs with rapidity and in great volume, and, after receiving the rivers of Bhotan and other streams, branches of it unite with those of the Ganges about 40 miles from the coast, but the two rivers enter the sea by different mouths, though they sometimes approach within two miles. The length of the Brahmapootra is probably 860 miles, so that it is 500 miles shorter than the Ganges: the volume of water discharged by it during the dry season is about 146,188 cubic feet in a second; the quantity discharged by the Ganges in the same time and under the same circumstances is only 80,000 cubic feet. In the perennial floods the quantity of water poured through the tributaries of the Brahmapootra from their snowy sources is incredible; the plains of Upper Assam are an entire sheet of water from the 15th of June to the 15th of September, and there is no communication but by elevated causeways eight or ten feet high: the two rivers, with their branches, lay the plain of Bengal under water for hundreds of miles annually. They begin first to swell from the melting of the snow on the mountains, but, before their inferior streams overflow from that cause, all the lower parts of Bengal adjacent to the Ganges and Brahmapootra are under water from the swelling of these rivers by the rains. The increase is arrested before the middle of August, by the cessation of the rains in the mountains, though they continue to fall longer on the plains. The delta is traversed in every direction by arms of the rivers. The Hoogly branch, at all times navigable, passes Calcutta and Chandernagor; and the Hauringotta arm is also navigable, as well as the Ganges properly so called. The channels, however, are perpetually changing, from the strength of the current, and the prodigious quantity of matter washed from the high lands; the Ganges alone carries to the sea 600,000 cubic feet of mud in a second, the effects of which are perceptible 60 miles from the coast. The elevation of the mountains, and indeed of the land generally, must have been enormous, since it remains still so stupendous after ages of such degradation. The Sunderbunds, a congeries of innumerable river islands formed by the endless streams and narrow channels of the rivers, as well as by the indentations of arms of the sea, line the coast of Bengal for 180 miles, a wilderness of jungle and heavy timber. The united streams of the Ganges and Brahmapootra drain an area of 650,000 square miles, and there is scarcely a spot in Bengal more than 20 miles distant from a river navigable even in the dry season.

These three great rivers of Southern India do not differ more widely in their physical circumstances than in the races of men who inhabit their banks, yet from their position they seem formed to unite nations the most varied in their aspect and speech. The tributaries of the Ganges and Indus come so near to each other at the foot of the mountains, that a canal only two miles long would unite them, and thus an inland navigation from the Bay of Bengal to the Gulf of Oman might be established.

An immense volume of water is poured in a series of nearly parallel rivers of great magnitude, and running in the direction of the meridian through the Indo-Chinese peninsula, to empty themselves into the ocean on either side of the peninsula of Malacca. They rise in those elevated regions at the south-eastern angle of the table-land of Tibet, the lofty but unknown provinces of the Chinese empire, and water the great valleys that extend nearly from north to south with perfect uniformity, between chains of mountains no less uniform, which spread out like a fan as they approach the sea. Scarcely anything is known of the origin or upper parts of these rivers, and with a few exceptions almost as little of the lower.

Their number amounts to six or seven, all large, though three surpass the rest—the Irawady, which waters the Birman empire, and falls into the Bay of Bengal at the Gulf of Martaban; the Menam, or river of Siam; and the river Cambodja, which flows through the empire of Annam: the last two fall into the Gulf of Siam and the China Sea.

The sources of the Irawady are in the same chain of mountains with the eastern affluents of the Brahmapootra more to the south. Its course is through countries hardly known to Europeans, but it seems to be navigable by boats before coming to the city of Amarapoora, south of which it enters the finest and richest plain of the empire, containing its four capital cities. There it receives two large affluents, one from the Chinese province of Yunnan, which flows into the Irawady at the city of Ava, 446 miles from the sea, the highest point attained by the British forces during the Burmese war.

From Ava to its delta the Irawady is a magnificent river, more than four miles broad in some places, but encumbered with channel islands. In this part of its course it receives its largest tributary, and forms in its delta one of the most extensive systems of internal navigation. The Rangoon is the only one of its 14 mouths that is always navigable, and in it the commerce of the empire is concentrated. The internal communication is extended by the junction of the two most navigable deltoid branches with the rivers Salüaen and Pegu by natural canals: that joining the former is 200 miles long; the canal uniting the latter is only navigable at high water.

The Menam, one of the largest Asiatic rivers, is less known than the Irawady; it comes from the Chinese province of Yunnan, and runs through the kingdom of Siam, which it cuts into several islands by many diverging branches, and enters the Gulf of Siam by three principal arms, the most easterly of which forms the harbour of Bangkok. It is joined to the Menam Kong, or Cambodja, by the small river Anan-Myit.

The river of Cambodja has the longest course of any in the peninsula: it is supposed to be the Lan-tsan-Kiang, which rises in the high land of K'ham, in eastern Asia, not far from the sources of the great Chinese river, the Yang-tse-Kiang. After traversing the elevated plain of Yunnan, where it is navigable, it rushes through the mountain barriers, and, on reaching a wider valley about 300 miles from its mouth, it is joined to the Menam by the natural canal of the Anan-Myit. More to the south it is said to split into branches which unite again.

The ancient capital of Annam is situate on the Cambodja, about 150 miles from the sea; a little to the south its extensive delta begins, projects far into the ocean, and is cut in all directions by arms of the river, navigable during the floods; three of its mouths are permanently so for large vessels up to the capital.

The Saüng, more to the east, is much shorter than the Cambodja, though said to be 1000 miles long, but Europeans have not ascended higher than the town of Sai-gon. Near its mouth it sends off several branches to the eastern arm of the Cambodja. All rivers of this part of Asia are subject to periodical inundations, which fertilize the plains at the expense of the mountains.

The parallelism of the mountain-chains constitutes formidable barriers between the upper basins of the Indo-Chinese rivers, and decided lines of separation between the inhabitants of the intervening valleys; but this inconvenience is in some degree compensated by the natural canals of junction and the extensive water communication towards the mouths of the rivers.

Four great systems of rivers take their origin on the eastern declivity of the great table-land of central Asia, and running from west to east, traverse the Chinese empire:—the Hong-Kiang, which, rising in the province of Yunnan, empties itself into the bay of Canton; the Yang-tse-Kiang, or Son of the Ocean; the Hoang-Ho; and the great river of Amur.

The length of the Hoang-Ho is 2000 miles, that of the Yang-tse-Kiang 2900. Though near their sources they are widely separated by the mountain-chains that border the table-land, they approach as they proceed on their eastern course, and are not more than 100 miles apart when they enter the Yellow Sea. From a map constructed by the

Jesuit missionaries in the 18th century it appears that the mouth of the Hoang-Ho or Yellow River has shifted to the enormous distance of 126 leagues from its former position. The Yang-tse-Kiang and the Yellow River in the lower part of their course are united by innumerable canals, forming the grandest system of irrigation and of internal navigation in existence.

The Hoang-Ho brings down so large a quantity of earthy matter to the sea, that, like the Tiber of old, it is called the "Yellow" River.

Strong tides ascend these rivers to the distance of 400 miles, and for the time prevent the descent of the fresh water, which forms large interior seas frequented by thousands of trading-vessels, and they irrigate the productive lands of central China, from time immemorial the most highly cultivated and the most densely peopled region of the globe.

Almost all the Chinese rivers of less note—and they are numerous—feed these giant streams, with the exception of the Ta-si or Hong-Kiang and the Pee-ho or White River, which have their own basins. The former, rising to the east of the town of Yunnan, flows through the plains of Canton eastward to the Gulf of Canton, into which it discharges itself, increased in its course by the Sekiang.

The White River, rising in the mountains near the Great Wall, becomes navigable a few miles east of Pekin, unites with the Eu-ho, joins the Great Canal, and, as the tide ascends it for 80 miles, it is crowded with shipping.

The Amur, the sources of which are partly in the Russian dominions, though its course is chiefly in the Mantchoo territory of China, is 2000 miles long, including its windings, and has a basin of 853,000 square miles. Almost all its tributaries come from that part of the Baikalian group called the Yablonnoi Khrebit by the Russians, and Khing-Khan-Oola by the Chinese. The river Onon, which is the parent stream, has its origin in the Khentai Khan, a branch of the latter; and though its course is through an uninhabited country, it is celebrated as being the birthplace and the scene of the exploits of Tshingis Khan. After passing through the lake of Dalai-nor, which is 210 miles in circumference, it takes the name of Argun, and forms the boundary between the Chinese and Russians for 400 miles; it is then joined by the Shilka, where it assumes the Tunguse name of the Amur or Great River: the Mandchoos call it the Sagalin or Black Water. It receives most of the unknown rivers which come from the mountain-slopes of the Great Gobï, and falls into the Pacific opposite to the island of Sagalin, after having traversed three degrees of latitude and thirty-three of longitude.

Three great rivers, the Lena, the Yenessei, and the double system of the Irtish and Oby, not inferior in size to any of the rivers of Asia, carry off the waters of the Altaï chain, and of the mountains which bound the northern border of the great Asiatic table-land. The Lena, whose basin occupies 800,000 square miles, springs from mountains north of the Lake of Baikal, and runs north-east through more than half its course to the Siberian town of Yakutzk, the coldest town on the face of the earth, receiving in its course the Vitim and the Olekma, its two principal affluents, the former from the Baikal mountains, the latter from Stannovoi Khrebit, the most southerly part of the Aldan range. North of Yakutzk, about the 63rd parallel of latitude, the Lena receives the Aldan, its greatest tributary, which also comes from the Stannovoi Khrebit; it then goes to the Arctic Ocean, between banks of frozen mud, prodigious masses of which are hurled down by the summer floods, and bring to view the bones of those huge animals of extinct species which at some remote period had found their nourishment in these desert plains. The length of the Lena, including its windings, is 1900 miles.

A difference in the pressure of the air has been observed on the banks of this river, on the shores of the Sea of Okhotzk, and at Kamtchatka; which indicates that in the distance of five degrees of latitude there is an apparent difference in the level of the sea amounting to 139 feet.[1] A similar phenomenon was observed by Captain Foster near Cape Horn, and by Sir James Ross throughout the South Polar Ocean.

The Yenessei, a much larger river than the Lena, drains about 1,000,000 square miles, and is formed by the union of the Great and Little Kem. The former rises at the junction of the Sayansk range, with the Baikalian mountains to the north-west of

[1] M. Erman.

Lake Kassagol; the latter comes from the Egtag or Little Altaï, in quite an opposite direction, so that these two meet nearly at right angles, and take the name of Yenessei; it then crosses the Sagaetses range in cataracts and rapids, entering the plains of Siberia below the town of Krasnojarsk. Below this many rivers join it, chiefly the Angara from the Lake Baikal; but its greatest tributaries, the Upper and Lower Tunguska, both large rivers from the Baikalian mountains, join it lower down, the first to the south, the latter to the north of the town of Yeniseisk, whence it runs north to the Icy Ocean, there forming a large gulf, its length, measured along its bed, being 2500 miles.

The Oby rises in the Lake of Toleskoi, "the Lake of Gold," in Great Tartary; all the streams of the Lesser Altaï unite to swell it and its great tributary the Irtish. The rivers which come from the northern declivity of the mountains go to the Oby, those from the western side to the Irtish, which springs from numerous streams on the south-western declivity of the Little Altaï, and run westward into Lake Zaidzan, 200 miles in circumference. Issuing from thence, it takes a westerly course to the plain on the north of Semipolatinsk. In the plain it is joined by the Tobol, which crosses the steppe of the Kirghiz Cossacks from the Ural Mountains, and soon unites with the Oby; the joint stream then proceeds to the Arctic Ocean in 67° N. lat. The Oby is 2000 miles long, and the basin of these two rivers occupies a third part of Siberia.

Before the Oby leaves the mountains, at a distance of 1200 miles from the Arctic Ocean, its surface has an absolute elevation of not more than 400 feet, and the Irtish, at the same distance, is only 72 feet higher; both are consequently sluggish. When the snow melts they cover the country like seas; and as the inclination of the plains in the middle and lower parts of their course is not sufficient to carry off the water, those immense lakes and marshes are formed which characterize this portion of Siberia.

The bed of the Oby is very deep, and there are no soundings at its mouth; hence the largest vessels might ascend at least to its junction with the Irtish. Its many affluents also might admit ships, did not the climate form an insurmountable obstacle the greater part of the year. Indeed all Siberian rivers are frozen annually for many months, and even the ocean along the Arctic coasts is rarely disencumbered from ice; therefore these vast rivers never can be important as navigable streams; but towards the mountains they afford water communication from the steppe of Issim to the Pacific. They abound in fish and water-fowl, for which the Siberian braves the extremest severity of the climate.

Local circumstances have nowhere produced a greater difference in the human race than in the basins of the great rivers north and south of the table-land of eastern Asia. The Indian, favoured by the finest climate, and a soil which produces the luxuries of life, intersected with rivers navigable at all seasons, and affording easy communication with the surrounding nations, attained early a high degree of civilization; while the Siberian and Samoide, doomed to contend with the rigours of the polar blasts in order to maintain mere existence, have never risen beyond the lowest grade of humanity; but custom softens the rigour of this stern life, so that even here a share of happiness is enjoyed.

CHAPTER XIX.

River Systems of North America — Rivers of Central America — Rivers of South America and of Australia.

North America is divided into four distinct water systems by the Rocky Mountains, the Alleghannies, and a table-land which contains the great lakes, and separates the rivers that flow into the Arctic Ocean from those which go to the Gulf of Mexico. This table-land, which is a level, nowhere more than 1200 or 1500 feet above the surface of the sea, is the watershed of the Mackenzie, the Mississippi, the St. Lawrence, and of the rivers that flow into Hudson's Bay. The St. Lawrence rises under the name of the St. Louis in 47° 43′ N. lat. and 93° W. long.; after joining the Lakes Superior, Huron, Erie, and Ontario, it issues from the last by the name of the Iroquois, and, expanding in its north-easterly course into Lakes St. Francis, St. Louis, and St. Peter, it is first known as the St. Lawrence at Montreal, from whence it runs north-east into the Atlantic and ends in an estuary 100 miles wide. It has a basin of 297,600 square miles, of which 94,000 are covered with water, exclusive of the many lesser lakes with which it is in communication.

North of the watershed there is an endless and intricate labyrinth of lakes and rivers, almost all connected with one another. But the principal streams of these Arctic lands are—the Great Fish River, which flows north-east in a continued series of dangerous and all but impassable rapids to the Arctic Ocean at Melville Strait; the Copper-mine River, of much the same character, which, after traversing many lakes, enters the Icy Sea at George the Fourth's Gulf; and the Mackenzie River, a stream of greater magnitude, formed by the confluence of the Peace River and the Athabasca from the Rocky Mountains, which, after flowing north over 16 degrees of latitude, enters the Frozen Ocean in the Esquimaux country beyond the Arctic Circle. All these rivers are frozen more than half the year, and the Mackenzie, in consequence of its length and direction from south to north, is subject to floods like the Siberian rivers, because its lower course remains frozen for several hundred miles long after the upper part is thawed, and the water, finding no outlet, flows over the ice and inundates the plains.

South of the table-land the valley of the Mississippi extends for 1000 miles, and this greatest of North American rivers has its origin in the junction of streams from the small lakes Itaska and Ussawa, on the table-land at no greater height than 1500 feet above the sea. Before their junction these streams frequently spread out into sheets of water, and the Mississippi does the same in the upper part of its course. This river flows from north to south through more degrees of latitude than any other, and receives so many tributaries of the higher orders that it would be difficult even to name them. Among those that swell its volume from the Rocky Mountains, the Missouri, the Arkansas, and the Red River are the largest, each being in itself a mighty stream, receiving tributaries without number. Before their junction the Missouri is a stream much superior to the Mississippi both in length and volume, and has many affluents larger than the Rhine. It rises in about 44° N. lat., and runs partly in a longitudinal valley of the Rocky Mountains, and partly at their foot, and drains the whole of the country on the right bank of the Mississippi between the 49th and 40th parallels of north latitude. It descends in cataracts through the mountain regions, and in the plains it sometimes passes through large prairies and sometimes through dense forests, in all accomplishing 3000 miles in a very tortuous and generally south-eastern direction till it joins the Mississippi near the town of St. Louis. Lower down, the Mississippi is joined by the Arkansas, 2000 miles long, with many tributaries, and then by the Red River, the former from the Rocky Mountains; the latter, which rises in the table-land of New Mexico, is fed by rivers from the Sierra del Sacramento, and enters the main stream not far from the beginning of the delta, at the head of which the Mississippi sends off a large branch called the Atchafalaya to the south, and then turning to the east it discharges itself by five mouths at the extremity of a long tongue of land which stretches 50 miles into the Gulf of Mexico, having formed a delta considerably larger than that of the Nile. The shore is lined with shallow salt lagoons; the greater part of the delta is covered with water and unhealthy marshes, the abode of the crocodile, and during the floods it is a muddy sea. This river is navigable for 2240 miles. Its valley is of variable width, but at its greatest width, at the junction of the White River, it is 80 miles.

The tributaries from the Rocky Mountains, though much longer, run through countries of less promise than those which are traversed by the Ohio and the other rivers that flow into the Mississippi on the east, which offer advantages unrivalled even in this wonderful country, only beginning to be developed.

The Ohio is formed by the union of the rivers Alleghanny and Monongahela, the latter from the Laurel ridge of the Alleghanny chain in Virginia; the former comes from sources near Lake Erie, and the two unite at Pittsburg, from whence the river winds 948 miles through some of the finest states of the Union, till its junction with the Mississippi, having received many accessories, six of which are navigable streams. There are some obstacles to navigation in the Ohio, but they have been avoided by canals. Other canals join both the Mississippi and its branches with Lake Erie, so that there is an internal water communication between the St. Lawrence and the Gulf of Mexico. The whole length of the Mississippi is 3160 miles, but, if the Missouri be considered the main stem, it is 4265, and the joint stream drains an area of about a million and a quarter of square miles. The breadth of the river nowhere corresponds with its length. At the confluence of the Missouri each river is half a mile wide, and after the junction of the Ohio it is not more. A steamer may ascend the Mississippi for 2000 miles from Balize without any perceptible difference in its breadth. The depth is 168 feet where it enters the Gulf of Mexico at New Orleans: the fall of the river at Cape Girardeau is four inches in a mile. This river is a rapid desolating torrent loaded with mud; its violent floods, from the melting of the snow in the high latitudes, sweep away whole forests, by which the navigation is rendered very dangerous, and the trees, being matted together in masses many yards thick, are carried down by the spring floods, and deposited over the delta and Gulf of Mexico for hundreds of square miles.

North America can boast of two other great water systems, one from the eastern versant of the Alleghannies, which flows into the Atlantic, and another from the western versant of the Rocky Mountains, which runs into the Pacific.

All the streams that flow eastward through the United States to the Atlantic are short, and comparatively small, but of the highest utility, because many of them, especially those to the north, end in gulfs of vast magnitude, and the whole are so united by canals that few places are not accessible by water—one of the greatest advantages a country can possess. There are at least 24 canals in the United States, the length of which is 3101 miles.

Many of the streams which ultimately come to the

Atlantic rise in the western ridges of the Alleghanny chain, and traverse its longitudinal valleys before leaving the mountains to cross the Atlantic slope, which terminates in a precipitous ledge for 300 miles parallel to the range. By falling over this rocky barrier in long rapids and picturesque cascades they afford an enormous and extensive water-power; and as the rivers are navigable from the Atlantic quite across the maritime plains, these two circumstances have determined the location of most of the principal cities of the United States at the foot of this rocky ledge, which, though not more than 300 feet high, has had a greater influence on the political and commercial interests of the Union than the highest chains of mountains have had in other countries. The Hudson in the north is navigable to Albany; the Delaware and Susquehanna, ending in bays, are important rivers; and the Potomac, which falls into Chesapeake Bay, passes Washington, the capital of the United States, to which the largest ships can ascend.

The watershed of the Rocky Mountains lies at a greater distance from the Pacific than that of the Alleghannies from the Atlantic; consequently the rivers are longer, but they are few, and little known; the largest are, the Oregon or Colombia, and the Rio Colorado. The former has its sources not far from those of the Missouri and of the Rio del Norte; and after an exceedingly tortuous course, in which it receives many tributaries, it falls into the Pacific at Astoria. The Colorado is a Mexican stream, which comes from the Sierra Verde and falls into the Gulf of California. The Sacramento with its tributaries, a Californian stream, lying between the two, and much inferior to either, has been brought into notice of late from the extensive and rich auriferous country through which it flows in its course to the Bay of San Francisco on the Pacific.

On the table-land of Mexico there is a basin of continental streams, which, rising from springs on the eastern side of the Sierra Madre, and fed by the periodical rains, flow northward and terminate in lakes, which part with their superfluous water by evaporation. Of these the Rio Grande, which, after a course of 300 miles, falls into the Parras, is the greatest.

The largest river in the isthmus of Mexico is the Rio de Lerma or Rio Grande Santiago, which rises on the table-land of Toluca, passes through Lake Chapāla, forms numerous cascades, and falls into the Pacific after a course of 400 miles. There are many streams in Central America, and above 10 rivers that are navigable for some miles; six of these fall into the Gulf of Mexico and Caribbean Sea, and four into the Pacific. Of these the Guasacualco, which traverses the Isthmus nearly from sea to sea, and which has by some been considered as the best point for a sea canal between the two oceans, and the Montagua, which rises in the mountains near Guatemala; the first empties itself into the Gulf of Mexico, whilst the second flows into the Gulf of Honduras, and has a long line of navigation.

In the southern part of the State of Guatemala is situated the River of San Juan, which drains the Lakes of Nicaragua and Leon, and by which it is supposed a water communication could be easily effected between the Atlantic and the Pacific.

The Andes, the extensive watershed of South America, are so close to the sea, that there are no rivers of considerable size which empty themselves into the Pacific; even some of the streams that rise in the western Cordilleras find their way to the eastern plains.

The Magdalena, at the northern end of the Andes, though a secondary river in America, is 620 miles long. It rises in the central chain, at the divergence of the Cordilleras of Suma Paz and Quindiu, and enters the Caribbean Sea by various channels; it is navigable as far as Honda. The Cauca, its only feeder on the left, comes from Popayan, and is nearly as large as its primary, to which it runs parallel the greater part of its course. Many streams join the Magdalena on the right, as the stream which waters the elevated plain of Bogota, and forms the cataract of Tequendama, one of the most beautiful and wildest scenes in the Andes. The river rushes through a chasm 30 feet wide, which appears to have been formed by an earthquake, and at a double bound descends 530 feet into a dark gloomy pool, illuminated only at noon by a few feeble rays. A dense cloud of vapour rising from it is visible at the distance of 15 miles. At the top the vegetation is that of a temperate climate, while palms grow at the bottom.

The river Atrato, parallel to the Cauca and Magdalena, but less considerable, empties itself into the Gulf of Darien. The rivers of Patia, of San Juan, of Las Esmeraldas, and of Guyaquil, all rise on the western declivity of the Andes to flow into the Pacific. With these exceptions all the water from the inexhaustible sources of the Andes north of Chile is poured into the Orinoco, the River of the Amazons, and the Rio de la Plata, which convey it eastward across the continent to the Atlantic. In the far south, indeed, there are the Colorado and Rio Negro, but they are insignificant when compared with these giant floods.

The basins of these three rivers are separated in their lower parts by the mountains and high lands of the Parima and Brazil; but the central parts of the basins of all three, toward the foot of the Andes, form an extensive level, and are only divided from one another by imperceptible elevations in the plains, barely sufficient to form the watersheds between the tributaries of these majestic rivers. This peculiar structure is the cause of the natural canal of the Cassiquiare, which joins the Upper Orinoco with the Rio Negro, a principal affluent of the Amazons. Ages hence, when the wilds are inhabited by civilized man, the tributaries of these three great rivers, many of which are navigable to the foot of the Andes, will, by means of canals, form a water system infinitely superior to any that now exists.

The Orinoco, altogether a Colombian river, rises in the Sierra del Parima, 200 miles east of the elevated Peak of Duida, and maintains a westerly course to San Fernando de Atabapo, where it receives the Atabapo, and Guaviare, which is larger than the Danube; here ends the Upper Orinoco. The river then forces a passage through the Sierra del Parima, and runs due north for three degrees of latitude, between banks almost inaccessible; its bed is traversed by dykes, and filled with boulders of granite and islands clothed with a variety of magnificent palm-trees. Large portions of the river are here engulfed in crevices, forming subterranean cascades; and in this part are the celebrated falls of the Atures and Apures, 36 miles apart, which are heard at the distance of many miles. At the end of this tumultuous part of its course it is joined by the Meta, and farther north by the Apure, two very large rivers, which drain the whole eastern side of the Andes in an extent of 10 degrees of latitude, and then runs eastward to its mouth, where it forms an extensive delta and enters the Atlantic by many channels. As the Upper Orinoco runs west, and the Lower Orinoco east, it makes a complete circuit round the Parima mountains, so that its mouth is only two degrees distant from the meridian of its sources.

The Cassiquiare leaves the Orinoco near the south base of the Peak of Duida, and joins the Rio Negro, a chief tributary of the Amazons, at the distance of 180 miles.

The Orinoco is navigable for 1000 miles at all seasons; a fleet might ascend it from the Dragon's Mouth to within 45 miles of Santa Fé de Bogota. It receives many navigable rivers, of which the Guaviare, the Atures, and the Meta are each larger than the Danube. The Meta may be ascended to the foot of the Andes; its mean depth is 36 feet, and in many places 80 or 90. It rises so high in the Andes that Baron Humboldt says the vegetable productions at its source differ as much from those at its confluence with the Orinoco, though in the same latitude, as the vegetation of France does from that of Senegal. The larger feeders of the Orinoco come from the Andes, though many descend to it from both sides of the Parima, in consequence of its long circuit among these mountains.

The basin of the Orinoco has an area of 300,000 square miles, of which the upper part is impenetrable forest, the lower is Llanos.

The floods of the Orinoco, like those of all rivers entirely within the torrid zone, are very regular, and attain their height nearly at the same time with those of the Ganges, the Niger, and the Gambia. They begin to swell about the 25th of March, and arrive at their full and begin to decrease on the 25th of August. The inundations are very great, owing to the quantity of rain that falls in the wooded regions, which exceeds 100 inches in a year.

Below the confluence of the Apure the river is three miles and a quarter broad, but during the floods it is three times as much. By the confluence of four of its greatest tributaries at the point at which it bends to the east, a low inland delta is formed, in consequence of which 3600 square miles of the plain are under water during the inundation. The Orinoco in many places smells of musk from the number of dead crocodiles.

Upper Peru is the cradle of the Amazons, the greatest of rivers, which drains the chain of the Andes from the equator to the 20th parallel of southern latitude. Its highest branch, which bears the name of Marañon, issues in two streams from the Lake of Lauricocha in the plain of Bombon, at a great elevation in the Andes: it runs in a deep longitudinal valley from south to north, till it bursts through the eastern ridge at the Pongo de Manseriche, near the town of San Borja, from whence it follows an uniform eastern course of nearly 4000 miles including its windings, till it reaches the Atlantic. West of San Borja and on its southern bank it receives the Huallaga and Yucayali, the latter a river of great size which rises in the Andes of Vilcañota, S. of Cusco, where its source was visited and its position determined by Mr. Pentland. The Amazons is supposed to drain an area of two millions and a half of square miles, which is ten times the size of France. In some places it has a great depth; it is navigable 2200 miles from its source, and is 96 miles wide at its mouth.

The name of the river is three times changed in its course: it is known as the Marañon from its source to the confluence of the Yucayali; from that point to its junction with the Rio Negro, it is called the Solimoes; and from the Rio Negro till it enters the ocean it is the River of the Amazons.

The number, length, and volume of its tributaries are in proportion to its magnitude; even the affluents of its affluents are noble streams. More than 20 superb rivers, navigable almost to their sources, pour their waters into it, and streams of less importance are numberless. Two of the largest are the Huallaga and the Yucayali: like their primary, the former has its origin in the mining district of Pasco, and after a long northern course between the Cordilleras it breaks through a gorge similar to that of Manseriche and joins the Marañon in the plains; it is almost a mile broad above its junction. The Spanish governor of Peru sent Pedro de Orsoa down this river in the year 1560 to search for the Lake of Parima and the city of El Dorado. The Yucayali, not inferior to the Marañon itself, is believed by some eminent geographers to be the true Marañon. In a course of 1080 miles it is fed by accessaries from a wide extent of country, and at its junction with the main stream, near the mission of San Joaquim de Omaguas, a line of 50 fathoms does not reach the bottom, and in breadth it is more like a sea than a river. By these streams there is access to Peru, and there is communication between the Amazons and the most distant regions around by other navigable feeders. Nothing is known of the rivers that empty themselves into the Amazon on its southern bank, between the Yucayali and the Madeira; the latter, which is its greatest affluent, comes near the sources of the Paraguay, the principal accessary of the Rio de la Plata. The River of the Amazons is not less extensively connected on the north. The high lands of Colombia are accessible by the Putumayo, the Japura, and other great navigable rivers; the Rio Negro, nearly nine miles broad, a little way above its junction with the Amazons, unites it with the Orinoco by the Cassiquiare; and lastly, the sources of the Rio Branco come very near to those of the Essequibo, an independent river of Demerara.

The main stream, from its mouth nearly throughout its length, is full of river islands, and most of its tributaries have deltoid branches at their junction with it. The annual floods of the Amazons are less regular than those of the Orinoco, and, as the two rivers are in different hemispheres, they occur at opposite seasons. The Amazons begins to rise in December, is at its greatest height in March, and its least in July and August. The quantity of rain that falls in the deep forests traversed by this river is so great that, were it not for the enormous evaporation, and the streams that carry it off, the country would be flooded annually to the depth of eight feet. The Amazons is divided into two branches at its mouth, of which one joins the Parà south of the island of Das Joanes or Marajo, the other enters the ocean to the north of it.

The water of some of the rivers in equatorial America is white; in others it is of a deep coffee-colour, or dark green when seen in the shade, but perfectly transparent, and, when ruffled by a breeze, of a vivid green like some of the Swiss lakes. In Scotland the brown waters come from peat-mosses; but it is not so in America, since they occur as often in forests as in savannahs. Sir Robert Schomburgk thinks they are stained by the iron in the granite; however, the colouring matter has not been chemically ascertained. The Orinoco and the Cassiquiare are white; Rio Negro, as its name implies, is black, yet the water does not stain the rocks, which are of a dazzling white. Black waters are sometimes, though rarely, found on the table-lands of the Andes.

The Rio de la Plata forms the third great water system of South America. The Rio Grande, its principal stream, rises in the mountains of Minas Geraes, in Brazil, and runs 500 miles on the table-land from north to south before it takes the name of Paranà. For more than 100 miles it is a continued series of cataracts and rapids, the greatest of which, the Salta Grande, is in about 24° 5′ lat. Above the fall the river is three miles broad, when all at once it is confined in a rocky pass only 60 yards wide, through which it rushes over a ledge with thunderous noise, heard at the distance of many miles. The Paranà receives three large rivers on the right—the Paraguay, the Pilcomayo, and the Vermejo: all generally tend to the south, and unite at different distances before entering their primary at Corrientes. The Paraguay, 1200 miles long, is the finest of these: in its upper part it is singularly picturesque, adorned with palms and other tropical vegetation, and its channel islands are covered with orange-groves. It springs from a chain of seven lakes, on the southern slopes of the Campos Parecis, in Brazil, and may be ascended by vessels of considerable burthen through nineteen degrees of latitude. The Pilcomayo and Vermejo both come from Bolivia; the former traverses the desert of the Gran Chaco, the latter the district of Tarija. At Santa Fé the La Plata turns eastward, and before entering the Atlantic is augmented by the Uruguay from the north, which takes its name from the turbulence of its streams.

The Rio de la Plata is 2700 miles long, and for 200 miles from its mouth, up to Buenos Ayres, it is never less than 170 miles broad. Were it not for the freshness of its water it might be mistaken for the ocean: it is, however, shallow, and loaded with mud, which stains the Atlantic for 200 miles from its mouth.

The Paraguay is subject to dreadful floods. In 1812 the atmosphere was poisoned by the putrid carcases of drowned animals. The ordinary annual inundations of the Paranà, the principal or upper branch of the La Plata, cover 36,000 square miles.

In consequence of the vast extent of the very level plains along the base of the Andes, the basins of the three great rivers are apparently united. So small are the elevations that determine their direction, that, with the exception of a portage of three miles, a vessel might sail from Buenos Ayres in 35° S. lat. to the mouth of the Orinoco in 9° N. lat. by inland navigation.

The Colorado, which runs in a long shallow stream through the Pampas of Buenos Ayres to the Atlantic, is formed of two principal branches, one from the west, and the other from the north, which unite at a great distance from the Atlantic, into which the river flows.

The Rio Negro or Cusu-debu rises at a great elevation, and separates the Pampas from Patagonia. In its long course through arid deserts to the Atlantic it does not receive a single adjunct, but it forms a communication between that ocean and Chile, as it reaches a pass in the Andes that is free from snow. There is some vegetation in its immediate neighbourhood; it has a bar at its mouth, and is navigable only for four miles above Carmen; it has floods twice in the year, one from the rains, the other from the melting of the snow in the Andes.

Some other streams from the Chilian Andes run through, but do not fertilise, the desolate plains of Patagonia.

There are various rivers in South America, unconnected with those described, which in any other country would be esteemed of a high order. Of many which descend from the mountains of Guiana, the Essequibo is the largest; its general width is a mile and a quarter; its water, though black, is transparent; and on its banks and those of all its adjuncts the forest reigns in impenetrable thickness. It rises in the Sierra Acaray, which separates its basin from that of the Amazons, and, after a northerly course, falls into the Atlantic near 7° N. lat. by an outlet 14 miles broad, separated by three low islands into four branches. Sir Robert Schomburgk, whose scientific journeys have made us acquainted with a country of which so little was known, has shown that, by cutting a canal three miles long between the Madeira and Guapore, an affluent of the Mamore, an inland navigation might be opened from Demerara to Buenos Ayres, over an extent of 42 degrees of latitude, with the exception of a portage of only 800 yards in the rainy season between Lake Amucu and the Quatata, a branch of the Rupununi, which flows into the Essequibo. But that is not the only water communication between Guayana and remote countries, great though the distance be, for the Napo, a tributary of the Solimoes, offers communication with Quito, the Huallaga with Peru and countries not far distant from the Pacific Ocean. By the Rio Negro, the Orinoco, the Cassiquiare, and its tributary the Meta, there is uninterrupted navigation to New Granada and to within eight miles of Santa Fé de Bogota. "If," says the distinguished traveller already mentioned, "British Guayana did not possess the fertility which is such a distinguishing feature, this water communication alone would render it of vast importance; but, blessed as it is with abundant fruitfulness, this extensive inland navigation heightens its value as a British colony; and, if emigration sufficient to make its resources available were properly directed thither, the port of Demerara would rival any in the vast continent of

South America." It is certainly very remarkable that the tide of emigration has never set towards a country of such promise, abounding in valuable natural productions, and so much nearer to Great Britain than her colonies in the Pacific.

The Parà and San Francisco are the chief Brazilian rivers: both rise on the table-land; the former results from the union of the Tocantins and Araguay; it descends from the high lands in rapids in its northerly course, and, after running 1500 miles, joins the southern branch of the Amazons before entering the Atlantic south of the island of Marajo. The San Francisco is only 1275 miles long: it rises in the Sierra Canastra in the province of Minas Geraes, and, after travelling northward between mountain ranges parallel to the coast, it breaks through them and reaches the ocean about the 11th degree of S. lat. As in the Appalachian chain, so here, many rivers come down the edge of the table-land to the level maritime plains of the Atlantic.

The historical renown and the high civilization of Asia and Europe, their great wealth and population, may be attributed in a very great degree to the facility of transport afforded by their admirable river systems, and still more to the genius of the people who knew how to avail themselves of them; the same may be said of the inhabitants of the United States of America, while the Indians who have possessed these countries for ages never took advantage of the noble streams with which Providence had enriched and embellished them.

RIVERS OF NEW HOLLAND.

After America, the land of the river and the flood, New Holland appears in more than its usual aridity. The absence of large rivers is one of the greatest impediments to the improvement of this continent. What it may possess in the interior is not known, but it is certain that no large river discharges its water into the ocean, and most of the small ones are absorbed before they reach it.

The streams from the mountains on the eastern side of the continent are mere torrents, and would have short courses did they not run in longitudinal valleys, as for example the Hawkesbury. The Murumbidgee, the Lachlan, and the Macquarrie, formed by the accumulation of mountain-torrents, are the largest.

The Murumbidgee rises in the ranges west of St. George's Lake, and, running south-west, meets the Lachlan, of unknown origin, coming from the east. After their junction they run into the Murray, a much larger stream, though only 350 feet broad, and not more than 20 feet deep: before entering the ocean in Encounter Bay, it passes through the Alexandrine Marsh: it is too shallow even for boats. The Darling is supposed to be merely the upper part of the Murray, probably rising towards the head of St. Vincent's Gulf. The origin of the Macquarrie is unknown: it is called the Fish River between Bathurst and Sydney; after running 600 miles north-west it is lost in the marshes.

Swan River, on the western side of the continent, has much the same character; and from that river to the Gulf of Carpentaria, along the whole of the western and northern shores of the continent, there are none. The want of water makes it hardly possible to explore the interior of this continent. No country stands more in need of a complete system of irrigation, which could easily be accomplished from the nature of the rivers, which lie in deep channels, and might be converted into canals by dams, from whence the water might be conveyed by channels over the surrounding country, as in Lombardy.

END OF VOL. I.

London: Printed by William Clowes and Sons, Stamford Street.

D

WORKS RELATING TO

SCIENCE, NATURAL HISTORY, &c.

The Connexion of the Physical Sciences. By MARY SOMERVILLE. *Eighth Edition.* Plates. Fcap. 8vo. 10*s.* 6*d.*

"The style of this astonishing production is so clear and unaffected, and conveys with so much simplicity so great a mass of profound knowledge, that it should be placed in the hands of every youth the moment he has mastered the general rudiments of education."—*Quarterly Review.*

Cosmos; or, A Physical Description of the WORLD. By ALEXANDER VON HUMBOLDT. Translated under the superintendence of Lieutenant-Colonel SABINE, F.R.S. *Seventh Edition.* Vols. I. and II. Post 8vo. 2*s.* 6*d.* each.

"The only English translation which is recognised as authentic by the distinguished author. We commend it to the notice of all our readers, as a most desirable addition to a medical library."—*Medical Gazette.*

The Martyrs of Science; or, The Lives of GALILEO, TYCHO BRAHE, AND KEPLER. By Sir DAVID BREWSTER. *Second Edition.* Fcap. 8vo. 4*s.* 6*d.*

"Gem-like portraitures of three extraordinary geniuses."—*Literary Gazette.*

Memoir of William Smith, the Father of Geo-LOGY. By JOHN PHILLIPS, F.R.S. 8vo. 7*s.* 6*d.*

"A grateful and gratifying recollection."—*Literary Gazette.*

Principles of Geology; or, the Modern Changes OF THE EARTH AND ITS INHABITANTS. By Sir CHARLES LYELL. *Seventh Edition.* Woodcuts. 8vo. 18*s.*

"Should be read by every one who takes an interest in this rising branch of Natural History."—*Jameson's Journal.*

Journal of Researches into Natural History and GEOLOGY, DURING A VOYAGE ROUND THE WORLD. *New Edition.* By CHARLES DARWIN. Post 8vo. 8*s.* 6*d.*

"The author is a first-rate landscape painter, and the dreariest solitudes are made to teem with interest."—*Quarterly Review.*

The Geology of Russia in Europe and the Ural MOUNTAINS. By Sir RODERICK MURCHISON, G.C.S. With Coloured Map, Tables, Woodcuts, &c. 2 vols. Royal 4to.

"The publication of this system forms an epoch in geological research. . . The author has developed the first broad outlines of a new system of classification, capable of effecting for geology what the natural system of Jussieu had effected for botany. It is a work which must necessarily become a standard for geologists."—*Spectator.*

On the Philosophy of the Moral Feelings. By JOHN ABERCROMBIE, M.D. *Seventh Edition.* Fcap. 8vo. 4*s.*

On The Intellectual Powers and Investigation OF TRUTH. By JOHN ABERCROMBIE, M.D. *Eleventh Edition.* Fcap. 8vo. 6*s.* 6*d.*

Thoughts on Animalcules; or, A Glimpse at the Invisible World, as revealed by the Microscope. By G. A. MANTELL, D.C.L. Plates. Crown 8vo. 10*s.* 6*d.*

"The object of this volume is in the highest degree commendable. There is no branch of science more interesting, none whose revelations are more wonderful, than that which unfolds the forms and nature of minute creatures."—*Chambers' Journal.*

Facts to Assist the Memory, in Various Sciences. *Second Edition.* Fcap. 8vo. 6*s.* 6*d.*

Journal of a Naturalist. *Fourth Edition.* Post 8vo. 9*s.* 6*d.*

"A book that ought to find its way into every rural drawing-room in the kingdom."—*Quarterly Review.*

A Popular Introduction to the Natural System OF PLANTS. By Mrs. LOUDON. Woodcuts. Fcap. 8vo. 8*s.*

"To any one who wishes to comprehend the names and nature of plants, this charming volume can be safely recommended."—*Spectator.*

6