THE CHIEF CONTINENTS
From which the Present Continents have been derived.

GEOGRAPHY

STRUCTURAL, PHYSICAL, AND COMPARATIVE.

BY

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PREFACE

The main object of this book is to state the most important facts concerning the structural geography of the earth, and the evolution of our present continents from older lands. Although the study of the essential structure of continents involves questions usually included in geology rather than in geography, I have tried to state the facts without the use of geological terms. As, however, geological dates are mentioned in some cases, a list of geological horizons is given for reference in Appendix I.

Two chapters have been devoted to Climate and Ocean Currents; but it has not been considered necessary to deal with general questions that are adequately treated in current elementary text-books of physical geography.

As the book is intended for use in schools, it contains few references to original authorities; but a list of some readily accessible works, from which further information can be obtained, is given in Appendix II. This list frequently mentions Professor E. Suess of Vienna, to whom this book is deeply indebted; and the descriptions of the structure of Europe and Asia are little more than an elementary statement of his conclusions. This special acknowledgment is imperatively due to Professor Suess—the most original force in contemporary geography, and I regret that I cannot refer by name to the many workers, the results of whose explorations and research I have endeavoured to explain. I should, however, thank Dr. Tempest Anderson for having kindly given permission for the use of certain copyright photographs.

I have used various English words in what seems to me to be their generally accepted English meaning, and not in the technical sense in which they are also used.

Some of the opinions stated in this book are not yet fully established, owing to the scantiness of the available data; my endeavour has been to avoid including hypotheses for which there is not considerable weight of evidence.

J. W. GREGORY.

GLASGOW, *April, 1908.*

Opportunity has been taken of a reprint of this book to make a few alterations, for some of which I am indebted to the kindness of Mr. Bernard Hobson, Dr. J. D. Falconer, and Rev. A. Chaplin.

April, 1913.

CONTENTS

PART I

THE EARTH—ITS STRUCTURE AND MATERIALS

PART II

EARTH FORMS AND HOW THEY ARE MADE

PART III

THE INFLUENCE OF THE ATMOSPHERE AND OCEANS

PART IV

DESCRIPTIVE GEOGRAPHY

LIST OF PLATES AND COLOURED MAPS

GEOGRAPHY

STRUCTURAL, PHYSICAL, AND COMPARATIVE

Part I

The Earth—its Structure and Materials

CHAPTER I

THE EARTH—ITS STRUCTURE AND SHAPE

It is still a popular belief that the earth consists of a hard shell around a liquid, fiery interior. This belief is familiar to our literature, in which there are numerous references to the earth's internal fires. "For a fire is kindled in mine anger," says Deuteronomy, "and shall burn unto the lowest hell, and shall consume the earth with her increase, and set on fire the foundations of the mountains."

Facts inconsistent with this fiery interior of the earth were known to Sir Isaac Newton, who estimated that our earth is between five and six times as heavy as an equal-sized globe of water. The rocks of the earth's crust weigh, on an average, only about two and a half times as much as an equal volume of water; so that Newton was aware that the earth as a whole weighs more than twice as much as it would do, if composed throughout of rocks equal in weight to those on the surface.

The earth was first actually weighed by Maskelyne in 1774; he observed the amount that a plumb-line, hung at the foot of Mount Schiehallion, in Perthshire, was drawn from a precisely vertical position by the attraction of the mountain. He thus determined how many times the earth is heavier than that mountain; he calculated the weight of Mount Schiehallion and used it as a weight, with which he weighed the world. This work showed that the material of the earth as a whole is about twice as heavy as the rocks, of which Mount Schiehallion is composed. Hutton, who made the detailed calculations based on Maskelyne's observations, concluded, in 1779, that the world is somewhat lighter than Maskelyne's estimate, and only weighs four and a half times as much as an equal volume of water; but Hutton had underestimated the weight of Mount Schiehallion. The mean weight of the earth is probably 5.67 times as heavy as an equal-sized globe of water; so that Newton's estimate was quite correct.

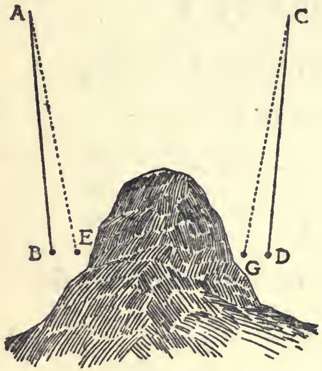


Fig. 1.—The Schiehallion Experiment

The plumb-line when suspended at points below A and C, one at the northern and one at the southern foot of Schiehallion, was deflected towards the mountain the average amount of 5.8 seconds.

The belief that the interior of the earth is

> "A dungeon horrible, on all sides round,
> As one great furnace, flamed . . ."

has been further disproved by other evidence. Observations made on the tides show that the earth, according to Lord Kelvin's estimate, is as rigid as a ball of steel. Astronomical estimates, confirmed for example by Professor T. J. J. See, make the rigidity greater than that of ordinary steel, and equal to that of the hard nickel-steel used for the armour-plate of war-ships and for projectiles. According to Professor J. Milne the extreme rapidity with which earthquake shocks pass from their place of origin through the interior of the earth to their antipodes, shows that the earth is twice as rigid as a globe of steel.

The earth is more rigid than would be possible if it consisted of a solid shell around a liquid interior, if the word liquid be used with its ordinary popular meaning. The interior of the earth is, however, unquestionably fluid in the technical sense of the term; for its material is under such immense pressure that its particles will flow, just as lead flows when forced through a hole by a hydraulic press. Thus, below the comparatively shallow depth of about eight miles, all the materials in the earth are fluid, for they flow under the pressure of the overlying rocks. The heavier weight of the interior of the earth is generally regarded as due to the large quantities of metals it contains; and the heavy core of the earth has therefore been called the "barysphere" (Greek *barus*, heavy, *sphaira*, sphere).

In the process of purifying iron by puddling, the workman plunges his puddling-bar into a bath of impure, molten iron; some of the iron collects in a viscous state on the end of the bar; as this is moved about by the puddler, more iron adheres to it, forming into a round, solid mass of white-hot iron, which cools till it is only red-hot. This mass is rolled about by the puddler on the floor of the furnace; it gives off gases which burn on the surface in small jets of blue flame. The various stony impurities in the iron are also gradually separated and forced to the surface, where they collect as a stony crust, which for a short time adheres to the mass of metallic iron.

This process illustrates the earth's structure. The earth is a vast projectile, whirling through space; it probably consists for the most part of an internal mass of metallic iron, which, like a modern cannon-ball, is hardened with nickel. The whole mass was perhaps once much hotter than it is now; and, while it cooled, its stony impurities were separated from the iron and pushed to the surface, where they solidified into the rocks of the earth's crust. While these rocks cooled, they gave off the gases and vapours which they contained; the vapour condensed on the surface to form water, and the gases remained as part of the surrounding atmosphere.

It is, however, probable that the earth was originally formed by the collection of a multitude of meteor-like planetary bodies, which, being infinitesimal planets, are called "planetismals". They would have been originally cold, but as they were welded together by shrinkage the mass would have been heated by the pressure. Hence the interior of the earth is perhaps as warm now as it has been in any period of its history. The consolidation of this swarm of planetismals would have produced an earth composed of a central metallic barysphere, surrounded by a lithosphere formed by the separation of the stony materials.

The earth, like the ball of puddled iron, consists of concentric layers. In the interior is the vast unknown mass, called the centrosphere from its position, or the barysphere from its great weight. Around the barysphere is the rocky crust, called the lithosphere. Then follows the hydrosphere, which consists of the waters of the oceans, lakes, and rivers, as well as those found within the rocks at a shallow depth below the surface. Above the hydrosphere, and surrounding the whole earth, is the atmosphere, consisting of the gases given off from the cooling earth.

The barysphere is the largest part of the earth; and it is the part of which we have least knowledge. The one certain fact is its great weight. This weight is probably due to the segregation of heavy materials in the interior of the earth; but it may be due to the compression of the internal materials by the weight of the overlying rocks. That the interior of the earth is heavily charged with metals is supported by various lines of evidence. For example, the meteorites which fall in showers upon the earth from outer space represent the fragments of other heavenly bodies; and the bulk of this meteoric material is nickel-iron. Hence it is most probable that the interior of the earth is mainly a mass of nickel-iron, like the meteorites.[1] Iron is then possibly the element which contributes the largest proportion to the composition of the whole of our sphere; while oxygen is the most abundant constituent in the lithosphere, hydrosphere, and atmosphere.

The shape of the earth depends on the fluidible[2] nature of

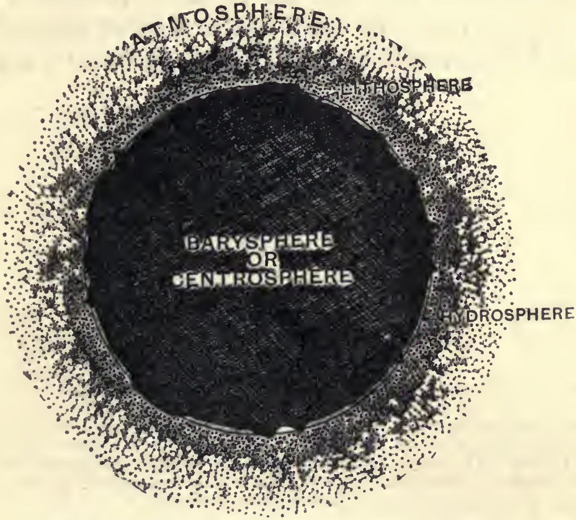


Fig. 2.—Diagram of the four Concentric Zones of the Earth

its interior, and on the fact that the earth is spinning on its axis at such a rate, that every point upon the equator travels 1000 miles an hour. This rapid rotation moulds the world to approximately the shape of a ball. That the earth is globular was known to the ancients. It was proved, for

[1] This view is supported by the evidence as to the distribution of radium within the earth; for, according to the calculations of R. J. Strutt, there is no radium below the depth of forty-five miles, and there is no radium in the iron meteorites.

[2] This term expresses the fact that though the internal material of the earth is rigid in the sense that it resists compression like a solid, it changes its shape under pressure as readily as a fluid.

example, by Eudoxus and Aristotle, from observations of the stars. They pointed out that when a man travels northward, stars which formerly were low near the horizon are seen to rise higher and higher in the sky; and stars, which were vertically overhead when he started, appeared to occupy a lower position towards the south. This fact they rightly concluded was a clear proof that the surface of the earth is curved; and, by measuring the form of this curve, Eratosthenes (about 250 B.C.) proved that the earth was a globe of approximately 30,000 miles in circumference. This measurement was slightly

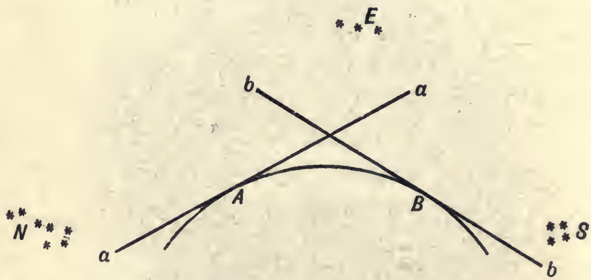


Fig. 3.—The Curvature of the Earth proved by the varying Elevation of the Stars

An observer at B, whose horizon is the plane *bb*, sees the Southern Cross, S, above the southern horizon; Orion's Belt, E, is high above the northern horizon. If the observer travels northward to A, where his horizon is *a a*, the Southern Cross will have disappeared, Orion's Belt will have passed directly overhead, and now stand at a lower elevation to the south, and the Great Bear, N, will have appeared above the northern horizon.

above the truth, but it was remarkably correct considering the simplicity of the instruments employed.

That the earth has the form of a ball is shown by observing the shadow of the earth upon the face of the moon during an eclipse. The shadow is always circular or part of a circle; and it is only a ball-shaped body that would always give a circular shadow; for a round, flat disc would sometimes give a flat-edged shadow, and an egg-shaped body would sometimes give an oval shadow. The circular shadow of the earth is sometimes thrown on the clouds immediately after sunset. When the western sky is clear and the eastern sky is cloudy, if a person stand on an elevation above a wide plain and gazes eastward he will see the earth's shadow on the clouds.

A further proof of the curved form of the earth is given

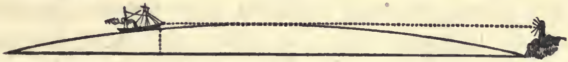


Fig. 4.—Diagram to illustrate Curvature of the Earth

by the familiar observation that, as a ship sails towards the land the mast appears before the hull; for as the hull is so much the larger, it would on a plane surface be visible first.

These simple observations, repeated at many parts of the earth, prove that it is globular in form; but the determination of the exact shape of the earth requires elaborate measurements, which are difficult and expensive. The direct method of determining the shape of the earth is the measurement of the length of a degree of longitude and of a degree of latitude in various parts of the earth. If the earth were a perfect sphere, then degrees of latitude would be of the same length all the world over, and the length of each degree of longitude along the Equator (or along any parallel of latitude) would be the same.

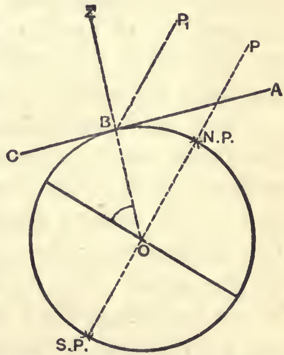


Fig. 5.—The relation of Latitude to the Angular Height of the Pole Star

B, an observer, sees the Pole Star P_1 at an angle P_1BA with his horizon. The angles ZBP_1 and BOP being equal, as BP_1 and OP are parallel, it follows that the angle P_1BA is equal to the angle between BO and the equator, which is the latitude of B.

The measurement of latitude is comparatively easy; for the angular height of the Pole Star above the horizon of any locality is its latitude. Thus the Pole Star is exactly overhead at the North Pole, the latitude of which is therefore 90°; the Pole Star appears to rest on the horizon at the Equator; so, the elevation of the Pole Star being 0°, the latitude of the Equator is 0° (fig. 5). The latitude of any place can therefore be easily determined by a theodolite on any clear night; and from the latitudes of two places which are on one north-and-south line, and the distance between which is known, an easy division sum shows the length of a degree of latitude; and as there are 360 degrees in a circle, 360 times the length of the degree gives the approximate size of the earth. Provided the two places are some distance apart, this method gives fairly accurate results from even comparatively crude observations. Thus in 1637 Norwood determined the size of the earth with remarkable accuracy by the careful use of a simple method: he observed the latitude of London and York, and measured the distance between them by walking from one place to the other and counting his paces.

These early measurements could not have given exactly the right result, because the calculations were based on the assumption that the shape of the earth is a sphere, in which case every section across it would be exactly circular, and the distance from the centre to all points on the surface would be the same. In 1672 a French astronomer, Richer, found that a pendulum-clock which had kept true time at Paris (lat. 49° N.), lost two minutes a day at Cayenne, in French Guiana (lat. 5° N.). The explanation of this fact was given by Newton. A pendulum swings faster near the earth's centre than when farther away from it; thus a pendulum swings backward and forward in a shorter time at the sea-level than it does upon the top of a neighbouring mountain. Newton therefore suggested that Richer's clock went more slowly near the Equator than at Paris, because Paris was the nearer to the centre of the earth. Richer's clock thus first indicated that the earth is flattened in the polar regions. Newton's view was contradicted by two French observers, J. and D. Cassini, who, from their measurement of the length of the degrees of latitude on a line across France from north to south, maintained that the degrees were shorter to the north; and that therefore the earth was a prolate spheroid, being elongated like an egg, instead of being an oblate spheroid, or flattened like an orange. A furious controversy ensued between those who followed Newton and the disciples of the Cassinis. The French Academy resolved to settle the dispute by measuring the length of a degree of latitude on the Equator and of another in the Arctic regions. An expedition under de la Condamine and Bouguer went to Ecuador, and there measured the length of a degree of latitude on the Equator, a task which took from 1735 to 1745. A second expedition left Paris in 1736 under Maupertuis and went to Lapland, where it measured a degree of latitude to the north of Tornea, at the northern end of the Gulf of Bothnia. The work of these expeditions showed that the degree of latitude is longer in the Arctic regions than it is at the Equator, and that therefore the earth is flattened towards the Poles. As Voltaire remarked, Maupertuis flattened at once both the Poles and the Cassinists.

The earth, however, is not only flattened at the Poles, but pendulum observations suggest that the degree of flattening is different in the Northern and Southern Hemispheres. This conclusion was also asserted by La Caille, in 1752, as according to his measurements of a degree of latitude in Cape Colony, the South Pole was farther from the centre of the earth than the Equator; according to La Caille the Southern Hemisphere was prolate and not oblate. This great difference between the shape of the Northern and Southern Hemispheres was not confirmed by Maclear, who, by observations which occupied over six years, remeasured the length of the degree of latitude near Cape Town; but his work, as well as pendulum observations, show that there is a difference in the form of the Northern and Southern Hemispheres. The earth, therefore, is not an oblate spheroid. In fact it is not a spheroid at all; for there is evidence to show that the earth is compressed laterally as well as at the Poles, so that the Equator is not a circle, but an ellipse. The earth, therefore, has no regular geometrical form. As Sir John Herschell said: "The earth is earth-shaped". It appears to resemble a badly made peg-top rather than an orange.

The final method of determining the shape of the earth is by the measurement of the length of the degree of latitude and longitude throughout the earth. But measurements with the necessary precision are very costly. There is fortunately a simpler method available. Richer's clock varied in its time-rate, as its pendulum oscillated more slowly at the Equator than at Paris. To keep Paris time at Cayenne the pendulum should have been shortened by about $\frac{1}{12}$ in. The time in which a pendulum of a fixed length takes to beat a second gives a measure of the distance of the locality, where the pendulum is swinging, from the centre of the earth. The same result can be obtained by determining how much a pendulum has to be lengthened or shortened to continue to beat true time when taken to a different locality. The exact length of the pendulum which makes one beat per second has been determined for many distant localities.[1] Thus at Gibraltar the pendulum has to be $\frac{1}{25}$ in. longer than at the Equator; in the north of Spain $\frac{2}{25}$ in. longer; in London $\frac{3}{25}$ in. longer; in Iceland $\frac{4}{25}$ in.; and in Spitzbergen $\frac{5}{25}$ in. The observations have been taken in so many places that Steinhauser has prepared a map of the world with lines drawn through places where the second-beating pendulum is the same length. This map (reprinted as figure 6) shows that the lengthening is irregular, and does not correspond in the two hemispheres; therefore the earth is not a spheroid, but is of an irregular shape. The earth, to use Listing's term, is a geoid, which is simply another way of saying the earth is earth-shaped; it has a form peculiar to itself.

[1] In practice the shorter pendulum, which beats once in half a second, is now generally used.

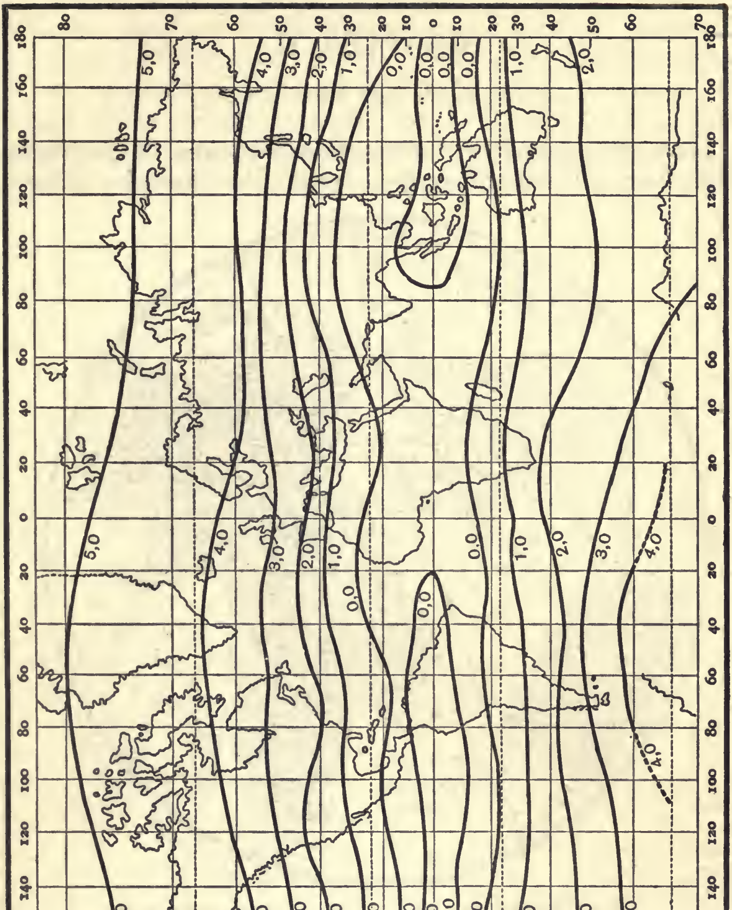


Fig. 6.—Map showing the Variations in the Attraction of Gravity as indicated by the Length of the Pendulum beating Seconds

0 = the standard length for the equatorial belt: 1.0 to 5.0, the lines along which the pendulum has to be lengthened by from 1 to 5 millimetres in order that it may continue to beat seconds in those latitudes. After Steinhauser. (An inch is approximately 25 millimetres.)

CHAPTER II

THE PLAN OF THE EARTH

Since the beginning of the systematic study of geography it has been a belief among geographers, that there is a definite

Fig. 7.—Northern Hemisphere, showing the Greatest Mass of Land

plan in the distribution of land and water upon the globe. This view was formulated by the classical geographers from the apparently radial arrangement of land and sea around the Mediterranean and in South-western Asia, an arrangement depicted in the "wheel-maps" of the Middle Ages. The same view was reasserted by Bacon from the shape of the

Atlantic, and is accepted by modern geographers from the distribution of mountain chains. This belief has been based on what are known as "geographical homologies", which are certain striking resemblances in the distribution of land and water on the globe, and in the shape and arrangement of the different continents.

Fig. 8.—Southern Hemisphere, showing the Greatest Mass of Water

The first obvious fact, on the inspection of a map of the world, is that a much larger portion of the surface is covered by water than by land. There are two and a half times as much sea as land. The land and water, moreover, are not equally distributed over the surface of the earth. There is a great excess of land in the Northern Hemisphere and of water in the Southern Hemisphere; so that London is near the centre of a land hemisphere, which includes most of the land of the earth; whereas our antipodes (Antipodes Island, to the south of New Zealand) is in the centre of a water hemisphere, containing most of the water of the earth. There is, in fact, thirteen times more land in the Northern than in the Southern Hemisphere.

A second significant fact is that most of the geographical units are somewhat triangular in shape. The continents are triangular, with a broad base to the north, whence they taper to an apex in the south. This feature is shown in the general shape of North America, of South America, of Africa, and it is repeated on a smaller scale in the numerous peninsulas which project southward from Europe and Asia. India has the most regularly triangular form, but all the other peninsulas on the southern coast of Europe and Asia taper to the south; their shapes are somewhat irregular, but a tendency to a triangular form may be recognized in them all, as in Spain, Italy, the Balkans, Arabia, India, the Malay Peninsula, and Siam. This southward tendency of peninsulas is so general that it has been described as a geographical law, to which the usually-admitted exceptions are Denmark and Yucatan; and though the list of exceptions is longer, including Labrador, the Boothia Peninsula in North America, the Taimyr Peninsula in Northern Asia, and the Northern Territory and Cape York Peninsulas in Australia, the general rule holds good throughout the world.

The triangular shape of the geographical units is true also of the seas and oceans; the Pacific and most of its off-lying seas, the seas of the Indian Ocean, and the basins of the Mediterranean are all sub-triangular.

The third striking fact in the distribution of land and water is that the great masses of land are arranged as a land ring in the Northern Hemisphere. The broad northern bases of Europe, Asia, and North America are placed in line, forming a nearly complete circle around the Arctic

Ocean. The land ring is broken by the narrow Bering Strait, between Asia and America; by Smith Sound to the west of Greenland, and the straits through the North American Archipelago. The only broad outlet from the Arctic Ocean is into the North Atlantic; but this, the only wide break in the continuity of the northern land ring, is shallow and of modern origin, for Greenland and the north of Scotland are connected by a submarine ridge, of which Iceland and the Faroe Islands are the highest summits. When this ridge was above sea-level, the Boreal land-ring was nearly complete around the enclosed Arctic Ocean. From this ring the land projects southwards in three pairs of continents, in each of which the land tapers to the south. Thus North America is succeeded to the south by South America; Europe is succeeded to the south by Africa, the northern part of which, by its mountain structure, is intimately associated with Europe; and, farther east, Asia is prolonged to the south through Malaysia into Australia.

The lands are cut off to the south by a continuous band of sea, beyond which is the island continent of Antarctica, now widely separated from the other lands by the Southern Pacific and the Southern Ocean.

The lands of the world may therefore be described as consisting of a continental ring around the North Pole, with three meridional land-belts projecting southward, and of a south polar continent; while the waters of the earth form a southern oceanic belt, which is continuous around the southern hemisphere, whence three oceans project and taper northwards. Land and water are therefore arranged like a pair of interlocking cog-wheels, each with three teeth, and the wheels are on an axis which is depressed at the northern extremity and projected at the southern.

The fourth feature in the distribution of land and water is not so conspicuous as the others, but it is even more significant. It is the antipodal arrangement of land and water. It is most easily recognized by examination of a globe. If a globe be rolled about on a table, when land occurs on the part of the globe which is uppermost, then the opposite point of the globe, which touches the table, will generally be water. If a straight line be drawn through the centre of the globe from one point on the surface to its antipodes, it is found that if one antipodes be on land, the other will nearly always be in water. If the antipodes of

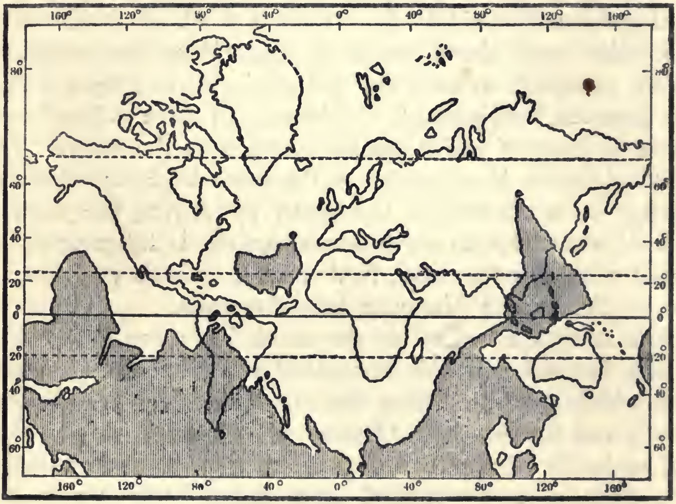
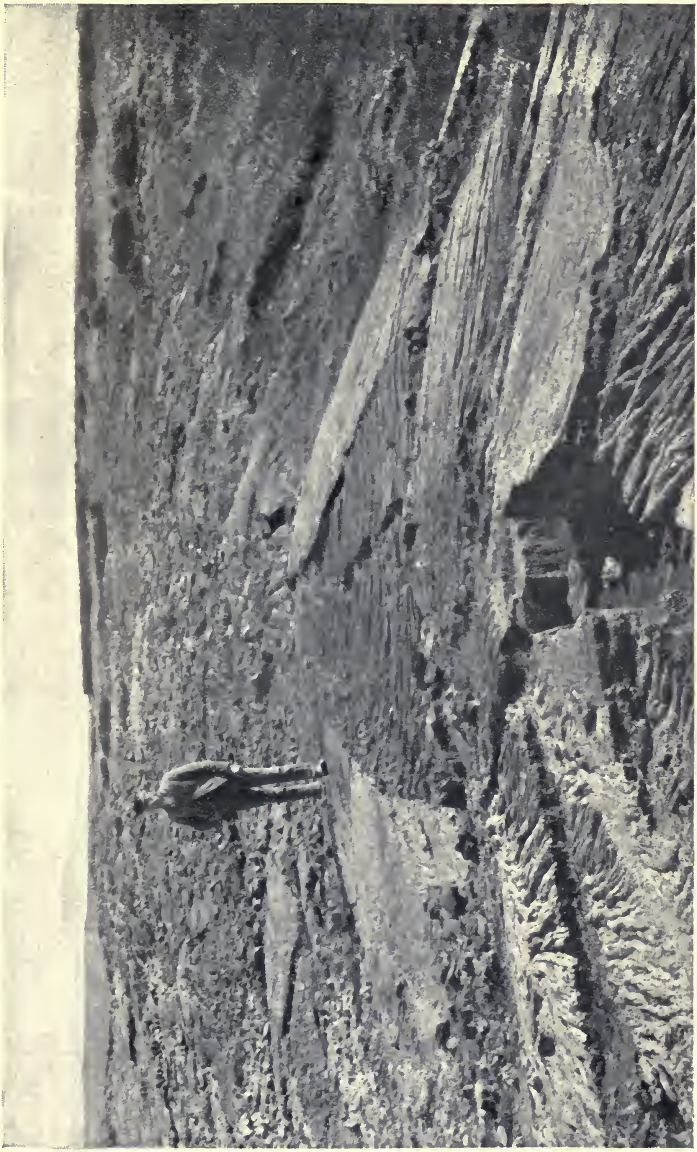


Fig. 9.—Map illustrating the Antipodal Position of Oceans and Continents

all the points on the coasts of North America be marked on a map of the world (fig. 9), an inverted map of North America is drawn on the southern half of the Eastern Hemisphere, and it will be found that North America is antipodal to the Indian Ocean. The continent of Australia is similarly antipodal to the central basin of the North Atlantic. Europe and Africa are antipodal to the middle of the Pacific Ocean. The Arctic Ocean is antipodal to the Antarctic land. The only important exception to the rule is that the southern part of South America is antipodal to

PLATE I



Photograph by Dr. Tempest Anderson.

A LAVA STREAM (page 21)

Showing ropy-structure of the surface, North Iceland

part of China, but this exception is comparatively so small, that only one twenty-seventh of the land of the globe has land antipodal to it.

Such, then, is the plan of the earth, and this plan is determined by the distribution of elevation and depression on the surface of the lithosphere; for the continents are simply the elevations and the oceans occupy the depressions on the surface of the earth.

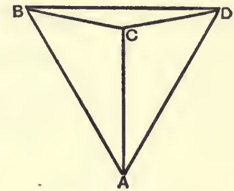


Fig. 10.—A Simple Tetrahedron with four equal Triangular Faces

The arrangement of the lands of the earth may be described as tetrahedral, as it corresponds with that of the raised edges of a tetrahedron. A tetrahedron (*tetra*, Gr., in composition = 4, *hedra*, Gr., a base or surface) is any four-based or four-faced solid figure; a regular tetrahedron (fig. 10) is one in which the four faces are four equal and equilateral triangles; hence there are four solid corners or "coigns", and the four faces meet along six edges. If a tetrahedron be placed standing upright on one of its four corners, then the corner on which it is resting may be regarded as the south pole of the tetrahedron, and the north pole will be in the centre of the opposite face. A tetrahedron looks quite unlike the shape of the earth; but a six-sided pyramid may be placed on each face of the tetrahedron; and if the pyramids had elastic sides, which could be blown out and their faces rendered curved, then the tetrahedron would gradually pass into the shape of a sphere. Further, experiments on collapsing spheres, on rubber balloons, and on gas bubbles under pressure in water show that a homogeneous sphere tends to contract into a tetrahedral form. If then the air be pumped out of a

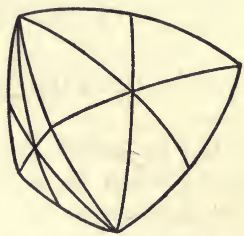


Fig. 11.—A Six-faced Tetrahedron, having a Pyramid with six Curved Faces on each of the four Faces of the simple Tetrahedron

thin hollow sphere, the surface would sink in four places, and thus the sphere suffer a tetrahedral deformation. A tetrahedron with elastic sides could be blown up into a sphere, and on relief from pressure would collapse again into a tetrahedron; and during these changes the edges of the tetrahedron would undergo comparatively little movement. If these edges were drawn on the sphere resulting from the inflation of a tetrahedron, the trace of the edges would be found to form a circle around the top, and three edges would run from this circle down the side and meet at the bottom of the sphere (fig. 11).

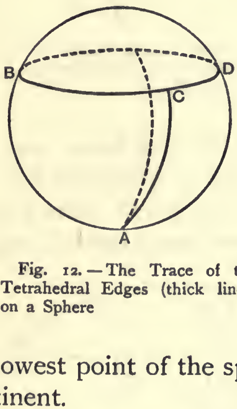


Fig. 12.—The Trace of the Tetrahedral Edges (thick lines) on a Sphere

The land of the earth is arranged on the globe with a tetrahedral symmetry; for the horizontal circle around the top of the blown-out tetrahedron represents the northern land belt; the three meridional lines running downward from it would represent the lines of the three southward-projecting lands, South America, Africa, and Australia; and the projection where the three meridional lines meet at the lowest point of the sphere, would represent the Antarctic continent.

The mountain system of the earth has also a tetrahedral plan, though its development is irregular, for the mountain lines have been diverted by the resistance of the stronger rock masses. In the Eastern Hemisphere the chief younger mountains belong to the Alpine-Himalayan System, which crosses Europe and Asia, running east and west; and in the Southern Hemisphere the main mountain lines run north and south. In America the most conspicuous mountains run north and south; but to the north they bend round till they run east and west. Thus the eastern mountains of North America, the Appalachians, bend eastward at their northern end till they strike out to sea between Newfoundland and

Nova Scotia on a curve which, if continued, would carry them along the line of the submerged ridge which crosses the North Atlantic from Newfoundland to Ireland. In a like manner the western mountains of America abandon their meridional trend and curve westward, till they sweep across the end of the North Pacific to join the mountain lines of Asia.

The tetrahedral plan of the water on the earth's surface is also in harmony with the tetrahedral plan of the land. If a volume of water could be held upon the surface of a tetrahedron by attraction from the centre of the tetrahedral body, as water is held on the surface of the earth by attraction from the internal mass of the earth, the water would first collect in the middle of the four faces, because they are the parts nearest the centre of the tetrahedral mass. This is represented by the circles drawn on the three visible faces of the tetrahedron in fig. 13. If now the volume of the water were sufficient to cover five-sevenths of the surface of the tetrahedron, then the water would cover the middle of each face, and meet the areas of water on the adjoining faces at the middle part of each edge. And such, in broad outline, is the actual distribution of land and water on the globe. For the circular ocean on the top face would represent the Arctic Ocean surrounded by a nearly complete ring of land. Each of the three side faces would include an ocean tapering northward and united on each southerly side to the adjacent oceans. These oceans would represent the positions of the Atlantic, the Indian, and the Pacific, the last being on the unseen side of the inflated tetrahedron. The complete ring of water round the Antarctic continent

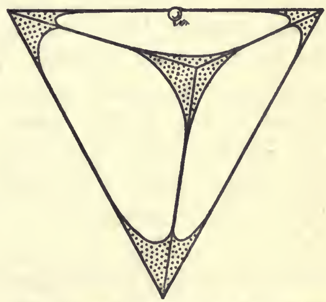


Fig. 13.—A Tetrahedron in which the dotted and plain areas correspond in extent to the proportions of land and water on the earth. The water occupies the parts of the surfaces nearest the centre of the tetrahedron.

would correspond to the Southern Ocean and the Southern Pacific.

The tetrahedral plan of land and water on the globe is therefore a simple statement of fact, which can be recognized by examination of a map. This tetrahedral arrangement is not a mere coincidence, but a natural development. It follows inevitably, if the earth be correctly regarded as composed of a hard crust over a plastic, contracting interior. The sphere is the body which has the maximum volume for a minimum of surface. The tetrahedron, on the other hand, is the regular body which has the maximum of surface to the minimum of volume. As the internal mass of the earth contracts, the hard crust sinks down with it, and thus is forced into a smaller area. The crust has to adapt itself to the smaller space available. The earth, therefore, tends to that shape which most easily gets rid of the excess of surface due to its contraction; and it most easily gets rid of its excess of surface by sagging on the four faces, and thus collapses with a tetrahedral deformation. The sagging of the four faces has formed the four ocean basins. The projections left between them form the continents; and as each projecting corner of a tetrahedron occurs opposite a flat face, so on the earth a continent is antipodal to an ocean basin.

The tetrahedral deformation is opposed by the rotation of the earth, which constantly tends to restore the spheroidal form; and the shape of the earth and the arrangement of land and water on it are the result of these two opposing influences.

The three chief features in the plan of the earth, viz. the excess of land in the Northern and of water in the Southern Hemisphere, the land ring in the Northern Hemisphere, with the three land masses projecting to the south and the oceanic girdle round the Southern Hemisphere, and the antipodal position of ocean and continent, are due to the tendency of the earth to collapse in four faces, in order thus most easily to adapt itself to its gradually shrinking interior.

CHAPTER III

THE MATERIALS OF THE EARTH'S CRUST

The crust of the earth is composed of rocks, which are the firm coherent masses that form the main part of the lithosphere. The rocks are often covered by sheets of softer or looser material, such as clay, sand, loam, and gravel. The exposed surfaces of rocks and of sheets of sand or clay decompose into soils, and between the soils and the bed below them is a layer of partially decomposed material known as the "subsoil".

Rocks are of two main kinds: primary rocks, formed by the solidification of material that was either actually molten, or under such heavy pressure and at so high a tem-

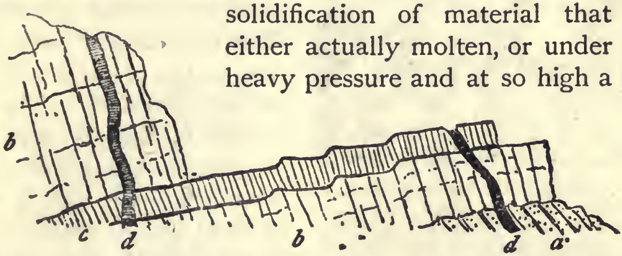


Fig. 14.—Section of dolerite sill (*b*, *b*) cut by another sill (*c*), both being traversed by dykes (*d*, *d*): stratified rocks are seen at *a*: Rudh' an Iasgaich, western side of Sleat, Skye. (After Sir Archibald Geikie.)

perature that it was plastic and its particles arranged themselves in the condition of crystalline minerals. Rocks of the other kind are known as secondary, because they are formed by the destruction of primary rocks, and the redeposition of the materials thus obtained. The primary rocks are of three main groups. First, lavas, those molten rocks which are poured out over the surface of the earth from a volcano (Plate I). Second, intrusive sheets or masses which have been forced in a molten state into fissures or cavities in other rocks. They occur sometimes as horizontal sheets or sills; sometimes as vertical sheets or dykes; sometimes as huge lensshaped masses known as laccolites. The regularly-banded appearance of some British hills, such as the Campsie Fells near Glasgow, is due to the horizontal sheets; while the Devil's Dyke at Millport, and the Whin Sill which crosses northern Yorkshire for about sixty miles, are examples of dykes. Both sills and dykes are shown in the section (fig. 14) from the isle of Skye. The third group of primary rocks includes those known as plutonic. They have been formed at great depths beneath the earth's surface; hence they have consolidated very slowly and under heavy pressure, so that the whole of their constituents have solidified in the condition of crystalline minerals. The best known of the plutonic rocks is granite, which consists of three minerals: small blobs of hard glassy material—the quartz; larger crystals of a pink, grey, or white mineral, which breaks into flat, smooth surfaces, and can be scratched by a sharp knife—the felspars; and flakes of a scaly mineral, which is white, black, or dark brown in colour, and can easily be broken by a knife into thin elastic scales—this is the mica.

Fig. 15.—A Piece of Coarse-grained Granite. The white areas are the felspars, the dotted areas (which in the granite look like dark ground-glass) are quartz, the black areas are the crystals of black mica.

Other varieties of plutonic rock are composed of different combinations of simple minerals; they agree in being composed wholly of crystalline minerals, and they are usually so coarse in grain that their separate constituents can be recognized by the naked eye. They never contain natural glass, which is found in lavas.

The secondary rocks are formed by the breaking up of the primary rocks. The primary minerals may be broken up by frost or heat, or by the solution of their soluble constituents;

the fragments may be blown about by the wind, or carried away by rivers and deposited beside their banks during floods or spread over the floors of lakes or seas.

The constituents of the primary rocks are redeposited in secondary rocks of three main kinds. The coarser grains are deposited as beds of sand, which usually consist of grains of quartz. When the grains are firmly attached to one another as a rock, it is a sandstone (fig. 16). Larger fragments or pebbles form beds of gravel; the spaces between the pebbles are usually filled with sand grains, and when such material is cemented into a rock it is known as conglomerate (fig. 17), or, if the pebbles be angular, as breccia (fig. 18). The finest material or silt is deposited in the form of mud, which dries into clay. Clay consists of very minute particles. They are so small that when clay is moistened with water it becomes plastic and can be moulded beneath the fingers; whereas, if sand is moistened, owing to the large size of its grains, it falls apart into loose powder. Some beds of clay consist of quartz powder, which is so fine that the separate grains cannot be recognized by the naked eye, and the material is plastic when moistened. Many clays, however, including those used for the manufacture of pottery and fire bricks, are made up of minute particles of the mineral kaolinite.[1]

Fig. 16.—Sandstone

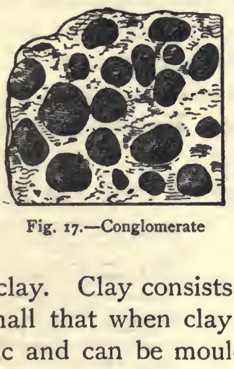


Fig. 17.—Conglomerate

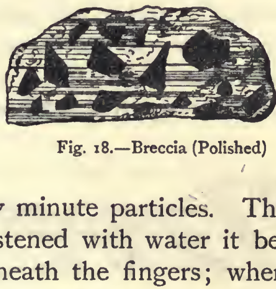


Fig. 18.—Breccia (Polished)

[1] This mineral is composed of the metal aluminium combined with silicon and oxygen, whereas quartz consists only of silica, *i.e.* silicon combined with oxygen.

Loam is a mixture of sand and clay.

Some of the material obtained by the decomposition of the primary rocks is dissolved in water and carried away in solution; it may be deposited by the evaporation of the water, as beds of rock salt or gypsum (sulphate of lime). The carbonate of lime dissolved in water is extracted by plants or animals, and they use it to build up their stems, skeletons, or shells, which, on the death of the organism, are deposited on the floor of sea, lake, or river. The accumulations of the shells of shell-fish and the skeletons of corals and calcareous sea-weeds give rise to beds of limestone (fig. 19). Calcareous material is not always deposited in beds of pure limestone, but is often mixed with clay, and is then known as marl.

Fig. 19.—Microscopic Structure of Chalk (after Sorby)

Loose beds of sand and clay, and accumulations of shells, are sometimes hardened into rock by the pressure of overlying deposits, and by the percolation of water, which deposits a cement between the loose particles, binding them into a firm, compact rock.

The secondary rocks are distinguished from the primary rocks by three main characters: (1) The secondary rocks are usually composed of fragments, as may be seen by examining a bed of gravel in a pit, or a specimen of sandstone with the aid of a magnifying-glass; (2) they are deposited in layers or beds (strata), so that they are described as "stratified" rocks (figs. 20–22); and (3) they frequently

Fig. 20.—Diagram showing a Horizontal Series of Stratified Rocks laid on the Worn, Uptilted Edges of an Older Series

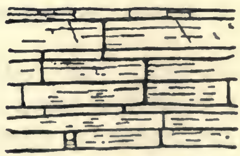


Fig. 21.—Diagram showing a Bed of Stratified Rock divided into Blocks by Joints

contain the fossil remains of animals and plants that lived during their formation. These fossils indicate the conditions under which the rocks were formed.

There is a third group of rocks, including those intermediate between the primary and the secondary. They are known as the metamorphic rocks, because they have been formed by the alteration of other rocks. Metamorphism may be due to the influence of great pressure, which compresses clay into slates, and which can completely alter rocks by

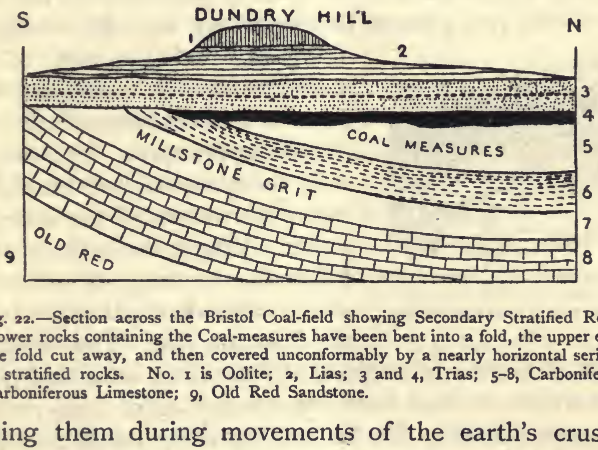


Fig. 22.—Section across the Bristol Coal-field showing Secondary Stratified Rocks; the lower rocks containing the Coal-measures have been bent into a fold, the upper edges of the fold cut away, and then covered unconformably by a nearly horizontal series of later stratified rocks. No. 1 is Oolite; 2, Lias; 3 and 4, Trias; 5–8, Carboniferous; 8, Carboniferous Limestone; 9, Old Red Sandstone.

smashing them during movements of the earth's crust. A second type of metamorphism is due to the action of intense heat, as when rocks have been in contact with molten rocks that have flowed across them in lava flows or been forced into them as dykes. Rocks in such positions are often rendered very hard, and sometimes crystalline, and are said to be altered by "contact metamorphism". Rocks may also be changed by a combination of great heat and immense pressure, which leads to such a complete alteration in their materials that wide sheets of rock may be rendered crystalline like primary rocks; and the minerals thus formed are usually arranged in thin parallel layers, as in gneiss (fig. 23) and schist. Gneiss is composed of the same minerals as granite, from which it differs by the arrangement of its minerals in successive layers. This arrangement resembles the bedding of secondary rocks; hence the metamorphic rocks have been called transition rocks, owing to their apparent combination of the characters of the primary and secondary rocks.

The chief raw materials which contribute to the wealth of a country are its soils, with their animal and vegetable products, and its minerals. The various kinds of soils may all be divided into two groups, the sedentary and the transported.

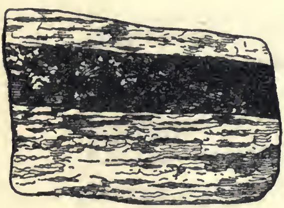


Fig. 23.—Gneiss. The banding, due to the arrangement of the Minerals in successive layers, is known as Foliation.

Sedentary soils consist of loose material formed by the weathering of rocks and the accumulation of the debris on the spot. The sedentary soils therefore depend immediately upon the nature of the underlying rocks. Where the rocks consist of minerals, the decay of which gives rise to abundant plant foods, then the soils are rich. Thus many volcanic rocks contain phosphate of lime, lime, soda, and potash; soils therefore formed from the weathering of such rocks are rich in plant foods. Rocks, on the other hand, which, like pure sandstone, consist mainly of silica, yield barren soils, for they contain little material that plants can use as food. Hence districts occupied by wide sheets of sandstone have poor soils and are of little agricultural value, though they may be useful for raising sheep and cattle. Igneous rocks, containing much lime and phosphate, yield rich stores of plant foods, and the lower slopes of districts occupied by decayed volcanic rocks, such as Vesuvius, are of great fertility. Limestones also usually give rise to rich soils, though these soils are often very thin; for limestone is soluble in rain-water on account of the carbonic acid which such water always contains. Hence most of the rock is removed in solution, and the soil is formed of the small quantities of the less soluble materials either scattered through the rock or blown on to the district by the wind. This residue is left on the surface as a thin layer, which gradually decomposes, forming a rich soil, often dark red in colour, as it is stained by iron rust. Limestone soils on moors and uplands are apt to be very dry; they are then of most value from their rich turf, which supports flocks of sheep.

The second group of soils are known as *transported soils*, because their materials have been derived from distant rocks and have been carried to their present position by wind, water, or ice. These soils do not therefore depend upon the nature of the underlying rocks. Transported soils may be formed by the action of the wind blowing fine material from exposed positions and dropping it into sheltered hollows. The wind carries the finest and lightest particles of soil as dust through the air, and it rolls the coarser grains along the surface of the ground. In a dry district, where the wind has most transporting power, it separates the coarse and light particles. The larger grains are collected and piled up in sand-dunes; the lighter particles are carried away to leeward and spread out in broad sheets of very fine-grained clay. This fine material is known as loess, and its grains are irregularly arranged, and it is often traversed by vertical pipes, left by the dead grass stems. Hence one of the most striking characters of this material is that, although soft, it stands up in vertical, smooth, wall-like faces (Plate III). Loess is well developed in the valley of the Rhine and of the Danube, where it has been accumulated by the wind sweeping over the steppes of Central Europe at a time when the climate was drier than it is at present.

Transported soils are also produced by rivers, which carry down sediment washed into them by the rain, or worn away from their beds or their banks. The amount of material which a river can carry depends upon its velocity. A river with a quick current will carry more and heavier material than a river with a slow current. The velocity of a river is diminished when it leaves the hills or the steeper slope of the upper part of its course and reaches more level country; hence the river drops on the lowlands the materials which it has been able to carry, while its flow was rapid, among the hills. The river usually deposits most of its material in the form of a flood-plain along the floor of its valley; for rivers carry down most sediment during floods, and drop it in the comparatively stagnant sheet of water that has overflowed from the main channel, whilst more of the sediment is dropped on the bed of the river, as the flood subsides. Where a river widens out into a lake, or enters the sea, all the rest of the material carried in suspension in the water is deposited, as the velocity of the current is suddenly reduced upon meeting the wider sheet of water. The coarse sands are dropped at once, as a delta, and the fine silt is spread over the floor of the lake or the sea.

Fig. 24.—An Erratic Block, resting on a glaciated surface of rock

Thus the transported soils due to river action may occur as beds of sand, gravel, and loam along the floor of a river valley, or as wide sheets of the same materials on the site of a filled-up lake.

Ice is the third chief agent in the formation of transported soils, and its action is limited to the cooler regions of the earth, or to great elevations above the sea. The material is picked up by the ice from the rocks over which it flows, or which fall on to it from adjacent cliffs. As the ice melts away, the mud and stones in it are deposited in heaps, ridges, or broad sheets. This material is generally washed and re-sorted by rain and streams; it may be thus redeposited in sheets of sand, gravel, and clay, and is of the same agricultural value as the beds formed by river action. Beds formed by ice action, however, usually contain numerous large blocks of hard rock, brought from some distance; they are found in the soil, or stand up as conspicuous boulders above the surface (fig. 24).

FUEL

Man is dependent for his chief supplies of fuel on wood, peat, coal, or oil. Wood is usually the most easily obtained and convenient fuel, and most early civilizations have developed in districts where neighbouring forests gave abundant firewood. In sparsely timbered districts the available supply of firewood may be soon burnt up, and the inhabitants are dependent on peat in wet, cold, moorland countries, or on dried dung, or on the fat of animals. But these supplies are too scanty for any considerable population, so the people have continually to move to fresh localities. Thus when the Europeans first settled in North America, the Indians thought that the whites had been driven from their own country by the exhaustion of the firewood.

Fig. 25.—Section across the South Wales Coal-field from north to south. (Length of Section about 22 miles.)
1, Old Red Sandstone; 2, Carboniferous Limestone; 3, Millstone Grit; 4, Lower Coal-measures; 5, Pennant Sandstone; 6, Upper Coal-measures.

Wood uses up some of its available heat in evaporating the moisture which it always contains; a greater amount of heat, therefore, can be obtained by first driving off the moisture;

to effect this the wood is slowly burnt or "charred" in covered heaps; thus all the volatile constituents are driven off, while most of the carbon remains behind as charcoal. Since this is nearly pure carbon, it gives rise, when burnt, to intense heat.

Coal is a better fuel than wood, owing to its greater heating-power and its compactness; but it is usually buried so deep beneath the earth that primitive man could not procure it. Some British coal was dug for fuel by the Romans, but after their departure the coal was not mined

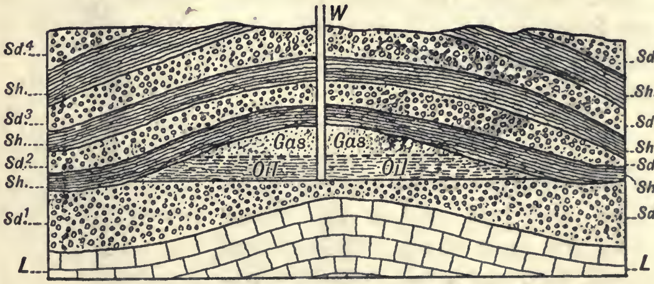


Fig. 26.—The sandstone (*Sd*¹) receives oil and gas produced by decomposition of the organic matter in *L*; it collects below the impermeable bed of shale (*Sh*), the upper part of the arch of sandstone being impregnated with gas and the lower with oil; the gas and oil escape to the surface when the natural reservoir is reached and the oil well bored at *W*.

until the thirteenth century. The exhaustion of the British forests would have prevented the economic development of the country, unless some other source of fuel had been found. Coal is, however, abundant and easily mined, and it has become the main source of power used in the manufactures and industries of the British Isles. Coal is usually of vegetable origin, and has grown in old forests, or swamps, or been formed from accumulations of vegetable matter carried by rivers into lagoons and lakes. These accumulations have been covered by sheets of sand and clay, and the gradual removal of the moisture and volatile constituents, and the pressure of the overlying rocks, convert the plant materials into hard, black coal.

Petroleum, the third chief source of natural fuel, is an oil that has been formed by the distillation of organic material. Remains of animals and plants are embedded in rocks, where heat, due to pressure, to volcanic action, or to the internal heat of the earth, produces the oils, which collect in any adjacent beds of porous rock, such as sandstone. Here they may remain until a bore-hole or some natural outlet is formed, when they rush to the surface and discharge as an oil-well or oil-spring. The most important oil-fields in the world are in Baku near the Caspian, in Pennsylvania, California, and Mexico, Burmah, the Midland Valley of Scotland, and Roumania; but small quantities occur in most deltas and estuaries, or wherever buried organic matter is decomposing.

CHAPTER IV

THE LAND FORMS

The geographical structure of the world is controlled by the arrangement of those geographical elements known as "land forms". The land forms are of two kinds. The solid masses and sheets of rock which constitute the earth's crust are known as the positive land forms; between them there are depressions and hollows—the negative land forms. The positive land forms include plains, plateaus, mountains, and highlands. The negative land forms include the various types of valleys and basins.

POSITIVE LAND FORMS

Plains.—Plains are wide-spread areas with an even horizontal surface, either slightly raised above the sea or at a level which is low in relation to the adjacent country. They are divided, according to their mode of origin, into four groups—two are plains of deposition, and two of denudation.

1. Coastal plains have been formed by the deposition of sheets of rock material over the sea floor and its uplift above sea-level. Typical coastal plains lie around the margins of continents, and slope gradually from the older rocks of the interior down to the sea.

2. River plains also are formed by deposition. The material is derived from the wearing away of the hills in the higher part of a river basin; this is swept along until the river reaches more level country, where the current flows more slowly, and is unable to carry as much sediment as did the rapid tributaries discharging into it. Hence the material is deposited on the bed of the river, which is thus gradually raised above the level of the ground on either side. This process goes on until a river may flow like a canal between raised embankments. In some heavy flood the river makes a breach in its banks, abandons its old channel, and adopts a new course over the lower ground. The river in time raises the level of its new channel, and again it is driven to find another line of lower ground. Thus the river wanders from side to side of its valley, gradually raising the level of its bed, and, after a time, the whole width of the river channel is converted into a level plain at the height to which the river rises in floods. Such river-formed plains include many of the most important plains in the world.

3. Plains of marine denudation have been formed, not by deposition, but by the wearing away of the coast by the surf. The breakers cut back the shore line, and the scour of the beach material, as it is swept to and fro by the tide, planes the belt between high and low tide lines into a smooth, level shore-platform.

4. Pene-planes are due to the levelling of a country by rivers or wind. As the rivers work their way to and fro across their valleys, they cut into their banks, while all their tributaries are lowering and widening their valleys; thus, in time, the whole of the country is worn down into a smooth plain, having a gradual slope from the interior to the coast. All

PLATE IV

PLAIN OF MARINE DENUDATION (page 32)
On the Yorkshire Coast, near Whitby

the rivers of the world are gradually tending to plane down the lands and carry the material into the sea. Plains thus formed cannot be quite horizontal, as they must have some slope to give the water power to act. Such plains are therefore known as peneplanes (*i.e.* nearly planes) or peneplains, a word analogous to peninsula.[1]

Plains, when first formed, have even surfaces; they are then known as "young plains". But, if a plain is raised above sea-level, the streams and rivers cut into it, and the surface becomes irregular; plains which have been thus transformed are known as "old plains".

Plateaus are plains at some considerable height either above sea-level or above the surrounding country. Plateaus in rainy countries are soon attacked by streams and rivers, which cut their channels deeply into them and gradually destroy the original level surface of the plateau. Plateaus thus altered are said to be "dissected plateaus". In arid regions plateaus are kept level; for any ridges are cut down by the sharp, driving sand, and the hollows are filled with wind-borne material. This process is aided by the occasional rain-storms, which wash the loose material down the slopes into the depressions, whence the water is removed by evaporation. The interior of vast plateaus in arid regions, such as Western Australia, have therefore gently undulating surfaces, and it is only their borders that are exposed to the attack of the rivers, which slowly cut their way backward and dissect the border of the plateau.

MOUNTAINS AND HILLS

Mountains and hills are great masses of rock which rise high above the surrounding country, and culminate in a well-marked summit or crest. Mountains may be regarded as very big hills, or the name mountain may be restricted to those

[1] The term is due to Professor W. M. Davis, and the form adopted in America is "peneplain"; the spelling "peneplane" is here adopted in deference to the wish of a distinguished geologist and scholar.

which have rugged, rocky outlines. Mountains appear as isolated mountains or peaks, or in series known as "mountain ranges". Several mountain ranges may be united to form a "mountain chain"; while many mountain chains, allied by some similar character common to them all, such as date or cause of formation, form a "mountain system", like the Alpine-Himalayan System, which extends from the Pyrenees, through the Alps, the Caucasus, and the Himalaya.

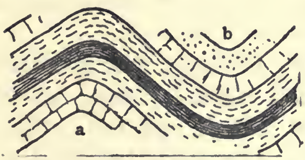


Fig. 27.—Diagram of a Fold, showing Syncline (b) and Anticline (a)

Mountains are built up in four chief ways:

1. Fold-mountains arise from the crumpling of bands of the earth's crust by lateral pressure. Such fold-mountains resemble the wrinkles formed when a table-cloth is pushed across a table. Arches or upfolds are known as anticlines and troughs or downfolds as synclines (fig. 27).

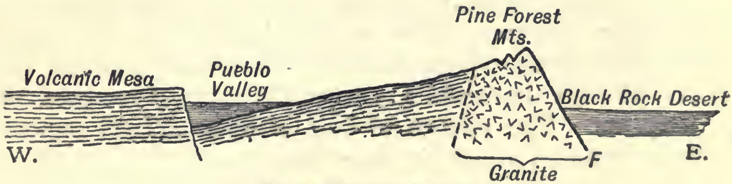


Fig. 28.—A Block-Mountain

The Pine Forest Mountains in Oregon, due to the tilting of the earth block, composed of granite and stratified volcanic rocks, between the Pueblo Valley and the Black Rock Desert. (After Russell.)

2. A Block-mountain is composed of a block of the earth's crust (an earth-block) which has been either uplifted above the surrounding country or has been left upraised by the subsidence of the adjacent earth-blocks. Large areas of high lands which have been left upstanding by the subsidence of the surrounding country are known as "horsts".[1] Korea,

[1] Horst is an old German term having several meanings. Its English equivalents are "hurst" and "hirst", a wood or grove, as in Lyndhurst and Chislehurst. Its

for example, is a horst standing between the foundered areas of the Yellow Sea and the Sea of Japan (fig. 84, p. 174).

3. Volcanic mountains are heaps of material, chiefly lava and volcanic tuffs, piled up by eruptions around volcanic vents.

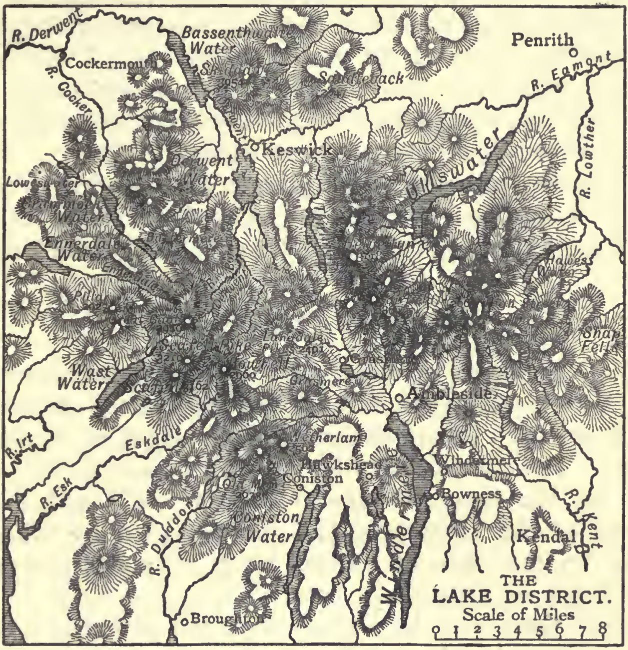


Fig. 29.—A Dissected Plateau

4. Residual mountains are due to the dissection of a plateau, where the rivers have cut such wide deep valleys that only ridges or pyramidal masses are left. The chief mountains of the Lake District of the north-west of England (fig. 29), and of the Highlands of Scotland, are fragments

German meanings include a wood in open country, an eyrie, a heap of sand or earth heaped up by water, and a place or heap of earth on a moor that remains dry in wet years. (Meyer's *Lexikon*, vol. viii, 1887, p. 731.) It is also used for a wooded hill, and, from its use in that sense for some of the old plateaus of Southern Germany, it was adopted by Professor Suess as a term in structural geography.

of old plateaus left as isolated peaks by the removal of the intervening rocks. Narrow valleys were formed across the plateau, and widened until the strips of plateau between the valleys were reduced to ridges, while prolonged denudation broke up the continuous ridges into detached mountains.

Highland areas consist of high rugged country formed by the wearing down of old mountain regions. Their surface is very irregular, for the rocks have different powers of resistance, and the rivers flow through valleys cut along the softer beds between ridges formed of the harder.

Mountains, plateaus, and highlands are bounded by slopes and cliffs; but there are cliffs and steep slopes called "scarps", which are formed by uneven movements of the earth's crust.

NEGATIVE LAND FORMS

The depressions, or negative land forms, may be grouped into two classes—basins and valleys. Those depressions which are wide in proportion to their length are known as basins. The greatest of these are the oceanic basins, occupied by the oceans. Smaller basins are found on the surface of the continents, and are occupied by lakes, by plains on the sites of former lakes, or plains formed of wind-borne or river-borne material.

Lake basins may be formed from the blocking up of a valley, either by the deposition of a dam across it, or by the tilting of the ground during a wide-spread earth-movement, or by an uplift of the lower part of the valley. Lakes also occur in volcanic craters, and in caldrons formed by local subsidences due to the falling in of subterranean cavities which previous volcanic eruptions hollowed out.

Valleys are long, narrow depressions. They usually rise in mountain regions, and gradually increase in width and in depth till they pass into the sea. Such are the ordinary valleys cut by the action of rivers.

Rift valleys have been formed by earth movements; they are found where long and comparatively narrow strips of the earth's crust have sunk between parallel fractures. The greatest of the rift valleys is that which extends from the Jordan valley through the Red Sea, and along the line of the East African lakes (see fig. 89, p. 194). Spencer Gulf, in Australia, and the Pre-Thian-Shan valley, in Central Asia (see Plate XIX), are also rift valleys.

Where a great river valley reaches the shore the sea extends inland as an estuary, bay, or gulf. These arms of the sea occupy "drowned valleys". Valleys which pass gradually into the sea with a long, steady slope are known as "rias" (fig. 38, p. 53); their tributaries and shores are usually sinuous, and the land near their mouths often projects into the sea in irregular promontories. Narrow deep valleys, whose course is generally straight, with branches going off at sharp, regular angles, and which often consist of a deep basin separated from the sea by a ridge at the mouth, are known as "fiords". Fiords occur in the fractured borders of old plateaus (fig. 37, p. 52).

CHAPTER V

THE EARTH FORMS BENEATH THE SEA

Land forms can be recognized not only on the land, but beneath the surface of the sea. A chart of one of the oceans shows that it consists of great level plains covered by ooze; and above these plains rise high peaks, ranges, and chains. Between the elevations there are valleys, and those on the shallower portions of the sea may represent the continuation of river-cut, continental valleys. Others have been formed as submarine rift-valleys, such as those of the West Indies; while the broader, deeper depressions, known as "deeps", correspond to the enclosed basins in the interior of the continents.

Some of the submarine valleys upon the margins of the continents, opposite great rivers, have probably been formed, not by denudation, but by deposition; material brought down to the sea by the river accumulates on either side of a channel, where the current prevents the deposition of sediment. Such, for example, is the probable origin of the submarine canyon off the mouth of the Congo (see p. 56).

The submarine land-forms include representatives of both the positive and negative classes. The following classification and names have been proposed for the submarine forms by a committee of the International Geographical Congress (*Geographical Journal*, vol. xxii, 1903, pp. 191–194).

The major forms are the shelf, the depression, and the elevation.

The "shelf" occurs along the land's edge from the tide lines to the depth of from 300 to 600 ft.; it generally ends there in a steep slope down into the deep oceanic depression.

"Depressions" are hollows enclosed on all sides by elevations of the sea-bed; they are divided according to their shape into—

(*a*) Basins, those which are approximately round, such as the basin of the Black Sea.

(*b*) Troughs, those which are both wide and long, such as the Atlantic trough; extensions of troughs into the land form "embayments", such as the Gulf of Carpentaria.

(*c*) Trenches, those which are long and narrow; their extensions into the land form "gulleys".

(*d*) The "deep", the deepest part of a depression.

The "elevations" above the sea-floor occur either as mountains rising from the oceanic plains, or as projections from the continents. The different kinds of elevation are—

(*a*) The "rise", which is comparatively low and has gradual slopes.

(*b*) The "ridge", which is long and narrow.

(*c*) The "plateau", of which the length and breadth are about equal.

(*d*) The "height", the summit of any rise, ridge, or plateau which does not rise above the sea surface.

The minor forms include both elevations and depressions. Elevations are represented by "ridges", and by single isolated peaks, including "domes", the summit of which is more than 600 ft. below the sea surface; "banks", which are from 35 to 600 ft. deep; "shoals" and "reefs", which are less than 35 ft. deep.

The depressions include the "caldron", a small basin-shaped hollow, and the "furrow", a valley-like hollow in a continental border.

Part II

Earth Forms and How They are Made

CHAPTER VI

THE MAKING OF THE LAND FORMS

The topography of the world, by which is meant the description and arrangement of land and water, depends on the distribution of the land forms. This distribution is the result of many forces; earth movements cause the uplift or subsidence of blocks of the earth's crust; volcanic action piles up domes of volcanic rocks or spreads out wide sheets of lava; and the earth is sculptured into strange forms by the destruction of the rocks on its surface and the deposition elsewhere of the material thus obtained.

Earth Movements. — The greatest features in the earth's topography are due to earth movements. The chief of these movements are subsidences caused by the contraction of the globe. As the interior shrinks the surface is left unsupported and sags down, forming wide basins. That the earth is slowly shrinking is shown by the folding of the crust by lateral pressure. The rocks on the earth's surface are hard and rigid, and if forced into a smaller area they are buckled into folds, just as the tough skin of an apple becomes wrinkled, when the size of the apple is diminished by the shrinking of the pulp. The crumpling of the rocks produces fold-mountains, which are distributed as long bands of crumpled rocks along weak lines in the earth's crust; they avoid areas composed of solid rock masses, which are strong enough to withstand the crumpling. The fold bands are pressed against these resistant blocks, and pass round them in long curves, as in the crescentic course of the Carpathians.

Earth Statics.—Except in the crumpling of fold-mountains, the uplifting of the earth's surface is less important than its sinking. An uplift sometimes results from an earthquake, as in New Zealand, where the earthquake of January, 1855, caused a nine-foot uplift of the shore of Cook Strait, to the east of Wellington. A more extensive but very gradual rising is now in progress in the northern part of the region of the Great Lakes of North America, and many of the great lake basins of the world have probably been formed by the tilting of wide tracts of country. These regional uplifts appear to be possible owing to the delicate equilibrium of the earth's surface; for the whole crust of the earth is continually trembling under various strains, so that a slight change will lead to a lowering or elevation of surface. The incoming of the tide adds the extra weight of a large volume of water upon the shore, and it is believed that the pressure of this water causes the western coast of Ireland to sink about 3 in. every high tide, the ground rising again when the tide recedes and the load is removed. One inch of rain falling upon a square mile of country places upon it a weight of 60,000 tons of water; and, according to Professor Milne, a heavy storm of rain on the western side of Japan causes the ground to sink; but it rises again as the water runs off, or is removed by evaporation.

There is much geological evidence to show that the earth's surface may sink when an extra load of material is placed upon it. Thus, when a river lays a sheet of mud over the sea-floor the ground may sink, so that it is ready for another layer of material to be deposited at exactly the same level. The next flood drops its load of sediment, which may cause the sea-floor to sink again. The great thickness of delta deposits is explained by the rate of subsidence being exactly equal to that of deposition. Again, rock masses are known which are

4000 ft. in thickness, although the whole has been laid down as shallow shore deposits within a few feet of sea-level. The accumulation of sediment has kept pace exactly with the sinking of the shore; and this coincidence is so common that it is probably the weight of the sediment which is the cause of the sinking. On the other hand, a country may be uplifted if lightened by the removal of some of its rocks; thus its level may be kept almost constant, in spite of the gradual removal of its material by rivers.

These facts suggest that the different blocks of the earth's crust are in isostatic equilibrium; the height of the earth's surface at any locality is dependent upon its weight. If the block of the earth's crust at that locality be lightened, it will rise; if an extra load be placed on it, it will sink, until equilibrium with the adjacent earth-blocks be restored. This isostasy is well illustrated by mountain chains; for some mountain regions have been proved to consist of lighter material than that in the lower ground around them.

The irregularities in the weight of blocks of the earth's crust may be illustrated by reference to India. The accurate survey of a country requires the precise determination of vertical and horizontal planes, and they are generally obtained by the action of gravity upon a plumb-line or spirit level. It was suggested during the survey of India that implicit faith could not be placed in the reference lines thus determined, as the plumb-line would not take up a precisely vertical position, but would be pulled a little aside by the attraction of the Himalaya. On careful investigation it was found that the plumb-line, as predicted, did hang a little aslant; but it was not deflected as much as was expected. The attraction of the great mass of material in the mountains to the north of India was counterbalanced by a diminished attraction from the ground beneath those mountains. The observations made by Basevi with a pendulum show that the earth's crust throughout India has a general deficiency of material as compared with the conditions in Europe, and

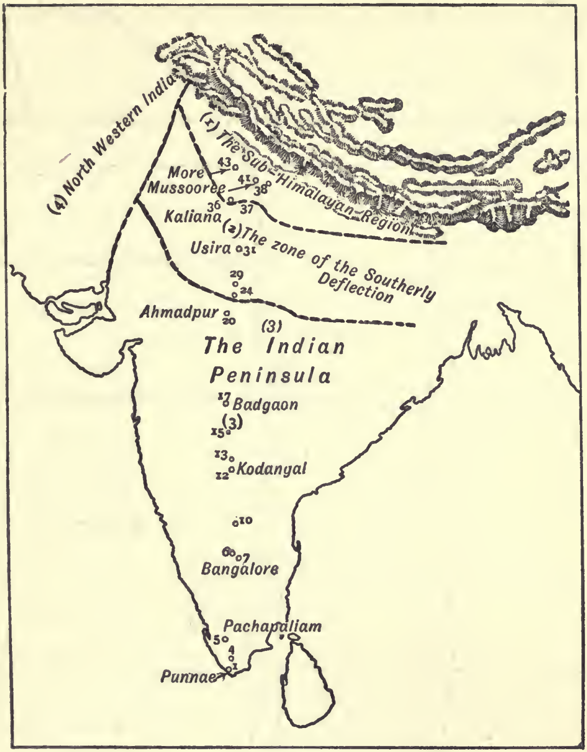


Fig. 30

Figs. 30 and 31.—Map and Sections across India (after Col. Burrard), showing the approximate static equilibrium of the crust. The map shows the existence of a zone in which the plumb-line is deflected southward by the greater density of Southern India as compared with the Himalaya. Section *a*, in fig. 31, shows the contour of the surface as determined by levelling. Section *b* shows the surface as deduced from pendulum observations, with the great deficiency of matter beneath the Himalaya, which compensates for their great height. Section *c* shows the weight of the crust, which varies within narrow limits, and at the highest station is no more than in stations in the lower country of Southern India.

the vast pile of matter in the Himalaya is compensated for by a deficiency of material below the mountains; and this deficiency occurs not only under the Himalaya, but under the plains for some distance to the south. These facts have been confirmed by observations on the deflection of the

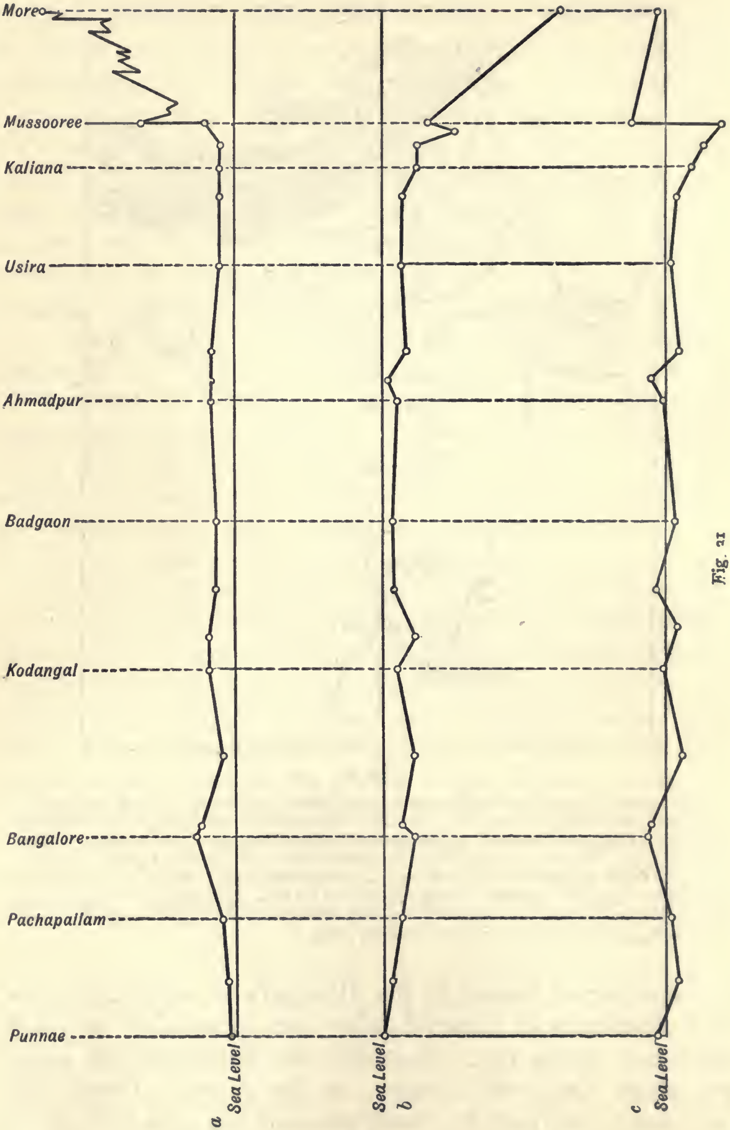

More
Mussooree
Kaliana
Usira
Ahmadpur
Badgaon
Kodangal
Bangalore
Pachapallam
Punnae
Sea Level
a
Sea Level
b
Sea Level
c

Fig. 21

plumb-line made by Colonel Burrard. His work shows that India may be divided into three areas, according to the weight of the earth-blocks of which they are built. In the southern or peninsular part of India the plumb-line takes up a vertical position. To the north of the peninsula is a wide zone occupying half a million square miles, in which the plumb-line is drawn to the south, as the attraction by the materials forming the earth's crust is greater to the south than to the north. But the country to the south consists of low plateaus, whereas to the north are the lofty Himalaya and the high plateau land of Thibet. An observer trusting to the indication of the plumb-line in this zone of southerly attraction would infer that the highest mountains were to the south of him, instead of their being to the north.

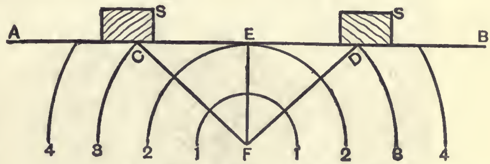


Fig. 32.—Diagram of Earthquake

A B, Surface of earth. F, Focus. E, Epicentre. 1–4, Successive positions of earthquake wave. S, S, Cracked walls; the cracks being at right angles to C F and D F give some indication of the depth of the focus.

The inference would be wrong, as the deflection is due to the material below Southern India being much denser than that of the Himalayan region. This difference in weight is in the crust of the earth and not deep within the interior, for the plumb-line generally confirms the results given by the pendulum; and if the difference in density of the earth's materials, which causes the effect, were deep-seated, it would have less effect upon the plumb-line than upon the pendulum.

Earthquakes are tremblings of the earth's surface due to movements and fractures in the crust; earth movements shake the rocks, and the vibration travels outward as an earthquake shock. Earthquakes happen therefore along the chief lines of earth movements. Volcanoes often occur in the same areas, but they are not necessarily connected with earthquakes; the most disastrous earthquakes happen along the great fracture lines and are often far from volcanic regions.

Volcanoes are vents by which material from the interior of the earth escapes to the surface. The molten rocks may overflow the surface as sheets of lava, or the explosions of the steam, which comes up with the lava, may blow it into fragments, that fall around the vent in piles of volcanic tuff and dust. A volcano is not therefore essentially a mountain. It is a hole in the ground or a vent. The heap of material around the vent is a product of the volcano, and not the

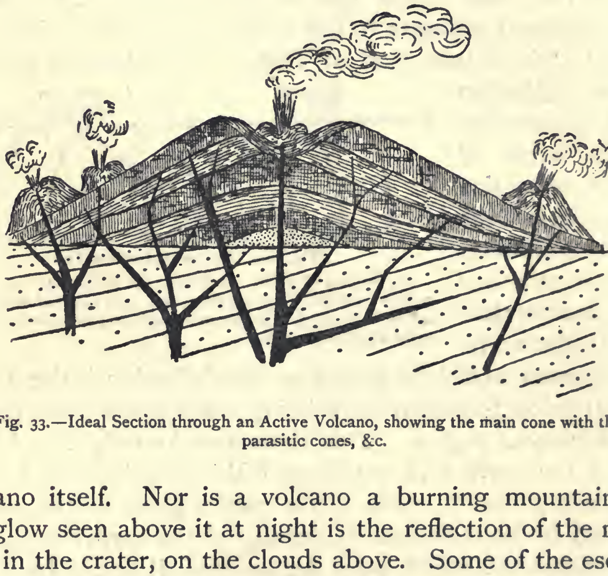


Fig. 33.—Ideal Section through an Active Volcano, showing the main cone with three parasitic cones, &c.

volcano itself. Nor is a volcano a burning mountain; the red glow seen above it at night is the reflection of the molten lava in the crater, on the clouds above. Some of the escaping gases may burn, but any such combustion is quite insignificant. The column above a volcano, often described as smoke, is really a cloud of steam darkened with volcanic dust.[1]

Volcanoes occur in groups or lines upon the chief earth fractures; they are therefore mostly found near coast-lines. But volcanoes also occur in the interior of continents, where

[1] The belief was widely held a century ago that volcanoes were due to the combustion of beds of coal beneath rocks that were easily melted; the use of such terms as smoke, cinder, and fire, in connection with volcanic phenomena, is a survival from the obsolete theory that volcanoes were burning mountains.

PLATE V

Photo. G. Brogi.

MOUNT ETNA: THE GREATEST VOLCANO IN EUROPE

The foreground is a plain with scattered masses of lava; in the distance is the tuff cone which surrounds the crater (page 46)

they are traversed by recent fractures, as along the Great Rift Valley in Africa, and in the series of extinct volcanoes that extend across Europe, concentric with the Alps, through Central France, Southern Germany, and Austria. (See map, fig. 78, p. 142.)

DENUDATION

The sculpturing of the earth's surface is due to the wearing away of the land by various agents; and the materials thus obtained are deposited elsewhere. The wearing away of the land is known as denudation, and it is mainly the work of the sea, of rivers, of the wind, and of ice.

The sea attacks the coasts; its waves batter the cliffs and undercut them, so that masses of rock fall down on to the beach, forming boulders and shingle, which are flung back with destructive force against the cliff in stormy weather. The coast is thus gradually cut back by the waves, and leaves a shore platform between the tide lines.

The action of rivers in carving out the earth's surface is more powerful and wide-spread than that of the sea. A river current carries along sand, which gradually files away the rocks on the bed of the river. This process is known as *corrosion*, and deep gorges or canyons are formed by its aid. These deep gorges are then widened by the cutting away of the sides of the river; this process is known as *erosion*. Lastly, the banks are rounded off by the action of wind and rain.

The wind is the great agent of denudation in arid regions. It sweeps along hard grains of sand, which wear away the rocks exposed to them, like a natural sand-blast. Bare rock surfaces in deserts are often polished, as well as characteristically sculptured, by wind erosion. The wind may pile up the loose material in dunes or sand-hills, or sweep it into the hollows, which are thus gradually filled up.

Sea-ice acts as a powerful agent of denudation upon Arctic and Antarctic shores. Sheets of ice, known as ice-floes, are formed by the freezing of the sea surface during the winter;

these are driven by the wind against the land, where they churn up the shore material, override the rocks along the shore, and, pressing against the base of the cliffs, tend to wear them away. Ice also denudes in the form of glaciers; these are rivers of ice, made from compressed snow, and they flow down the side of snow-covered mountains, discharging the surplus snowfall from the mountain summits. The ice in a glacier becomes charged with fragments of rock and sand, so that its base acts like a great file on the rocks over which it flows. Glacial abrasion easily removes soils and rocks that are soft through decay, and it readily wears away any hard projections on a rock surface; hence a country which has been crossed by a glacier shows numerous bare, hard, scratched, and rounded surfaces that give plain proof of its majestic passage.

Glaciers are now restricted to mountain districts except in the Arctic and Antarctic regions, where they are also found moving over lowland country. But at various periods in the earth's history glaciers have covered low levels in the temperate regions. Traces of the former existence of ice may be found over most parts of the British Isles, north of the Thames and the Severn.

DEPOSITION

The rock material obtained by denudation is carried down the continental slopes by rivers or glaciers, and is then spread over the lowlands or the sea-floor. Where the rivers escape from the mountains to the plains, they flow more slowly, and are no longer able to carry the coarse material collected by torrential mountain streams; the river therefore drops most of its sediment in a fan of debris spread out over the open level country near the mouth of the gorge. The fans increase in size, and those formed by adjacent rivers may unite, and thus they gradually form wide plains, such as the Canterbury Plains of New Zealand. Where the mountains pass gradually

PLATE VI

THE FRANZ JOSEF GLACIER, ON THE WEST COAST OF NEW ZEALAND
The rocks to the left of the glacier have been smoothed by the passage of ice across them (page 48)

into the lowlands, there is no such sudden fall in the velocity of the river currents; the river-borne material is deposited more gradually, and most of it falls in the bed of the stream, which is gradually raised till the river is forced to find a new channel on lower ground; hence the rivers, if uncontrolled by man, tend constantly to change their course and spread their material over a wide tract of country and produce riverine plains.

Fig. 34.—Boulder-clay containing many boulders, and overlying an ice-scratched or striated rock

Material transported by glaciers is deposited in lines of rough hills, where the ice melts away at the end of the glacier. Such hills are known as "terminal moraines". They mark the greatest extension of the glacier. Behind the moraine the country is often covered with sheets of sand and clay, containing many ice-scratched boulders or large stones. These deposits are found in those parts of the British lowlands that were once covered with ice, while the glacial deposits of the mountains include many well-preserved moraines; and beyond the moraines the floods formed by the melting of the ice deposited wide sheets of sand and gravel on the margins of the ice-covered areas.

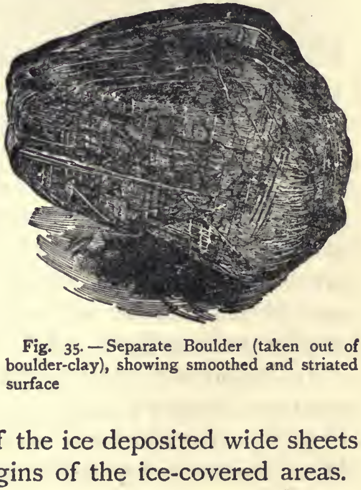


Fig. 35.—Separate Boulder (taken out of boulder-clay), showing smoothed and striated surface

CHAPTER VII

COASTS

An examination of the map of the world at first gives an impression that there are an infinite variety of coastal types. They vary from long, straight, open shores, such as that of West Africa, to deeply indented coasts like that of Norway, where the narrow branching fiords are fringed by such complex peninsulas and islands that it is impossible from the sea to distinguish between the mainland and the islands.

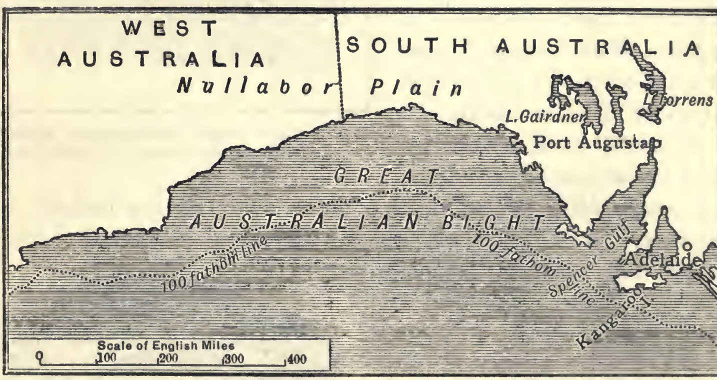


Fig. 36.—The Great Australian Bight

The more conspicuous indentations on coast-lines may be divided into three main groups—those in which the indentations are wide, and extend for a comparatively short distance inland; those in which the indentations are narrow, and extend far inland; and complex coasts, which have many narrow gulfs or fiords, and are guarded by numerous islands.

I. The most typical of the wide, short coastal indentations are those known as bights, such as the Great Australian Bight (fig. 36), or the Bight of Benin and the Bight of Biafra on the West African coast; and broad open bays, such as the Bay of

Biscay in western Europe. These broad bays are frequently formed by the subsidence of land which formerly extended seaward across their site; thus the Great Australian Bight has probably been formed by the sinking of a former southern continuation of the plateau of southern Australia. The Bay of Biscay occupies a depression left by the subsidence of the land between the Armorican Mountains of Brittany and the Cantabrian Mountains along the northern coast of Spain.

II. Narrow indentations into the land are known as bays, gulfs, fiords, lochs, firths, rias, sounds, &c. The meaning of these terms varies locally, and no precise universal definition can be applied to them. But, speaking generally, a bay is a wide indentation, and is usually comparatively small, such as Cardigan Bay or Dublin Bay; but the term is sometimes applied to seas, such as the Bay of Biscay and the Bay of Bengal, or to Hudson Bay, which is a partially enclosed sea. The term gulf, on the other hand, is generally applied to a long, narrow indentation, such as the Gulf of Salonica or the Gulf of California; but the term is also applied to widely open indentations into the land, such as the Gulf of Genoa; while some long narrow arms of the sea are called bays, such as the Bay of Fundy.

Many of the Scottish firths, such as the Firth of Forth and Firth of Tay, are typical gulfs, and so are some of the British sounds, such as Plymouth Sound; also Picton Sound in New Zealand. The term fiord, in which must be included many of the Scottish lochs, is given to narrow gulfs of a special character. They are long, narrow indentations which frequently branch. The branches may reunite, and cut off parts of the land between them as islands; when the upper part of a fiord has been silted up, and thus turned into a land valley, the adjacent islands are converted into hilly peninsulas joined to the mainland by a low alluvial plain. The branches from fiords, moreover, tend to part from the main fiord at remarkably regular angles, which are dependent upon the geological structure of the country. In most cases (according to a current terminology in all typical cases) the fiords are deeper inland, and become shallower at their mouth (fig. 37). Fiords, therefore, consist of a deep basin separated from the sea by a shallow ridge, by a bar, or even by a narrow band of land, which converts the upper basin into a lake. This restriction of the term fiord is due to the illustrious German geographer,

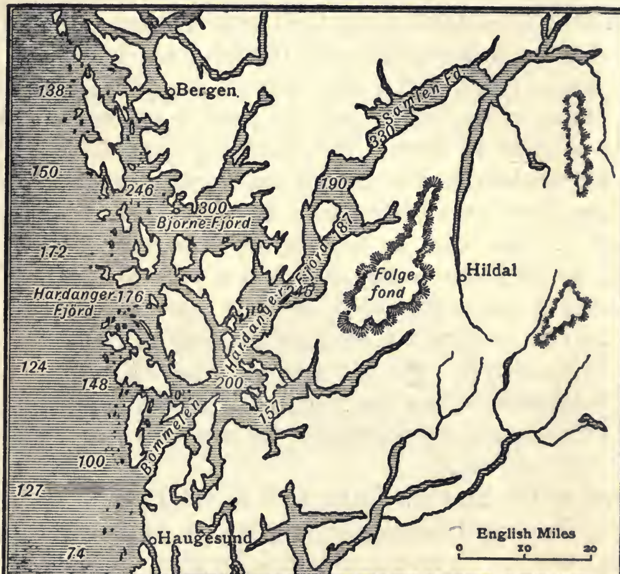


Fig. 37.—The Hardanger Fiord, Norway (depths in fathoms)

Baron von Richthofen. In most groups of fiords some of them may be freely open to the sea, and therefore the definition cannot be accepted absolutely; but it expresses such a general truth that it has been widely adopted.

A ria, on the other hand, is a gulf-shaped indentation which deepens steadily from its head and opens freely to the sea. A ria is generally bounded by irregular ridges, which project into it from the sides. The typical rias are those of the north-western corner of Spain, as the Ria de Vigo, Ria de Muros (fig. 38), Ria Arosa, and Ria Pontevedra. The group of bays on the south-western coast of Ireland, including Bantry Bay, Dingle Bay, and Kenmare River, are also typical rias. Rias are formed by the submergence of land valleys that have been flooded by the sea. The origin of a fiord, on the other hand, is more complex. Their peculiar characters have been gene-

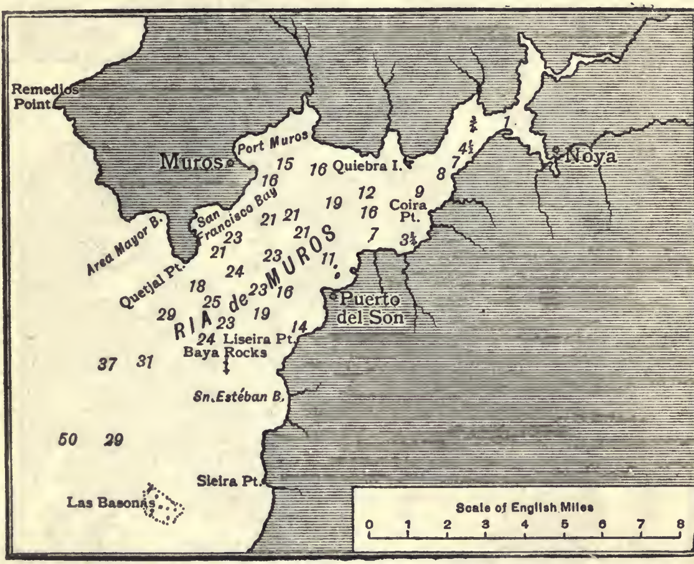


Fig. 38.—Chart of the Ria de Muros on the North-western Coast of Spain (depths in fathoms)

rally attributed to the excavation of their basins by land ice. But they always occur in fractured table-lands; and though the ice has no doubt in most cases enlarged them and given them their characteristic aspect, the fiords themselves are always older than the ice which occupied them and polished the rocks upon their shores.

III. Complex coasts are due to the submergence of an old or fractured land beneath the sea. When an old land, which has been worn into hills and valleys by rivers, is partially submerged, the sea floods the valleys and extends inland in bays and gulfs. Drowned coasts are marked by many, narrow, irregular peninsulas, which from their shapes are often compared to spider legs; they represent the crests of

Fig. 39.—Map showing the Geographical Changes that would be produced in South-western Scotland if drowned to the height of 500 feet

ridges that once separated the tributary valleys. The islands in Loch Lomond illustrate those formed by the ridges beside a submerged valley.

If Wales were flooded by the sea to the height of 500 ft. above the present sea-level, the resultant coast-line would be deeply indented and have many peninsulas and islands similar to the most complex of existing coast-lines. The estuary of the Clyde has a very irregular shore-line; and if the sea-level in it were raised another 500 ft., the coast-line would still be complex, and would repeat many of the existing irregularities of its shores. Comparison of the conditions that would then prevail with those of the present day would alone suggest, that the existing geography of the Firth of Clyde is due to the submergence of a former land valley.

Fig. 40.—Map of the District around Auckland in the North Island of New Zealand, showing its Drowned Valleys or Rias

Auckland Harbour, one of the most beautiful harbours in New Zealand, owes its numerous bays and sinuous peninsulas to the fact that it is a drowned valley. It is a variety of ria (fig. 40).

If a continental coast-line is fractured and partly submerged, a complex coast is formed, with angular parallel branches and deep, irregular basins.

Besides the bights, bays, and fiords, there are still greater indentations of the ocean, which form the various types of inland seas. They may be divided, according to the classification of Sir John Murray, into—

1. Inland seas—those which are at present entirely cut off

from the ocean; thus the Caspian is now quite isolated, though the seals which live in it indicate its former connection with the northern sea across the low lands of Western Siberia or Russia.

2. Enclosed seas—those with only one entrance to the ocean, such as the Mediterranean.

3. Partially enclosed seas—those which are connected with the ocean by numerous channels, such as the Caribbean Sea, which is marked off from the Atlantic by the chain of islands of the Caribbees.

4. Barred-off seas—those separated from the main ocean by a submerged ridge, *e.g.* the Norwegian Sea, which is separated from the Atlantic by the ridge that rises to the surface at the Faroe Islands.

Coastal features do not end at the present shore-line. The continuation of the continental structures may be recognized some distance out to sea. Thus, many great land valleys are prolonged seaward as depressions forming submarine valleys and canyons. This fact is at first somewhat surprising, as we should expect the sediment brought down by rivers to be deposited opposite their mouths; and many rivers have bars and shoals opposite their mouths, and others have deltas and alluvial plains. Nevertheless, the valley of the Hudson River, which discharges into the sea at New York, is continued out to sea by a deep submarine valley (fig. 41). Another well-known example is the submarine canyon off the mouth of the Congo. These valleys have been explained as old land valleys cut out by rivers and now drowned beneath the sea. According to this theory, the valleys date from a time when the land extended farther out to sea, and these now submarine valleys were once land valleys. There are many difficulties in this explanation, which is often inconsistent with the history of the adjacent land. According to Dr. J. Y. Buchanan the great submerged canyon of the Congo is probably not a channel of erosion, but of deposition—material

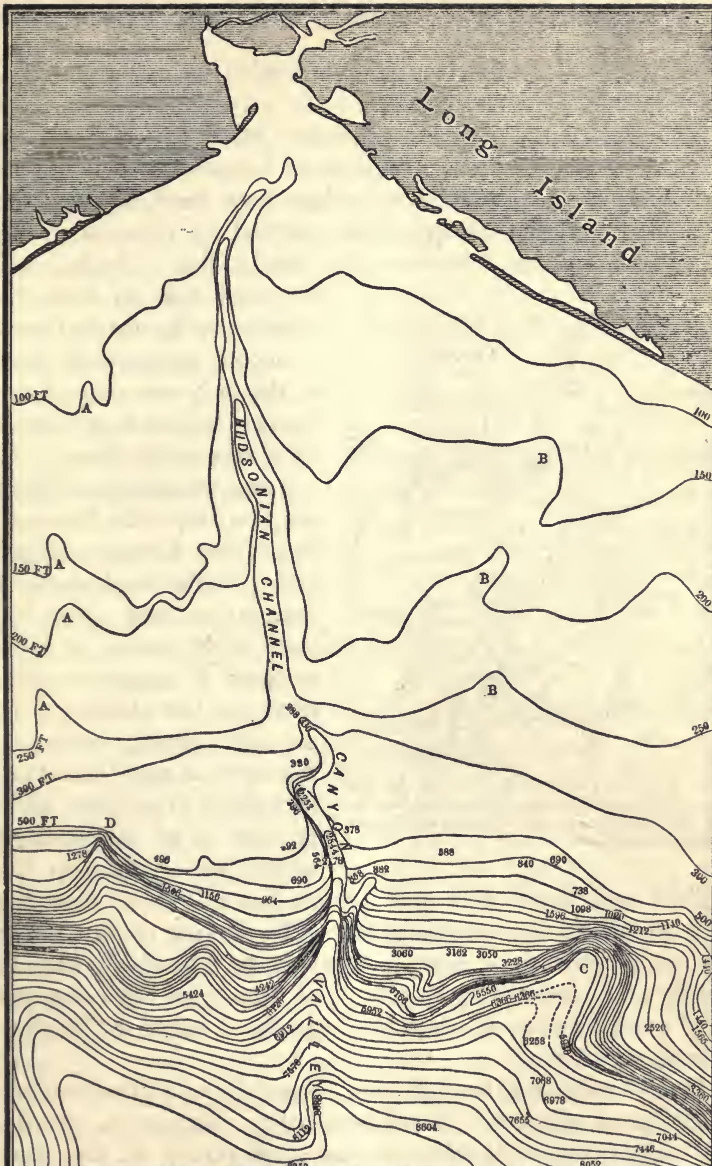


Fig. 41.—The Drowned Canyon in continuation of the Hudson River, near New York (After J. W. Spencer)

Scale, 15 miles to one inch

brought down by the river has been piled up on either side, leaving a deep central channel.

The continental structures are also continued seaward by promontories, peninsulas, and lines of islands which represent the summits of old mountain ridges now sunk beneath the sea. Such islands are gradually reduced by denudation till there remains only a low reef like the St. Paul's Rocks; and the reef will in time be worn away by the surf until a deeply submerged bank is the only remnant of the former seaward extension of a mountain chain.

Fig. 42.—San Francisco Bay, formed by the drowning of part of the Great Valley of California. The bay communicates with the ocean only by the narrow Golden Gate.

Long, straight coast-lines may be due to the foundering of the former continuation of the land along a straight fracture. The further development of such a coast is mainly dependent on the climate. In an arid country, owing to the lack of rain, there are no valleys of erosion; wind is the chief distributing agent, and it fills up the valleys and basins and wears down the ridges, so that the land acquires a low regular relief. The drifting of sand along the shore forms long lines of sand-dunes, which will help to smother any local irregularities, and thus give the coast the long curved sweep of what, in Australia, is called a "Ninety-Mile Beach".

In a wet climate the rivers are powerful and will cut valleys in the land, and carry the material thus obtained to the sea and deposit it as deltas, beaches, and shoals in the quiet waters of bays, while the tide and currents will spread out such material evenly along the coast. Thus, irregularities in the shore-line are removed by the deposition of sediment in the quiet water of bays, and the wearing back of any headlands by the full force of the surf.

Long, straight coast-lines may also be formed, where mountain ranges run parallel to the shore. The seaward slope of the mountains may end in a line of bluffs and cliffs. Rivers that have cut their valleys across mountains close to the sea usually have narrow outlets between high rocky headlands; but the narrow entrance often leads into a magnificent harbour in the valleys behind the coastal range. San Francisco harbour is a good representative of this type of harbour, for it occupies a part of the Great Valley of California that has been joined to the Pacific by the Golden Gate (fig. 42).

The distribution of the different coastal structures divides the coasts of the world into two main types. They were first recognized and described by Professor Suess of Vienna, who called them the Atlantic and the Pacific types. The Atlantic Ocean occupies a long channel fairly regular in width and curved like the letter **S**. Its islands are small and irregularly scattered; they are worn down volcanoes, such as Ascension; small archipelagoes of volcanic rocks piled upon limestone plateaus, such as the Azores and the Canaries; mere reefs, such as the St. Paul's Rocks; or stacks, such as the smaller Trinidad. The islands of the Atlantic are irregularly arranged, with the exception of those on the Faroes Ridge, which forms the northern boundary of the Atlantic, and the islands of the West Indies. The sinuous shape of the Atlantic, moreover, has no relation to the mountains or the geographical grain of the adjacent lands. Thus, it cuts abruptly across the old mountain line which runs across southern Ireland, southern England, and northern France, and also across the Cantabrian Mountains, which reach the Atlantic at the north-western corner of Spain; there can be little doubt that both these mountain lines once continued into the present site of the Atlantic. On the coast of North America the Atlantic cuts with equal abruptness across the remains of mountain lines in Nova Scotia and Newfoundland which must once have extended eastward into the present ocean; they probably represent the former continuation in America of the ancient mountain chains of Europe.

Similarly there are striking resemblances in structure between equatorial Africa and Brazil; the intermediate basin of the Atlantic has probably been formed by the foundering of the plateau land, which once connected South America and Africa.

The Atlantic coasts are accordingly much varied in structure. They follow in places the broken edges of old plateaus, which have comparatively regular coast-lines. Elsewhere the Atlantic is bounded by a fractured table-land, deeply intersected by fiords, as in the Highlands of Scotland and in Norway. In other places, as in Brittany and the south-west of Ireland, old mountain ridges run out to sea between rias formed by the flooding of land valleys. Along the south-western coast of France there are long even dunes that smother any irregularities under silt and sand.

The Pacific Ocean differs essentially from the Atlantic. It has a comparatively simple triquetral figure, *i.e.* a triangle with concave sides. Its islands are placed in linear series, and often in festoons draping the shores. Between the island festoons are partially-enclosed and barred-off seas. In the Central Pacific the islands lie in long regular chains.

The mountains that border the Pacific follow the course of the coasts. Thus all down the American coast of the Pacific, except in Central America, the mountain lines run parallel to the shore, as in the Cascade Range of British North America, the Sierra Nevada of the United States, and the Andes of South America. In Asia, the great central table-land sinks in successive steps to the Pacific shore (fig. 83, p. 172); and eastern Australia shows the same structure. In both cases the fold-mountain chains, that once

THE WORLD
showing the distribution of the Atlantic and Pacific Coastal Types

formed the continental edge, have been broken through, and their fragments, the island festoons of China and Australia, are separated from the continent by partially-enclosed seas. The eastern coasts of Asia and Australia may therefore be described as of a secondary Pacific type.

Another difference between the Pacific and the Atlantic naturally follows from the concentric arrangement of the Pacific mountains. The geographical grain of Asia or Australia is not continued across the Pacific Ocean into America; whereas the opposite coasts of the Atlantic often resemble one another in structure, because they are parts of a once-connected land area.

The Atlantic owes its coastal type to a succession of subsidences breaking irregularly across the grain of the adjacent continents. The Pacific has a simpler history, being surrounded by mountain lines formed by folds at the time of the subsidence of the Pacific floor. The Indian Ocean is mainly of the Atlantic type; for the eastern coast of Africa and the coasts of western and southern Australia have been formed by subsidences breaking across the grain of the continents, as in the case of the Atlantic. The coasts of Burmah and Siam and the main island chain of Malaysia are formed on the Pacific type, and so also are the coasts of Baluchistan and the Persian Gulf. The Pacific coast of Central America is on the Atlantic type, as it cuts across the mountain lines; for the geographical grain of Central America runs from east to west, and the former Pacific coast-line must lie some distance to the west, where it is buried beneath the Pacific. The coast of Antarctica appears to be formed on the Atlantic type to the south of the Southern Ocean as far as Wilkes Land; and to be on the Pacific type to the south of the Pacific from Victoria Land eastward to Graham Land.

CHAPTER VIII

ISLANDS

The islands of the world may be divided into two main types—the continental and the oceanic. The continental islands are formed of the same rocks as those that build up the neighbouring continents, to which they were once joined. Oceanic islands, on the other hand, have been built up at sea by corals or volcanoes, and have never been joined to a continent.

Continental islands are inhabited by animals and plants that reached them over the land; whereas in oceanic islands these have been transported to them over the sea. Hence oceanic islands have a very limited fauna and flora, for the only animals that can reach them are such birds and insects as can fly across a wide range of sea; or occasional animals, such as mice or rats, which may drift there on floating trees; or animals whose eggs or larvæ can be blown by the wind, or carried in mud upon the feet of birds.

Ireland is a continental island, for it is composed of the same rocks as Great Britain and the mainland of Europe, and its animals and plants entered it before its separation from the continent. The islands of the central Pacific are oceanic islands, for they consist of limestone built up by coral animals, or of materials ejected from volcanoes. They contain none of the typical rocks of the continents, such as granites, sandstones, or clays, except rarely, in a deeply-buried foundation; and they are inhabited only by plants and animals that have been carried across the sea, by means of winds, ocean currents, or birds. There are, however, special cases where continental islands have an oceanic fauna, as is the case in New Zealand, in the Fiji and other Pacific islands, as well as in Christmas Island, south of Java. For though many of these remote islands are remnants of former lands, they are now so far from the main continents that they are biologically oceanic.

The continental islands lie mainly along the borders of the continents, and are of three different types. They may be stacks, composed of hard rocks which have resisted the attacks of the waves, and form small islands, such, for example, as the Old Man of Hoy, off the coast of the Orkneys (Plate VIII), or the Bass Rock, a hard block of volcanic rock at the entrance of the Firth of Forth, or Heligoland.

More important are the continental islands, found in archipelagoes, separated from the mainland by fiords, sounds, and straits, like the numerous islands off the coasts of Norway and Scotland. The Arctic Archipelago, to the north of Canada, including Greenland, Grinnell Land, the Parry Islands, Baffin Land, Prince Albert and Victoria Land, and Banks Land, represents a former extension of the mainland of North America, now separated from it by numerous arms of the sea, and these arms, if we may judge from the canal-like form of some of them, have probably been formed along fractures. The British Isles were once part of the mainland of Europe. The Orkney and Shetland and Faroe Islands and Iceland are remnants of a former land that connected Greenland and north-western Europe. The Malay Archipelago consists of the fragments of a former continental land. The Grecian Archipelago, a group of sporadic islands, is the remnant of the land that foundered, and gave place to the Ægean Sea.

A third type of continental islands includes those that occur in festoons along the shores of the Pacific, as is shown in the map of the Pacific (Plate XXXII). The most complete festoons are to be seen along the Australian and Asiatic coasts, but the remains of festoons may still be recognized along the western shores of America.

The linear arrangement of the islands holds in the central Pacific, though it is only the western ends of the island chains that are connected with the land; and, in the Hawaiian chain, the line is now completely isolated in the mid-Pacific. On the western coast of America the festoons are well developed, as in the Aleutian Islands and among the islands along the coast of the Canadian Dominion; but they become more and more incomplete to the south, till, off Peru and northern Chile, only the last trace of the festoons is doubtfully represented by the islands of St. Felix and Juan Fernandez. But farther south, along the western coasts of Patagonia, the islands are developed as archipelagoes along a fiord coast. The islands in the Atlantic are of the oceanic type, are irregularly scattered, and are mostly piles of volcanic rocks that have been raised above sea-level by volcanic eruptions, such as the island of Teneriffe; but others are fragments of the ancient land known as Atlantis, and the St. Paul's Rocks are reefs of ancient continental rocks that once belonged to a land which has foundered beneath the sea. The Azores are a group of volcanoes built upon a foundation of limestones, similar to those of the Mediterranean countries.

Among islands of the oceanic type may be grouped those formed by the accumulation of material discharged during volcanic eruptions, and those built up by the agency of corals. The corals are a class of simple animals closely allied to the sea anemone, from which they differ mainly by the possession of a hard skeleton, consisting of carbonate of lime. This skeleton remains after the death of the coral, and, as the corals often live in great colonies, their skeletons form sheets or reefs of limestone. The coral animals can only live in warm water. They are therefore confined to tropical seas and to shallow waters. The reef-building corals do not live below the depth of about 150 ft., and do not flourish below the depth of about 90 ft., as the deeper water is too cold for them. They live along the shores of tropical lands, where their masses of limestone rise to the surface, forming coral reefs. When these reefs fringe the shore they are called "fringing reefs". When the reefs are separated from the land by wide channels of sea they are called "barrier reefs", and the water between them and the land is a "lagoon". The most important of the barrier reefs rises from a series of shoals off the coast of Queensland, and forms a line of reefs nearly 2000 miles in length. It is known as the Great Barrier Reef of Australia.

A third type of coral islands consists of low circular coral reefs, forming a ring of land around a central lagoon. Such islands are known as atolls. They occur in the tropical Pacific

Fig. 43.—An Atoll, or Ring-shaped Coral Island with Lagoon inside

and Indian Oceans. Their origin was for long a mystery, as they rise abruptly from ocean floors of great depth.

These islands were known to the earlier navigators as Low Islands, to distinguish them from the lofty volcanic islands found in other parts of the Pacific. It was at first thought that the atolls owed their shape to growth upon the rims of submerged volcanic craters; but their great size and irregular shape, and the absence of volcanic rocks from their neighbourhood, discredited this hypothesis.

The explanation of these atolls was discovered by Darwin. According to him, they are due to the upgrowth of coral reefs over islands that have slowly sunk beneath the sea. As the island sank, the fringing reefs on the shore were built upward,

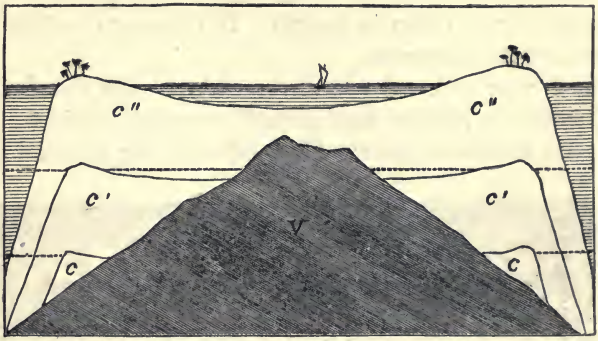


Fig. 44.—Diagram to illustrate Darwin's Theory of Coral Islands

V, originally a volcanic island; *c*, the commencement of a coral reef extending to the sea-level, and forming a *fringing reef*. As V sinks, the corals extend the reef as *c'*, which becomes an *encircling reef* round the islet. V at length disappears, the reef rises as *c''*, and forms an *atoll*.

so that the living part of the reef was kept near the sea surface; the reefs were gradually separated from the diminishing

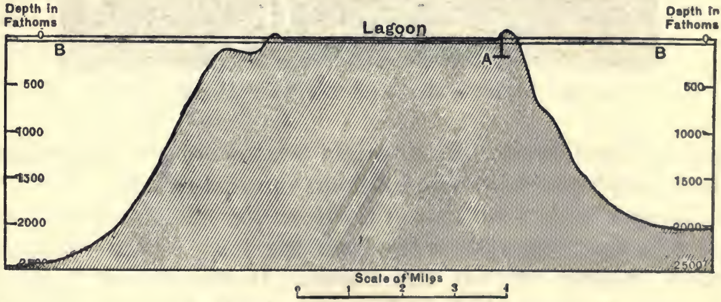


Fig. 45.—Section across the Atoll of Funafuti

Outline from a survey by Captain Field, 1897. Scale, vertical, 1 inch = 2000 fathoms. A, Coral reef proved by bore-hole; B, Maximum depth of life of reef-building corals (30 fathoms). Their usual limit in depth is about 15 fathoms.

land by a channel, and formed barrier reefs, with land in the centre of the lagoon. The island still sank, until in time it disappeared beneath the sea, and the only sign of its former presence was the ring of coral rock, which continued its upward growth. These atolls are, to use the phrase of the late Duke of Argyll, "garlands laid by the hand of Nature on the tomb of departed islands". This theory has been finally established by a deep boring put down on the atoll of Funafuti, under the auspices of the Royal Society, by Professor David and Mr. George Sweet. This bore showed that coral rock is found in the foundation of the atoll, at the depth of 1000 ft. below the level at which coral animals can live; so these coral reefs must have been formed at the surface of the sea, and sunk to their present depth by the subsidence of the sea-floor (fig. 45).

CHAPTER IX

LAKES AND LAKE BASINS

Fig. 46.—The Lakes at Durness, Sutherland; the southern lake has only a subterranean outlet

Lakes are accumulations of water, either fresh or salt, collected in depressions in the earth's surface; they are fed by rivers, rain that drains down the adjacent slopes, and by the water that rises in springs upon their beds. Lakes may have no outlet to the sea, as in the case of the Caspian or Lake Chad. Then the water is generally salt, for evaporation can only remove the water; the small quantities of salt carried into the lake by the rivers slowly accumulate, as the salt remains behind when the water is carried away by evaporation. Some lakes which have no apparent outlet discharge their surplus waters by percolation through the ground, or by some subterranean river channel, and are thus kept fresh. Thus Loch Borralaidh, near Durness, discharges by an underground passage through porous limestones that underlie it (fig. 46).

Most lakes discharge their surplus water through a comparatively shallow outlet on the rim of their basin; but the basin itself is often so deep that its floor is far below sea-level. The origin of deep lake basins is a problem that has given rise to prolonged and constant discussion.

I. LAKE BASINS DUE TO DEPOSITION

1. River-formed Dams.
2. River-raised Flood-plains.
3. Lakes in River-meanders.
4. Broads.
5. Storm-beach Dams.
6. Landslip Dams.
7. Glacier Dams.

1. *River-formed Dams.*—The simplest and commonest method of lake formation is the erection of a dam across a valley, as in the construction of an artificial reservoir. Such a dam may be formed either by the piling up of a bank of earth across a valley, or by an earth movement tilting the whole country. Most shallow lakes are formed by the deposition of a bank of earth across a valley. The bank may be built by one of several different agents. A tributary stream may deposit a fan of debris on the comparatively level floor of the main valley. The fan is gradually extended across the valley as a huge earth embankment. If the main stream has not sufficient power to keep open its channel, the water will accumulate behind the delta-fan as a lake. An excellent example of such a delta-formed dam is seen in the

Dora Baltea Valley above Aosta, where the fan formed from the Val Savaranche extends like a railway embankment almost completely across the Dora Valley. Such alluvial deltas may divide a lake into two; thus the alluvial plain at Interlaken, built as a delta by the Lauterbrunnen, has cut off Lake Brienz from Lake Thun (fig. 79, p. 146).

2. *River-raised Flood Plains.*—A second method of lake formation by river action results from the tendency of a

Fig. 47.—Lakes formed as Cut-off Meanders, and known as Billabongs, beside the River Murray in Victoria

river to raise its banks in floods, forming a raised flood-plain. Tributary streams, being unable to climb over this raised flood-plain, spread out in shallow lakes along the line of its junction with the main slope of the valley. The tributary may be forced to flow for some distance parallel to the main stream until some geographical accident has prevented the formation of the flood-plain, and the tributary is able to unite with the main river; otherwise the tributary may wander down the valley until its waters are all lost by evaporation. Instances of both cases are met along the Murray River in Australia. Its tributaries the Loddon and the Goulburn have been deflected from their original entrance to the Murray, and flow for some distance parallel to it. The Loddon spreads out into small lakes known as Lake Charm, Lake Mystic, and Reedy Lake; but at length, at Swan Hill, it joins the Murray. The Wimmera River, though once a tributary of the Murray, now spreads out into Lakes Hindmarsh and Albacutya, in which all its waters are lost by evaporation and percolation into the soil.

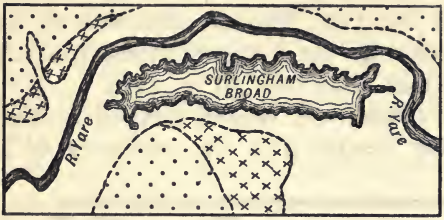


Fig. 48

3. *Lakes in River-meanders.*—A third type of river-formed lakes arises where a river abandons one of its horse-shoe

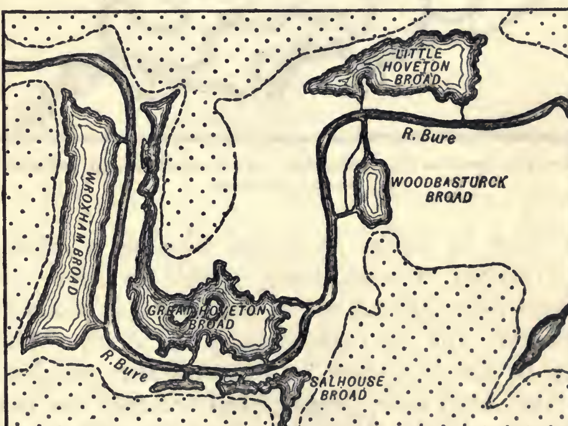


Fig. 49

bends or meanders by cutting a more direct channel across the loop. It leaves a sluggish back-water from the river, which is ultimately separated as a horseshoe-shaped lake. Such lakes border the Mississippi, and are there called ox-bow lakes; in Australia they are known as billabongs (fig. 47).

4. *Broads.*—Broads are lakes in shallow basins left during the filling up of an estuary by silting, or in deltas which are

Fig. 50.—The Silt Jetties and Lakes of the Mississippi Delta

gradually being extended by rivers into the sea. The broads of Norfolk are the remnants of a great estuary that has been partially filled up (figs. 48 and 49). Banks of mud were pushed out like jetties on both sides of the rivers entering into the estuary, and the meeting of two jetties from adjacent rivers enclosed a sheet of water as a broad. A great lagoon may be thus split up into a series of lakes, which, like docks, are connected with the main stream by occasional gaps through

Fig. 51.—Dubh Loch, Inveraray, separated from Loch Shira by a Bay-head Beach

their narrow embankments (fig. 49). The broads are gradually reduced in size by the increase in width of the embankments, till the lakes are completely separated from the river (fig. 48); by their further reduction the lakes are at length filled up, and the former estuary is left as an alluvial plain.

Similar lakes are formed where a river is building a hand-shaped delta, like that of the Mississippi, by pushing out finger-shaped processes farther and farther out to sea (fig. 50). The meeting of two adjacent finger-shaped branches of the delta encloses a sheet of salt water as a lake. Such are the small lakes left in the delta of the Po.

Fig. 52.—The Lagoon of Venice, separated from the Adriatic by a long Storm Beach

5. *Storm-beach Dams.*—A further type of lake basin formed by the accumulation of sediments is due to the piling up of storm beaches, where surf strikes a sloping shore of coarse shingle. A storm may raise a beach several feet above sea-level across the mouth of a bay or a river valley. The water from the land collects behind the barrier and forms a lake or lagoon. Dubh Loch (fig. 51), cut

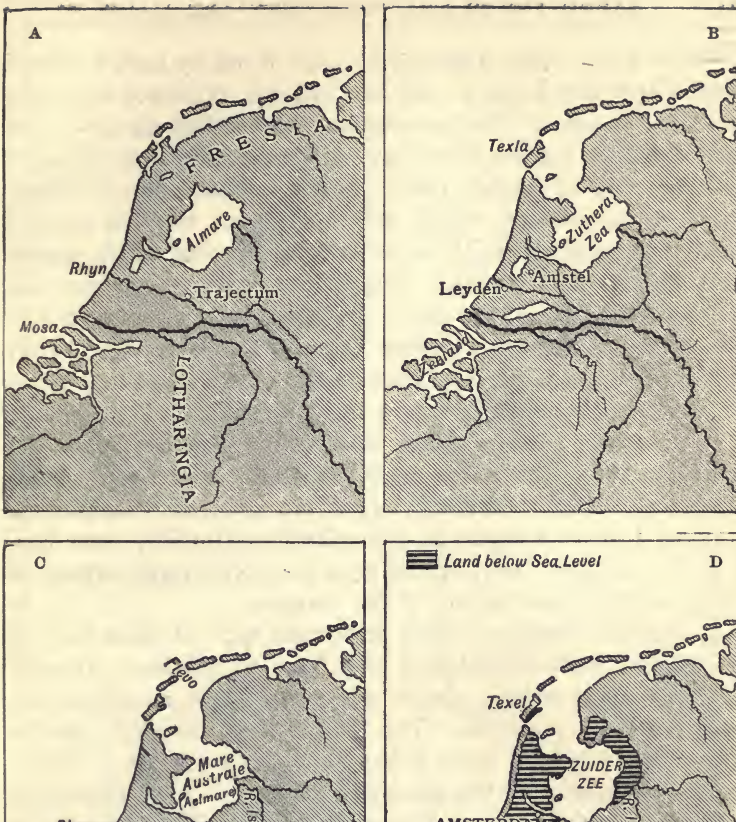


Fig. 53.—A–D, Geographical Changes in Holland

A, The Netherlands in the year 843; B, in the 13th century; C, in the 16th century; D, at the end of the 18th century. The areas shaded in figure D are below sea-level. (Figs. A–C after Spruner.)

[Trajectum and Utrajectum = Utrecht: Losdunen = Loosduinen: Mosa = R. Maas: Zuider Zee means the South Sea, in distinction to the North Sea.]

off from Loch Shira, a branch of Loch Fyne, by such a storm-beach, and the Looe, a lake in Cornwall, illustrate this type of lake formation. An incomplete storm-beach across a wide bay forms a lagoon like that of Venice (fig. 52). Storm-beaches may be further raised by the accumulation of blown sand or sand-dunes, which help to protect the low ground behind them from being inundated by the sea, which stands at a higher level outside. But if in subsequent storms this embankment should be burst through, the sea will reoccupy its old bay. Thus the Zuider Zee was formed by the North Sea bursting through the dunes on the Dutch coast in a series of irruptions between 1170 and 1395 (fig. 53).

6. *Landslip Dams.*—Some mountain tarns are made by landslips that form dams across valleys. The larger lakes made by landslips across valleys are generally temporary, such as Lake d'Alleghe in the valley of Agordo, near Belluno, in northern Italy, or the lake five miles long formed in 1892 in the upper valley of the Ganges.

7. *Glacier Dams.*—A third important type of lakes formed by natural barriers includes lakes due to glaciers. Glacier lakes are made when a glacier advancing down a valley dams back a tributary stream. The best-known European glacier lake is the Marjelen See; it has been formed by the Aletsch Glacier damming up the waters of a stream which discharges into the Aletsch valley. The water in the lake rises until it reaches the level of the depression at the head of its valley, and it then escapes into the adjacent valley of the Viesch River. Much larger glacier lakes occur in Greenland. The surface of the water in such glacial lakes is kept at the height of the lowest col or notch over which the water can discharge. By changes in the level of the lake, as the different cols are blocked by ice, parallel horizontal lake-beaches or shore-lines are formed along the hill-sides. The best-known British examples of such "parallel roads" are in Glen Roy, where three roads run, one at the level of each of the cols, successively uncovered by the melting of the ice that once filled the tributary valleys.

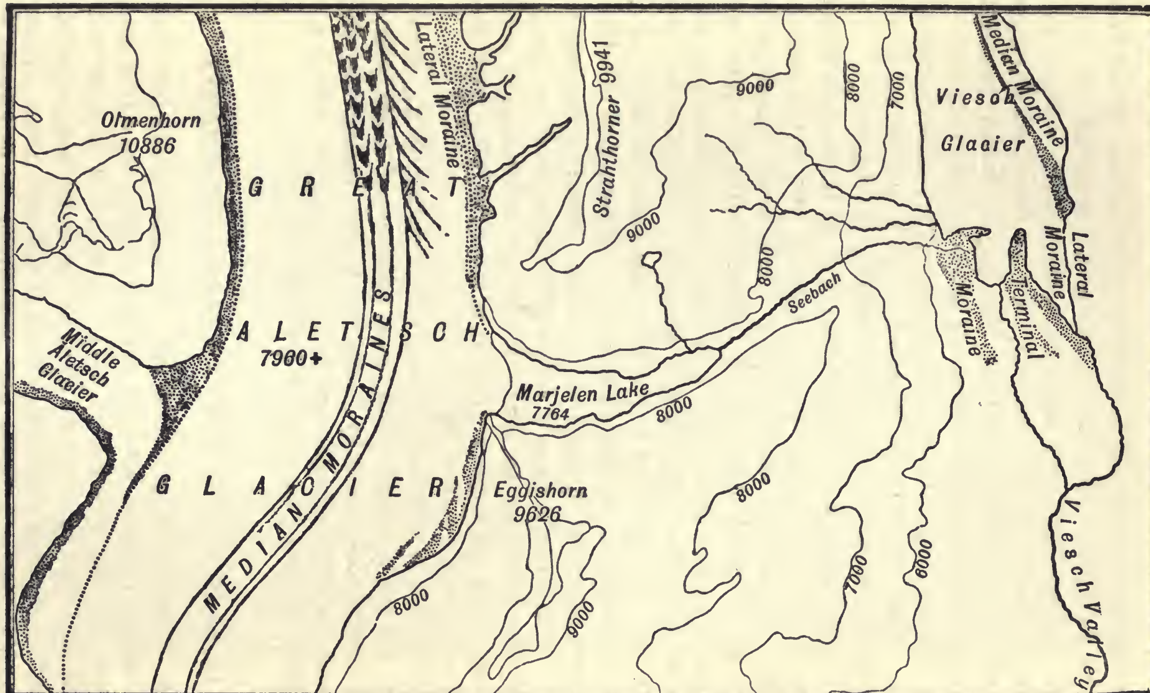


Fig. 54.—Map of the Marjelen Lake when at its greatest size, and with an Outlet through the Seebach to the Viesch Valley

A second type of lake formed by glacier action is one held up by moraines. Glaciers collect great quantities of mud, sand, and boulders, and carry them down their valleys; and when the ice melts, this material may be deposited in ridges known as terminal moraines (fig. 54). These terminal moraines are often high banks of impermeable material; if they stretch right across the valley, lakes collect behind them. Such are moraine lakes, of which examples are found in most countries that have been recently glaciated.

Terminal moraines are especially apt to be formed where a bar of rock rises across a valley near the end of the glacier; for the obstacle will catch material which would otherwise be more widely distributed. Thus a mile from the northern end of Loch Lomond is a bank of moraine matter, stretching out into the loch from both sides of the valley. It looks from the north like a simple bar of moraine, but from the south it is seen to be due to a ridge of rock, the northern face of which has been plastered by moraine material. Moraines commonly occur in such positions, and a lake which appears to be simply a moraine lake may be really due to a moraine-capped rock barrier. The only effect of such a moraine is to raise the level of the lake a few feet.

The material dispersed through an ice-sheet is deposited, when the ice all melts away, in a wide-spread sheet with a very irregular hummocky surface. Water collects in the hollows, as shallow pools and lakes, such as those which are so freely scattered over the North German plain.

II. LAKE BASINS DUE TO EARTH MOVEMENTS

The lakes in this group occupy the second main group of lake basins, those in which a valley has been converted into a basin by the uplifting of its lower end. It is now well established that not only are parts of the earth being uplifted, but adjacent areas are being moved at different rates. There is much evidence to show that Scandinavia is in process of

AN OLD SEA-CLIFF WITH BEACH AT ITS FOOT (page 77)
The foreground, now cultivated, was formerly the sea-bed. Estuary of the Clyde, west of Dumbarton

tilting, the northern part being uplifted while the southern part is being depressed.[1] The raised beaches along the Clyde and many of the Scottish lochs show that the land has emerged from the sea in recent times; whereas in the Orkney and Shetland Islands the evidence suggests that the land is being submerged instead of being in process of emergence. In North America there is similar evidence to suggest that the northern part of the country has been in process of emergence from the sea, while in the southern part of North America the relative height of the sea and land has been constant. Such differential earth movements will raise rock barriers across a valley and alter it from an open channel into a closed basin; and unless the rivers are able to cut their beds deeper, as quickly as the ground is being raised, a lake is formed. Such earth movements are most frequent in the neighbourhood of mountains of recent formation. Lakes of this group accordingly occur mainly in mountain areas. Thus in the Alps the lakes of Geneva and Constance have doubtless been formed by the warping of the valleys of the Rhone and the Rhine.

Lakes formed by earth movements of a different type are evolved where wide tracts of land are slowly sinking. The subsidences that formed the Mediterranean basin produced at first vast lakes, which subsequently became brackish, and then by continued sinking were flooded by the sea and formed one sea basin. Among other existing lakes formed by the foundering of areas of the earth's crust are the Dead Sea in Palestine, formed in a rift valley; and Lake Balaton, a wide shallow sheet of water formed by the sinking of the Hungarian plain.

[1] This view, however, is rejected by Professor Suess.

III. LAKE BASINS FORMED BY RIVER AND ICE CORROSION[1]

Lake basins are formed by corrosion, just as artificial reservoirs are made by the actual digging out of the ground. Basins are in some places due to the action of the wind which travels in great eddies across a slightly undulating plain, and lifts up the sand beneath the centre of the eddy and carries it away. Such a circular wind is called in Australia a willy-willy, and many of the shallow lake pans of the central Australian plain have probably been formed by its action.

Rivers may also scoop out shallow basins by their scour upon the river bed. The rush of water over a waterfall or down a cataract may cause the swirling round of a heavy stone. The rotation of this stone, aided by the sand beneath it, wears away the rock and forms a pot-hole, and the enlargement of such pot-holes will in time form a rock-basin below the general level of the river-bed. Everyone who has travelled on rivers that have not been artificially regulated like canals knows that, even where they are flowing across sheets of sand or clay, the depth of the river is irregular. Owing to the varied strength of the current, the material is scoured out in one place and piled up in shoals or shallows at another; so that if a river ceases to run, the water will be left in a series of water-holes separated by wide sheets of sand. Similarly, where a river is flowing over rocks, the scour of the sand will lead to the unequal deepening of the bed; but this process will be slower than where a river is flowing over loose material.

Rivers of water, therefore, have limited powers of digging rock basins. Rivers of ice, however, have still greater powers of excavation. A glacier flowing across hard rocks acts mainly as a polishing agent. It removes the loose weathered

[1] Corrosion is the action of a river in wearing away its bed. Erosion, on the other hand, is the action of a river in cutting away its banks. Corrosion deepens and erosion widens a valley. The cutting back of a cliff by the sea is generally known as "abrasion".

rock, and polishes the surfaces of the hard, undecayed rock, upon which it appears to have no very powerful direct action. Ice, moreover, has great lifting power. The weight of a thick sheet of ice will crush any decayed rocks beneath it, and the crushed material may then be frozen into the ice and carried away. The weathering of rocks takes place very irregularly; where ice is flowing over such weakened patches, which are apt to be especially deep along the lines of former earth movements, it removes the weathered material and polishes the hard, unaltered rocks beneath, and leaves bare, deep rock-basins.

It has been maintained that all great lake basins have been formed by the excavating powers of glaciers; but this view is disputed by other geologists of equal competence, and ice corrosion may be limited to the removal of rocks weakened by previous decomposition, except where the ice presses against projecting rocks.

IV. LAKE BASINS OF VOLCANIC ORIGIN

Lakes appear in volcanic countries; the outpouring of masses of lava from beneath has left the surface unsupported, and it sinks, just as the removal of sheets of ores or coal by mining leads to the sinking of the surface. Thus the mining of gold-bearing gravel in Australia causes the formation of long, irregular lakes, which exactly mark out the course of the mining operations. Small lakes are formed in the same way in Cheshire by the sinking of the ground where underlying beds of rock-salt have been removed.

If these subsidences are wide they form comparatively shallow basins, such as Lough Neagh in Ireland; but sometimes in the immediate proximity of a volcanic vent the subsidences are smaller and deeper, producing volcanic caldrons, such are those occupied by Lake Albano, near Rome, in Italy, and by some of the lakes in the volcanic plains of Victoria.

Volcanic regions often contain small lakes of another type.

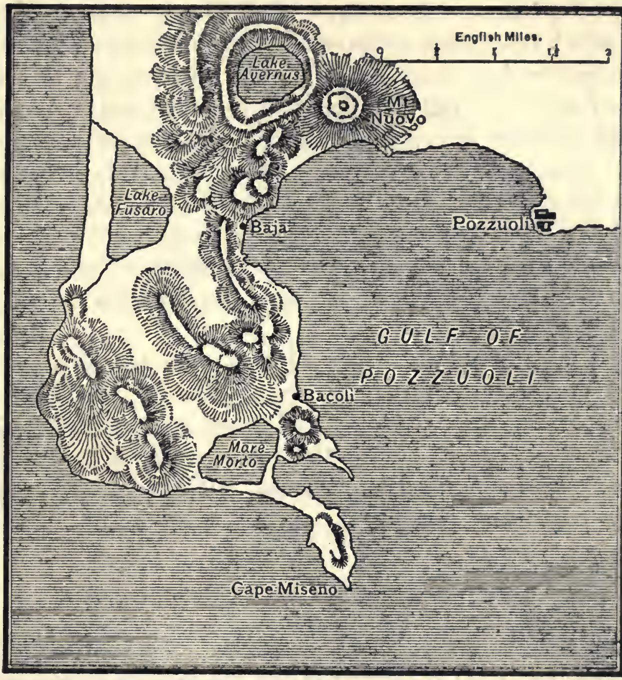


Fig. 55.—Lake Avernus, a crater-lake near Naples

They are called crater lakes, as they occupy extinct craters. One such existed in Vesuvius before it burst again into activity in the year A.D. 79; and Lake Avernus, near Naples, still remains a crater lake (fig. 55).

Part III

The Influence of the Atmosphere and Oceans

CHAPTER X

CLIMATE AND THE FACTORS THAT CONTROL IT

Climate is the average or prevalent condition of the weather. It is of great geographical importance, as it controls the growth of the geographical form, the conditions of life, and the economic development of different parts of the world.

The primary factor in climate is the supply of heat from the sun. The sun passes vertically over the tropical zone, which is therefore hotter than the regions outside the tropics; for in the polar regions the rays of the sun have a long course through the atmosphere, and thus some of the heat is absorbed by the air. Moreover, as seen by reference to fig. 56, a given amount of heat coming from the sun is dispersed over a wider space where the rays fall obliquely on the surface, as near the polar regions, than where they strike the ground at right angles, near the tropics.

The average temperature therefore gradually declines from the Equator to the Poles. The word climate, indeed, comes from a Greek word meaning "slope" or "inclination", indicating the dependence of climate on exposure to the sun, according to the inclination of the ground. But, as used by the seamen of the sixteenth and seventeenth centuries, the word climate meant the area between any two parallels of latitude of such a width that the length of the day was half an hour shorter on the one parallel than on the other.

Lines passing through places at sea-level which have the same temperature are called isothermal lines. They do not run exactly parallel to the Equator, because other factors bring about variations of temperature besides distance from the Equator. Thus winds and ocean currents deflect the isothermal lines. Highlands are colder than lowlands in the same latitude.

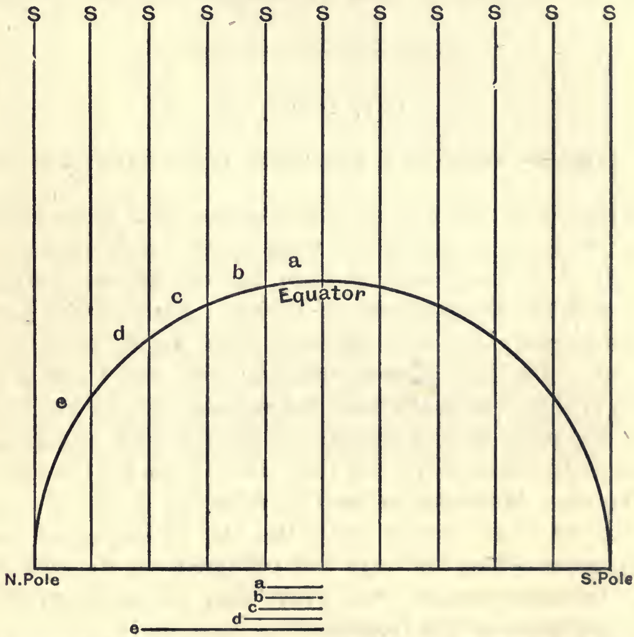


Fig. 56.—Diagram illustrating the unequal distribution of Heat received from the Sun. If the earth's surface were flat, each equal width would receive an equal amount of heat; but as the earth's surface is curved, the amount of heat received by the width *a*, at the equator, is spread over the width *e* near the poles.

This difference in temperature is due to the different degree in which air absorbs the heat reflected from the ground. The heat of the sun warms the surface of the earth, and this heat is reflected back into the atmosphere. But the atmosphere, though nearly transparent to rays of heat coming directly from the hot surface of the sun, is opaque to the heat rays reflected from the cold surface of the earth. This opacity of the atmosphere is due to the absorption of the reflected heat by the moisture and carbonic acid present in the air. They together act as a blanket, which allows the heat of the sun to pass through it to the earth, but prevents the heat being reflected back into space and thus lost. Most of the aqueous vapour is in the lower atmosphere. Half of it is below the level of 6000 ft. High ground, therefore, having a thinner blanket, loses more heat by radiation than low ground; and there is a fall of the temperature, on an average, of one degree for every 300 ft. in elevation. If the air were dry the fall would be one degree for every 180 ft. in elevation.

Another factor in the deflection of isothermal lines is the different effect of heat upon land and water. When water absorbs heat its temperature rises more slowly than that of land. The land, however, gives up its heat more rapidly than the water; consequently at night, or in winter, its temperature falls more quickly than that of the water. Hence the sea acts as a regulator of climate, cooling the land beside it in the summer, and warming it in the winter. That is why coast lands have both mild summers and mild winters; whereas localities in the heart of a continent suffer great extremes of heat in the summer and of cold in the winter.

The circulation of the atmosphere by the winds is another cause of the irregularity of the isothermal lines. The atmosphere presses down upon the earth with an average pressure of 14¾ lb. on the square inch. This pressure, however, varies from time to time, for the surface of the atmosphere rises and falls in waves like those of the sea, and the "blanket of air" is thicker in one place than in another. But it is not only the temperature which is affected by these waves of air, for the pressure also is greater beneath one of these raised waves or domes than that beneath a depression or trough. Hence we can tell whether a place is under a depression or an elevation of the atmosphere by observing whether the barometer is high or low. Lines passing through places having equal atmospheric pressure, as recorded by the barometer, are called "isobars" or lines of equal pressure.

The air is raised into a small, local, high-pressure area over

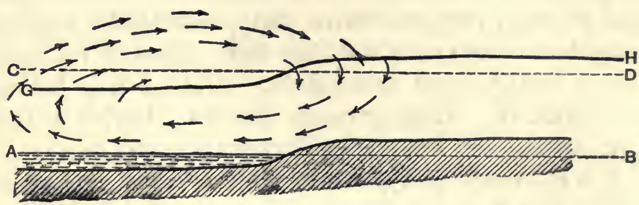


Fig. 57.—Diagram of Air-circulation in a Land Breeze

A B, Sea-level; C D, a plane in the atmosphere parallel to the sea-level; G H, a surface along which the air pressure is equal, owing to the condensation of the cooler air over the sea and the expansion of the warmer air over the land. Hence the air pressure at night is greater over the land than over the sea, and the balance is maintained by the flow of the lower air from land to sea.

an island at night; for as the land is cooled more quickly after sunset than the sea, it chills the air above it; and the column of air above the island becomes shorter as it cools;

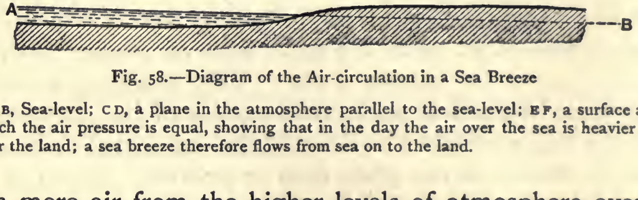


Fig. 58.—Diagram of the Air-circulation in a Sea Breeze

A B, Sea-level; C D, a plane in the atmosphere parallel to the sea-level; E F, a surface along which the air pressure is equal, showing that in the day the air over the sea is heavier than over the land; a sea breeze therefore flows from sea on to the land.

then more air from the higher levels of atmosphere over the sea flows in to fill up the depression in the upper surface of the island atmosphere. Hence there is more air above the cold surface of the island than there is above the warmer sea around. In the daytime, however, as the land is warmer than the sea, the air in contact with the land is warmed, and rises in an ascending current, and flows over to fill the depressed column of air which rests upon the sea. Hence, in the daytime, a low-level breeze will flow from the sea on to the land as a "sea breeze" (fig. 58), while at night the circulation will be reversed, and a breeze will pass from the land out to sea as a "land breeze" (fig. 57). Such daily reversals of wind direction, due to the alternate heating and cooling of a land surface, are called monsoonal changes.

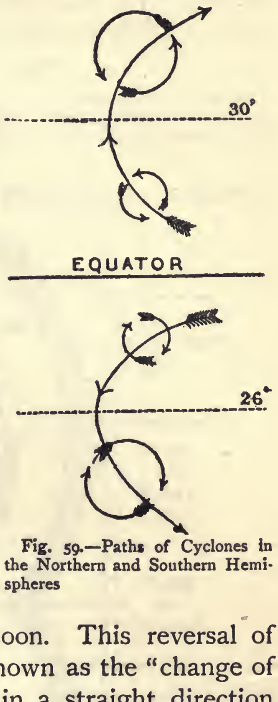


Fig. 59.—Paths of Cyclones in the Northern and Southern Hemispheres

Monsoons of a more powerful character, but of a similar origin, are developed owing to the unequal heating of the continents and the oceans. The continent of Asia is cooled in winter and warmed in summer. In summer there is a low-pressure area over the high plateau of Central Asia, and the air over the Indian Ocean is sucked north-eastward across the Arabian Sea into Asia as a south-west wind. In winter, however, Asia is covered by a high-pressure area, and the winds blow outward from it across the Arabian Sea and along the East African coast as the north-east monsoon. This reversal of the wind, happening twice a year, is known as the "change of the monsoons". Winds do not flow in a straight direction from the high-pressure to the low-pressure areas; but they take a spiral course, whence they are called cyclones.[1] The high-pressure areas, from which the winds blow outward, are called anti-cyclones. The low-pressure areas do not stand still, but pass across the earth from west to east.

[1] The term cyclone is often used popularly for any violent storm, and objection has been taken to the use of the terms cyclone and anti-cyclone for low-pressure and high-pressure systems. No satisfactory substitutes have yet been proposed.

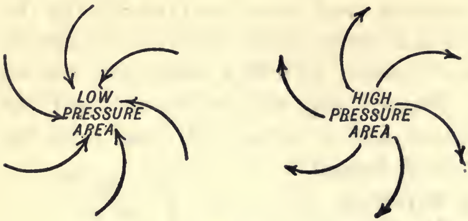


Fig. 60

Direction of Movement of the Air in a Cyclone in the Northern Hemisphere.

Direction of Movement of the Air in an Anticyclone in the Northern Hemisphere.

The winds blowing into a cyclonic area, owing to the rotation of the earth, are deflected like the trade winds, going to the right in the Northern Hemisphere, and to the left in the Southern Hemisphere. In the Northern Hemisphere winds going from north to south are

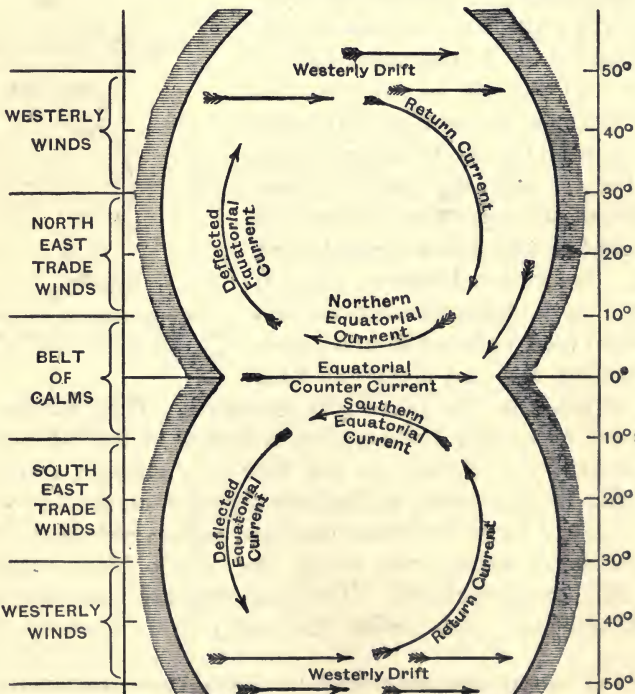


Fig. 61.—Diagram of the Typical Oceanic Circulation and its relations to the Winds

deflected to the right or west; and winds moving from south to north are deflected eastward. Thus the circulation of the air around a cyclonic centre in the Northern Hemisphere is in the direction opposite to the hands of a watch. The air movement in an anticyclonic area in the Northern Hemisphere is around the centre, in the direction of the hands of a watch. In the Southern Hemisphere the

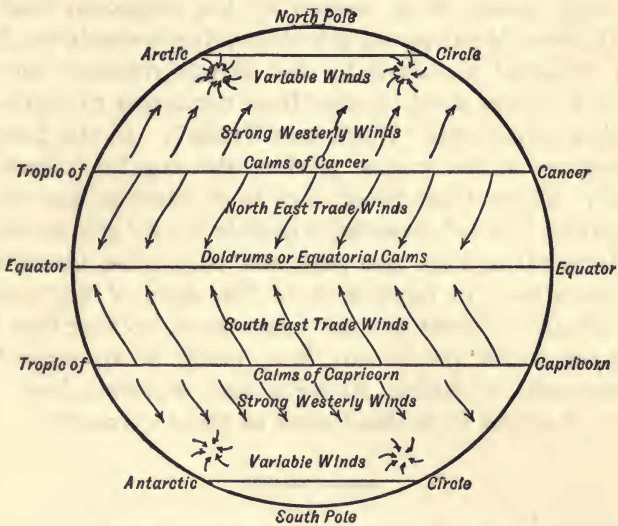


Fig. 62.—Diagram of the Wind Systems of the Earth

direction is reversed both for cyclones and anticyclones. It is therefore possible to infer, from the direction of the wind in one of these wind systems, the approximate position of the centre of the cyclone. The position is determined by Buys Ballot's "Law of the Winds", which states that if, in the northern hemisphere, you stand with your back to the wind, the barometer is lower on your left than on your right. Standing with your back to the wind the cyclonic area is to the left, and the anticylonic to the right. The positions are reversed in the Southern Hemisphere.

The cyclonic systems travel round the world from west to east in both Northern and Southern Hemispheres. They are especially powerful and numerous between the latitudes of 50° and 60°,[1] giving that zone its very variable winds and inconstant weather.

The prevalent winds of the tropics are determined by the flow of air towards the Equator to fill up the space left by the ascending current of air caused by the equatorial heat. In the Northern Hemisphere, the air moving towards the Equator is deflected westward by the earth's rotation, and thus there is a regular wind blowing from north-east to south-west, by sailors named the "North-east Trade". In the Southern Hemisphere similar causes produce the regular "South-east Trade". These trade winds owe their name to the old use of the word "trade", meaning a path or steady course, because they blow throughout the year, and they were, therefore, of great assistance to navigation in the days of sailing-ships. They are also of great climatic importance, because they blow the water across the oceans, and, piling it up against the eastern coasts of Africa, America, and Malaysia, lead to an outflow of waters from those areas as ocean currents.

CHAPTER XI

OCEAN CURRENTS

It has been remarked in Chapter V that there is a striking resemblance between the ocean floors and the continents, as both of them have valleys and ridges, mountains and basins. Comparisons have also been drawn between the surface of the oceans and the surface of the land. The tropical seas

[1] Latitude 50° passes through the Scilly Islands, the most southerly of the British Isles, while latitude 60° runs through the mainland of Shetland, quite at the north of the British group, which is thus practically contained between the parallels of greatest variability of the winds.

NORTH AMERICA
SOUTH AMERICA
West Wind Drift
California Current
North Equatorial Drift
Equatorial Counter Current
South Equatorial Drift
Peru Current
Summer
Winter
Gulf Stream
Labrador Current
Greenland Branch
N. Equatorial Current
Canaries Current
South Equatorial Current
Brazil Current
West Wind Drift
THE

EUROPE
ASIA
AFRICA
AUSTRALIA
Summer
Winter
Monsoon Drift
Indian Counter Current
Equatorial Drift
West Wind Drift
Kuro Siwo
Winter
Summer
Benguela Current
Agulhas Current
ORLD
OF OCEAN CURRENTS
of Current
Greenh 20

have been described as covered by "ocean meadows", from their abundant plant life; and the ocean currents are familiarly spoken of as the rivers of the sea. It has been thought that the sea-currents always flowed in well-defined, constant channels, like rivers on the land, and that they were entirely due to differences in temperature, the warm waters of the tropics flowing polewards as surface currents, and the cold water of the Arctic and Antarctic regions flowing towards the tropics as deep-level currents. It was further believed that the circulation of the ocean waters had a most profound influence on the adjacent lands. Thus the mild climate of north-western Europe, compared with the colder winter climate of the opposite coasts of America, was attributed to the action of the Gulf Stream. It is now known, however, that ocean currents are mainly caused by the wind; and, as the winds are usually variable, it is natural to find that the ocean currents are also variable in their strength and their range, and that the winds have a more powerful influence upon temperature than have the ocean currents.

The circulation of the ocean waters may be divided into two distinct types. There are broad, slow, ill-defined movements, which are called drifts, and are due to the water being blown along by the wind; and there are swifter, well-defined movements, known as currents, which may flow in opposition to the local winds. The power of the wind to affect the surface movements may be observed by anyone who cares to compare the actual and predicted times of high tide at any port up an estuary or river. When the wind is blowing strongly seaward, the high tide is late and low. If the wind be blowing up the estuary, the tide arrives early and is usually high.

The ocean which has been most thoroughly investigated is the North Atlantic. The prevalent idea of the circulation of the North Atlantic has been that tropical water is heaped up in the Caribbean Sea and Gulf of Mexico, where it is warmed, and that this warm water flows out through the Straits of

Florida, and along the United States to Newfoundland; thence it was assumed to continue as a well-defined, rapid stream across the whole of the North Atlantic to the shores of Europe, which it was thought to endow with a mild, warm climate. The comparatively cold climate of the eastern coast

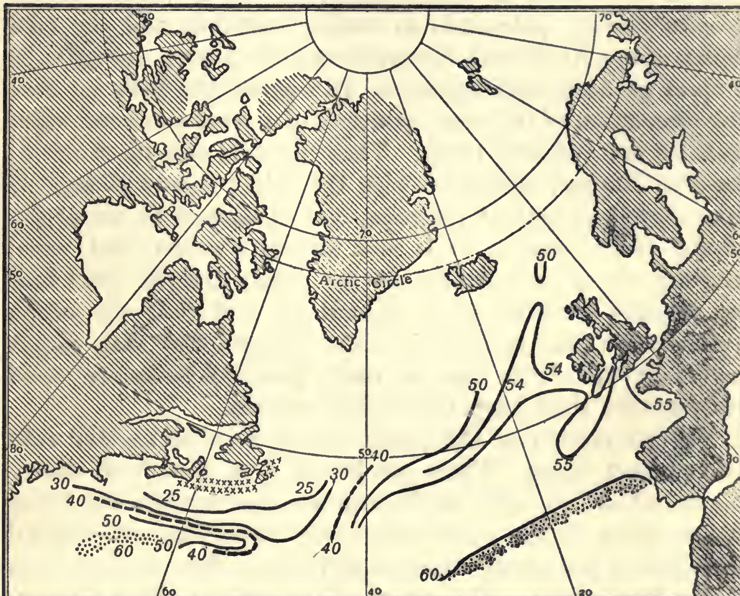


Fig. 63

Distribution of the salter Tropical and fresher Arctic Waters in the North

The tongue of warm salt water to the south of Nova Scotia in January is due to
due to the melting of the Arctic ice. In August the salt waters of the European
"isohalines", *i.e.* they pass through positions where the water is equally saline. Along
33 parts; along 40, 34 parts; along 45, 34.5 parts; along 50, 35 parts; along 54,

of America and Labrador was attributed to the chilling influence of the cold current flowing southward from the Arctic Ocean. The extension of the Gulf Stream across the Atlantic has been so long taught that it is firmly fixed in popular belief, and it has been further popularized by stories of boa constrictors from South America swimming ashore on the Scottish Isles.

Faith in this enormous influence of the Gulf Stream reached its zenith in 1870. The great German geographer Petermann then maintained that it is the Gulf Stream, and not our

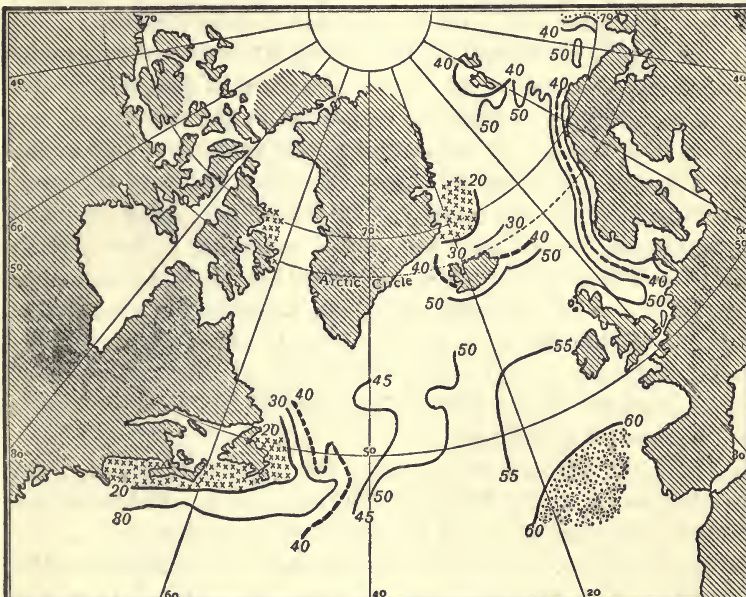


Fig. 64

Atlantic in January (fig. 63) and August (fig. 64), 1896 (after H. N. Dickson)

the Gulf Stream, which is overpowered there in August by the flow of fresher water current go farther north than in the winter. The lines across the ocean are the line 20 the water contains 32 parts of salt per 1000 parts of water; along 30, 35.4 parts; along 55, 35.5 parts; and along 60, 36 parts per 1000.

mild south-westerly winds, which warms western Europe; that northern extensions of the Gulf Stream are the main agents in the circulation of the North Atlantic, and that the Gulf Stream water makes the whole journey from the Straits of Florida to the shores of Europe in about two months.

But later and more detailed research has greatly diminished the length and importance of the Gulf Stream, which is found to end, as a definite ocean current, near the banks of Newfoundland. It does not reach the shores of Europe. Some of the Gulf Stream water is blown across the Atlantic by the prevalent winds from the west, but such water travels only as a slow, irregular drift, and its influence is insignificant.

The actual movement of the North Atlantic waters can be traced by observation of the temperature of the water, and more precisely by noting the variations in the amount of salt which it contains. By determining the amount of salt in the sea-water at a number of places at various times of the year, the movements of the water can be followed. After chemical examination of over 4000 samples of sea-water collected from the North Atlantic in 1896 and 1897, Dr. H. N. Dickson has prepared a valuable series of charts showing the changes in salinity of the water for every month in those years. Dickson's work, in conjunction with that of the many other hydrographers, shows that the currents of the North Atlantic are somewhat as follows.

The Gulf Stream flows along the American coast, from Florida, as far as the Banks of Newfoundland. There, during most of the year, it is cut off abruptly by cold water coming down the American coast from Labrador, which separates the tropical water brought north by the Gulf Stream from the great area of tropical water that lies off the western coast of Europe. The waters of the North Atlantic are drifted eastward by the wind and piled up against the European coast, and the water is forced to flow outward from this heaped-up area to make room for the further supplies from the west. Some of this water goes downward, and as it is warmer than the almost ice-cold water on the ocean floor, this movement warms the deeper part of the eastern Atlantic; more of the water works southward along the African coast; the rest flows along the European coast as a warm current which Dickson has called the European Current. The water of the European

Current overflows into the Arctic Ocean through three gaps in the northern rim of the Atlantic, viz., between Scotland and Iceland, Iceland and Greenland, and Greenland and Labrador. These three sub-currents are known respectively as the Norwegian, Irminger, and Greenland branches of the European Current (fig. 65). In the summer and autumn the melting of

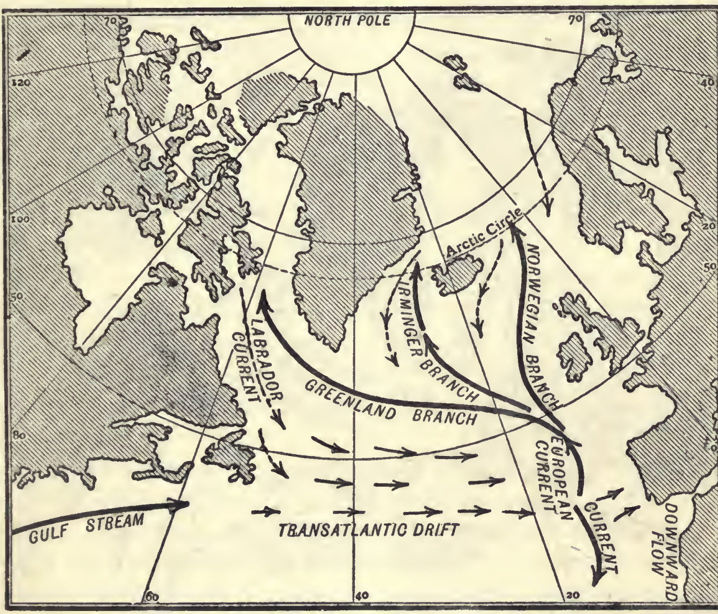


Fig. 65.—The Oceanic Circulation of the North Atlantic

the Arctic ice sets free great quantities of cold water, which flow southward in three currents that cover most of the North Atlantic with Arctic water.

Dickson's chart for August, 1896 (fig. 64), shows that the largest area of the North Atlantic, at that season of the year, is occupied by the cold Arctic waters, and that the ocean west of Europe, under such conditions, chills the climate of Europe instead of warming it.

This arrangement of the Atlantic currents does not last all the year. In winter these northward and southward currents are reduced, and the main movements are slow drifts eastward and westward across the Atlantic, combined with northward and southward movements along the coasts. The general circulation may be diagrammatically shown in fig. 65.

Fig. 66.—The Wind Systems of the North Atlantic

This North Atlantic circulation is the direct result of the wind (fig. 66). In the extreme north of the Atlantic there is a great area of low pressure, which generally surrounds Iceland, and in this area the winds move around in the direction opposite to that of the hands of a watch. Farther south, from about latitude 32° N. to 35° N., there is the centre of a high-pressure area, known as the North Atlantic anticyclone, around which the winds blow in the same direction as the hands of a watch.

Accordingly the prevalent winds across the North Atlantic, from the latitude of 40° to 60°, blow from the west, because the air on both the northern side of the anticyclone and the southern side of the Icelandic depression moves from west to east. The North Atlantic anticyclone and the Icelandic depression are not always in exactly the same position. Both of them vary in strength and position in different years, and their changes affect the movements and temperatures of the North Atlantic waters; these changes react on the winds which blow from the Atlantic against Europe. Thus the variations in British weather are partly due to changes in the North Atlantic which take place a year or more previously.

Ocean currents have a powerful effect on the climate of the coasts beside which they flow, although, perhaps, their influence is less than that of the winds. The currents which flow from the Equator poleward are warmer, while those flowing towards the Equator are colder, than the seas into which they pass. Hence currents flowing poleward have a warming, and currents flowing towards the Equator a chilling, influence.

Ocean currents have a specially marked effect upon the rainfall. Where air passes from a warm sea to a cold land, its temperature is lowered, and the moisture it contains is condensed and falls as rain. Where, on the other hand, the air blows from a cold sea to a warm land, its capacity for carrying moisture is increased, and it sweeps inland as a drying wind. Hence countries that are washed by cold currents, such as the south-western corner of Africa, the western coast of Australia, and the coasts of Peru and Chili, have a small rainfall. Coasts, on the other hand, washed by warm currents, have a heavy rainfall, such as the eastern coasts of Australia and Eastern Africa, south of the Equator, and the south-eastern coast of Brazil.

The ocean waters also affect the rainfall owing to a vertical circulation of the sea. The deep water of the sea is cold, because cold water sinks, while the lighter warm water remains floating on the surface. The ocean water is chilled mainly by the melting of the ice in the Arctic and Antarctic regions. The Arctic Ocean is, however, cut off from the great oceans by the lands that form a nearly complete ring around it; for the widest gap in that land ring, which occurs between Greenland, Iceland, and Scotland, is to a large extent blocked by a shallow ridge. The seas around the Antarctic regions, on the other hand, have wide, deep connections with the three great oceans. The water formed by

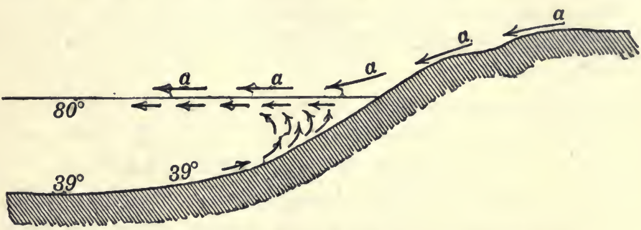


Fig. 67.—The Origin of Cold Shore-water in the Tropics

The land breeze, represented by the arrows *a a*, drives the surface water of temperature 80° F. out to sea; its place is taken by the ascent of the cold bottom water, with a temperature of only 39° F.

the melting of the Antarctic ice sinks below the Southern Ocean and the Southern Pacific, and drifts steadily northward as a deep, slow drift, which thus chills the whole of the deeper parts of the sea. The deep seas of the Southern Hemisphere, being nearer the chief source of cold water, are therefore cooler than those of the Northern Hemisphere. Even where the sea temperature at the surface may be over 80°, the sea-water on the deep ocean floor beneath it has a temperature of under 40°; and apparatus which has been lowered into the deep sea comes up, even at midsummer, feeling icy cold.

Off-shore winds blow the warm surface waters away from the land out to sea, and their place is taken by the cold waters which are drawn up from below (fig. 67). Hence coasts with prevalent off-shore winds are fringed by a band or belt of cold shore-water; and the winds that cross it to the land are chilled and pass on as drying winds. The presence of this cold shore-water explains the arid climate of the western coasts of South America, south-western Africa, Western Australia, and of Somaliland.

Part IV
Descriptive Geography

CHAPTER XII

THE BRITISH ISLES

In considering the geography of the British Isles it will be instructive to note the changes which would be effected by the lowering or raising of the surface of the sea; changes which have taken place in the past, and which may recur in the future. The lowering of the surface of the sea 600 ft. would revolutionize the geography and the political conditions of the British Isles (fig. 68). When the sea had sunk the first 200 ft. Great Britain would have lost the protection of its sea-moat, and would no longer be an island. The Straits of Dover would have been drained into a broad land valley, and England would have been re-joined to the Continent, from which, geologically speaking, it has only recently been separated. The whole of the southern part of the North Sea, as far as the Dogger Bank, would have become land, and the Irish Sea would be a plain traversed by a long gulf running from north to south. By the time the sea-level had sunk another hundred feet, nearly all the North Sea would have been restored to its former condition of a gently undulating plain; all the rivers of the eastern slope of Britain would once again be engrafted on to one main trunk, which, when last in existence, either flowed northward to the west of the Dogger Bank, or joined a northern extension of the Rhine, and discharged into the Arctic Ocean through a gulf

Fig. 68.—The British Isles as modified by Lowering the Surface of the Sea 600 feet and 6000 feet

along the Norwegian coast. When the sea had sunk the whole 600 ft., the British Isles would have been fully joined to the Continent, both on the south to France by the conversion of the English Channel into a land valley, and on the east to the Netherlands and Germany, and on the north-east to Denmark and Sweden by the disappearance of the North Sea. The British Isles would have been completely merged in the Continent by the development of a land to the north-west along the oceanic margin. The numerous islets of the Faroes would all have become united into an island nearly half the size of Ireland, and the peak of Rockall would have grown into a considerable land area.

This change would have converted the British Isles into a plateau some 600 ft. in height, with a low coastal plain at its western edge, some 40 to 80 miles in width, extending beyond the Outer Hebrides and the western coast of Ireland. Above the 600-ft. plateau would rise the still higher plateaus, of what are now the British uplands. Most of the lakes, sea-lochs, and estuaries would have been turned into valleys; but even if the Scottish lakes were drained by canals cut from them at sea-level, some of them would remain as lakes; for the deepest part of Loch Lomond would still be a little below sea-level, while it would require the emergence of the land for about 1000 ft. before the bed of Loch Morar would reach sea-level.

The lowering of the sea for 2400 ft. farther, although four times as great a fall, would produce comparatively slight changes in the geographical relations of the British Isles. They would then be linked to Iceland and to Greenland, the Norwegian Gulf would be drained, and the Rhine would have to flow farther northward before reaching the sea; and Rockall, though still an island, would be as large as Ireland. But the great extra emergence would make very little addition to the land to the south-west of England; the new shore would follow the same course as the shore-line of the 600-ft. emergence, with the addition of only a narrow

Fig. 69.—The British Isles as modified by raising the Surface of the Sea 500 feet

strip, about 50 miles wide, along the shore. If the emergence of the land were to continue further, so that the sea-level were 6000 ft. lower than it is at present, then the band of land connecting Greenland and Scotland would have grown wider, till it included Rockall on the south, and Jan Mayen on the north. But the change on the south-western shore-line would again be barely appreciable. Nor would the British lands receive any great extension there, even if the sea-level were lowered 12,000 ft.; for the sea, in the deep depression known as the Biscay Deep, would still occupy the Bay of Biscay and bound the south-western shores of the British area, and extend nearly to the present coasts of France and Spain. But elsewhere the changes would have been more important, for the North Atlantic would have ceased to be a great ocean; it would have been divided into two seas by a long peninsula running southward from the Arctic land that would connect North America and northern Europe. This peninsula would occupy the middle of the present site of the Atlantic, along the line of the submarine mountains known as the Challenger Ridge; it would include the islands of the Azores, and extend southward nearly as far as the northern coast of Brazil.

Thus the sinking of the sea-level by a depth of 600 ft. would revolutionize the geographical conditions of the British Isles; but a further subsidence, even to the depth of 12,000 ft., would make comparatively little alteration in the extension of the British area, except by the widening of its land connection with North America, though that land emergence would have completely altered the whole geography of the North Atlantic.

If the surface of the sea were to rise 500 feet above its present level, so that the land would be submerged to the present 500-ft. contour line, there would be produced almost as striking a change in the geography of the British Isles as that effected by the 600-ft. emergence (fig. 69). Southern and eastern England would all be drowned beneath the sea,

BRITISH ISLES
GEOGRAPHICAL DIVISIONS
Scale of English Miles
0 20 40 60 80
Lowlands
Uplands
Red lines indicate the Geographical grain of the Country. The dotted red lines under the S.E. of England show the grain of the buried ridge on the site of the Armorican Mountain Folds
NOTE
Geographical Grain
Grain is the structure of a country which is composed of alternate bands of harder and softer rocks; like the grain of wood
ORKNEY ISLANDS
HEBRIDES
SCOTTISH HIGHLANDS
MIDLAND VALLEY OF SCOTLAND
SOUTHERN UPLANDS
UPLANDS OF
CHEVIOT HILLS
Highland Boundary Fault
Southern Boundary Fault
Great Glen
Suilven
Ben Slioch
Inverness
Findhorn
Spey
Deveron
Don
Aberdeen
Dee
N. Esk
S. Esk
Dundee
Tay
Perth
Oban
EDINBURGH
Dunbar
GLASGOW
Lanark
Tweed
Berwick
Ayr
Girvan
North Channel
Dumfries
Carlisle
Newcastle
Tyne
Sunderland
Durham
Tees
Skiddaw 3054
Solway Firth
Mull of Galloway
Londonderry
Bann
Donegal
L. Neagh
Belfast
NORTH SEA
OCEAN


FRANCE
ENGLISH CHANNEL
LA MANCHE
IRISH SEA
ATLANTIC
FOLDS
SOUTH ENGLAND
PLAIN OF CENTRAL AND EASTERN ENGLAND
MIDLAND PLAIN
WELSH UPLANDS
MIDLAND PLAIN
END OF THE ARMORICAN
DISLOCATED
Norfolk Broads
Ipswich
Cambridge
Ouse
The Fens
Welland
Lincoln
Hull
Ouse
York
Leeds
Sheffield
Don
Trent
Leicester
Derby
Charnwood Forest
Birmingham
Warwick
Wolverhampton
Severn
Malvern Hills
Hereford
Wye
Chester
Manchester
The Peak
Lancaster
Liverpool
Barrow
Douglas
Holyhead
Snowdon
Dee
Cardigan
Teifi
Carmarthen
St. Davids Hd.
Swansea
Cardiff
Bristol Channel
Bristol
Mendip Hills
Cotteswold Hills
Chiltern Hills
Vale of the Thames
London
Thames
Dover
St. of Dover
North Downs
The Weald
Hastings
South Downs
Guildford
Southampton
Wilts Downs
Salisbury Plain
Poole
I. of Wight
Exmoor
Exeter
Dartmoor
Plymouth
Channel Islands
Scilly Is.
DUBLIN
Dundalk
Drogheda
Wexford
Barrow
Kilkenny
Suir
Waterford
Dungarvan Bay
St. George's Channel
Shannon
Limerick
L. Derg
Galway
L. Mask
L. Corrib
Blackwater
Cork
Killarney
2 Longitude West of Greenwich
0 Longitude East of Greenwich

except for a few small islands left by the higher summits of the Chiltern and Cotswold Hills, the North and South Downs, Dartmoor, and the moors of Yorkshire. The whole of eastern and south-eastern England would have been occupied by the widening of the North Sea and the English Channel; the plains of Lancashire and Cheshire would be added to the Irish Sea; Wales would be left as a large island, its coasts guarded by islets. The Pennine Range would remain above sea-level with a deeply indented coast, long gulfs running inland between angular ridges. Two arms of the sea, one running up the valley of the Aire in Yorkshire, and the other up the valley of the Ribble in Lancashire, would almost divide the range into two parts; the northern Pennines would be joined to the highlands of the Lake District, and also to the Southern Uplands of Scotland, by the plateau of the Cheviots between the Solway and the Tweed. The Midland Valley of Scotland, from Edinburgh to Glasgow, would be a strait between the islands formed by the Scottish Highlands and the Southern Uplands. The Scottish Highlands would be the least altered part of the British Isles. They would be somewhat contracted in size; many of the lower valleys would be occupied by fiords; and a strait up the Great Glen would completely flood the Caledonian Canal, and cut the Highlands into two large islands.

Ireland would consist of a broken ring of peaks around the drowned central plain.

If the submergence were doubled, and the sea raised to the height of 1000 ft. above its present level, the further changes would be less marked. The few islands in southern and eastern England would have disappeared; the Irish islands would have shrunk into islets; and those that marked the sites of Wales, the Pennine Range, and the Scottish Highlands would be much diminished in size.

THE LOWLANDS AND UPLANDS

Among the changes we have been considering, the supposed submergence of the land to the depth of 500 ft. presents us with the most instructive picture. It clearly marks off the lowlands from the uplands, a most important distinction, for the lowlands differ from the uplands, not merely in level, but in essential structure. The British lowlands consist of rocks similar to those that form the northern plains of France and Germany. These rocks may be described as geologically young, for they were formed in the later periods of the earth's history. The uplands, on the other hand, consist of old rocks. The chief difference between young and old rocks, in their influence on the general geography of a country, lies in their hardness. Rocks usually become harder as they grow older. They are rendered more compact by the pressure of the masses of rocks that have covered them; they are further hardened by water percolating through them and filling the interstices with cementing material which binds the once loosely connected grains into a compact, rigid rock. These old rocks, owing to their hardness, best resist the action of the forces which are continually attacking rocks and wearing them away. The younger rocks, being softer, yield more readily to the attacks of rain, wind, and weather; and thus the younger rocks have been cut down into lowlands, while the harder rocks stand up as the resistant uplands.

The British mountains have not been piled up in heaps like volcanoes, or raised by crumpling of sheets of rock like the Alps; they are "residual mountains", carved out of once level-topped rock-masses by the removal of the softer material. The harder parts of the old plateaus have been left as hills; the softer parts have been removed in the formation of valleys.

A journey along the valleys of the Scottish Highlands is apt to give the impression that the mountains are an irregular complex of mountains; but if we look over the country from one of the higher peaks, as, for example, from Ben Ledi, the tumbled series of ridges and peaks are all seen to rise to the same general level (Pl. XIII). There is no one peak rising to a much greater height than any of the others in its neighbourhood. The ridges, one beyond another, all reach the same general horizontal plane; and if we look around with eyes half closed, so as to obscure the details, then the ridges appear to merge, and we get the impression that we are looking across an undulating plain. If we could have visited Ben Ledi millenniums ago we should have found that the Grampians consisted of a plateau with a rolling, undulating surface, with a slight slope to the south-east. This old plateau has now been destroyed by the action of rivers; they have carved out valleys, which they are still deepening. If we could revisit the country in the far distant future we should find that the valleys have been cut a little deeper and much broader. The ridges would accordingly be narrower and lower, and many of them would have almost disappeared; but a few of the mountains, though left isolated by the removal of the intervening ridges, would still rise to nearly their present height, and thus indicate the level of the original surface. At present the ridges and mountains are more conspicuous than the valleys; the grazing lands are on the wide upland moors, and there are but few farms in the narrow valleys. But in time the valleys will become much wider than the broken ridges and isolated peaks which will represent the old uplands, and the largest farms will be on the wide floors of the valleys, with but narrow bands or patches of sheep moors on the last remnants of the old uplands. This stage in the dissection of a plateau is represented in northern Sutherland, where a few peaks, such as Ben Hope and Ben Loyal, stand out, like pyramids, above a wide, undulating plain.

Whatever may be the structure of the British mountains they all have one feature in common. The existing mountains are the worn stumps of old earth-blocks; the peaks are hard blocks that have been left by denudation, and the present forms of the mountains are not due to their original structure. Thus the chief mountains of North Wales, such as Snowdon (3570 ft.), are composed of volcanic rocks; but the old craters have completely disappeared; the old volcanic mass of Snowdon has been worn down; valleys have been carved out by the streams, and new peaks have been left

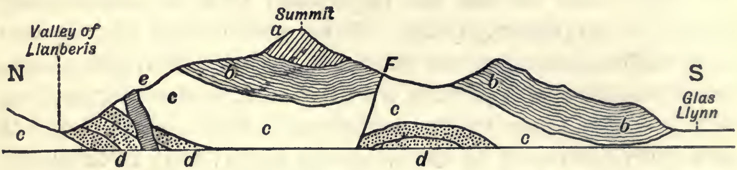


Fig. 70.—Section across Snowdon from North to South

a, Columnar lava of the summit; *b*, volcanic ashes containing some marine fossils; *c*, bedded lavas; *d*, grits and sandstones; *e*, intrusive dyke.

standing; and the present hills and valleys do not occupy the same position as the ridges and hollows of the original volcanic mass (fig. 70).

THE GEOGRAPHICAL SUBDIVISIONS OF THE BRITISH ISLES

As we have seen, the division of the British Isles into lowlands and uplands is the result of denudation; but the subdivision of the uplands themselves depends mainly on their original structure and arrangement.

The British Isles may be divided into five main divisions. The oldest part of the British Isles is in the *Highlands of Scotland*; it is a fragment of an ancient continent called Arctis, which united Scotland to Scandinavia and Greenland. This land was composed of ancient crystalline rocks, of the kinds known as schists and gneiss. The rivers that flowed across this continent cut out large valleys and spread over their floors thick sheets of sands, now converted into sandstone. Some of this rock was deposited by rivers, some in

PLATE XIII

Photo. Wm. Ritchie & Son.

A VIEW ACROSS THE GRAMPIANS FROM THE SUMMIT OF BEN LEDI

Illustrating the structure of the Grampians as a dissected plateau (page 105)

lakes, and some of it may have accumulated as blown sand on open, arid plains. This sheet of sandstone, known as the Torridon Sandstone, filled up some of the old valleys, and has thus preserved part of the old land surface buried beneath it. Some of the best-known hills in north-western Scotland, such as Ben Slioch and Suilven, consist of blocks of Torridon Sandstone, which, as well as similar hills in northern Norway, are no doubt fragments of a sheet of Torridon Sandstone, which once extended from Scotland to Scandinavia across the North Sea.

The ancient crystalline rocks beneath the Torridon Sandstone are called Archean rocks. These Archean rocks form the Hebrides, and the foundation of the Scottish islands, and of the mainland as far south as the northern edge of the Midland Valley of Scotland. Fragmentary remains of the same rocks are exposed in various parts of the British Isles, as in the Charnwood Forest near Leicester, the Malvern Hills, perhaps in the St. David's promontory of South Wales, and in Cornwall. But in England and Wales these rocks are only found in scattered masses, that here and there appear on the surface from beneath the sheets of later rocks, which once completely buried them. There is a wide extension of the Archean rocks in northern Ireland, that continues the Scottish line, which once reached north-eastward into Scandinavia.

The southern limit of these ancient rocks in Scotland is a line known as the Highland Boundary Fault; they have there been dropped, by a fracture, below a sheet of younger rocks that has buried their southern continuation. These younger rocks were no doubt once spread over the Archean rocks to the north, but they have been worn away and the old rocks are exposed on the surface. To the south of the Highland Boundary Fault lies the *Midland Valley of Scotland*; its rocks include sheets of Old Red Sandstone deposited partly on land and partly in fresh water, in lakes, or along rivers. The Old Red Sandstone is covered by sheets of somewhat younger deposits, including limestones, clays, and sandstones, which are associated with beds of iron ore and seams of coal. These rocks form the Carboniferous System, and it is owing to their rich stores of coal, iron ores, and oil-shales that the Midland Valley is the richest and most important part of Scotland. It is the site of all the largest towns and of the chief manufacturing and mining industries of the country.

The Midland Valley is bounded to the south by a second series of faults, which bring older rocks to the surface; they, owing to their greater hardness, stand up and form the *Southern Uplands* of Scotland (fig. 71). The chief rocks of the Southern Uplands are older than the Carboniferous rocks and the Old Red Sandstone of the Midland Valley, but they are much younger than the Archean rocks of the Highlands; for their beds of slate and shale contain numerous fossils, the remains of the animals that lived when these rocks were being deposited. From the character of these animals we know that the rocks belong to the Ordovician and Silurian systems, and are intermediate between the Archean and the Old Red Sandstone.

The Southern Uplands occupy the country between two lines, one drawn across Scotland from Girvan, on the Ayrshire coast, to Dunbar, passing about 10 miles to the south-east of Lanark and Edinburgh; the other one drawn along the Solway Firth and the Cheviot Hills. These old Upland rocks extend south-westward to the Mull of Galloway, on the Scottish side of the North Channel; and similar rocks, with their grain in the same direction, occur on the Irish side of the strait, to the south of Belfast, and occupy the counties of Down, Armagh, Monaghan, and Cavan. There can be no doubt that this district of Ireland was at one time connected with the Southern Uplands of Scotland as part of the same mountain line.

South of the Solway Firth there is another area of rocks of somewhat the same age as those of the Southern Uplands.

Fig. 71.—Generalized section, from north-west to south-east, across the western part of the Southern Uplands of Scotland, an area of contorted slates, sandstones, and lavas, which are thrown by a fault (*F*) against the younger rocks belonging to the Old Red Sandstone, which includes a bed of lava at *a a*. For convenience of reference in tracing the folding of the beds, their relations are shown in the following table:—

O.R.S.	Old Red Sandstone	Devonian System.
a	Its interbedded lava	
W	Wenlock Series	Silurian System.
L	Llandovery Series	
C	Caradoc Series	Ordovician System.
D	Llandeilo Series	
A	Arenig Series (mainly lavas)	

They form the hills of the *Lake District*, including Scafell (3210 ft.), the highest peak in England, and Helvellyn (3118 ft.), and Skiddaw (3054 ft.); but though composed of rocks of the same general age as those of the Southern Uplands of Scotland, they differ in their characters, for they were laid down under different geographical conditions. They consist of great masses of slate, such as the Skiddaw slate, and the green Borrowdale slates, which are formed of volcanic materials; and there are also bands of limestone formed in the sea.

The Isle of Man consists of a detached fragment of the Lake District, which has been separated from the mainland of England by the formation of the Irish Sea. Before the Irish Sea existed, the Isle of Man was not only joined to England but to Ireland, and the rocks of the coast of Man reappear, trending in the same direction, on the Irish coast, near Dublin.

Wales is another upland country, and most of its rocks are of the same age as those of the Lake District and the Southern Uplands of Scotland; but still older rocks of the same age as those of north-western Scotland are

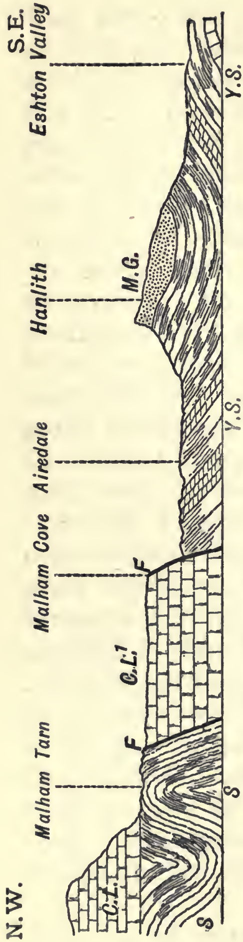


Fig. 72.—Section across the Pennine Range, near Settle, in North-west Yorkshire

The hills at the north-west end of the section consist of Carboniferous Limestone (*C.L.*), resting on contorted Silurian Sandstones (*S*); a block of Carboniferous Limestone (*C.L.*¹) has fallen between the two branches of the Craven Fault (*F F*), and forms the plateau between Malham Cove and Malham Tarn. The beds on the floor of Airedale are the Yoredale Shales (*Y.S.*), which are younger than the Carboniferous Limestone, but have been dropped to a lower level by the Craven Fault. Hanlith is a mass of Millstone Grit (*M.G.*), left in the floor of a trough-shaped fold, but now forming a hill owing to the removal by denudation of the rest of the fold.

exposed here and there from beneath the others. Wales also contains the remains of ancient volcanoes, that built up the volcanic pile out of which Snowdon has been carved. The grain of the rocks in North Wales is cut across abruptly by the St. George's Channel, showing that the land must once have extended out to sea; and further in the same direction, similar rocks with their grain having the same trend reappear to the west of St. George's Channel, and form the south-eastern corner of Ireland. Thus the Wicklow Mountains must at one time have been part of the same mountain area as Wales.

The *Pennine Range* forms another upland area. It consists of younger rocks than the hills of Wales, of the Lake District, and the other uplands previously considered; its rocks are of the same age as those around Glasgow in the Midland Valley of Scotland. The rocks are limestones, clays, and sandstones, and most of them were laid down beneath the sea. The rocks of the Pennines were raised like an arch, with the sides sloping down to the east and west, while the axis of the arch ran approximately north and south. The wearing away of the top of the arch by wind, rain, and weather has exposed the older rocks along its central line. The typical structure of the Pennines results from a series of faults or fractures, by which different earth-blocks have been upraised to different levels. Thus a section across the Pennine Range, as in fig. 72, shows that its highest ridges and plateaus have been caused by the movements of earth-blocks. The Pennines extend from north to south across the western parts of Northumberland and Durham, along the border-line between Yorkshire and Lancashire, and into the heart of England, where they form the hills of the Peak in Derbyshire. The Pennines consist principally of limestones and shales, belonging to the lower part of the Carboniferous System; while the sandstones, clays, and coal-seams of the upper part of the Carboniferous System rest upon their flanks. Thus, on the eastern side of the Pennines lie the coal-fields of Northumberland and Durham, and those of South Yorkshire, Derby, and Nottingham. On the western side there are the coal-fields of the Cumberland coast and of South Lancashire. Lastly, round the southern end of the Pennine Range are the isolated, buried coal-fields of Staffordshire, Derbyshire, and the coal-fields near Birmingham.

The last of the British uplands forms the *moors of Devonshire and Cornwall.* The rocks of this area trend from east to west, and the geographical grain of this district can be followed from northern Devon, across the south-western peninsula of Wales around Pembroke and St. David's, and in southern Ireland in the counties of Cork and Kerry. The rocks of this part of Ireland are of the same age as those of Devonshire, and have been bent into similar folds, of which the axes run approximately east and west. They form part of a mountain line, in which the axes ran east and west, and that extended from the west of Ireland into Central Europe. As these mountains were apparently highest in Brittany—the ancient Armorica—they have been called the *Armorican Chain.* The northern edge of this chain crosses Ireland from Dingle Bay, along the valley of the Blackwater, in the county of Cork, to Dungarvan Bay in Waterford; it crosses Pembrokeshire, and skirts the northern shore of the Bristol Channel and the northern foot of the Mendip Hills. The Armorican mountains occupied the area covered by the mouth of the St. George's Channel and the English Channel, the counties of Devon and Cornwall, and the peninsulas of Brittany and La Manche; for the rocks of north-western France have the same arrangement as those of southern Ireland and south-western England; and the old mountains extended southward to the district of La Vendée, beyond the mouth of the Loire. The various ridges which formed this wide mountainous area are cut off abruptly to the west by the Atlantic. They must once have projected farther westward over the site of the Atlantic Ocean. The eastern extension of these Armorican mountains is buried beneath sheets of newer rocks; but the planed-down base of this mountain system occurs at the depth of over 1000 ft. under the south-east of England and the north-east of France, and the old rocks reappear at the surface in Belgium.

The uplands of Devon and Cornwall and the south of Ireland are therefore part of a mountain chain which ran across this part of Europe, from far out in the Atlantic on the west to beyond Belgium on the east.

The South-eastern Plain.—The whole of the south-east of England is occupied by young, soft rocks, which are so easily worn away by the action of wind, rain, and rivers that the highest of them rise but a little over 1000 ft., and their general level is much lower. The only hills in the south-east of Britain are a series of low ridges, which begin in Yorkshire on the north and run southward into the centre of England. There the hills bend round to the south-west, and they occur in two main parallel ridges; to the east are the chalk hills of Cambridgeshire, with their continuation, the Chiltern Hills, in Oxfordshire and Buckingham; and to the west are the Cotswold Hills in Gloucestershire, of older oolitic limestones. Both these lines are interrupted by ridges running from east to west above that buried base of the Armorican Mountains, which forms the foundation of most of the Thames Valley and of the country to the south of it. These east-and-west ranges, known as the Mendip Hills, the North and South Downs, and the Isle of Wight, have been left upraised above the general level of the country, owing to the rivers having cut out the intervening valleys. Between these hills there are broad vales, such as the Weald of Kent, wide stretches of downs, such as Salisbury Plain, long river valleys, with broad sheets of level gravel and alluvium on their flood plains, as along the Thames, and wide-spread low-lying plains, such as those of the Fen country, or around the Broads of Norfolk. The level country is so wide in proportion to the hills that the whole of this south-eastern part of England is a gently undulating, dissected plain.

Fig. 73.—Succession and General Arrangement of Strata in Wales and part of England

1, Cambrian and Ordovician. 2, Silurian. 3, Old Red Sandstone (Devonian). 4, Carboniferous Limestone (Carboniferous). 5, Coal-measures (Carboniferous). 6, Permian. 7, New Red Marl and Sandstone (Trias). 8, Lias. 9, Oolite. 10, Chalk, &c. (Cretaceous). 11, London Clay, &c.

THE BRITISH RIVER SYSTEM

The arrangement of the ridges and valleys of the eastern and central plain of England has been determined by the irregular denudation of the superficial rocks; these were laid down in sheets upon a foundation of the rocks of the Armorican Mountains, which had been previously cut down to a wide plain. The rocks of this buried plain have been reached by deep bore-holes in search of water in London, Ware, and Harwich, and by shafts to work coal near Dover.

These old rocks now lie at the depth of about 1000 ft. beneath London; they are covered by layers of clay, limestones, and sands, which extend inland from the eastern coast as far west as a line past Exeter, Bristol, Warwick, Nottingham, and York to the mouth of the Tees. These rocks have been slightly uptilted on the western side, so that they have a gentle slope downward from north-west to south-east. Owing to the hardness of the old rocks in the north-west of the British area, we still find the highest parts of the country in the north-western districts of Scotland, England, Wales, and Ireland; and as these highlands are nearest to the western ocean, they receive a heavier rainfall than the rest of the country. Much of this rain used to run south-eastward down the slope of the younger rocks, so that the general course of the chief British rivers was at first from north-west to south-east. As the original rivers took this direction in consequence of the slope of the ground, they are called *consequent rivers*. Such consequent rivers are the lower part of the Tay, its tributary the Garry, the Forth, and Upper Tweed, in Scotland; the Yorkshire Ouse; the Swale, the Nidd, the Wharfe, and the Aire, in Yorkshire; the part of the Severn from Shrewsbury to Tewkesbury, the Wye, and the Upper Thames. A map of the rivers of the British Isles (Pl. XIV) shows, however, that there are other rivers, including some of the most important, which flow at right angles to the direction of these consequent rivers. Thus, the Lower Severn and its continuation, the Warwickshire Avon, the Trent from Burton to the Humber, the Witham above Lincoln, and the rivers that enter the Wash, the Nen and the Great Ouse, all flow from south-west to north-east.[1]

The courses of most British rivers show features which at first appear puzzling. The rivers, instead of taking the easiest course from their source to the sea, often cut their way in narrow gorges through ridges and hills instead of taking what appears to be an easier and less obstructed route.

[1] See Note in Appendix, p. 284.


BRITISH ISLES
Showing the River Systems
English Miles
0 20 40 60 80 100
Consequent Rivers
Subsequent "
The black dotted lines mark the former continuation of the Tweed across the Clyde valley through Gare Loch & Loch Goil to Argyleshire: and the former connections of the Don with the Witham, and of the Severn with the Upper Thames.
12
10
8
6
4
2
0
2
58
56
OCEAN
NORTH SEA
SCOTLAND
Naver
Thurso
Helmsdale
Shin
Oykel
Carron
Beauly
Ness
Nairn
Findhorn
Spey
Deveron
Ythan
Don
Dee
Aberdeen
N. Esk
Garry
Tummel
Isla
S. Esk
Tay
Dundee
Earn
Forth
Whistlefield
Gare Loch
GLASGOW
EDINBURGH
Clyde
Tweed
Ayr
North Channel
Nith
Annan
Dee
Cree
Tyne
Newcastle
Tees
Londonderry
Foyle
Bann
Mourne
Belfast
Lagan


ENGLAND
WALES
IRELAND
FRANCE
IRISH SEA
ENGLISH CHANNEL
ATLANTIC
Bristol Channel
St. George's Channel
The Wash
LONDON
Dover
Harwich
Portsmouth
Exeter
Plymouth
Bristol
Gloucester
Tewkesbury
Worcester
Shrewsbury
Birmingham
Warwick
Oxford
Reading
Pangbourne
Ware
Liverpool
Manchester
Sheffield
Nottingham
Burton
Lincoln
York
DUBLIN
Waterford
Limerick
Cork
Galway
Bure
Yare
Waveney
Stour
Medway
Lee
Colne
Chess
Thames
Mole
Wey
Black-water
Kennet
Thame
Cherwell
Isis
Ock
Coln
Avon
Great Ouse
Nen
Welland
Witham
Trent
Don
Dearne
Ouse
Aire
Wharfe
Humber
Dove
Mersey
Severn
Wye
Usk
Dee
Exe
Tamar
Boyne
Liffey
Slaney
Nore
Suck
Shannon
Blackwater
Lee
Bandon
Long. W. of Greenwich o Long. E. of Greenwich
54
52
50
2
4
6
8
10

Thus, the Thames, after its junction with the Cherwell at Oxford, instead of continuing its course to the north of east, turns abruptly to the south-east. Here its course appears to be blocked by the Chiltern Hills, while an easy outlet is offered, in continuation of its first direction, by a broad continuous valley along the course of the Thame, thence over a low gap into the valley of the Great Ouse, and so to the sea. The Thames, however, flows straight towards the Chiltern Hills, and runs through them in a narrow deep valley—the picturesque gorge of the Thames at Pangbourne—till it reaches the basin of the Lower Thames near Reading. Many other British rivers appear to avoid their natural route to the sea, preferring to cut their way through high rocky ridges. This arrangement clearly indicates that the course of such rivers was determined at a time when the surface of the country was very different from that of the present time; the rivers, in fact, are older than the hills. The course of the Thames through the Chiltern Hills was determined before the hills had been carved out from their sheets of sediment, and the rivers flowed over a plain above the level of the existing hilltops. Clear evidence for this belief is given by the fact that the Chiltern Hills are cut through, not only by the gorge of the Thames, but by a series of river-cut gaps not used by rivers at the present time. They have clearly been cut by rivers which have now disappeared, and left only a "wind-gap" or "air-gap" through the hills. These air-gaps should be well known to railway travellers from London, for when they go to the south coast the Downs on the southern side of the Thames valley are traversed by long railway tunnels; but when they go to the north of England, they cross through the Chiltern Hills by an open daylight route. The air-gaps in the Chiltern Hills have been cut by streams, which at one time rose on the central plateau of England and flowed south-eastward as consequent rivers. But little by little the Great Ouse on the one side, and the Thame on the other, have worn away the band of clay which runs from north-east to south-west at the foot of the Chiltern Hills, for the clay was washed away by rain and streams more easily than the limestones beside it. In this way the Great Ouse lengthened its valley south-westward; it diverted into its own valley some of the streams from their original course south-eastward across the Chilterns to the Thames. The Great Ouse—to use the phrase by which this process is known—"beheaded" the Chiltern rivers and "captured" their upper waters. The result, therefore, of this encroachment south-westward of the Great Ouse has been to divert drainage from the Thames valley to the Wash. Meanwhile the Thame was working its way north-eastward and beheading more of the Chiltern streams, and their waters were added to the Upper Thames instead of the Thames below Reading.

At a much earlier date than these changes in the Thames it is probable that the Upper Severn continued farther to the south-east; its present course from Shrewsbury to Tewkesbury passed over the Cotswold Hills, and formed the head waters of the Thames. The Lower Severn wore away the soft rocks at the foot of the Cotswold Hills, and cut its long broad valley from the Bristol Channel past Gloucester to Tewkesbury; and the Avon, on the extension of the same line, cut its wide valley from Tewkesbury to Worcester. The formation of this transverse river, therefore, beheaded the Thames by capturing the Upper Severn. As these rivers, such as the Lower Severn and the Avon, have been developed subsequently to the original river system, they are called *subsequent rivers.* These subsequent rivers flow along planes of weakness or bands of soft rock. Hence subsequent rivers are generally parallel to the grain of a country, while the original consequent rivers generally flow at right angles to the trend of the rocks.

Another important subsequent river in England is the Trent, which has captured the drainage of a series of rivers that once flowed south-eastward from the Peak and southern

Yorkshire into the Fen country; the Trent now collects this drainage and carries it into the Humber. The upper part of the Don probably once flowed down the slope across the present valley of the Trent and united with the upper Witham, and thence passed through the Lincolnshire Wolds by a large gap at Lincoln and continued south-eastward to the Wash.

The rivers of Scotland show similar changes in their former course. The present river systems are the result of a long struggle between the eroding rivers and the resisting rocks. The Tay is, in its upper part, a subsequent river which has grown by the rapid wearing away of the rocks along their line of strike. The Garry was once the main stream, and the Tay was a tributary to it; but as a valley along the grain of a country grows more quickly than one across the grain, the Tay has outgrown its tributary, and is now the main stream. The Clyde now flows from south-east to north-west; but there is clear evidence, from the existence of well-developed wind gaps, as at Whistlefield at the head of the Gare Loch, of an earlier river system which flowed from north-west to south-east; but that system was destroyed so long ago that only scattered fragments of it still remain.

ECONOMIC GEOGRAPHY

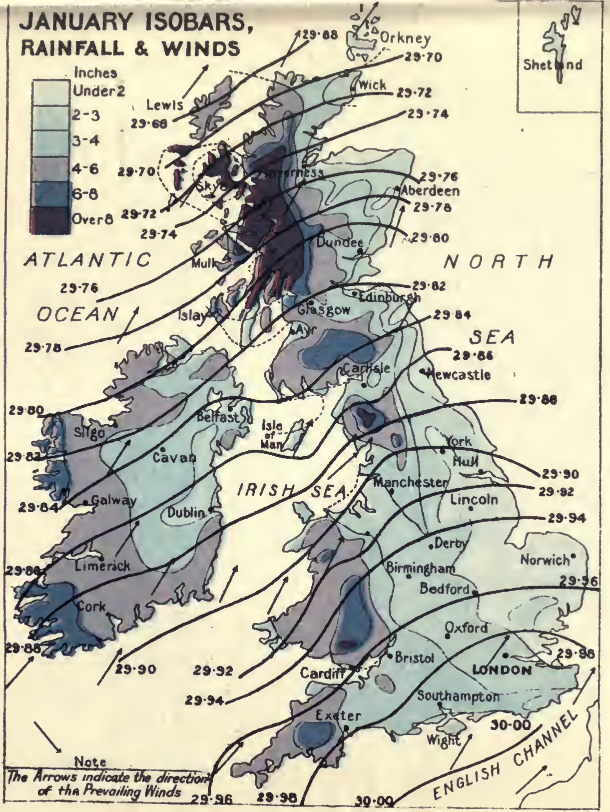
The Climate and Soils.—The distribution of uplands and lowlands in Great Britain is also important, because it controls the economic development of the country. Many geographical factors combine to render the Highlands of Scotland less fertile than the valleys of the south-east of England. This difference does not arise because the Highlands, being farther north, have a colder climate; for a map (Pl. XV) of the distribution of temperature in the British Isles shows, that the north of Scotland has much the same mean annual temperature as London. The isothermal lines, instead of running east and west, owing to the peculiar meteorological position of the British Isles run north and south. But the climate of the Highlands is less favourable for agriculture than that of southern England, because it has much less sunshine; for moist winds constantly blow inland from the Atlantic, and are chilled by being forced to rise over the hills, their moisture is condensed, and the sky is generally thick with clouds. Again, the heavy rainfall keeps the ground wet, and the evaporation of the surface water lowers the temperature and chills the climate. The summer, too, is short as well as cloudy, and the growth of many forms of vegetation is prevented by the length of the winter and the shortness of its days. Moreover, as the Highland rocks are hard, they produce a thinner soil than the softer rocks of the south-east of England, and the constant rain washes the soluble food constituents out of the soil. Thus the soil is poorer than would be produced by the decay of the same rocks in a dry country.

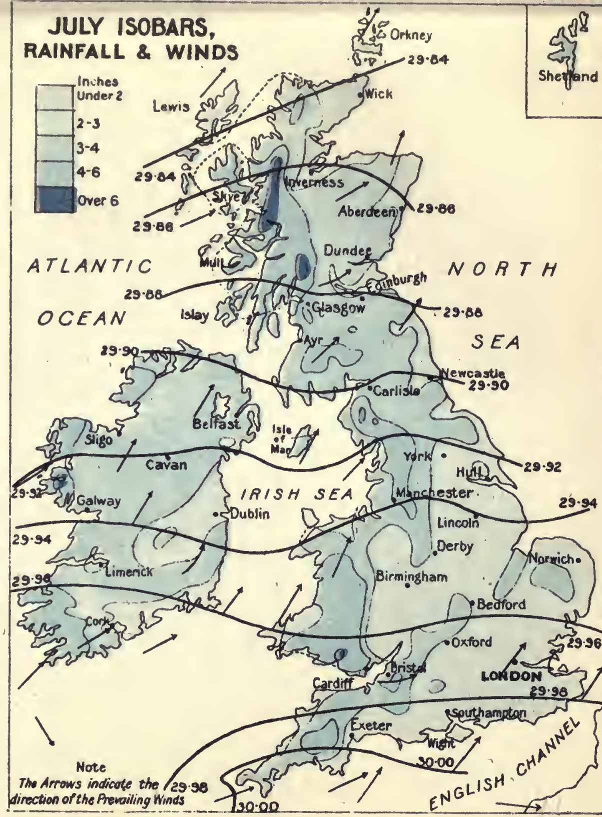
The Scottish Highlands remained uninhabited long after England had been occupied, for the primitive stone implements used by the earliest inhabitants of England have not been found in Scotland.[1] In Roman times Scotland had a considerable population, and the pearls found in the freshwater mussels of the Highland rivers were valued articles of trade. In olden times the easy communication by sea along the Scottish lochs and sounds, the many facilities for defence, the comparative richness of the moors in game, the abundant fish and shell-fish in the sea lochs, and the wide extent of naturally-cleared land suitable for cattle attracted to it a somewhat advanced population; its early inhabitants made elaborate stone buildings, the Pictish towers. But in modern times, owing to the severity of the climate and the poverty of the soil, the Highlands have been unable to maintain their population in face of the competition of parts of the British Isles which can afford modern standards of comfort, and where the conditions of life are easier. In the Highlands useful crops can be grown only in the valleys, while the

[1] Implements of the later stone age (Neolithic) are found in Scotland.


JANUARY ISOTHERMS
Above 40°
38° to 40°
Below 38°
ATLANTIC
OCEAN
NORTH
SEA
IRISH SEA
ENGLISH CHANNEL
Shetland
Orkney
Lewis
Skye
Mull
Islay
Wick
Banff
Inverness
SCOTLAND
Aberdeen
Montrose
Perth
Dundee
Oban
Edinburgh
Glasgow
Berwick
Ayr
Hawick
Dumfries
Newcastle
Sunderland
Carlisle
Kendal
Isle of Man
Londonderry
Belfast
Sligo
Cavan
IRELAND
Galway
Kildare
Dublin
Limerick
Tipperary
Wexford
Cork
York
Hull
Manchester
Liverpool
Lincoln
Chester
Stafford
Derby
Norwich
ENGLAND
WALES
Birmingham
Bedford
Gloucester
Oxford
LONDON
Cardiff
Bristol
Southampton
Brighton
Exeter
Wight
FRANCE
40°
41°
42°
38°
39°
43°
44°


JULY ISOTHERMS
Above 62°
60° to 62°
Below 60°
ATLANTIC
OCEAN
NORTH
SEA
IRISH SEA
ENGLISH CHANNEL
Shetland
Orkney
Lewis
Skye
Mull
Islay
Wick
Banff
Inverness
SCOTLAND
Aberdeen
Montrose
Perth
Dundee
Oban
Edinburgh
Glasgow
Berwick
Ayr
Hawick
Dumfries
Newcastle
Sunderland
Carlisle
Kendal
Isle of Man
Londonderry
Belfast
Sligo
Cavan
IRELAND
Galway
Dublin
Kildare
Limerick
Tipperary
Wexford
Cork
York
Hull
Manchester
Liverpool
Lincoln
Chester
Stafford
Derby
Norwich
ENGLAND
WALES
Birmingham
Bedford
Gloucester
Oxford
LONDON
Cardiff
Bristol
Southampton
Brighton
Exeter
Wight
FRANCE
55°
56°
57°
58°
59°
60°
61°
62°
63°
64°


JANUARY ISOBARS, RAINFALL & WINDS
Inches
Under 2
2-3
3-4
4-6
6-8
Over 8
ATLANTIC OCEAN
NORTH SEA
IRISH SEA
ENGLISH CHANNEL
Shetland
Orkney
Lewis
Wick
Skye
Inverness
Aberdeen
Dundee
Mull
Islay
Edinburgh
Glasgow
Ayr
Carlisle
Newcastle
Belfast
Isle of Man
Sligo
Cavan
Galway
Dublin
Limerick
Cork
York
Hull
Manchester
Lincoln
Derby
Birmingham
Norwich
Bedford
Oxford
Bristol
Cardiff
LONDON
Southampton
Exeter
Wight
29·68
29·70
29·72
29·74
29·76
29·78
29·80
29·82
29·84
29·86
29·88
29·90
29·92
29·94
29·96
29·98
30·00
Note
The Arrows indicate the direction of the Prevailing Winds


JULY ISOBARS, RAINFALL & WINDS
Inches
Under 2
2-3
3-4
4-6
Over 6
ATLANTIC OCEAN
NORTH SEA
IRISH SEA
ENGLISH CHANNEL
Shetland
Orkney
Lewis
Wick
Skye
Inverness
Aberdeen
Dundee
Mull
Islay
Edinburgh
Glasgow
Ayr
Carlisle
Newcastle
Belfast
Isle of Man
Sligo
Cavan
Galway
Dublin
Limerick
Cork
York
Hull
Manchester
Lincoln
Derby
Birmingham
Norwich
Bedford
Oxford
Bristol
Cardiff
LONDON
Southampton
Exeter
Wight
29·84
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29·88
29·90
29·92
29·94
29·96
29·98
30·00
Note
The Arrows indicate the direction of the Prevailing Winds

hills are left as runs for flocks of hardy, black-faced sheep and for deer forests[1]. The depopulation of some districts to make room for deer has helped the natural causes tending to reduce the population, which has declined till the county of Sutherland, in spite of the numerous towns on its eastern coast, has only ten inhabitants to the square mile.

The Archean rocks of the Highlands, moreover, contain no coal, therefore no important industries have yet been developed there, except in the coast towns. The abundant water power may in time be utilized as the source of electric power for manufactures. The hilly nature of the country hinders development, for it is difficult of access; railways and roads are expensive to make; internal communication is slow, and transport costly. There are good fishing-grounds off the coasts, but the markets are remote.

The geographical conditions of the uplands of the Lake District and of Wales are somewhat similar to those of Scotland. The country is very serviceable for sheep farms; but as both areas are smaller, more accessible, and nearer large centres of population than the Highlands, they are more used as places of residence and holiday resorts.

The Pennine uplands are of value, as their limestone soils support a rich growth of turf; and, the climate being drier than that of the Highlands, the sheep produce a better variety of wool.

The uplands have generally remained of secondary economic value, and they are still the most sparsely peopled districts in the British Isles.

THE COAL-FIELDS

The chief manufacturing districts and industrial centres of the British Isles are on the coal-fields, of which the chief are those of the Scottish Midlands, Northumberland and Durham,

[1] The term forest here means an open space or hunting-ground (Lat. *foris*, "out of doors"). They are now open, treeless moors.

South Yorkshire, Derbyshire, Nottinghamshire, Lancashire, South Staffordshire, the smaller fields of the Midlands, and that of South Wales with its off-liers in the Forest of Dean and Bristol. In all these districts, owing to the cheapness of fuel, large manufacturing industries have been established. The rocks associated with coal often contain rich deposits of iron ore and bands of limestone. The ore, the fuel, and the flux often occur together; the conditions were therefore favourable for the development of the iron industry, which still has its chief centres at Sheffield, Newcastle, Glasgow, Middlesbrough, and the Birmingham district.

The South Wales coal-field yields a steam-coal or anthracite which, being smokeless, is of especial value for war-ships, since their presence is not betrayed by black smoke, such as is given off from ordinary bituminous coal. Anthracite is also useful for many industrial purposes, as it gives out more heat than any other coal in proportion to its bulk.

The chief Scottish coal-fields are in Lanark, Ayrshire, and beside the Firth of Forth. The Lanarkshire coal-field was most easily worked, as its coal-seams are thick and near the surface. It therefore developed the most rapidly, and thus Glasgow became the commercial metropolis of Scotland. The extensive coal deposits in Fifeshire, near Edinburgh, and under the Firth of Forth were less obvious and are more difficult to work, so the mines in those fields were opened later.

Ireland had extensive coal-fields which no doubt once covered all the central plain; but the coal-measures have been swept away, except small patches which have been preserved by being faulted down amongst the older rocks, as at Limerick. The Irish coal-fields are comparatively unimportant, so that the development of manufactures in Ireland has taken place only along the eastern coast at places to which coal can be cheaply carried from Britain.

Commerce.—The commercial wealth of the British Isles depends partly on its geographical position and varied structure, but largely on the enterprise of its people. The lowlands of the south and east of England were first occupied owing to their proximity to the Continent, with which England had a direct land connection at the time of its first occupation. In later times, though still at the very dawn of history, the British Isles were visited by Phœnician traders in search of tin. The tin was obtained by mining in Cornwall, and carried across the south-east of England along a track now known as the "Pilgrim's Way". The tin was probably sold at a market in eastern Kent, and thence carried across the Straits of Dover. It was thus in search of one of the products of the older rocks of the West of England that the country was first visited by traders, and this trade developed prehistoric routes across the southern lowlands. The proximity of the south-eastern corner of England to the Continent naturally led to its development before the north and west. South-eastern England developed as an agricultural and pastoral country. It has the advantages of an adequate rainfall, combined with more sunshine than the north or west. It still contains the best orchards and market gardens, and grows the most valuable of British agricultural products, such as hops.

London was founded by the Romans on the site of a pre-Roman fishing village, on a hill which had a fair water-supply and commanded the lowest ford across the Thames. It was accessible by boat from the Continental ports, and formed an admirable centre for the internal administration of England, as easy roads could be made radiating from it to all parts of the country. It is in a good agricultural district, for the soil of the surrounding plains had been fertilized during the glacial period by ground-up limestone, derived from the hills to the north and north-west. Its comparatively large amount of sunshine, and its moderate, yet adequate, rainfall, which in parts of Essex is on an average 21 in. to the year, rendered its agricultural development easy. There were neighbouring forests, which gave an ample supply of fuel and building material. Its natural position gave it such an advantage that Winchester soon ceased to be the administrative capital of England. London has grown into the administrative, distributive, and chief residential centre of the British Empire, and it has gradually drawn into itself most of the trade of the south-east of England. Of recent years, however, the cost of fuel has driven some of its industries, such as shipbuilding, to the north of England and to the Clyde; and the cost of living in so great a centre of population has led to the removal of many factories to the outlying towns, where rates are lower and workmen can find cheap residences close to their work.

The limestone bands that traverse the south-eastern plains of England decay into soils which yield rich crops of grain; this is indicated by the name "corn-brash", given to one of them.

The fine pasture on the downs supported flocks of sheep, whose wool was for long the most valuable of British products. It was exported to Germany, where it was manufactured in hand-looms into cloth, and what England required for her own use was returned in the woollen goods purchased. Wars and civil disturbances drove many Continental artisans to seek refuge in the British Isles. They taught us their arts and industries, and, protected by our insular position from the disastrous effects of Continental wars, our manufacturing industry developed comparatively undisturbed.

The early trade with the Continent produced a series of towns along the southern and eastern coasts, and they were crowded near the Straits of Dover, where the passage to the Continent was short and easy. The old "Cinque Ports" have, however, lost their former commercial importance, and now exist as holiday resorts, as stations for the Continental ferry, or, in the case of Dover, as a military and naval station. Ports which were serviceable to the small vessels of olden times have become useless to modern ships, and the chief British ports have been rendered available for modern trade mainly by the work of man. They have either been deepened, or canalized like the Clyde at Glasgow. A century ago the Clyde at Glasgow was a shallow stream which could be forded at low tide, but it has been so enlarged that it can be used by deep-draught modern ships. The Thames has been deepened and rendered more serviceable by the construction of docks. The entrance to Liverpool is kept open by continual dredging.

The discovery of America introduced another important factor in the distribution of British commercial centres. An important commerce developed with America, and it gave a great advantage to the western ports; for sailing ships saved the delays of beating up the English Channel, and avoided the risks they ran there during war. Accordingly Bristol became an important port, as the Bristol Channel faced directly to the west.

The opening of the coal-fields introduced another fresh factor. British manufactures were begun in districts where there was ample wood for fuel. Thus iron was smelted in the Weald of Sussex from pre-Roman times until the nineteenth century; and in the seventeenth century there were ironworks in the Scottish Highlands till the available forests had been destroyed. Coal was first largely worked in the Northumberland coal-field, and thence distributed by ships; from this came its name of "sea-coal" in London. The increasing dependence of the country on coal gave increased importance to the northern and western districts, where the coal lies near the surface along the edge of the older rocks of the uplands. Coal has now superseded wool as our most valuable commercial product. Our present civilization is a coal civilization, and it has, therefore, been remarked that it would be more appropriate if the wool-sack, on which the Lord Chancellor sits in the House of Lords, were replaced by a coal-sack.

The cheapness of fuel has collected the chief manufacturing industries upon the coal-fields. The British weaving and textile industries had been founded in localities which had water-power near large sheep-raising districts, as on the Yorkshire dales and in the valleys of the Cotswolds. The woollen manufacture was begun in the south-west of England, in the towns of Trowbridge, Frome, Stroud, and the Wiltshire Bradford, where the wool of the Wiltshire downs was made into the famous West of England broad-cloth. The industry was established in this district owing to the rivers giving cheap power to drive the mills, and the presence of a thick bed of Fuller's Earth, which is used in cleaning the wool. Settlements of Flemings and French Huguenots established weaving industries in Spitalfields in the east of London, and at other southern towns, such as Sudbury in Suffolk. Coal, however, gave the northern towns a great advantage in manufacturing, and the great modern wool industry of England has grown up in Yorkshire at Leeds, Bradford, Huddersfield, Halifax, &c., where is woven the wool raised on the plains of Australia, the Cape, and the Argentine; the cotton industry is collected in the coal-fields of South Lancashire, near the ports of Liverpool and Manchester, through which the supplies of cotton are imported from America; and the silk industry is principally on the coal-fields of Nottinghamshire and Macclesfield, in Cheshire.

Birmingham, with the numerous towns grouped around, is the centre of the metal-working industry, and from the smoke of its widely scattered foundries this district is known as the "Black Country". Sheffield, on the South Yorkshire coal-field, early became the centre of the cutlery trade, owing to the proximity of the Millstone Grit, which supplies good grinding-stones; and, owing to the high metallurgical skill required in the preparation of steel for cutlery, Sheffield has during recent years become one of the chief manufactories of armour-plate for war-ships. The chief pottery towns are on the Midland coal-fields, and the factories began in such localities as Stourbridge, where there were good supplies of suitable clay; but for many years this industry has depended upon imported clay. The large brewery town, Burton-on-

Trent, owes its success partly to the various qualities of water that can be obtained by deep wells from different beds in the New Red Sandstones of the Staffordshire plains.

The metallic ores were once an important part of the mineral wealth of the British uplands, for they yielded gold, silver, tin, copper, and lead; but the supplies of these metals are now of secondary importance in comparison with coal and iron. Gold has been found from prehistoric times in some districts of Scotland. Tin has only been found in quantities that pay to mine in Cornwall and Devon. It is there often associated with copper, which is also found in Wales. Lead is somewhat widely distributed, and occurs in veins in the limestones of the Pennine Range, in North Wales, the Mendip Hills, and also in veins in slate amongst the older rocks of Wales and Scotland. The British mines are able to supply only a small proportion of the metallic ores that are required. Tin is the only metal, except iron, of which the British Isles are one of the leading producers. But, owing to the possession of large supplies of easily-worked coal, ores from other countries are largely imported, and smelted and manufactured in Great Britain. It is because of the large supplies of lead, copper, and zinc obtained from Spain, America, and Australia that the metal mines of the British uplands have lost their former importance.

Most of the chief ports of England developed after the opening of the coal-fields. Liverpool, the second port, receives cotton from America, and transmits it to the manufacturing towns on the coal-field of South Lancashire; but Manchester, by its ship canal, now receives some of its cotton directly from America. It was because of the greater extent of the coal-fields behind it that Liverpool easily surpassed the older port of Bristol.

Cardiff, the third English port, was developed still later, and has taken most of the trade of the Bristol Channel, owing to its position as the chief port of the Welsh coal-field. The Tyne port, Newcastle, takes advantage of its position on the Northumberland coal-field to build ships, and manufacture guns and other heavy steel and iron goods. Of the secondary English ports, Southampton has a large share of the South African, West African, and West Indian trade, and takes some of the passenger traffic to America, owing to its proximity to London. Hull is the outlet for the manufacturing towns of Yorkshire, and from its central position on the North Sea is the chief centre of trade with the Baltic and Scandinavia. Swansea is a great metal-smelting town, working the copper ores of Spain.

In Scotland the chief port is Glasgow, which is now the second city of the Empire, with a population of little less than a million. It owes its first foundation to its position on the rich soils of the Clyde valley, and its proximity to the agricultural and pastoral districts of Ayrshire. Its main development followed the opening of the Lanarkshire coal-field, with its thick seams of easily-worked coal, beds of lime-stones and fire-clays, and rich bands of iron ore. The local iron ores have been largely exhausted, but the iron industry is maintained by the import of iron ore from Spain and Algeria. The metallurgical industries required the extensive manufacture of chemicals, and they rendered it possible to found other industries. Glasgow is the seat of the greatest shipbuilding industry of the world.

Edinburgh owes its historic importance as capital of Scotland to its attractive situation, the formerly impregnable position of its castle, its dry, sunny climate, and to its proximity to the Firth of Forth, whence there was easy sea connection with England and the Continent.

Stirling, like Edinburgh, is built under the protection of a strong fortress, and it commanded the road to the Highlands, where the entrance is narrowest between the Firths of Forth and of Clyde.

Aberdeen depends largely on its granite industry, and its manufactures of linen made from Russian flax, and of jute from India. Dundee and Peterhead were the chief Scottish ports from which whaling-ships sailed, but since the decline of the whale fishery Dundee has become dependent on its manufactures, including marmalade, jute, and linen.

Turning to Ireland, Dublin became the capital and administrative centre owing to its position on a good bay, convenient of access by sea from England, and by road from all parts of Ireland. Belfast is now the greatest industrial city in Ireland, and its best-known industries are shipbuilding and the weaving of linen, which are maintained with coal imported by boat from Britain. The position of Cork, with the port of Queenstown, has made it an important port of call for American mail steamers, the British mails being shipped across the Irish Sea from Holyhead to Kingstown, and thence carried overland by railway to Queenstown.

CHAPTER XIII

EUROPE

Europe is geographically the most complex of the continents. It is the western part of the great continent Eurasia, which includes Europe and Asia, and structurally should include northern Morocco, Algeria, and Tunis; for those three countries are European rather than African in the characters of their animals and plants, their structure, and their geographical history. Europe is, however, treated as a separate continent, because of its historic and political importance, for it was the birthplace of modern civilization and of the ruling nations of the world.

Europe consists of two different divisions: eastern Europe, including only Russia, is essentially continental, and is a western extension of Asia; western Europe, on the other hand, is essentially peninsular, and consists of the peninsulas and archipelagoes of the western margin of Eurasia (fig. 74). The axis of the continent is a peninsula, consisting of Germany, Austria, Switzerland, the Netherlands, and France; and this axial peninsula gives off branches on either side. To the south are the secondary peninsulas of Spain, Italy, and the Balkans; to the north are Denmark and the peninsula of Scandinavia, which projects south-westward from the northern

Fig. 74.—The European Peninsulas

corner of Russia. The British Archipelago was also once a secondary peninsula, projecting northward from France.

THE GEOGRAPHICAL SUBDIVISIONS OF EUROPE

The complex structure of western Europe makes it very varied in geographical characters, and its geographical plan can only be understood by reference to the history of its development. Its most conspicuous existing feature is the chain of fold-mountains which traverse it from west to east, including the Pyrenees, the Alps, the Carpathians, the Balkans, and the Caucasus, and, as off-branches from this chain, hanging in loops to the south, are the Sierra Nevada of southern Spain, the Atlas Mountains of northern Africa, the Apennines of Italy, the Dinaric Alps, and the Pindus Mountains of the Balkan Peninsula. This system of fold-mountains includes the highest existing summits in Europe, Mont Blanc in the Alps (15,775 ft.), and Mount Elburz in the Caucasus (18,526 ft.); and it forms the geographical barrier which separates France from Spain, and the countries of the north European plain—Germany and Russia—from the countries along the Mediterranean. The essential features which all parts of the Alpine mountain system have in common are that they are young mountains, and that they have been formed by great folds, due to pressure acting, in the case of the mountain chain, from south to north, and in the basins within the Alpine loops, from the interior of the basin outward.

The variations in the course of the mountains of the Alpine System depend upon the resistance of the older earth-blocks, against which these fold-mountains have been pressed. The old earth-blocks are the remnants of an older mountain system which once extended across Europe from Ireland to western Russia. These older mountains are now recognizable only by their worn-down fragments. Their peaks and ridges have been planed down by denudation, and the old rocks that formed the roots of the mountains are now exposed as irregular uplands. These mountain fragments form the chief European plateaus.

The ancient plateau of north-western Europe has been broken up by the formation of the North Sea and the north-eastern Atlantic. Its fragments form the foundations of the various elements in north-western Europe; one of them forms Scandinavia, which is still connected with Finland and Lapland; detached fragments form the Highlands of Scotland, and the hilly country in the north-west of Ireland. The peninsula of Spain and Portugal is formed in the main of an ancient plateau known as the Meseta, and the geographical nucleus of France is composed of a block of old rocks known as the Central Plateau of France; and in south Germany the old plateaus of the Schwarz Wald or the Black Forest, the Taunus and the Hunsruck, the Harz Mountains and the Ore Mountains (Erzgebirge) of Saxony, are all ancient plateau blocks; and in western Russia the old plateau known as the Russian Platform is of similar structure.

I. The North-Western Highlands

The oldest important element in the geography of Europe is the area of the North-Western Highlands. The study of the British Isles will have served as a useful introduction to the study of the map of Europe, for most of the chief European elements are represented in them. Thus, beginning in the north, the ancient rocks of the Scottish Highlands occur in Scandinavia, Lapland, and Finland; and that Scotland and Scandinavia were once united is indicated by many resemblances in their structure. The geographical grain of Scotland is repeated in Scandinavia. If the grain of a piece of wood extends to the edge, and is there cut off abruptly, it is a safe conclusion that the piece was once larger, or the grain would not have continued unaltered to the edge. It is the same with the geographical grain of a country. If it extends unaltered to the coast, the land must once have extended farther out to sea; and if we find the grain repeated on the same lines in the land beyond the sea, it is probable that the two lands were once connected. There is an example of this fact in the geographical grain of Scotland. Since it is broken across abruptly both on the eastern and western coasts, it is evident that the land once extended farther east and west; and since the grain is continued on the same lines in Ireland, Scotland, and Scandinavia, it is a natural inference that all three countries were once connected, and that they have been severed by the formation of the North Sea and the sea to the west of Scotland. According to some authorities, there is evidence to show that the severance of

Scotland from Scandinavia has taken place since the arrival of man in north-western Europe; so that the Vikings who made piratical raids from Scandinavia upon Britain may have followed in their war-vessels the routes traversed by their ancestors on foot.

But as the Orkney vole or field-mouse is more nearly related to that of Germany and Austria than to that of Scandinavia, the last continental connection of Scotland appears to have been with Central Europe rather than with Norway.

Scandinavia largely consists of a plateau of the greatest geographical antiquity. Its rocks are chiefly composed of crystalline schists, which had been worn down and the material redeposited as sandstones, like those of the Scottish Highlands, at the earliest times known to geology. The Scandinavian plateau no doubt once extended across the Gulf of Bothnia into Finland, and it includes the whole of Lapland. The southern part of Sweden, the province of Scania, is composed of younger rocks, which are not part of the ancient plateau. The plateau is most highly raised on its northern and western edges. It has a steep slope westward to the Atlantic, and a more gradual slope across Sweden to the Baltic. Accordingly the highest mountains, many of which are snow-covered and support large glaciers, rise on the western side of Scandinavia, and the rivers of that side consist of short torrents rushing down to the Atlantic. The Swedish slope is longer, and is crossed by numerous parallel rivers which widen out into lakes; and the wide plains between the rivers afford better agricultural country than there is in Norway. The most striking difference along the coast-lines is the occurrence in Norway of the deep fiords which are the most famous feature of the country. They are deep rifts which run far back into the land. Their walls are steep; their course is very angular; they often divide, reunite, and enclose mountain blocks, which are cut off as islands when the valleys between are flooded by the sea. The country is so high that internal communication is difficult. Farming is possible on the small flats deposited by the rivers at the heads of the fiords, or at the mouths of tributary streams that plunge over the edge of the plateau into the fiord. Hence the dwellers along the Norwegian fiords depend on boats for much of their food and communications. They are fishermen as well as farmers, and are, in proportion to the size of the country, one of the most nautical nations in Europe.

The Swedish coast is also irregular; it is skirted by innumerable small islands, forming the Skargaard; the indentations between these islands have low shores, and are known as fiards. The fiords occur along the fractured western margin of the Scandinavian plateau, where it faces the depression of the Norwegian Deep, which runs along the coast southward from the Arctic Ocean. This depression is deepest at its southern end, in the Skager Rak, where it runs along the same line as the Christiania Fiord and the long valley of Glommendal and the basin of Lake Mjosen; and the structure of the country around Christiania shows evidence of repeated fractures as well as of the volcanic outbursts which have so often accompanied important earth-movements.

II. The European Plain

A second important element in Europe is the European Plain, which is the eastern extension of the eastern plain of England. This plain reappears in the Netherlands, where part of the country is now below sea-level, and is protected from the sea by the lines of dunes and artificial dykes along the Dutch coast. The dune line has been broken through by the sea, and the submerged land behind it forms the Zuyder Zee; the fragments of the broken barrier that once kept out the sea remain as the Frisian Islands (see fig. 53, p. 73). To the east of Holland the European Plain continues across northern Germany, including Denmark, southern Sweden, and the islands of the southern Baltic. The plain widens, on entering Russia, till it occupies nearly the whole width of Russia, and ends to the east at the Ural Mountains. The highest point on this plain is the summit of the Valdai Hills, 1100 ft. above sea-level.

III. The Armorican and Variscan Mountains

The uplands of the south of Ireland and the south-west of England are part of the highlands which once bounded the European Plain to the south and west. They are continued on the mainland by the fragments of an ancient mountain chain which once bounded the European Plain, while its fragments have determined the course of the Alps and of part of the Alpine System. The old hills of South Ireland and Cornwall are the westernmost fragments of this mountain chain. Its highest peaks probably rose in Brittany and La Vendée, and Suess has therefore described it as the *Armorican Mountains.* This chain consisted of fold-mountains, and they were formed by pressure acting from south to north; hence the axes of the folds, and the hills and valleys left by the unequal wearing away of the different bands of rocks, trend from east to west. The northern edge of this mountain line ran across south Ireland approximately along the valley of the Blackwater, across South Wales, and past the northern foot of the Mendip Hills, and under southern England into western Belgium. The southern border was to the south of Brittany, and extended through the Vendée into that mass of old rocks known as the Central Plateau of France.

The Armorican Mountains were formed in the Upper Carboniferous period at about the same time in the earth's history as the deposition of our coal-seams. Almost simultaneously another mountain chain was formed across Central Europe from the Ardennes to southern Silesia. The various fragments of this mountain chain have been named by Professor Suess the *Variscan Mountains.* They include the Ardennes in the south-east of Belgium, the hills of the Eifel, the Westerwald, the Sauerland west of Cassel, the Hochwald, the Hunsruck, and the Taunus. They also include the Vosges Mountains to the west of the Rhine, and the Schwarzwald or Black Forest to the east. Farther north-east they include the Harz Mountains, a mountain mass which projects into the European Plain south of Brunswick. The Harz

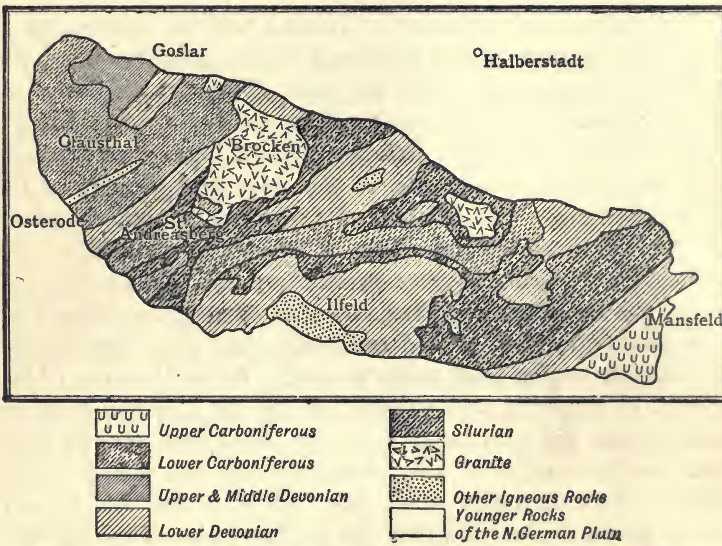


Fig. 75.—The Geographical Grain of the Harz Mountains, showing that the trend is independent of the structure

Mountains well show, by the abruptness with which the grain is cut off to the north-east and south-west, that they were part of a much longer mountain area (fig. 75). To the south-east of the Harz the Variscan Mountains are continued in Saxony and Bohemia by the Ore Mountains or Erzgebirge; they extend westward into Bavaria as the Fichtelgebirge and the mountains of Thuringia. To the east of Saxony the Ore Mountains are continued by the Riesengebirge and the mountain line of the Sudetes.

These Variscan Mountains are fragments of an old mountain chain which extended across Central Europe; its position was to the north of that of the Alps, and both mountain lines followed similar curves. The geographical importance of the Variscan Mountains is due to their influence on the course of the Alpine System.

IV. The Alpine System

The fourth element in the structure of Europe is geographically the most conspicuous at the present day. It consists of the mountains of the Alpine System, which extends across Europe from the Pyrenees on the west to the Caucasus on the east. Their essential characters are stated on p. 129. The part of the Alpine System in Europe contains the main chain, and two branches, which hang in loops to the south. The main chain begins in the west with the Pyrenees, cut off abruptly at their eastern end by the Mediterranean, in the Gulf of Lions. The abrupt termination of the mountains shows that they once extended farther to the east; they were kept to the south of the mouth of the Rhone by the resistance of the massive earth-block, forming the Cevennes and the Central Plateau of France. The Alpine System is next represented by the mountains of Hyères, on the French coast, east of Toulon, which are one link of the chain that connected the Pyrenees and the Alps.

From this locality the Alpine line curves northward, passing the edge of the Central Plateau of France, and, keeping to the east of the Rhone Valley, enters Switzerland. The northern edge of the chain of the Alps is the Jura Mountains and the mountains of northern Switzerland, which are jammed against the old earth-block that forms the Schwarzwald or Black Forest. The southern ranges of the Alps trend in Switzerland from west-south-west to east-north-east; but at their western end they turn more to the south, and, after passing Mont Blanc, run southward as the Graian

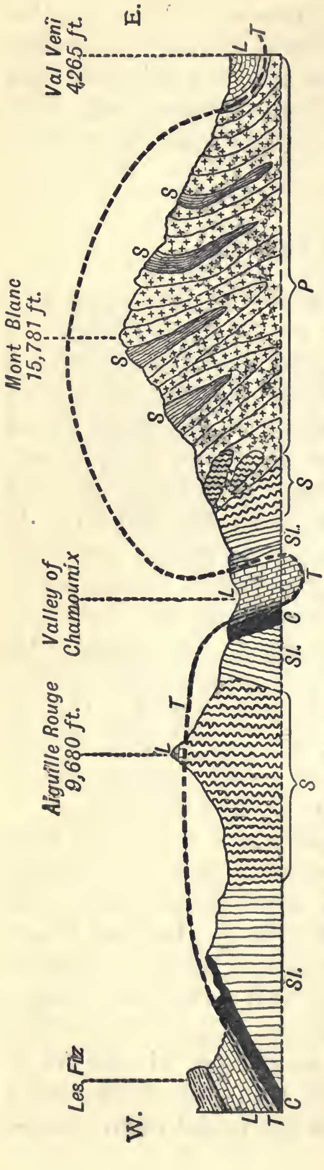


Fig. 76.—A Section across Mont Blanc—a typical Alpine Mountain (after Michel-Levy and Duparc)

L, Limestone (Jurassic); *T*, sandstone (Trias); *C*, Carboniferous; *Sl.*, slate; *S*, schist; *P*, protogine gneiss of Mont Blanc. Mont Blanc consists of a mass of "protogine gneiss", which is a foliated granite; it was covered by an arch of sedimentary rocks, which are seen in trough folds in the valleys on both sides; a patch of the sedimentary rocks, a remnant of a second arch, is seen on the summit of the Aiguille Rouge, on the western side of the Chamounix Valley. The dotted line marking the course of the originally horizontal sheet of the Trias shows the general nature of the folding of the rocks.

and Cottian Alps, and the mountains of Dauphiné, of which the chief summit is Mount Pelvoux (13,460 ft.). The best-defined ranges are those of the Cottian Alps, which form the frontier between Italy and France. At the southern end of the Cottian Alps, the main Alpine line bends round sharply to the east and north-east, and is continued as the Maritime Alps, which pass into the Apennines, the mountain backbone of the Italian Peninsula. The main chain of the Alps continues from Switzerland eastward through the Tyrol and Styria. The northern ranges are forced to the south by the old mountain block of Bohemia; but, having passed this obstacle, the line, still under pressure from the south, was able to extend towards the north. It crosses the Danube near Vienna, and beyond it runs north-eastward along the Little Carpathians, and thus into the great crescentic chain of the Carpathians. These run first to the north-east, between Hungary and Moravia; here the Carpathian folds are thrust forward over the end of the Sudetes, an older mountain line of which the grain meets that of the Carpathians at a high angle. Farther east the Carpathians are forced to bend southward, forming the frontier between

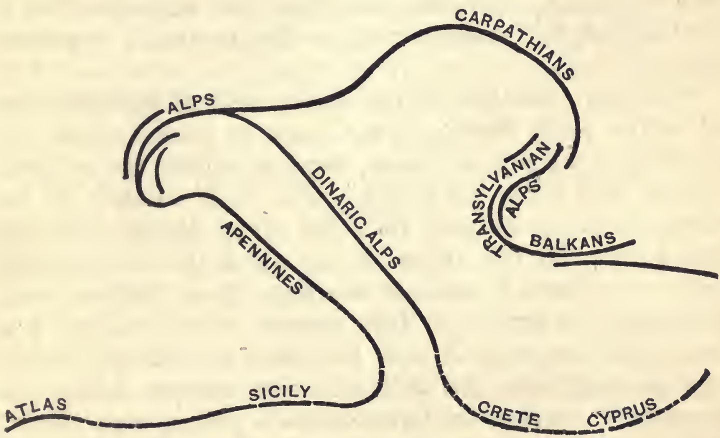


Fig. 77.—Trend Lines of the Carpathians (after Suess, modified)

Galicia and Hungary, owing to the resistance of the block of old rocks forming the Russian platform. They continue as the eastern frontier of Transylvania, where they take a southerly course and then run back westward as the Transylvanian Alps to the Danube. Here they cross the Danube, which has cut through them the narrow gorge called the "Iron Gates of the Danube". They extend in a curve through the Balkan Peninsula as the Balkan Mountains, which end to the east in the Emineh promontory on the Black Sea between Varna and Burgas; here the mountains are truncated by the recent foundering of the Black Sea. At some former period they must have been continued across the north-western part of the Black Sea, as they reappear in the chain of fold-mountains that forms the axis of the Crimea. The mountain line is next broken by the Strait of Kertch, and then reappears finally in Europe as the chain of the Caucasus. The Caucasus has been snapped off at its eastern end by the subsidence which formed the Caspian Sea; and the extremity of the Caucasus forms the Apsheron Peninsula, which projects into the Caspian Sea by the oil-fields of Baku. The same mountain line reappears east of the Caspian, but there belongs to the mountain system of Asia.

From the main line of the Alpine system branches pass off to the south forming great loops or festoons, and surrounding a number of basins, some of which are occupied by seas and some by plains. The most westerly of the mountain loops hanging from the main Alpine chain has been broken up into fragments, of which the most important is the Sierra Nevada in southern Spain (highest peak, Mulahacen, 11,420 ft.). This western mountain loop probably left the main Alpine line to the south of France, and, passing near the Balearic Isles, entered Spain. It crosses the province of Granada on a course from east to west, and then, bending southward, reaches Gibraltar. It once crossed the Straits of Gibraltar, and its line is continued southwards in Africa by the fold-mountains of the Atlas, of which the highest peak, Mount Ayashin, is about 14,150 ft. high. The Atlas Mountains run east and west across Morocco, Algiers, and Tunis, and these districts structurally belong rather to Europe than to Africa. They are separated from the Plateau of the Sahara by a broad valley, the eastern end of which, the Belal-al-Jerid, or "country of date-palms", is below sea-level, and contains some large shallow salt-water lagoons. From Tunis a former continuation of the Atlas crossed the Mediterranean into Sicily, and thus joined the line of the Apennines, whereby this loop is reunited to the Alps.

The second loop from the Alpine System starts from the Tyrol, and runs south-eastward through Carniola and Croatia, and along the Dinaric Alps, down the eastern coasts of the Adriatic, and thence through the Pindus Mountains into Greece. Two of the three prominent southern capes of Greece are due to ridges belonging to this mountain chain. South of Greece this mountain line was bent abruptly eastward, and is represented by the islands of Crete and Cyprus. The line returns northward and enters Asia Minor, it joins the line of the Taurus Mountains, and, crossing the highlands of Mesopotamia, reunites with the main Alpine line in the region of the Caucasus.

V. The Peninsulas and Basins of Southern Europe

Southern Europe may be divided into eight geographical divisions: 1. To the west is the peninsula of Spain and Portugal, which consists of a high ancient plateau, the Meseta, formed in the main of a worn-down fragment of a mountain chain much older than the Alps (being of Carboniferous Age); it ran from Galicia in the north-west of Spain south-eastward till it is broken off by a fracture along the valley of the Guadalquivir. Spain is separated from France by the Pyrenees, an Alpine mountain chain formed by pressure acting from south to north. To the south-east of Spain is the recent fold-mountain chain of the Sierra Nevada, formed probably at the same period as the Pyrenees; and it is simply a recurved fragment of the Atlas Mountains of Africa.

2. The basin of the western Mediterranean is due to the foundering of a block of the earth's crust which had been undermined at the time of the formation of the Alpine mountains. This basin has broken across the grain of the Spanish Peninsula, destroying the former eastern continuations of the Pyrenees and the Sierra Nevada. It also

fractured the western coast of Italy, where part of the Italian plateau, older than the Apennines, which are pressed against it, has been left exposed along the coast.

3. Sardinia and Corsica are fragments of the land of Tyrrhenis, that once occupied the western basin of the Mediterranean. They were formerly connected with Italy. This is shown by the extinct animals which used to inhabit them. They have been isolated by the formation of the Tyrrhenian Sea. It is probably the pressure of the foundered earth-block that excites the volcanic eruptions around it, in Vesuvius, Etna, and the Lipari Islands.

4. The Italian peninsula consists of five main elements. (*a*) The northern mountains between the Swiss frontier and the Po basin, and the western mountains of the Po basin along the French frontier belong to the Alpine System. (*b*) The backbone of the peninsula consists of the Apennines, a chain of fold-mountains; they continue through Calabria into Sicily, and form nearly the whole of that island. (*c*) The country west of the Apennines, from Pisa to south of Naples, is a fragment of the ancient land of Tyrrhenis; other fragments of this land occur in the Isle of Elba, in Calabria, and north-eastern Sicily. (*d*) The peninsula of Otranto and the Adriatic coast as far north as the peninsula of Gargano and Monte Conero, near Ancona, are fragments of the old plateau land of Dalmatia, which once extended across the Adriatic into the Balkan peninsula, and was then separated from Italy by a narrow sea, which ran up from the Gulf of Taranto to the northern Adriatic along the foot of the folded belt of the Apennines. (*e*) The basin of the Po, or Plain of Lombardy, occupies a depression between the Alps and the northern Apennines, and is a landward continuation of the depression the lower part of which is occupied by the Adriatic.

5. The Adriatic Sea is a foundered area like the western basin of the Mediterranean. It has probably sunk in times so geologically recent that the ancestors of the jackals, that

lived till lately on the island of Paçman, off Dalmatia, may have walked there overland; and Dr. Forsyth-Major has recently discovered that the peninsula of Otranto is inhabited by a vole more nearly allied to the voles of the Balkan Peninsula than to those of the rest of Italy.

6. The Balkan peninsula is formed by a southward curve of the main Alpine chain; and the peninsula of Greece owes its chief geographical features to a mountain loop hanging from the Alpine System, of which Crete (with Mount Ida, 8070 ft. high) and Cyprus are detached fragments.

7. The Archipelago of the Ægean Sea consists of the fragments of a land which has been destroyed by the foundering of the area within the Grecian-Cretan mountain loop; its formation is of quite recent date. The formation of its volcanoes, of which Santorin was in eruption in 1866, was probably connected with this subsidence, just as Vesuvius and Etna were connected with the subsidence of Tyrrhenis.

8. The Hungarian basin is surrounded by mountains of the Alpine System; it includes the Carpathians on the north and east, the Transylvanian Alps on the south, and the dependent loop of the Dinaric Alps to the west. Its floor is occupied by a broad plain; the two shallow salt lakes, Balaton and Neusiedler, occupy depressions upon its floor, and on its borders are the remnants of extinct volcanic craters, like those at Chemnitz. The Hungarian basin is therefore geographically homologous to the basin of the western Mediterranean; but the subsidence has been less profound, so the floor of the depression still stands above sea-level.

VI. The European Volcanoes

The earth movements connected with the Alpine folds have produced in Europe two sets of volcanic outbursts (fig. 78). The more recent volcanoes, some of which are still active, are situated along the edges of the foundered basins of the Mediterranean. Vesuvius, Etna, and the Lipari Islands lie around the Tyrrhenian subsidence; Santorin, in the Grecian archipelago, stands beside the foundered area of the Ægean, and the ancient volcanoes of Chemnitz, on the northern border of the foundered Hungarian plain, are homologous to those of southern Italy.

Fig. 78.—Distribution of the European Volcanoes. (The black areas and spots are volcanic.)

The remains of an older chain of volcanoes occur in a line along the northern edge of the Alpine System. The best known of these volcanoes are the seventy extinct craters, or puys, of the Auvergne Mountains in central France, the old craters of the Eifel in north-western Germany, and the numerous extinct volcanoes and the caldrons connected with them in southern Germany.

In the north-western Highlands of Scotland are the remains of a still earlier series of volcanoes forming the hills of Mull and Skye. They were probably caused by the foundering of the North Atlantic, and the still active volcanoes of Iceland also represent this volcanic system.

VII. The European River System

The rivers of Europe have no definite dependence on the Alpine System. It is true that most of the rivers flow either northward or southward from a main divide, which runs along the continent from the north-east to the west or south-west. But this old divide is not the Alpine Chain, and is probably much older than it. In Russia the northward-flowing rivers are the Dvina, which flows into the White Sea, and the Duna and Niemen, which flow into the Baltic. They rise on the northern slopes of the uplands of the old Russian Platform. To the south of the Russian watershed, the Ural River, the Volga, the Don, the Bug, the Dnieper, the Dniester, and the Pruth all flow southward into the Caspian or Black Seas. Both sets of rivers are to the north of the line of the Alpine System.

The main European divide and the Alpine crest happen, however, to coincide at the head of the Vistula; but they soon separate, for the divide runs first north-west along the Sudetes and then south-east along the Heights of Moravia. The River March drains the basin between the Heights of Moravia and the Little Carpathians, and, together with the Danube, carries through the breach in the Alpine line at Pressburg the drainage of large areas in Moravia, Upper and Lower Austria, and Bavaria, which all belong to the north of the Alps.

The Elbe, of which the uppermost tributary is the Moldau, rises on the edge of the Danube valley, and only some 20 miles from the Danube between Passau and Linz. The Rhine rises among the Alps, near the source of the Rhone. It has had a complex history, and it now escapes to the

North Sea through a rift-valley cut across the Variscan Mountains.

The Seine and the Loire both rise on the Central Plateau of France, and it is only the Garonne and the Adour, with some tributaries of the Ebro, which have their watershed on the Pyrenees.

The rivers of Spain and Portugal flow through river-valleys carved by denudation on the surface of the Meseta, and they have generally cut across the grain of the country; but the Guadalquivir, and the Segura, which flows on the same line as the Guadalquivir into the Mediterranean, both run parallel to the Alpine Sierra Nevada, and are both dependent on the fault scarp that forms the southern edge of the Spanish Meseta.

The drainage across Europe southward into the Mediterranean is as independent of the Alpine watershed as that of the northern slope. The Rhone rises in the Alps near the sources of the Rhine, and flows along an inter-Alpine valley into Lake Geneva. After leaving that lake it cuts across the northern fold lines of the Alps to the south of the Jura, and then passes between the Central Plateau of France and the Alpine mountains of Dauphiné. The course of the lower Rhone all lies to the north of the Alpine line, as it reaches the Mediterranean in the gap between the Pyrenees and Hyères (Plate XVI).

The Po lies in the foundered area within the Alpine-Apennine curve.

The Danube shows the most complete independence of the Alps of any European river. It rises to the north of the Alps and cuts twice across the Alpine System. Its sources are on the highlands within the angle between the part of the Rhine valley running from east to west from Lake Constance to Basel, and the part trending north and south from Basel to Frankfort. The Upper Danube has a long course across southern Germany; it cuts through the Alpine line into the basin of Hungary, and then escapes from it by a second gorge through the main Alpine System at the Iron Gates of the Danube; it there enters the basins of Roumania and Bulgaria, and discharges into the Black Sea.

VIII. The Lake System of Europe

The lake system of Europe is in many districts closely connected with the river system, for several of the best known of the European lakes fill the wider and deeper parts of river valleys.

Except where the basins have been re-excavated by ice-action, or where the earth movements have happened so recently that the rivers have not yet had time to fill up the basins so formed, lakes are practically confined to mountainous regions; for the mountains represent the areas of the most recent disturbances, and lakes are an indication that the topography of a country is comparatively young, for few geographical forms are usually so short-lived. The rivers that flow out of lakes are always endeavouring to drain them by cutting away the barriers that uphold them, while the rivers that enter them carry in large quantities of sediments and silts, and are thus continually filling their basins and converting them into alluvial plains.

The European lakes may be divided into the following classes: 1. The expansions of river valleys, which may be due, as in Lake Geneva, to the warping of a river valley by an earth movement, which raises the lower part of the valley and converts the upper part of it into a closed basin.

2. Other lakes caused by the damming up of valleys by various types of embankments; such embankments may be formed from moraines deposited by the melting of a glacier, *e.g.* Lake Como, and Lake Skene and Loch Garry in Scotland; or banks formed across a mountain valley by landslips, as in Lake d'Alleghe; or delta-fans may be built by a river entering a valley from the side, and converting the upper part

of it into a closed basin, *e.g.* the Lauterbrunnen at Interlaken has separated Lake Brienz from Lake Thun by the formation of the alluvial delta on which stands the town of Interlaken (fig. 79). One interesting group of lakes in dammed valleys are those in the loch and fiord basins of Scotland and Norway. They occur along lines of valleys which have probably been first cut out along lines of weakness. In many cases these lochs occupy basins which go down far below sea-level, and as they approach the coast they gradually become

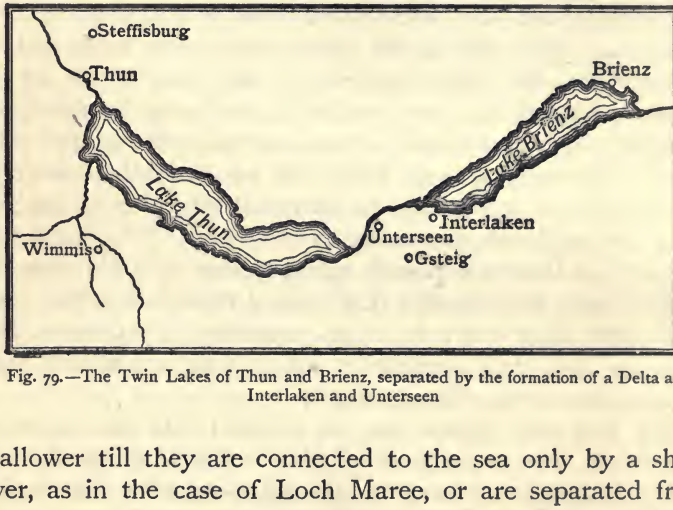


Fig. 79.—The Twin Lakes of Thun and Brienz, separated by the formation of a Delta at Interlaken and Unterseen

shallower till they are connected to the sea only by a short river, as in the case of Loch Maree, or are separated from the sea only by a bar of rocks, as in Loch Etive, or by a shallow strait, as Kyke-Sku, which connects Loch Glencoul and the sea.

3. Lakes filling depressions in plains; they are generally round in form, and often shallow in comparison with their area. Many small lakes of this broad, shallow type are scattered over the north German plain. They occupy depressions amongst the loam hills, and are slowly being filled up by the growth of peat, from moss and other aquatic vegetation. Lake Balaton, in Hungary, with an area of 230

sq. miles, is another example of lakes in depressions; it is on the Hungarian plain, at the elevation of 420 ft. above sea-level, and is nearly cut in two by a hilly peninsula, and its greatest depth is only 147 ft.

The lakes of Europe occur in various groups, where areas have undergone recent geographical changes, as along the course of the young mountain chains, in regions of recent subsidence and powerful glacial activity, along growing shores, and in still incomplete deltas. The Alpine lakes are the most famous in Europe, owing to the beauty of their scenery and to their fine blue colour, due to the minute particles of mica floating in their water. The Alpine lakes include many little tarns and lakelets lying in small rock basins, or in depressions in valleys that have been dammed across by moraines or landslips. Many of the mountain basins which had been regarded as excavated out of solid rock have been proved to be only valleys dammed across by moraine material; the moraines have choked the main valley, so that the water collects till its level reaches one of the notches on the side of the valley, and it escapes by this new outlet over a bar of rock. This explanation of the basins of the British lakes, in the hills of Westmorland and Cumberland, is due to Marr.

The chief Alpine lakes occur in the river valleys, where they have been converted into basins by earth movements; for the great depth of many of these lakes, their floors having sunk even below sea-level, renders it more probable that they have been formed by subsidence rather than by any process of excavation. Thus Lake Geneva occupies the basin in the valley of the Rhone due to an uplift across the Rhone valley, on the line of the Jura Mountains. Lake Geneva, with an area of 220 sq. miles, has a maximum depth of 1015 ft., so that its floor is 215 ft. below sea-level. Lake Constance, the second largest of the Swiss lakes, occurs in a somewhat similar position in the Rhine valley, where it approaches the northern end of the Jura folds. The lakes of the southern valleys of the Alps often sink below sea-level, as is shown by the following table:—

	Area. Square Miles.	Maximum Depth. Feet.	Altitude of Lake Surface above Sea-level.	Depth of Bed below Sea-level. Feet.
Lake Geneva........	220	1015	800	215
Lake Garda.........	142	1135	215	920
Lake Maggiore......	82·7	1230	635	595
Lake Como.........	59⅓	1341	700	641

The three last lakes in this list have old glacial deposits in crescentic lines around their southern ends, and their basins have therefore been attributed to glacial corrosion. But the moraines probably occur on pre-existing rock ridges, and the shape of their basins appears inconsistent with their having been dug out by ice.

The lakes of the highlands of Europe include numerous small lakes in mountain valleys, as in southern Germany, and also the rock basins which give rise to the lochs of Scotland and the fiords of Norway. They lie in deep basins along the floors of valleys; some of them are occupied by fresh water, and some have sunk so far that their rims are below sea-level; hence they have been submerged by the sea, and are known as sea lochs or fiords. The basins of both the fresh-water and salt-water lakes of this series have essentially the same structure. They have been formed on the western and higher side of the ancient table-lands of Scotland and of Scandinavia; and they occur in rifts in the fractured border of a high plateau country. Some of these lochs are of great depth; one of them, Loch Morar, a small lake, only 10⅓ sq. miles in area, with a surface 30 ft. above sea-level, is in one place 1017 ft. deep (fig. 80). These lakes occur in areas of former powerful glacier action, either along or in intimate association with faults. Whatever may have been the final agent in the formation of these basins, the position and shape of the lakes are probably due to the earth movements which fractured the table-land.

The third and most important group of European lakes includes those on the plains; there are three chief varieties.

1. Lakes in rock basins on the plains include the largest lakes in Europe. They are best developed in Finland and in the adjacent districts of Russia. The largest is Lake Ladoga, with an area of 6960 sq. miles; it has an altitude of 16 ft. above sea-level, and a maximum depth of 732 ft., and an average depth of about 300 ft. Lake Onega has an area of 3290 sq. miles. Its surface is 125 ft. above sea-level, and its maximum depth is 407 ft. South of the Gulf of Finland the chief lakes are Lake Peipus and Lake Ilmen; while in Finland there is a complex series of long, narrow, sinuous lakes, which branch repeatedly, and are connected by short rivers and rapids; they cover one-tenth of the whole area of Finland.

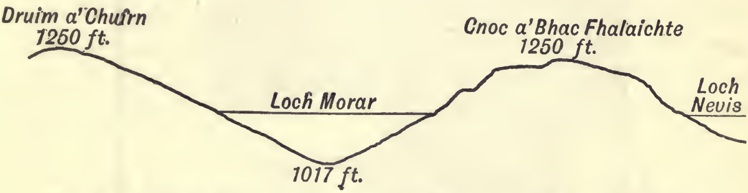


Fig. 80.—Section to Natural Scale across Lake Morar, near Mallaig, in Inverness-shire (after Dr. T. N. Johnston). Only two other lake basins in Europe sink so deeply below sea-level.

Examination of the map of Finland and north-western Russia shows that the lakes are on lines running from north-west to south-east, and that they lie parallel to the lower parts of the Onega and Dvina rivers, and also to the three chief arms of the White Sea. The north-western coast of Lake Onega is broken into numerous bays by ridges also running from north-west to south-east. The lakes occur in valleys which have no doubt been occupied by ice. They are usually surrounded by banks of glacial deposits known as osar, so that they have probably been formed by erosion, and partly by the deposition of glacial embankments.

The lakes of southern Sweden are amongst the largest in Europe, and they lie in the lowest depressions in the lowlands of southern Sweden, which were once covered by an arm of the Baltic. They include Lake Wener, 2410 sq. miles, with its surface 144 ft. above sea-level and a maximum

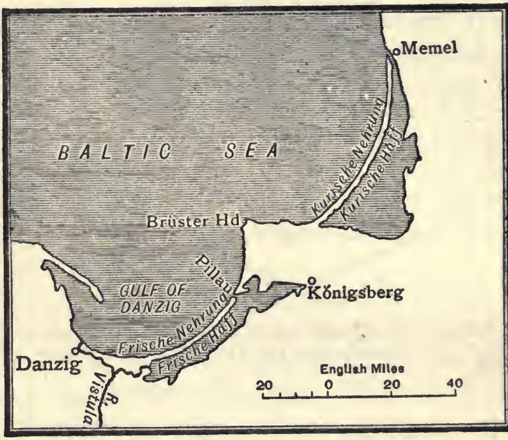


Fig. 81.—The Lakes behind the Storm-beaches of the Baltic

depth of 292 ft.; Lake Wetter, 760 sq. miles and 390 ft. above sea-level, and occupying a basin formed by two parallel fractures; Lake Hjelmar, 185 sq. miles and 60 ft. above sea-level; Lake Malar, 450 sq. miles, and 210 ft. above sea-level.

2. A second variety of lakes on the plains includes those formed along the coast behind storm beaches and sand-dunes. Such are the lakes on the German shore of the Baltic, where each is called a "haff". The largest are the Kurische Haff, at the mouth of the Memel (Niemen); the Frische Haff, the mouth of the Pregel and of one arm of the Vistula, and the Stettner Haff, at the mouth of the Oder (fig. 81).

The depression now filled by the Zuyder Zee was once cut off from the sea by the deposition of moraines and beaches along the line of the Frisian Islands. It has been restored to the sea, which has burst through the formerly continuous barrier and left a few fragments known as the Frisian Islands (fig. 53, p. 73).

3. The lakes of the third group formed on the plains are formed by subsidences. They include the two shallow lakes in depressions on the Hungarian plain — Balaton See and Neusiedler See. Lake Balaton is 230 sq. miles in area, and is less than 150 ft. deep. The Neusiedler See is even more shallow, and in exceptionally dry seasons has been completely empty. Lough Neagh, Ireland, the largest of the British lakes, with an area of 155 sq. miles, an altitude above sea-level of 48 ft., and a maximum depth of 100 ft., has been formed by a volcanic subsidence in the basalt plateau of Antrim. This geological explanation of its origin agrees with the local traditions, as expressed in Moore's poem:

> "On Lough Neagh's bank as the fisherman strays,
> When the clear cold eve 's declining,
> He sees the round towers of other days
> In the wave beneath him shining;
> Thus shall memory often, in dreams sublime,
> Catch a glimpse of the days that are over;
> Thus, sighing, look through the waves of time
> For the long-faded glories they cover".

Subsidences in volcanic regions give rise to another type of lake basin: they are known as volcanic caldrons; they are deep in proportion to their diameter, and are usually more or less round and have steep sides. They are represented in Europe in the Eifel district in Germany and in the volcanic hills near Rome. Lake Avernus, near Naples, is of a different origin, being a lake in an extinct volcanic crater (see fig. 55, p. 80).

THE ECONOMIC RESOURCES OF EUROPE

The economic geography of Europe depends upon its supplies of raw materials, upon the climatic conditions that control the use that can be made of them, and upon the characters of its inhabitants.

The raw material, on which the economic development of a country mainly depends, is the soil. The soils of Europe can be divided into (1) the transported soils due to ice action, which cover most of northern Europe; (2) the transported soils of the great alluvial plains along the chief rivers; and (3) the sedentary soils (due to the weathering of the surface rocks) that cover most of southern Europe to the south of the regions formerly affected by ice.

Nearly the whole of northern Europe—including Ireland, most of Great Britain north of a line from the mouth of the Severn to the mouth of the Thames, and the northern plains of Germany and Russia—was once occupied either by sheets of land ice, or by lakes and sea covered by floating ice. The earth and stones in the ice have been deposited, the finest as sheets of clay, the coarser earthy material as sand, and the stones as gravel; so that most of the northern parts of the British Isles, most of Holland, Denmark, Scandinavia, northern Germany, and northern Russia, are covered by a sheet of transported soil. This sheet is not universal in those districts, for some localities remained free of ice, while in others the ice swept away all the loose soil and decayed rocks formed by the weathering of ages, leaving broad areas of bare, barren rocks exposed upon the surface. The materials removed from these areas have been spread across the plains in a thick mantle of glacial clay with beds of sand and gravel. The glacial clay is generally so dense in its texture that it is heavy to work, and it is so impermeable that the water that falls upon it remains as pools in the hollows upon the surface, until it is slowly removed by evaporation. Thus these clay soils are cold and often water-logged, unless they be drained artificially, and the natural products of these irregular hummocky sheets of glacial clay are mosses, rushes, and various peat-producing plants in the wet hollows, with low forest scrub on the intervening ridges. Under the lee of limestone hills which have been crossed by ice the glacial clays are often rich in limestone debris; from this a soil is formed which, if suitably drained, produces fine crops of grain. In some places the melting of the ice has deposited sheets and hills of coarse sand and gravel, and they have in places been again sifted by the wind, producing areas of sand-dunes. The soils on hills of sand and gravel are too light and too poor in plant foods to give a rich soil; but such hills are frequently covered by forests of pine and fir, which do not need a rich soil.

Some outliers of transported glacial soils, to the south of the main area, occur at the base of the chief mountains, such as the Alps and the Pyrenees; they have been formed by the extension of the glaciers around these mountains.

The alluvial river plains are also occupied by transported soils, which as a rule are richer and more easily worked than soils due to ice action. Sometimes these plains include areas of sandy loams and pebble gravels, which give a dry barren soil; but even these poor soils can often be highly cultivated, since the towns that usually rise along the river plains are rich markets and provide large supplies of stable manure, which enable comparatively poor soils to be used for market gardens.

The sedentary soils of southern Europe are more directly dependent upon the underlying rocks than are those of northern Europe. Good soils, moreover, are more widespread, because the rocks are deeply weathered; and it is only in local areas, where wind is especially powerful and has blown away the loose material, or on steep mountain slopes where the soil is washed down by rain, or on modern lava flows, that there are extensive exposures of bare rock. Sedentary soils, as a rule, are deep, and where the underlying rocks contain many constituents suitable for plant foods such soils are rich; but the decay of some rocks, like pure sandstones, or rocks like granite, which crumbles to sand grains, yield an infertile soil.

The minerals of economic importance in Europe are those used as fuel and those worked for metals, and various non-metallic materials.

The most important mineral fuel is coal; it is mainly found in the north European plain and in the adjacent uplands. The ancient rocks of the Scottish Highlands, of Scandinavia, and of the old mountains of Central Europe were formed earlier than the period of coal formation, while the coal-fields along the Mediterranean have so far proved unimportant. The coals are of two chief kinds, the old, hard, black coals, and the younger, softer, brown coals.

The black coals are mostly found in the rocks of the Carboniferous System, and are widely distributed in the British Isles, occurring in the coal-fields of South Wales, the Forest of Dean, Bristol, the Midlands, South Lancashire, Yorkshire, Northumberland and Durham, the coast of Cumberland, and the Midland Valley of Scotland. Black coal is also mined in various scattered coal-fields in France, in Belgium, and in the Rhenish provinces of Germany. In Russia there are large coal-fields near the Polish frontier, to the south of Moscow, and in the basin of the Donetz in southern Russia. Black coal may again be divided into two principal kinds. (1) The ordinary household bituminous coal, which burns with a bright flame, and produces black smoke and bituminous products; (2) anthracite, which is a hard, bright, glistening coal that burns without flame or smoke, and gives off a very intense heat. Anthracite is more difficult to light, and is not therefore adapted for household purposes, unless used in special grates, but is of value for war-ships and factories in large towns.

Brown coal is of much younger age than black coal, and is softer in character. It is of less value as a fuel, for it usually contains more moisture and more ash, which is the incombustible earthy material in coal. Brown coal is largely mined in southern Germany and in Austria.

The chief oil-field in Europe is at Baku, on the western side of the Caspian, whence the oil is pumped across to the Black Sea and distributed to the rest of Europe by steamers.

The most important metal produced in Europe is iron. The modern iron industry was founded in the British Isles, and the ores used are those mined in the country or imported from Spain, Scandinavia, Greece, &c. The metals first used by man for tools and weapons were probably iron and bronze. Iron was probably the first metal much used, but the articles made of it have been destroyed by rusting away; and the oldest tools that remain are of copper and bronze. The copper was obtained in prehistoric times from the mines of Tarshish, in southern Spain, and of Cyprus. It is still obtained in Europe from many mines in southern Spain, as well as in Wales, Cornwall, the Balkan Peninsula, Italy, and Germany. Owing to the softness of copper, it is of little use as a cutting tool, unless it is hardened into bronze by being alloyed with tin. The tin used for this purpose by the ancient people of the Mediterranean was apparently obtained from mines in Cornwall. There the mines have been worked from prehistoric times. One of them, the Dolcoath Mine, is still one of the greatest tin mines in the world.

The chief European supplies of lead at the present day come from Spain, but the lead mines in the limestone moors of the north of England, in Derbyshire, Wales, and Leadhills in southern Scotland, and those of the Harz and Erzgebirge in Germany, have been historically of the greatest importance. The precious metals gold and silver are prized on account of their ornamental value, their comparative scarcity, and their suitability for use as coins. Europe yields less gold than any other continent, but it was mined by the Romans in Britain and in Servia; and small supplies of gold are still obtained amongst the older rocks of the British Isles, Spain, Scandinavia, and Austro-Hungary. The chief gold-mines in Europe are in the Ural Mountains and in Hungary. Silver is widely distributed through Europe, being generally found in lead ores.

Platinum is found associated with gold in the Urals, and the chief supply is obtained by washing the river gravels of that district.

Amongst the non-metallic minerals, the most important are limestones, building stones, clays, potash salts, which are mined in Germany for use as manures, and rock salt, which is obtained from the salt-mines of Cheshire, Germany, and northern Austria. Amber is a mineral of secondary importance, except from its historic interest; it is a fossil gum derived from the buried forests of the German coast. It was highly prized by the ancients, and the prehistoric trade routes across Europe were established mainly for the amber of north Germany and the tin of Cornwall.

The distribution of the mineral wealth of Europe may be summarized as follows:—

Gold—Older rocks of Urals, Scandinavia, Balkan Peninsula, and British Isles.

Copper, Silver, and Lead—Upland slates and limestones, and older sedimentary rocks.

Coal—Younger British uplands and European plain.

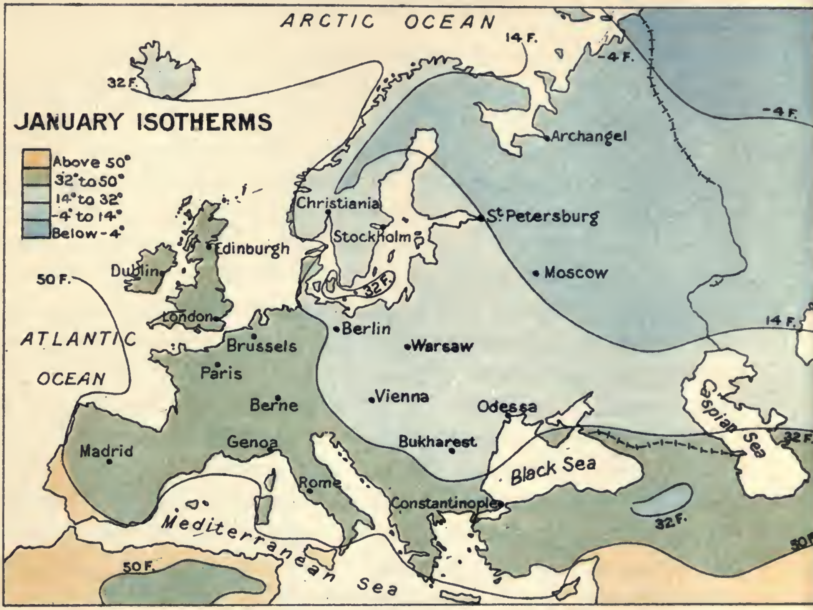
Rock Salt—Rocks of European plain and uplifted beds on northern slopes of the Alps.

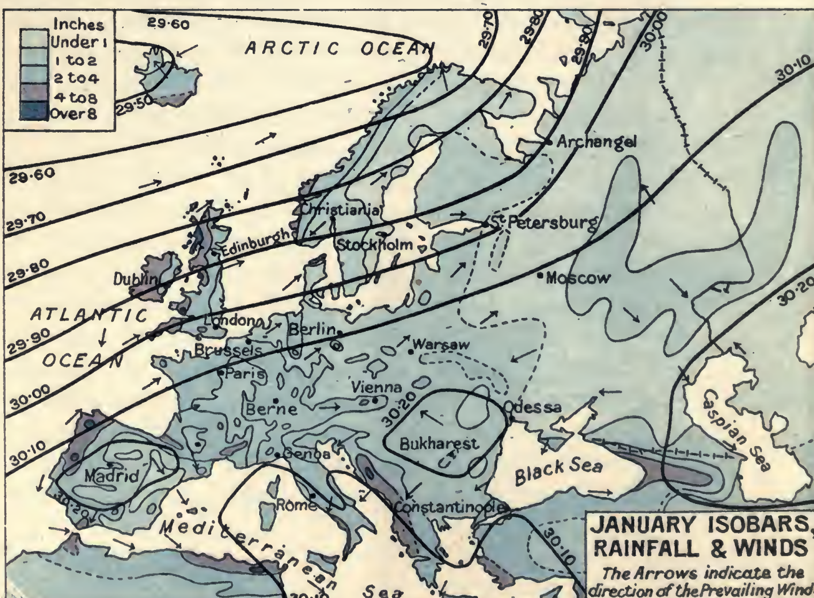
The fisheries of Europe are of importance as a food-supply and for their oil. The European fisheries are the most important in the world, owing to the abundance, in the seas of north-western Europe, of the small plants which serve as the food of fish. The chief fish, the cod and herring, feed and breed upon the shallow banks beneath the North Sea, or frequent the fiords and bays of Norway and the western coasts of the British Isles. Fisheries for pilchards, anchovies, and sardines are carried on somewhat farther to the south, on the coasts of Cornwall and France. The movements of the fish are largely controlled by variations in the temperature of the water and variations in its salinity, which affect the abundance of food; thus the scientific study of the movements and variation of the waters in the European seas promises results of great economic value in the management of European fisheries.

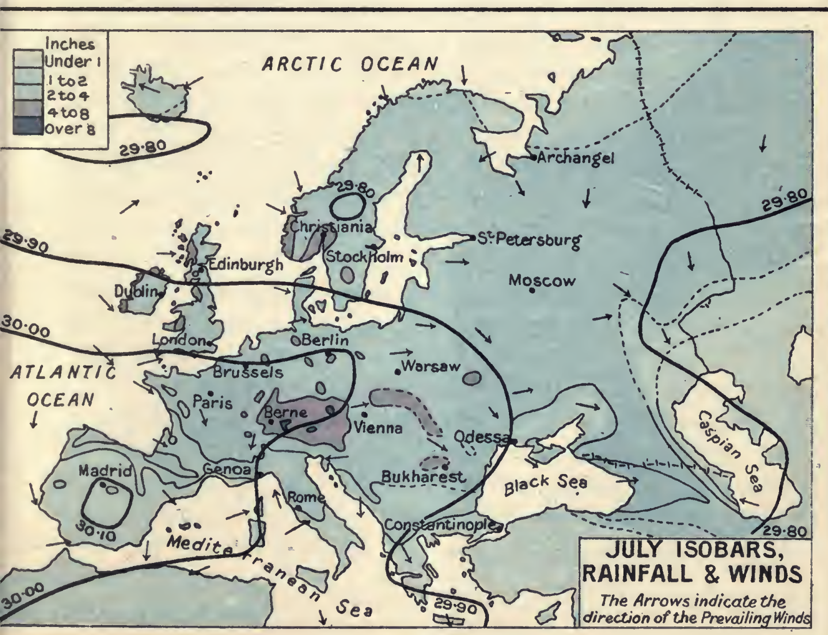
SOME FACTORS THAT CONTROL THE ECONOMIC DEVELOPMENT

Powerful as is the influence of the mineral composition of a soil, the climate which surrounds it is still more powerful in determining the use that can be made of it. The influence of climate on agriculture depends mainly on the rainfall and temperature. The rainfall map of Europe shows that the rainfall is generally heaviest in the west, and gradually diminishes eastward to the Russian steppes. This distribution is determined by the fact that the prevalent winds of Europe blow from the south-west, and they bring from the Atlantic the moisture that falls in rain over Europe; therefore the rainfall is heaviest along the coasts of western Europe, since it is nearest the source of supply. The moisture in the winds is precipitated as rain mainly by the agency of ascending air-currents; they lift the air to colder regions, where the moisture is condensed and falls as rain. When the air blows against mountains, it is driven upward, and thus its moisture is precipitated as snow or rain. Hence the heaviest rainfall in Europe occurs on the mountains near the western coasts. For the same reasons the rainfall is also heavy where there are highlands on the eastern side of any large sheet of water. Thus there is an area of heavy rainfall in the country to the east of the Black Sea, and the rainfall on the western coast of Italy is heavier than on the eastern coast, so there is a marked change in the character of the vegetation on the two sides of the country.

The temperature of Europe naturally diminishes from south to north. The isothermal lines, which pass through places having the same mean annual temperature, tend to run across Europe from east to west; but the lines are by no means regular in their course. For the south-western winds, which blow against Europe from the Atlantic, produce a great gulf of warm temperatures running northward along the coast of Scandinavia. These south-westerly winds give a much warmer temperature to places on the European coast than is enjoyed by those in the same latitude on the coast of America, or farther east in the interior of Europe. Owing to its position on one side of this gulf of warmth, the isothermal line of 40° F. in January crosses Great Britain approximately north and south from Glasgow to Oxford, where it turns round and pursues a more normal course to the east. The influence of these south-western winds, and the equalizing effect of the adjacent ocean, render the variations in temperature between summer and winter far less marked in western Europe than they are in eastern Europe. The plains of southern Russia have a shorter and hotter summer, and a much colder and longer winter, than places in the same latitude in western Europe. Nevertheless, in spite of these abnormal occurrences, the main contrasts of temperature in Europe are between the north and the south. The lands around the Mediterranean have a warmer, sunnier climate than prevails to the north of the Alps; and they raise the most valuable fruits, oil-bearing plants, and vines. Vines also range northward into southern Germany and southern France. Apple orchards and wheat grow best in the southern parts of the British Isles, in northern France, and in Germany. Wheat grows especially in limestone districts or other areas where the soil is rich in lime. Farther north, wheat is replaced by barley and rye, and the forests of oak, elm, and beech, and the groves of walnut and fruit-trees, are succeeded by birch and pine woods. Beyond the Arctic circle the long winter is fatal to the growth of trees; but leafy plants, stimulated by the continuous three months' daylight in the summer, grow with remarkable luxuriance and rapidity.


JANUARY ISOTHERMS
Above 50°
32° to 50°
14° to 32°
-4° to 14°
Below -4°
ARCTIC OCEAN
ATLANTIC OCEAN
Mediterranean Sea
Black Sea
Caspian Sea
32 F.
14 F.
-4 F.
50 F.
Archangel
Christiania
Stockholm
St. Petersburg
Moscow
Edinburgh
Dublin
London
Berlin
Warsaw
Brussels
Paris
Berne
Vienna
Odessa
Bukharest
Madrid
Genoa
Rome
Constantinople


Inches
Under 1
1 to 2
2 to 4
4 to 8
Over 8
ARCTIC OCEAN
ATLANTIC OCEAN
Mediterranean Sea
Black Sea
Caspian Sea
29·50
29·60
29·70
29·80
29·90
30·00
30·10
30·20
Archangel
Christiania
Stockholm
St. Petersburg
Moscow
Edinburgh
Dublin
London
Berlin
Warsaw
Brussels
Paris
Berne
Vienna
Odessa
Bukharest
Madrid
Genoa
Rome
Constantinople
JANUARY ISOBARS, RAINFALL & WINDS
The Arrows indicate the direction of the Prevailing Winds



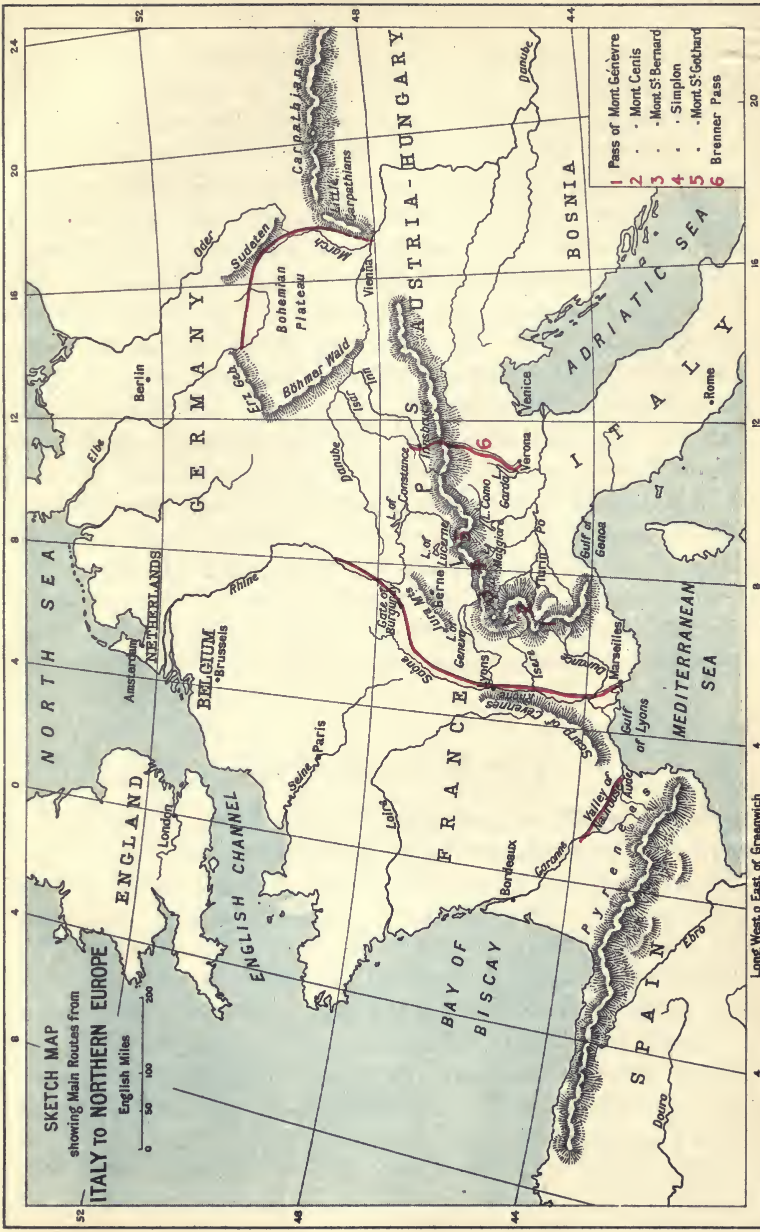
JULY ISOBARS, RAINFALL & WINDS

The Arrows indicate the direction of the Prevailing Winds

The climatic control, therefore, produces the richest European vegetation around the Mediterranean. Agriculture was first developed in those fertile lands, and many of the most valuable agricultural products are still confined to southern Europe. To the north of the Alps stretches the great region of the forests; the climate is cold and wet, so the soils are sodden with water and require to be drained before profitable agriculture is possible. Hence the inhabitants of the rough forests of northern Europe remained as nomads long after the development of the settled civilizations of the Mediterranean. The northern people lived on the wild game of the forests, on the fish of the cool, clear waters, and on their herds of cattle. To the north of the forest zone there are in northern Russia vast barren plains with few trees, except occasional firs, larches, and birches, and wide tracks of marsh and peat-moss, where agriculture is practically impossible. The limestone hills and the bare, turf-clad plains found along the northern edge of the forest zone, as well as on the dry, sandy soil of the Spanish plateau, are unsuitable for agriculture, but adapted for rearing sheep and cattle. Hence the early inhabitants of northern Europe were largely dependent on their flocks and herds for food, and on hides and wool for clothing; while Spain was once the chief sheep district in Europe, as its dry, warm climate was suited to the rearing of herds of merino sheep. Its wool crop, however, is now of less importance, as the quality of the wool has deteriorated, while that of the great herds of Australia has steadily improved. Sheep are the most important economic product on the limestone downs of Britain, of Germany, and of the wide steppes of southern Russia.

Since Europe is divided into three climatic zones, that generally trend east and west, the most important lines of internal communication were those from south to north. The early civilization of Europe developed around the Mediterranean, where the conditions of life were easier and more pleasant than in northern Europe. The beginnings of civilization are believed to have arisen on the rich alluvial plains of Babylon and Egypt, and to have developed in the cities of Asia Minor and of Greece; thence, owing to the easy water communication along the Mediterranean, it spread around its shores in the coast settlements of Italy, Carthage, Marseilles, and Spain. The Phœnicians founded colonial ports, and made settlements at Tarshish for working the copper-mines of southern Spain. The early merchants found their way in search of tin and amber through the Straits of Gibraltar and along the coasts of western Europe to the British Isles, which were first explored by Pytheas of Marseilles. Owing to the length and arduous nature of this voyage, overland trade routes were established from the commercial cities of the Mediterranean, across the mountains of the Alpine System to northern Europe. The most westerly and easiest route from southern to northern Europe is by the valley of Narouse in southern France, as the Alpine System has there been cut through by the formation of the Gulf of Lyons; and the shores of the Mediterranean are geographically therefore on the northern side of the Alpine mountain axis of Europe. The low valley of the Narouse leads easily into the basin of the Garonne, and to the Atlantic port of Bordeaux. A second valley leads from Marseilles up the valley of the Rhone, between the Cevennes Mountains, the scarp of the Central Plateau of France on the west, and the Alpine chains of Dauphiné on the east. From Lyons this route continues north-eastward up the valley of the Saône, at the foot of the north-western flanks of the Jura Mountains; it then leads by a pass known as the Gate of Burgundy to the valley of the Rhine, which gave easy water carriage into the plains of northern Germany and the Netherlands. East of this route the Alps bar the passage from the Mediterranean to northern Europe, and the next easy crossing is that from the plain of Austria, through the valley of the March, into the upper part of the valley of the Elbe of south-eastern Germany.

The Alps, however, in spite of their great height, are crossed


SKETCH MAP
showing Main Routes from
ITALY TO NORTHERN EUROPE
English Miles
0 50 100 200
1 Pass of Mont Genèvre
2 " Mont Cenis
3 " Mont St. Bernard
4 " Simplon
5 " Mont St. Gothard
6 Brenner Pass
NORTH SEA
ENGLAND
London
ENGLISH CHANNEL
BAY OF BISCAY
FRANCE
Paris
Seine
Loire
Bordeaux
Garonne
Lyons
Marseilles
Rhone
Saône
Cevennes
Gulf of Lyons
Valley of Narbonne
Aude
Pyrenees
SPAIN
Ebro
Douro
BELGIUM
Brussels
NETHERLANDS
Amsterdam
Rhine
GERMANY
Berlin
Elbe
Oder
Sudeten
Erz Geb.
Böhmer Wald
Bohemian Plateau
Danube
Isar
Inn
March
Vienna
Carpathians
Little Carpathians
AUSTRIA-HUNGARY
BOSNIA
ALPS
Gate of Burgundy
Jura Mts
Berne
L. of Geneva
L. of Lucerne
L. of Constance
Innsbruck
L. Como
L. Maggiore
L. Garda
Verona
Venice
Turin
Po
Isère
Durance
Gulf of Genoa
ITALY
Rome
ADRIATIC SEA
MEDITERRANEAN SEA
Long. West 0 East of Greenwich

by a series of passes which lead into the rich plain of Lombardy from France or southern Germany. The following are the most important of these passes historically: the Pass of Mount Génèvre—by which Napoleon, possibly following the route of Hannibal, crossed from Dauphiné into the valley of Susa, and thus reached Turin—is a little south of the Mont Cenis Tunnel, the main railway route from France to Italy. The Great Saint Bernard is a mountain pass leading from the valley of the Rhone into the valley of Aosta. The upper Rhone valley is connected with Lake Maggiore, in Italy, by a carriage road over the Simplon (6595 ft.), built by Napoleon between 1800 and 1806; the route is now opened for railway communication by the Simplon Tunnel. Farther east the Pass of the Saint Gothard leads from the Lake of Lucerne into the Italian lakes, and this pass also is now traversed by a railway. The next important pass to the east is the Brenner, which was the main route used by the Romans from Verona, on the Italian side, to southern Germany and western Austria; and this pass continued through the Middle Ages to be the main road across the Alps from Italy to Germany.

THE PEOPLE OF EUROPE

Most of the people of Europe belong to the race known as the Caucasian, whose first home was probably in south-western Asia, whence they early spread along the Mediterranean. The Caucasians are characterized by their long hair, which is either straight or slightly curly; the lips are thin, the nose straight, the forehead high, and the cheek-bones not projecting. The race has two main types, the fair and the dark. The fair variety (the Xanthochroii of Huxley) has light hair and blue eyes, and its most typical representatives live in Scandinavia. The members of the dark variety (the Melanochroii of Huxley) have black hair, a dark or even black skin, and dark eyes. They inhabit southern Europe, northern Africa, Arabia, and India. The black Caucasians of Somaliland in Africa are often inky black in colour, their skins being darker than those of negroes; but they have long hair and the features of Europeans. The mixture of the fair Caucasians and the dark Caucasians produce an intermediate type, often marked by red hair.

The people of the European countries beside the Mediterranean, including Italy, southern France, and Spain, belong to the dark type of the Caucasians. The fair-haired type occurs in Scandinavia and in northern Germany, and constitutes the Anglo-Saxon element in the British people. One off-shoot of the dark-haired section of the Caucasians wandered through Spain and around western Europe into the British Isles. They were the Celts, a race now represented by the Gaels of the Scottish Highlands, the Irish, the Welsh, the Cornish, and the Bretons of Brittany.

The earliest inhabitants of Scotland were pre-Celtic, and belonged to the Iberian race, at the present day represented by the Basques, now confined to a small area in northern Spain, to the south of the Bay of Biscay. Their language is generally recognized as allied to that of the Berbers, the dark Caucasians of North Africa. According to many authorities, the Picts, the early inhabitants of Scotland, some of whom still survive in the Outer Hebrides, belong to this Iberian, pre-Celtic race.

Many of the familiar Scottish place-names are of unknown meaning, and date from the pre-Celtic period—such as Perth, Bute, Arran, Ben Nevis, Lewis, Skye, and Tay; while the name Caithness, the northernmost county of Scotland, is sometimes regarded as a relic of pre-Celtic influence and allied to the Lapp word *Ketje*, meaning an extremity.[1]

The three sections of Caucasians most important in modern Europe are the Teutonic, Latin, and Slav races. The Teutons entered Europe from Asia, crossed Russia, and

[1] The termination *ness* is Norwegian; *Caith* is probably pre-Celtic, but of uncertain origin and meaning.

Fig. 82.—The Distribution of Races in Europe

occupied Germany, Scandinavia, and most of Austria, and have contributed the Anglo-Saxon, Danish, and Norse elements in the British people. The Anglo-Saxons invaded southern and south-western England, where their settlements are recorded in the names Essex or East Saxons, Sussex or South Saxons, and Wessex the West Saxons of Somerset. The Danes settled in the Danebrog of eastern England, and the range of their influence is marked by towns with names ending in "by", such as Derby, Grimsby, Whitby, &c., which are confined to eastern England, except along the coasts reached by the piratical Danes, as Tenby in Pembrokeshire. A name like Danbury, applied to old Danish settlements, is also a reminiscence of Danish invasions.

The Scandinavians settled in north-western Scotland, and the population of the Shetland and Orkney Islands, and of the north-eastern corner of Caithness, including the districts around Thurso and Wick, belong to the Scandinavian race.

The Teutons, though essentially the people of northern Europe, made large settlements in southern Europe, of which the chief is the Lombard settlement of northern Italy.

The Latin races developed in southern Europe, and are best represented in Italy and Spain. The French are also largely of Latin origin, but they are modified by intermixture with the Teutons, such as the Franks of northern France and the Norse settlers in Normandy, and also with the Celtic people of Brittany and the Iberian Basques of south-western France.

The Slavs inhabit most of Russia and parts of the Balkan Peninsula, such as Bulgaria and Servia; while some of the German people, such as the Wends of Prussia, are due to the intermingling of Teuton and Slav.

Teutons, Latin races, Celts, Iberians, and Slavs are all Caucasians, but Europe includes inhabitants of the second primary division of the human race—the Mongols. They are an Asiatic people, who have been driven westward into Europe by the pressure of nomadic tribes from Central Asia. The Mongols are a yellow or dark-skinned people, with long, straight, dark hair, round heads, narrow, almond-shaped eyes, and high cheek-bones. The most familiar representatives of the Mongols are the Chinese and Japanese. The Mongolian race is represented in Europe by three nations—the Hungarians, who have now been Europeanized, perhaps partly by intermarriage with Caucasians; the Turks of the Balkan Peninsula; the Samoyedes and Lapps of northern Russia and Norway. The Finns are an intermixture of Mongolian and Caucasian.

CHAPTER XIV

ASIA

Asia is the largest of the continents. Its area is a little over seventeen million square miles; it contains nearly one-third of the land of the world, and more than half the people. It is closely joined to Europe on the west; but whereas Europe is geographically a dependency of Asia, politically Asia is a dependency of Europe, owing to the stronger character of the European people. The only Asiatic states that are independent of European control are Japan and China; and China, to preserve its independence, has had to grant political concessions to Europe, which it has only given under compulsion.

Asia is confined entirely to the Northern Hemisphere, extending for a width of some 5300 miles from the latitude of 78° 30′ N., at Cape Cheljuskin, to Cape Romania opposite Singapore. Its greatest extension is from east to west, from Cape Baba (long. 26° E.), in Asia Minor, to East Cape (170° W.), on Behring Strait. In structure Asia includes the eastern continuation of Europe and of northern Africa; it consists of four great physical divisions—the northern or Siberian plains, the mountain backbone, the southern valleys, and the southern peninsular plateaus.

1. The northern part of the continent is a broad belt of plains, which extend from the Caspian northward and eastward across Turkestan and Siberia. These plains extend from the foot of the Ural Mountains eastward to the mountains on the eastern boundary of the Lena valley, and from the Arctic Ocean southward across the barren, swampy plains (the Tundra) and the plains of Siberia, till they end against the mountainous region of Central Asia. The plains are widest in western Asia, and there extend farthest south, for they cover 40° of latitude from 76° on the shore of the Arctic Ocean to 36° in Turkestan. The south-western part of the plain contains the Sea of Aral, 158 ft. above the level of the Black Sea, and the Caspian Sea, which is 84 ft. below the level of the Black Sea. These plains are mostly at a comparatively low level, sinking below sea-level near the Caspian, while the higher parts of the Siberian steppes rise to the height of 1700 ft. The plains are largely covered by sheets of alluvium, but in many areas the old rocks beneath are exposed to view, and rise as plateaus above the general level of the steppes. But, on the whole, there is a general slope from the foot of the scarps of Mongolia northward to the Arctic Ocean. The plains consist of two main divisions—the low alluvial plains in the west, and the worn-down base of the northern part of the old continent of Angaraland (see Frontispiece) in the east.

2. The second division of Asia is the great mountain backbone of the continent, and forms the most conspicuous feature in its geography. The youngest of these mountains, like the Alps, were made by folds, and they were formed about the same time as the Alps. The chief elements in this mountain backbone are the Asiatic continuations of the Alpine Mountain System of Europe; but in Eastern Asia the mountains include the fractured table-land of Mongolia, the old plateau of the Yablonoi and Stanovoi Mountains, and the old Manchurian coign, which together form the southern and eastern parts of Angaraland. The course and structure


ASIA
GEOGRAPHICAL DIVISIONS
English Miles
0 200 400 600
Geographical Grain
ATLANTIC OCEAN
ARCTIC OCEAN
Nova Zembla
Timan Mts
Ural Mts
Ural
Obi
SIBERIAN PLAIN
Irtish
L.Balkash
Ili
Thian-
BLACK SEA
Ergeni Hills
Mantych
Caucasus Mts
Pontic Mts
Old Mt. Line
Kur
CASPIAN SEA
Aral Sea
Syr or Jaxartes
MEDITERRANEAN SEA
Taurus Mts
Mt. Ararat
Armenia
Kurdistan Mts
Plains of Mesopotamia
Tigris
Euphrates
Jordan
Dead Sea
Mt. Demavend 18,500
Elburz Mts
Balkans
Oxus
Hissar Ra.
Alai
Kizil-su
PAMIR
Hindu Kush
Paropamisus Mts
Basin of Iran
Basin of Seistan
Sulaiman Mts
Mt. Godwin Austin 28,260
Indus
Sutlej
Persian Gulf
Zagros Mts
PERSIAN LOOP
RED SEA
ARABIAN PLATEAU
PLATEAU
INDO-GANGETIC
PENINSULAR PLATEAU OF INDIA
Western Ghats
REMNANTS OF THE ANCIENT CONTINENT OF GONDWANA-LAND
ARABIAN SEA
Gulf of Aden
Laccadive Is.
Maldive Is.
INDIAN OCEAN
Longitude East
40 50 60 70 80

PLATE XIX


East C.
100
120
140
160
70
60
C. Cheljuskin
New Siberian Islands
Arctic Circle
BEHRING SEA
d r a
Aleutian Is.
Lena
DISSECTED PLATEAU OF YABLONOI AND STANOVOI MTS
Kamchatka Penina.
50
ANCIENT CONTINENT OF ANGARA-LAND
SEA OF OKHOTSK
A N
Kurile Is.
MANCHURIAN COIGN
TUSCARORA DEEP
Angara
Horst of Krasnovarsk
Lake Baikal
Amur
40
Mts
Amphitheatre of Irkutsk
Rift Valleys of Trans Baikal
Yenisei
FRACTURED TABLELAND OF MONGOLIA
Khinghan Mts
SEA OF JAPAN
Altai Mounts
Fuji-yama 12,365
DESERT OF GOBI
Inshan Mts
Mts
Pre-Thian Shan Rift Valley
G of Pe-chi-li
30
Lob Nor
Plateau of Ordos
Yellow Sea
Nan-Shan Ra.
Hoang-Ho
Hoang-Ho
PLATEAU OF THIBET
Tsin-ling Mts
Tapa Shan Mts
Ta-sui-Shan Mts
Fracture line of Eastern Coast of Asia
Lu Chu Is.
Tropic of Cancer
Dhaulagiri 26,820
Mt. Everest 29,000
Yang-tsi-Kiang
CHINESE PLATEAU
Formosa I.
20
Mt. Kanchanjanga 28,173
A MOUNTS
AIN
Ganges
Brahmaputra
Naga Hs
Patkai Hs
Irrawadi
Arakan Yoma
Salwen
R
PHILIPPINE ISLANDS
10
BAY OF BENGAL
Mekong
CHINA SEA
G. of Martaban
Andaman Is.
Gulf of Siam
Nicobar Is.
Malay Penina.
0
A N
Sumatra
enwich
90
110
BORNEO
120
130
C. Romania
J A P A N
PACIFIC OCEAN

of the mountain backbone dominates the whole geography of the continent.

To the south of the mountain backbone lies the third great physical division of Asia. This is a chain of important valleys and basins, by which the fold-mountains to the north are separated from a series of detached plateau lands to the south.

The fold-mountains are the most dominant feature in the geography of Asia. They consist essentially of two chains of fold-mountains, which traverse the continent in a sinuous course from west to east; the two lines are in places widely separated by basins, then they come together in a mountain knot, and separate again around another basin.

The course of these mountain lines is diagrammatically shown on the map of Asia (Pl. XIX). The northern line begins on the west with the Caucasus, which is Asiatic, the true European frontier being along the Manytch valley at its northern foot.

The chief element in the Caucasus is a chain of limestones (mostly Mesozoic), bent into gentle folds like the Jura Mountains; the southern side of the Caucasian folds has been dropped by fractures below the valley of the Kur River; and at the head of this foundered rift valley is a band of Archean rocks, which, like the Ergeni Hills to the north, trend north and south nearly at right angles to the main trend of the Caucasus.

To the south of this Archean ridge and of the Kur valley is the mountain knot or table-land of Armenia, wherein the folded mountain lines of the Taurus from the south, and the Pontic Mountains of the northern side of Asia Minor, are brought close up to the Caucasus. Farther west, the Caucasian and Taurus lines are widely separate; between them lies the southern and deeper part of the Black Sea basin and the lands of Asia Minor. The north-western corner of the Black Sea lies to the north of the former mountain line that once connected the Crimea and the Caucasus with the Balkan Mountains.

To the east of the mountain knot of Armenia and the Caucasus, the mountain backbone of Asia divides into two main branches; to the south there is the mountain loop which surrounds Persia and Afghanistan; the main axis continues directly across northern Persia and northern Afghanistan. The Persian loop consists of four chief mountain chains; it begins on the west with the mountains of Kurdistan. They extend south-eastward from the southern border of Armenia, and form the northern and eastern boundary of the plains of Mesopotamia and the valleys of the Tigris and Euphrates. The mountains of Kurdistan are continued south-eastward as the Zagros Mountains, along the south-western border of the Persian table-land; thence eastward across southern Persia and Baluchistan, where they bend northward again and pass into the Sulaiman Mountains, along the western frontier of India, till they join the Hindu Kush.

The main mountain line of Asia crosses this loop from Armenia and the Caucasus to the Hindu Kush, and thus connects the two ends of the Persian loop. The main axis consists of two lines. The northern line represents the continuation of the Caucasian line, though the Caucasus mountains themselves end abruptly on the western shore of the Caspian, as they have been broken across by the foundering of the Caspian basin. On the eastern side of the Caspian the Caucasus line reappears as the chain of the Great and Little Balkans. The southern branch of the main mountain axis starts from the mountains of northern Armenia, and extends round the southern side of the Caspian Sea as the Elburz Mountains, on which the volcanic pile of Demavend rises to the height of 18,500 ft. above sea-level. These mountains unite with the Kopet Dagh, the continuation of the Great and Little Balkans, and the united chain crosses north-eastern Persia into Afghanistan. It there forms the lofty mountainous highlands of northern Afghanistan, including the Paropamisus to the east of Herat; and farther east it continues as the still loftier Hindu Kush. The name Hindu Kush is said not to be known in the district, and it is generally explained as due to the destruction of a Hindu army by exposure when trying to cross one of the passes into Turkestan. The name appears to have been first used by the Arab traveller Ibn Batuta (who died in 1377); according to him it means "that which kills the Hindus", as many Hindu slaves died in the high, cold passes. The Hindu Kush end in the second mountain knot on the fold-mountains of Asia, the Pamir, or "Roof of the World", which is the greatest mountain knot in the world.

Between the Elburz-Hindu Kush on the north and the mountain loop of Persia and Baluchistan on the south are enclosed the basin of Iran in Persia and the basin of Seistan in Afghanistan. They are both areas of internal drainage, as their rivers have no outlet to the sea, and, as is usual under these conditions, their floors are largely desert, with sheets of salt deposited by the evaporation of the flood-waters.

The width of the Pamir is increased by the junction of two southern lines with a third mountain band from due west. The Caspian depression is continued eastward in the steppes of Turkestan, on the floor of which is the Sea of Aral; this sea receives the drainage of two considerable rivers—the Oxus from the south and south-east, and the Syr (or Jaxartes) from Tashkent on the east.

The Oxus comes from the plains of Bokhara and Merv; these are separated from the Syr basin and Tashkent by a belt of mountainous country which projects into the steppes of Turkestan towards Samarkand, and passes to the east into the mountain knot of the Pamirs. Its chief mountain line is the Hissar range, continued eastward as the Alai Tagh, which is separated from the Pamirs only by the valleys of the Alai, a tributary of the Oxus, and of the Kizil-su, one of the head streams of the Tarim, which lies in the basin of Kashgar. The floor of the Alai valley at its head is over 10,000 ft. above the sea.

From the Pamir knot the mountain system is continued in three main lines to the east. The most important is a broad band of mountainous country which extends south-eastward as the highlands of Tibet; this plateau is itself traversed by mountain lines, and its northern edge is the Kuen-lun chain, which forms the southern boundary of the basin of Kashgar.

The central line of the Pamir is continued south-eastward as the Karakoram Range, of which the highest summit is Mount Godwin Austen, 28,260 ft. (or K_2, to use the symbol by which it was marked on the maps of the Indian surveyors and is well known from its adoption by Sir Martin Conway).

The southern boundary of Tibet is the chain of the Himalaya, which extends in a curve along the boundary between Tibet and India, from the valley of the Indus to that of the Brahmaputra. It is the greatest and highest mountain line in the world; its valley floors are higher than Mont Blanc; amongst its chief summits are Dhaulagiri (26,820 ft.), in the central part of the chain, Mount Everest (29,000 ft.) on the frontier of Nepal, and Kanchanjanga (28,173 ft.), in Sikhim.

The Himalaya end to the east at the Brahmaputra valley, which coincides with another great change in the direction of the Asiatic mountain backbone; for the southern side of the Brahmaputra valley is formed of a series of fold-mountains, including Cretaceous rocks, which trend to the south-west. They have been folded by pressure from south-east to north-west, whereas in the opposite chain of the Himalaya the pressure was exerted from north to south. The southern mountains include the Patkai Hills, and their south-western continuation the Naga Hills. These fold-mountains pass near the Khasi Hills of Assam, which trend east and west, and are only an outlier of the peninsular plateau of India, from which they are separated by the Ganges valley. The Assam Hills end abruptly to the west on the edge of the lowland basin of the Indo-Gangetic Plain. Across the eastern edge of this plain the Brahmaputra escapes from the mountains to the Bay of Bengal. The fold-mountain chain of south-eastern Asia is continued southward across Burmah as the Lushai Hills and the Arakan Yoma, which are still fold-mountains of the same age as the Himalaya; but they were formed by pressure from east to west, which was, moreover, less violent than in the Himalaya. They are bounded to the east by the low valley of the Irrawadi, beyond which is the old plateau land of Siam and south-western China.

The Arakan Mountains are broken across at their southern end by the sudden inbend of the Gulf of Martaban; so that the Archean plateau reaches the Sea of Bengal and forms the Lower Siam and Malay peninsula.

The line of the Arakan Mountains is continued as the broken festoon of the Andaman and Nicobar Islands and along the line of islands to the south-west of Sumatra, the south-western band of which has shared in the folding.

The main mountain chain of eastern Asia therefore passes through western Burmah, and probably beneath the line of the Andaman Islands and Nicobar Islands; it skirts western Sumatra, and thence continues eastward across Malaysia. The two other chief fold-mountain lines of eastern Asia branch from the Himalaya-Burmese line at the mountain knot of the Pamirs; thence the Kuen-lun Mountains proceed due east into Tibet, while the Thian Shan and Sayan Mountains pass to the north-east. Between the Kuen-lun Mountains and the Himalaya is the high plateau basin of Tibet, the floor of which is for a great part between 14,000 and 16,000 ft. above sea-level. The Kuen-lun Mountains have been formed by folds, and to the north of them there is a deep descent to a low-lying region. The western part of this region forms the basin of the Tarim River and Lake Lob Nor, the level of which is only 2200 ft. above the sea. The Tarim basin contracts to the east between the Nan-Shan range, a branch of the Kuen-lun chain to the south, and the eastern end of the Thian Shan chain to the north. The floor of the Tarim basin rises eastward and widens to form the great basin of the Desert of Gobi, most of which is at the level of about 4000 ft. above the sea. The Desert of Gobi is bounded to the east by the fold-mountains forming the Khingan Mountains, which are connected to the Kuen-luns by the Inshan Mountains. The Kuen-luns also continue eastward as the Tsin-ling Mountains into China. The old

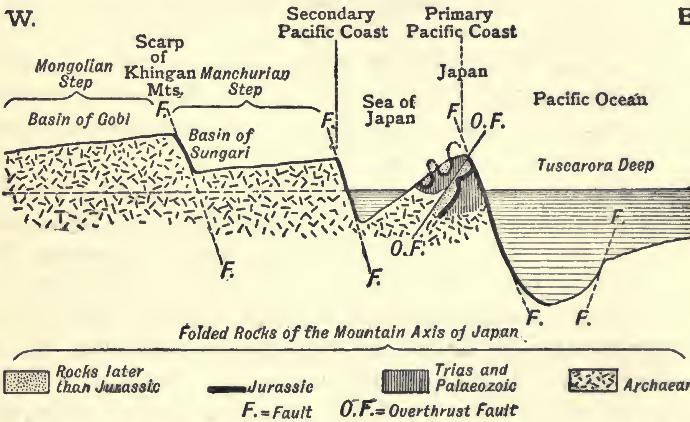


Fig. 83.—Section across Eastern Asia showing the Fold-mountains and Overthrust Faults of the main Pacific Coast in Japan; and the tilted earth-blocks of Manchuria and Mongolia rising in steps to the plateau of Central Asia. The width of Japan is exaggerated in the figure, and the folds shown in the rocks are diagrammatic.

plateau of Ordos, round which the Hoang-Ho passes in a horse-shoe curve 1100 miles in length, lies between the two branches of the folded continuations of the Kuen-lun Mountains. South-eastern China consists of an old plateau, of which the grain runs in general from north-east to south-west. It has been broken up, like all eastern Asia from Manchuria to Siam, into a series of step-like platforms by fractures roughly parallel with the coast, by which the highlands of Mongolia and Tibet descend to the fracture line which forms the Pacific shore.

The northern boundary of the basins of the Tarim and Gobi is geographically more complex than the eastern. It is formed of the fractured plateau of Mongolia, and consists of a vast table-land of old rocks which has been broken up by fractures. Thus on the line of the Thian Shan Mountains, to the north of Lob Nor, is a rift valley, which has been named by Suess the Pre-Thian Shan. This high table-land shows a grain due to old folds, the trend of which is across that of the main mountain line of the continent. The high table-land of Mongolia ends to the north in a steep scarp overlooking the Siberian plains. The edge of the table-land is often irregular, as it varies according to the grain of the country. Its general course is from south-west to north-east, but the mountain ranges on it trend from north-west to south-east, or nearly north and south; they are separated by valleys probably due to denudation. The Thian Shan Mountains are separated, by the valley of the Irtish River, from the parallel ranges of the Altai, which trend from north-east to south-west. Farther east the plateau boundary is formed by the scarp known as the Sayan Mountains, which overlooks the low basin called by Suess the Amphitheatre of Irkutsk. The floor of this amphitheatre is part of the great plains of northern Asia, but it is composed of old rocks belonging to the ancient continent of Angaraland, whereas the plains to the west of the Yenisei are covered with recent alluvium.

Parallel to the fractures which form the south-eastern boundary of the Irkutsk Amphitheatre is the basin of Lake Baikal. The lake is long and narrow, and, like the long African lakes, appears to have been formed in a rift valley.

To the east of Lake Baikal are the highlands on the western part of the Manchurian coign; the mountains which cross it trend in the main from south-west to north-east, and are due to fractures. They meet the Khingan Mountains round the eastern end of the basin of Gobi, and the mountain country continues in the rugged plateau of the Yablonoi and Stanovoi Mountains, which form the north-eastern projection of Asia.

The course of the eastern coast of Asia is determined by numerous subsidences that have broken across the original grain of the country. The land rises from the coast inland in a series of step-like platforms, each bounded on the interior by a scarp (fig. 83). The broken remains of older fold-mountains which trended parallel to the general course of the coast-line may be recognized, but they have only a secondary influence on the geography. Thus in Korea (fig. 84) the fold-mountains run transversely across the peninsula from north-east to south-west, at right angles to its length. The former continuations of the Korean folds have sunk beneath the Yellow Sea and the Sea of Japan, and the long parallel coasts of Korea follow along the fractures between the horst of Korea and the foundered areas now occupied by the sea. The Yellow Sea is partially enclosed by the festoon of islands between Japan and Formosa, and the structure of this island festoon indicates that the sea on the inner

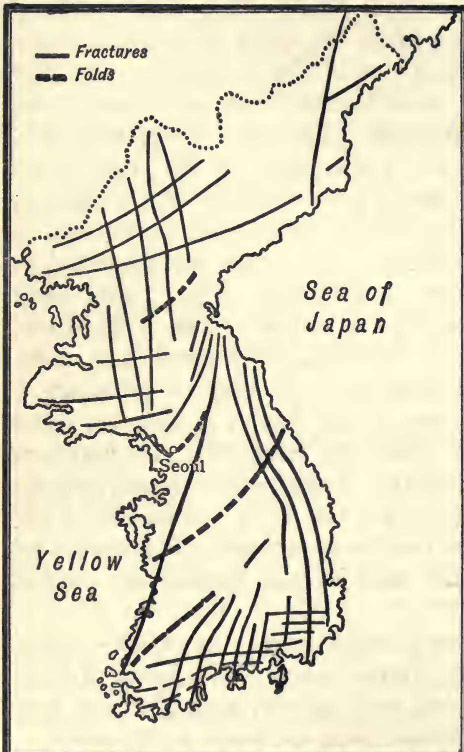


Fig. 84.—The Horst of Korea, traversed by Folds, and its extent determined by Fractures or Faults.

side of the curve was formed by subsidence; for, like the Caribbean chain (p. 239), this island festoon is composed of continental sedimentary rocks on the outer side, facing the Pacific Ocean, and of piles of volcanic rocks on the inner side, facing the foundered area.

The most conspicuous feature of the Pacific coast is the series of island festoons, remains of fold-mountains, which once formed the shore of the Pacific. The festoons hang along the coast from Malaysia to Alaska. Thus, from the main chain of Malaysia the islands of Borneo, the Philippines, and Formosa enclose the Chinese Sea. The festoon of the Liu-Kiu Islands, connecting Formosa and Japan, encloses the Yellow Sea and the Japanese archipelago, and the festoon of the Kurile Isles encloses the Sea of Okhotsk; and the Aleutian Islands, connecting the peninsulas of Kamschatka and Alaska, form the southern boundary of the Behring Sea.

The other islands of Asia are less regular in their arrangement, and are either detached fragments of the continent or have been built by volcanoes. The New Siberian Islands are disconnected fragments of Siberia; Nova Zembla is a continuation into the Arctic Ocean of the Ural Mountains; Ceylon is a detached fragment of the Indian peninsula. The other islands in the Indian Ocean are the chains of the Andaman and the Nicobar Islands, which are volcanic in origin, while the Laccadives and Maldives, to the south-west of India, are a chain of coral islands marking a submerged ridge parallel to the Western Ghats of India.

3. The great mountain region of Asia is bounded to the south by a series of valleys, the continuity of which has been broken by branches of the Indian Ocean having extended northward nearly to the foot of the fold-mountain chains. These valleys begin on the west with the valley of Mesopotamia, the valleys of the Euphrates and Tigris Rivers, and the Persian Gulf. This long valley separates the fold-mountains of Asiatic Turkey, Armenia, and Persia from the high

ancient plateau of Arabia. The Persian Gulf opens into the Arabian Sea, where the Indian Ocean washes the foot of the fold-mountains of Baluchistan. Then the great valley runs north up the valley of the Indus and passes over a low divide into the valley of the Ganges; and thus the low Indo-Gangetic Plain separates the Himalaya from the ancient plateau that forms the peninsular region of India.

4. *The Peninsular Plateaus.*—The fourth chief element in the composition of Asia consists of its southern peninsular plateaus. These plateaus are composed of very old rocks, which appear to have remained above sea-level throughout most of the earth's history, although their margins have been often washed by the sea. The two chief plateaus are those of Arabia and the peninsular part of India. The history and structure of southern India are much better known than those of Arabia; and the Indian evidence shows that these plateaus are fragments of the ancient continent of Gondwanaland, which once extended across the Indian Ocean to Australia on the east and Africa on the west. The fold-mountains of the great mountain backbone of Asia have been diverted in their course by the resistance of these massive earth-blocks.

The volcanoes of Asia occur along the edges of foundered areas. Some occur beside the fractures in the central tableland, but most of them are near the coasts, which follow the great fractures between the oceanic subsidences and the continental blocks. Thus the active volcanoes of Japan and the Kurile Isles are situated opposite the belt of abysmal sea along the western edge of the Tuscarora Deep. The volcanoes of the Andaman Islands occur along a ridge between the foundered areas of the Bay of Bengal and of the Burmese Sea; the extinct craters of Aden were built by eruptions connected with the foundering of the Gulf of Aden; and the volcanoes of the Red Sea occur along the course of the Great Rift Valley. The most famous of Asiatic volcanoes are Fuji-yama, in Japan, notable for its height (12,365 ft.) and its graceful conical form, and Krakatoa, the sudden explosion of which altered the sea-floor of the Straits of Sunda, devastated the adjacent coasts of Java and Sumatra, and, by the distribution of fine dust throughout the atmosphere of the world, caused the pink sunset glows for which the autumn of 1883 was memorable.

THE RIVER SYSTEM

As the continental core of Asia is very old, and the chief fold-mountains are comparatively young, it is not surprising that the rivers which rise on the central highlands are older than the mountain chains upon its southern border. The distribution of the chief southern rivers of Asia is largely independent of the course of the fold-mountains. The main watershed of Asia crosses the continent from east to west, along a more regular course than that of the fold-mountain line of the Caucasus and Himalaya. The chief rivers rise on the central plateau, and some of them cut their way through the mountains on its edge. It has been suggested that the present course of such rivers is due to the head streams having cut their way backward through the mountains and captured the drainage from the plateau behind. The damming up of a river valley will cause a lake that will overflow across the lowest gap on its rim. The rush of the escaping water will soon cut down this gap till the lake is emptied, and thus the rivers that drained into it may be diverted to a new course. It is, however, also possible that those Asiatic rivers which cut through the mountain chains are older than the mountains, and follow the courses that they occupied prior to the elevation of the mountain chains. They may therefore belong to the group of what are known as "antecedent" rivers.

Most of the Asiatic rivers rise on the slopes or in the basins of the central table-land. The three great rivers of northern Asia, the Obi with its tributary the Irtish, the Yenisei and its great head-stream the Angara which passes through Lake Baikal, and the Lena, all flow across the great Asiatic plains to the Arctic Ocean. The chief rivers that discharge into the Pacific are the Amur, the Hoang-Ho, and the Yang-tsi-Kiang. The Amur rises on the plateaus to the south of Lake Baikal. The Hoang-Ho and the Yang-tsi-Kiang both rise on the plateau of Tibet, and flow down its scarped eastern slope to the coast plain. The Hoang-Ho, before the year 1887, discharged into the Yellow Sea to the south of the Shan-tung peninsula. But it then burst through the raised flood-plain which it had slowly built, devastated the country, drowned a million Chinese, and flowed out through a fresh channel into the Gulf of Pe-chi-li, on the northern side of the Shan-tung peninsula.

The southern drainage of Asia includes the Mekong and the Salwen, both of which rise on the Tibetan plateau near the source of the Yang-tsi-Kiang. They flow southward, the Mekong into the Gulf of Siam and the Salwen into the Gulf of Martaban. The Irrawadi of Burmah rises on the inner side of the great Asiatic fold-mountain chain, which is here represented by the Arakan Mountains to the west of the Irrawadi; as the mountains are cut off to the south by the Gulf of Martaban, the Irrawadi discharges into the Indian Ocean instead of to the Pacific.

The two largest of the Indian rivers, the Brahmaputra and the Indus, also rise in Tibet. They first flow parallel to the Himalaya on its northern side, until they cut through it in deep gorges; the Indus and its tributary, the Sutlej, thus reach the Punjab and discharge into the Arabian Sea; the Brahmaputra cuts through the eastern end of the Himalaya, and then, doubling back to the west between Bhotan and Assam, reaches the Bay of Bengal.

The Ganges, the sacred river of India, rises on the southern slopes of the Himalaya; it flows through the low country of the Indo-Gangetic plain, between the Himalaya and the Indian Peninsula, and discharges into the Bay of Bengal, through a delta which it shares with the Brahmaputra. The other chief Indian rivers rise on the peninsular plateau, and flow across it into the Bay of Bengal or into the Arabian Sea.

The Euphrates and Tigris have their sources on the mountains of Armenia, and flow through the valley of Mesopotamia into the Persian Gulf, between the fold-mountains of Armenia and Persia, and the ancient plateau of Arabia. The other chief rivers of Asia—the Ural, which discharges into the Caspian Sea; the Syr Daria and the Oxus, which flow into the Sea of Aral; the Ili, which empties into Lake Balkash; the Tarim, of Turkestan; and the Jordan, which pours into the Dead Sea—all occupy areas of internal drainage.

CLIMATE

The climate of Asia is typically continental; it shows great extremes, not only between its Arctic and tropical regions, but also between winter and summer. Most of the continent is in the temperate zone; there is a comparatively small portion of northern Siberia to the north of the Arctic circle, and the tropical regions include only the southern part of Arabia, the southern peninsular part of India, and the peninsula of Siam and Malaya. Northern India and the Ganges valley are outside the tropics, Calcutta and the mouths of the Ganges being just within them. The whole continent is north of the Equator, the southernmost point, Cape Romania, being about 100 miles distant from it.

Owing to its vast size, the interior of the continent suffers great extremes between its winter and summer temperatures. The coldest inhabited region on the earth is in north-eastern Siberia, where the mean temperature of January is $-60°$ F., or 92° below freezing.

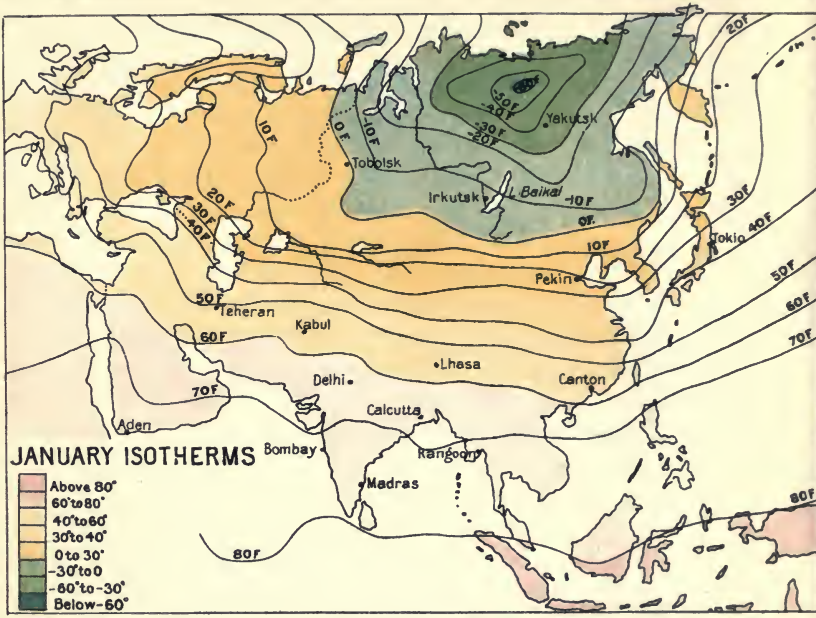
The high elevation of the central table-land of Asia gives it a very cold climate, and lowers the mean temperature of the continent. The eastern coast is warmed by the Kuro

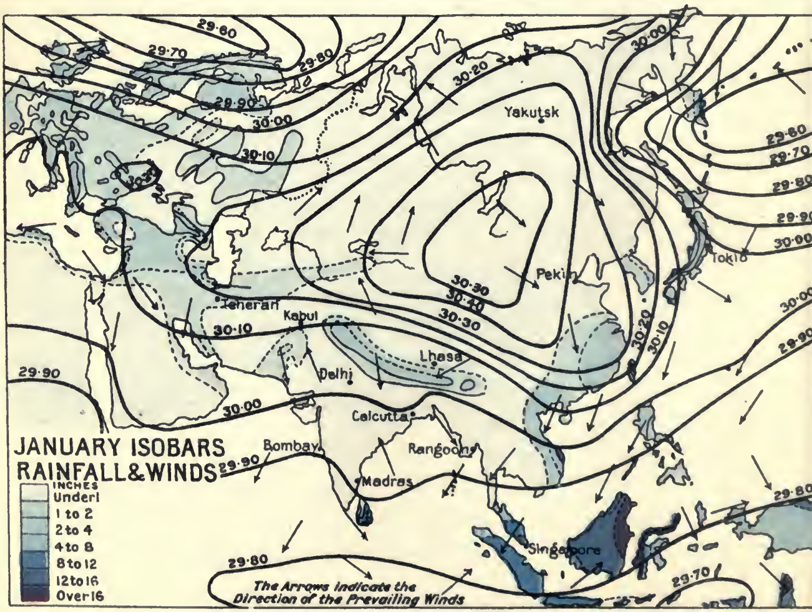
Siwo, a warm current which flows from south to north along the eastern coast of Asia. It is comparable with the Gulf Stream along the American coast, which it far surpasses in volume and length. This current helps to give Japan a mild climate, while opposite localities on the mainland, though only in the latitude of the British Isles, have winters of Arctic severity. The Gulf of Pe-chi-li, in the latitude of southern Italy, is closed to trade in the winter by ice.

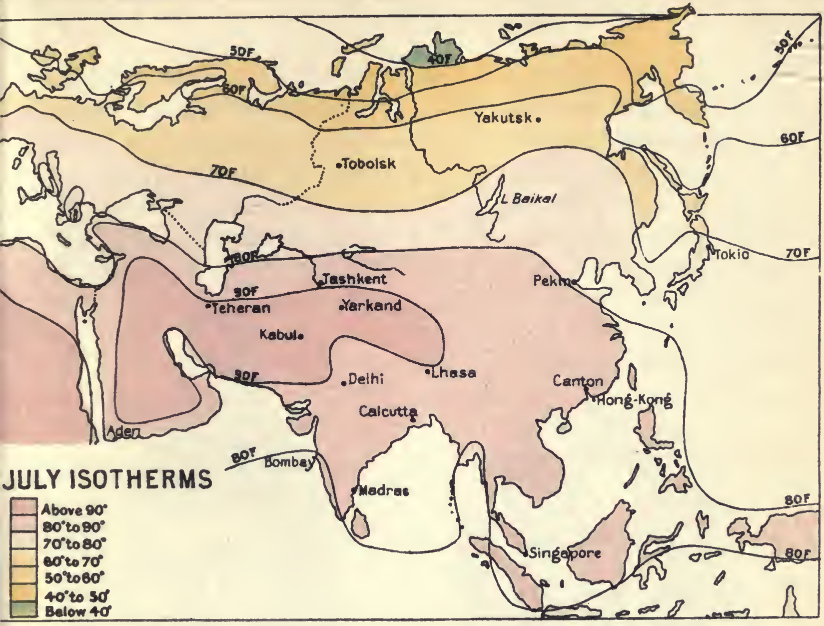
The rainfall in the interior is naturally scanty, as the winds from the oceans drop most of their moisture on the coastal regions, or on the outer slopes of the highlands. The mountains along the Indian Ocean have a heavy rainfall, as the winds which blow inland from the warm sea are charged with moisture, which is chilled by being forced to rise over the mountains. Cherrapunji, in the Khasi Hills, on the south of the Brahmaputra valley, has an average rainfall of 474 in. per year, and 600 in., or 50 ft. of water, have been recorded in a single year. In one day (14th June, 1876) a fall of 40 in. was recorded.

The vegetation of Asia ranges from the rank tropical jungles of India, and the dense teak forests of Burmah, to the barren moss- and lichen-covered swamps of the Arctic steppes. Most of the continent is covered by open plains, and owing to the high elevation of the temperate regions of the continent, it has comparatively little of the dense rank forests which are so wide-spread in Africa and South America.

The wild animals are large and numerous. They include the elephant, tiger, the buffalo, the yak, and the camel. A wild horse lives in Turkestan, and the wild ass roams over the plains from Syria to China. Lions live in Arabia, Persia, and parts of India, and the tiger ranges from India and China northward into Siberia. The mountains and plains of the arid belt have many species of wild sheep, of which the largest is *Ovis poli*, the biggest of living sheep. Antelopes occur in India, and range northwards into Siberia, where they


JANUARY ISOTHERMS
Above 80°
60° to 80°
40° to 60°
30° to 40°
0 to 30°
-30° to 0
-60° to -30°
Below -60°
Yakutsk
Tobolsk
Irkutsk
L. Baikal
Tokio
Pekin
Teheran
Kabul
Lhasa
Delhi
Canton
Calcutta
Aden
Bombay
Rangoon
Madras


JANUARY ISOBARS RAINFALL & WINDS
INCHES
Under 1
1 to 2
2 to 4
4 to 8
8 to 12
12 to 16
Over 16
The Arrows indicate the Direction of the Prevailing Winds
Yakutsk
Pekin
Tokio
Teheran
Kabul
Lhasa
Delhi
Calcutta
Bombay
Rangoon
Madras
Singapore


JULY ISOTHERMS
Above 90°
80° to 90°
70° to 80°
60° to 70°
50° to 60°
40° to 50°
Below 40°
50F
40F
60F
70F
80F
90F
Yakutsk
Tobolsk
L. Baikal
Tokio
Pekin
Tashkent
Teheran
Yarkand
Kabul
Lhasa
Delhi
Canton
Hong-Kong
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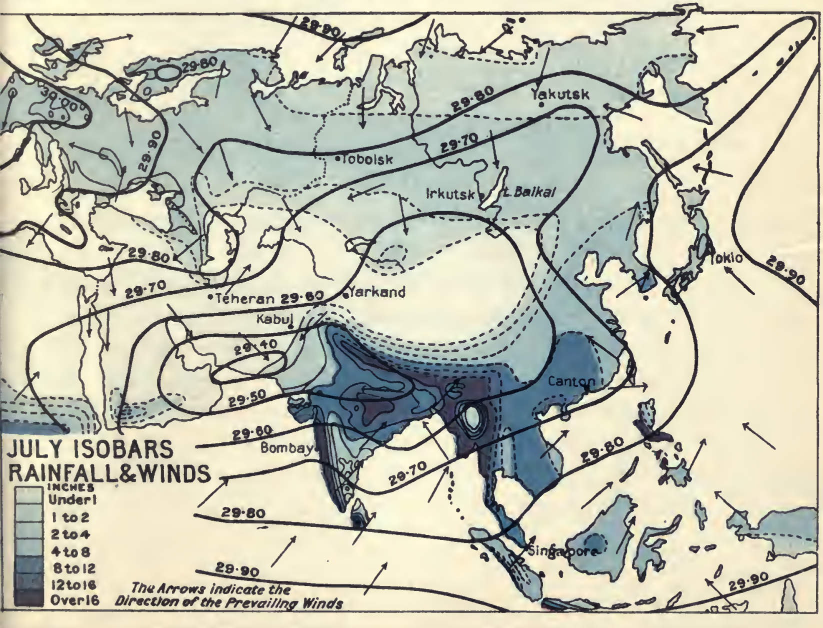
Aden
Bombay
Madras
Singapore


JULY ISOBARS
RAINFALL & WINDS
INCHES
Under 1
1 to 2
2 to 4
4 to 8
8 to 12
12 to 16
Over 16
The Arrows indicate the
Direction of the Prevailing Winds
29·90
29·80
30·00
29·70
29·60
29·50
29·40
Yakutsk
Tobolsk
Irkutsk
L. Baikal
Tokio
Teheran
Yarkand
Kabul
Canton
Bombay
Singapore

are represented by the small Saiga antelope. Siberia yields many fur-bearing animals, as well as reindeer and Samoyede dogs, which are the chief transport animals in the far north.

The inhabitants of Asia belong to three race groups. The Mongolians are most numerous, including the Japanese (fig. 85), Chinese, Burmese, and the Tibetans, and also the Turks and other modified races in western Asia. The Caucasians inhabit India, Persia, and most of south-western Asia. Western Asia was the home of the white Caucasians, who migrated thence to Europe; and the tribes still living in Asia belong to the section of the black Caucasians, represented by the Semitic people of Arabia and Palestine, many of the tribes of India, including the primitive Veddas and Todas, and also the Hairy Ainus of Japan (fig. 86). Along the meeting line of the Caucasian and Mongolian races there are many tribes formed by intermarriage. The third division of Asiatic people are the Negritoes, a small negroid people, who are best represented by the Andaman Islanders and the Negritoes of the forests of the Malay Archipelago.

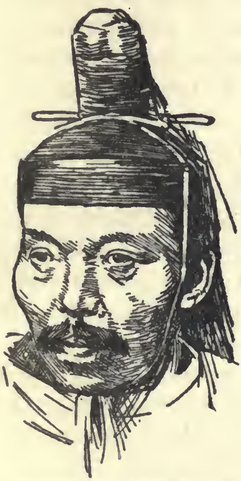


Fig. 85.—Mongolian (Japanese)

Fig. 86.—Ainu. A primitive Caucasian race living in Japan

The Asiatic people have given to the world its four chief religions — Christianity, Mohammedanism, Buddhism, and Brahmanism.

ECONOMIC GEOGRAPHY

Owing to the great size of Asia, its products are varied in kind and vast in quantity. Its primary industries are agricultural and pastoral, but it has great mineral resources, and many of the people have high artistic and manufacturing skill. Thus the wool-weaving of India, the silk-weaving of China, the metal work of Japan, with its bronzes and lacquers, and the pottery of China and Persia are of high excellence; for, owing to the skill of the people, the abundance of labour, and the low wages allowed by the inexpensive standards of life, the artisans are able to devote great individual care to their work. The continent is, however, far behind either Europe or America in the utilization of its great resources.

The characteristic industry of the arid plateaus from Arabia to Tibet is the care of herds of horses, sheep, goats, and camels, and the people are generally nomadic; but the great bulk of the population of Asia are agriculturists, and live on the plains of India and China. The main foods are cereals. Wheat grows as far north as 62°. The typical Asiatic cereal is rice, which is grown in Japan, China, India, and Ceylon. Coffee is native to Arabia, and is now cultivated in other countries as well. Tea came originally from China only, but it is now largely grown also in India (Assam) and Ceylon.

The mineral wealth of Asia is widely distributed, but still imperfectly worked. Gold has been found in India from prehistoric times, and there are large mines now at work in Mysore. Gold is also found in Siberia, Arabia, Burmah, Japan, and Korea. Asia used to be the chief source of the world's supply of gems, including diamonds from India, rubies from Burmah, emeralds, sapphires, and many other kinds from Ceylon. Coal is worked in India and China, where there are great coal-fields.

The development of railways and internal communication is backward except in India, which has a full railway system; while Siberia is crossed by a railway from Russia to Vladivostock and Port Arthur on the Pacific. Transport on the Central Plateau is mostly by droves of camels, yaks, or porters. The rivers are used for traffic in China, Burmah, and India.

CHAPTER XV

AFRICA

Africa is in many respects the simplest of the continents. Its structure and its relations to Europe show the geographical plan of the Old World in its most typical development. The most northern region of Africa consists of the southern end of a loop from the Alpine System of Europe. A great fold-mountain chain enters Africa from Spain at the Straits of Gibraltar, and extends across northern Africa through the northern ranges of the Atlas Mountains. This mountain chain is cut off to the east by the Mediterranean on the coast of Tunisia; but it was formerly continued across the strait between Sicily and Tunisia, and by the fold-mountains of Sicily into the Apennines of Italy. The connection of the Atlas Mountains with the Alpine System of Europe has been broken by the formation of the Straits of Gibraltar and the subsidence of the land, of which Malta is one of the last fragments.

The largest part of Africa offers a striking contrast to the North-African Alpine loop; it consists of a vast plateau land, which has the same relation to the Atlas that the plateau of the Indian Peninsula has to the Himalaya. Moreover, the folded Atlas Mountains are separated from the great African plateau by a broad valley, which corresponds to the Indo-Gangetic Plain between the Himalaya and the plateau of southern India. This valley crosses southern Morocco, southern Algeria, and Tunisia; in places it sinks below the level of the sea, and is occupied by salt marshes and lagoons known as "shotts". The great African plateau agrees with the Indian Peninsula in several respects: they are both composed of rocks of vast antiquity; the old rocks are covered in places by wide, thick sheets of sedimentary and volcanic rocks; but there are no marine sediments or fossils to indicate that the country has ever been covered by the sea. Marine rocks lie against the edges of the plateau in Somaliland, and along the east African coast, as at Mombasa; also around Cape Colony and along the western coast, as in Angola. The sea once covered part of the basins of the Niger and Lake Chad, an arm of the ancient Mediterranean having extended southward around the northern edge of the Sahara. This girdle of marine rocks on the flanks of the African plateau only emphasizes the complete absence of marine deposits from the surface of the plateau itself. The sedimentary rocks that occur on it have been formed on land, or in rivers, or in great lakes; and these continental sediments have been found in so many localities of central Africa that if marine beds existed there they would no doubt have been already discovered. The Equatorial plateau was probably once connected with the Indian Peninsula by a land which occupied the northern part of the Indian Ocean. Madagascar and the old rocks which form the Seychelles Islands are fragments of this ancient continent. Its foundering formed the Indian Ocean. It is sometimes known as "Lemuria", for it was the home of the lemurs; but it is better known as Gondwanaland, the name given it by Suess, from the thick series of fresh-water and land deposits, in southern India, called the Gondwana beds.

The region of the Atlas Mountains is intimately connected with Europe in structure, and by the nature of its animals and plants. So many European plants and animals live in Morocco, Algeria, and Tunisia that these states are included

EUROPE
ASIA
NORTH ATLANTIC OCEAN
MEDITERRANEAN SEA
BLACK SEA
CASPIAN SEA
Persian Gulf
Cyprus
Malta
Gulf of Gabes
Strait of Gibraltar
C. Ceuta
Riff Coast
Oran
Beni Hassan Hills
Shotts of Shergioi
Shott Jerid
6t. Atlas Mts. 6570
ALPINE FOLD MTS. OF ATLAS REGION
Anti Atlas
Tizi-n-Tamjurt
14500
Wargla
C. Ghir
C. Nun
C. Juby
Canary Islands
Wady Draa
IGIDI SAND DUNES
Tademayt Plateau
Tasali Plateau
SAHARA OR GREAT DESERT
THE AFRICAN SUDAN
Alexandria
CAIRO
Nile
RED SEA
Tropic of Cancer
1st Cat.
Aswan
2nd Cat.
Nubian Desert
Dongola
3rd Cat.
4th Cat.
5th Cat.
6th Cat.
Berber
Atbara
Khartum
Tibesti Mts.
Timbuctoo
C. Verde
Niger
Sokoto
Bussa
Benue
L. Chad
Darfur Plateau
BASIN OF BAHR-EL-GHAZAL
L. No
Ghazal
Sobat
Ras Detchen
VOLCANIC PLATEAU OF ABYSSINIA
GREAT RIFT V
Gulf of Aden
Eastern Horn of Africa


AFRICA
GEOGRAPHICAL DIVISIONS
English Miles
0 200 400 600
Rift Valley
Uplands
Lowlands
Basins
Highlands
Volcanic Plateaux
GULF OF GUINEA
Equator
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
Tropic of Capricorn
MIDDLE CONGO
PLATEAU
MADAGASCAR
Mozambique Chan.
EAST AFRICA COAST PLAIN
MOZAMBIQUE COAST PLAIN
TANGANYIKA-NILE-RIFT-VALLEY
VOLCANIC PLATEAU OF EAST AFRICA
Kamerun Mt. 14,000
Stanley Pool
Stanley Falls
Congo
Ruwenzori Mt.
Albert Nyanza
Albert Edward Nyanza
Victoria Nyanza
Mt. Elgon
Mt. Kenya
L. Baringo
L. Rudolf
Mt. Kilima Njaro
Mombasa
Zanzibar I.
L. Tanganyika
L. Rukwa
L. Nyasa
L. Bangweulu
Rovuma
Kebrabasa Rpe.
Lower Zambezi
Middle Zambezi
Upper Zambezi
Mashonaland
Matabeleland Plateau
Victoria Falls
Kwando
Makarikari Salt Pans
L. Ngami
Limpopo
Delagoa B.
Durban
Drakensberg
Basutoland
Pretoria
Vaal
Orange
KARROO BASIN
FOLD MOUNTAINS OF CAPE COLONY
Port Elizabeth
CAPE TOWN
Cape of Good Hope
Kalahari Desert
Damaraland Plateau
Afrikander Mts.
Walfish B.
Cubango
Cunene
Mt. Lovili and Bihe Plateau
Serra de Chella
Benguela
Mossamedes
0 Longitude East of 10 Greenwich

in the same biological division of the world as Europe. None of the animals characteristic of Africa, such as the giraffe, rhinoceros, or elephant, now extends farther north than the valley separating the Atlas folds from the Ethiopian plateau.

The former northern extension of Africa, however, is indicated by the animals whose bones have been found in the caves of Malta, including pygmy elephants and pygmy hippopotami; they are typical members of the Ethiopian fauna, and their ancestors must have wandered northward when Africa extended across part of the site of the Mediterranean. These animals were cut off from the African continent by the foundering of the land which once connected the Atlas with the Apennines, and they gradually dwindled in size owing to the restriction in their range and food-supply. The bigger elephants required more food and more room for wandering, and so were at a disadvantage in the struggle for existence in the overcrowded island, while the smaller elephants were better suited to the changed conditions; and as successive founderings further reduced the area of the Maltese islands, the animals became smaller and smaller, until at last the elephants were no bigger than Newfoundland dogs. Further evidence of the former extension of Africa to the north is given by the presence of extinct African animals, discovered by Forsyth Major in Samos and by Miss Bates in the caves of Cyprus.

The Atlas Mountains are named from the Berber word "adrar", a mountain, and they consist of a series of ranges separated by basins and crossing Morocco, Algeria, and Tunisia. The main chain begins on the Atlantic shore at Cape Ghir and Cape Nun, and extends thence inland in parallel mountain lines, of which the main chain, the Great Atlas, passes a little to the south of the town of Morocco. Its highest peak, Tizi-n-Tamjurt, is estimated at 14,500 ft. in height; its summit and all the highest peaks along the main ridge are above the level of perpetual snow. To the south of the Great Atlas is the range known as the Anti-Atlas, varying from 5000 to 10,000 ft. above sea-level. The two

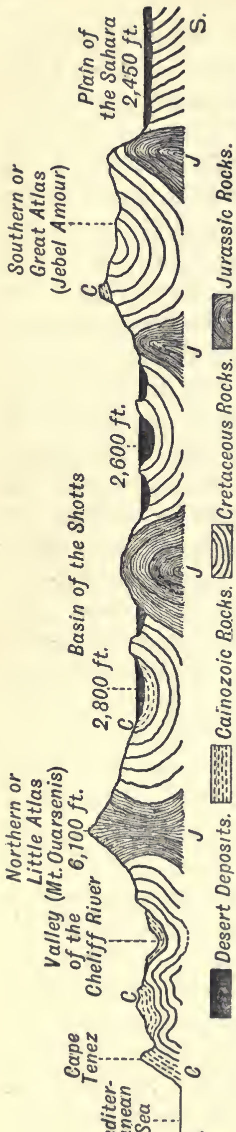


Fig. 87.—Structural Section across the Atlas Mountains in Algeria to the east of Oran; through the fan-shaped fold-mountain of Mount Ouarsenis, the Basin of the Shotts, and the folded chain of Jebel Amour, to plains north of the Sahara.

chains are cut off abruptly to the west by the Atlantic, which cuts obliquely across the geographical grain of southern Morocco. The foundation of the Canary Islands, which occur in line with the extension of the line of the Great Atlas, may be part of the former continuation of those mountains southwestward into the Atlantic.

Eastward the Atlas Mountains enter Algeria. They form the southern boundary of the province of Oran, they cross the province of Constantine, and finally pass out to sea on the coast of Tunisia between Cape Bon and Cape Africa. Most of the Atlas consists of gently-folded sheets of limestone (fig. 87) which were crumpled into mountains at the same time as the formation of the Alps, and, like the Alps, the Atlas Mountains contain masses of very ancient Archean rocks, which are best developed in the Great Atlas in Morocco.

The northern ranges of the Atlas are a continuation of the Sierra Nevada of Spain, and are in part built of ancient rocks. This line enters Morocco on the southern side of the Straits of Gibraltar, forming the cliffs of Cape Ceuta and the mountains of the Riff coast, which attain their highest point in the Beni Hassan Hills, 6570 ft.

in height. Farther to the south this line turns to the east, takes a course parallel to the Great Atlas, and forms the foundation of northern Algeria. Morocco and Algeria also contain a series of volcanic hills along the coast, where eruptions have occurred along the fractures connected with the sinking of the Mediterranean. From the shore the land rises in a series of terraces across the northern mountain ranges, then falls to a chain of depressions, of which the chief is the basin of Oran. They are basins of internal drainage, and on their floors, about 3800 ft. above sea-level, are sheets of barren sand and some salt lakes, such as the Shotts of Gharbi and Shergioi. These basins are closed to the south by the main line of the Atlas.

The mountain range of the Atlas is cut off to the south by a long depression. This depression begins in the valley of the Wadi Draa, which enters Morocco from the Atlantic between Cape Juby and Cape Nun. It widens out in southern Algeria into the plain at the foot of the Atlas at Wargla, continues through the Shotts of Tunisia, such as Shott Jerid, and passes into the Mediterranean at the Gulf of Gabes. This valley is bounded to the north by the mountain group of the Atlas and to the south by the plateaus on the northern edge of the Sahara, of which the best known are the plateaus of Tademayt and Tingher.

The African plateau is the principal feature of the African continent. It extends from the Sahara on the north to Cape Colony on the south, from Somaliland on the east to the Atlantic shores of Guinea on the west. It is the home of the typical African big game—the giraffe, the African elephant, the two-horned rhinoceros, the hippopotamus, the zebra, the eland, the kudu, the gnu, and many kinds of antelopes. It is also the land of the African negro. It includes the course of the Congo, the sources and most of the basin of the Nile, and it is the land which for so many centuries held the attractive mystery of its unknown interior and the pathos and the tragedy of African life.

In structure, Africa, excluding the Atlas region, is essentially a vast plateau left isolated by the sinking of the regions beneath the Atlantic and Indian Oceans. The surface of the plateau has been broken up by the sinking of its various parts, and by the denuding action of rivers. It has no modern fold-mountains, except those pressed against its borders in Cape Colony.

The African plateau is best developed south of the Equator, where a vast plateau, over 3000 ft. in height, extends from the Atlantic coastal plain to that of the Indian Ocean, and is interrupted only by the low-lying basin of the middle Congo and the floors of the deeper river valleys. The Atlantic coast plain in Angola is narrow, with an average width of about 50 miles; south of Mossamedes it is less, the foot-hills of the plateau being only 15 miles back from the coast, and the rapids on the Cunene River only 10 miles from its mouth. The coastal plain ends inland at the foot of a series of scarps, each of which is the front of a terrace, and thus the land rises step by step to the Bihé Plateau. The scarps are often ragged, rivers having cut their gorges backward into the plateau; so, when seen from the lowlands in front of them, the edges of each step appear jagged, like the crest of a mountain ridge. One of the best known of the scarps in Angola is situated 60 miles east of Mossamedes; it is named the Sierra de Chella, owing to its serrated aspect. Some of its peaks rise over 6000 feet above sea-level, and in spite of being only about 15° S. of the Equator they are often streaked with snow. The highest part of the Bihé Plateau occurs east of the port of Benguela; the highest peak is Mount Moko, which rises to nearly 8600 ft. Farther inland the country is lower, the average height being only 3000 ft.; and this general level is maintained, though with occasional elevations rising above 5000 ft., until the plateau ends abruptly above the narrow coastal plain along the shore of the Indian Ocean.

The surface of the 3000-ft. plateau rises occasionally into higher plateaus, and upon it are piled lofty volcanic domes.

The highest lands generally occur near the rim of the plateau. Thus on its western side, south of the Bihé Plateau, there is another area of high land in Damaraland, east of Walfisch Bay, where the Jenker-Afrikander Mountains, well known from their copper-mines, rise above the 3000-ft. plateau. A crescentic belt of land, also above the 3000-ft. level, bounds the African plateau to the south and south-east; it comprises the mountain band that extends across Cape Colony; it is continued north-eastward by the mountains that separate the basins of the Orange River and the Transvaal from the coast lands of Natal and Mozambique.

The eastern rim of the plateau is broken through by the Zambesi valley; but the level rises again in the highlands on both sides of Lake Nyassa, and farther north in the plateau to the east of the Victoria Nyanza, where the surface is in places over 8000 ft. in height; and upon it is placed the volcanic pile of the highest African mountain (Mount Kilima Njaro), which rises nearly 20,000 ft. above sea-level.

The great African plateau is bounded both east and west by the scarps which separate it from narrow coastal plains. The plains are low in elevation, with a warm, humid climate, and are often very unhealthy. But they are comparatively narrow, and they are easily crossed to the higher, healthier land behind them. The scarps of the plateau have been gradually worn back, for in a rainy region high cliffs on the edges of a table-land are very unstable, and are rapidly worn away. Hence the scarps do not themselves indicate the position of the great fractures to which they are due. The lines of the fractures come nearer the coast, and are buried under the debris derived from the cutting back of the plateau.

The plateau structure of Africa has placed great difficulties in the way of the commercial development of the country; for though the rivers may be navigated for great distances upon the surface of the plateau, their lower courses consist of rapids and waterfalls down the steep slopes near the coast. Thus the Congo is navigable from Stanley Pool (alt. 920 ft.)

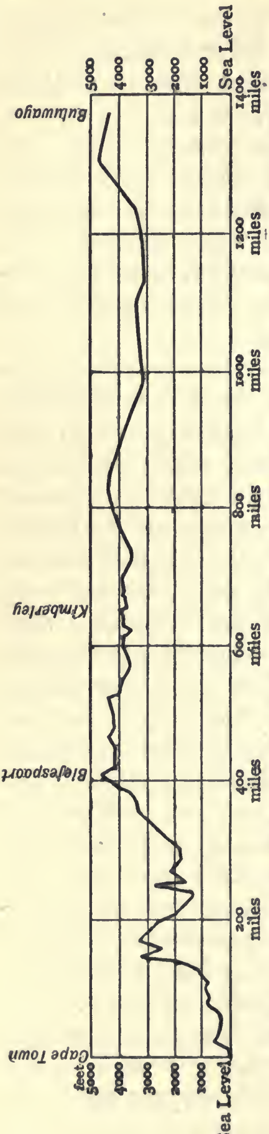


Fig. 88.—Section on the Railway from Cape Town to Buluwayo, showing the steep ascent on to the South African Plateau at Biejespoort (403 miles from Cape Town, altitude 4518 feet), and the gently undulating surface thence to Buluwayo (1362 miles, altitude 4469 feet).

for 1000 miles farther into the interior to Stanley Falls (alt. 1320 ft.). This navigable portion of the river is cut off from the sea by the wild rapids of the Lower Congo, but the upper river has been connected to the coast by railway.

Railway development is hampered by the plateau structure, because the railways into the interior have a steep ascent early in their course; but when once they have reached the plateau they may run for great distances over gently undulating country. The plateau structure is well shown by the gradients on the railway lines. Thus the railway from Cape Town climbs steeply up the mountain passes of Cape Colony till it reaches the plains in the basin of the Karoo; across this district it has a slow, steady ascent northward to the Transvaal and Rhodesia (fig. 88). The railways from Port Elizabeth, Durban, and Delagoa Bay have each to climb on to the plateau, after which they have much easier grades for the rest of their journey into the interior. The Uganda railway in eastern Equatorial Africa begins its steep ascent actually from the sea-shore, after which it has a long ascent over undulating country on to the high plateau of Masai-land.

The eastern and western boundaries of the African plateau are marked by the weathered lines of the old fractures, whereby former continuations of the land have sunk westward beneath the Atlantic, and eastward beneath the Indian Ocean. To the south the plateau ends against the fold-mountain chain of Cape Colony; to the north it passes into the Sahara.

The western edge crosses the Lower Congo between Stanley Pool and the Atlantic; it forms the country of the French Congo, and crosses the German territory of the Cameroons, where an extinct volcanic dome rises on it to the height of 14,000 ft. above the adjacent shore. The north-western extension of the plateau reaches the Lower Niger; it is cut across by the great tributary of the Niger, the Benue, beyond which it forms the country of Sokoto; thence it extends westwards, crossing the Lower Niger and forming the mountainous countries in the interior of Dahomey, Togoland, Ashanti, the French Ivory Coast, and Liberia. The southern scarp of the plateau is known as the Kong Mountains. The mountain range of Sierra Leone is one of the western terminations of the plateau, the last low ends of which stand between the colonies of Sierra Leone and the Gambia.

The main northern extension of the African plateau passes to the west of the Victoria Nyanza and forms the high country that divides the Congo and the basin of Lake Chad from the Nile. This part of the plateau widens northward and forms the plateau of Darfur, which is all above 3000 ft. in height, and rises in places over 5000 ft.; thence it continues northward across the central Sahara, where its highest part is known as the Tibesti Mountains. It ends to the west of Fezzan and south of Algeria, where the Tasali plateau is the last area above 2000 ft. in height. Thence the ground slopes downward to the valley that separates the African plateau from the fold-mountains of Morocco and Algeria.

The north-eastern part of the plateau extends northward from the eastern side of the Victoria Nyanza. It forms the high lands to the east of the Upper Nile. It includes the whole of the plateau of Abyssinia, some of the peaks of which rise to the height of 15,000 ft. One arm of the plateau extends eastward as Somaliland, the "Eastern Horn of Africa", the projection into the Indian Ocean to the south of the Gulf of Aden. From Abyssinia a band of plateau country, much of it from 4000 to 5000 ft. in height, forms the high lands between the Red Sea and the Nile.

Most of northern Africa is at a lower level than the plateau of southern and Equatorial Africa. The Sahara is on an average about 1000 ft. above sea-level; a lower basin runs southward, includes the basin of Lake Chad, and widens farther south into the basin of the middle Congo. A somewhat similar extension southward from the eastern Sahara follows the Nile valley, and spreads out to the west of Abyssinia in the broad basin of the Bahr-el-Ghazal.

There are comparatively few well-defined mountain ranges upon the African plateau. Most of the higher land has been left by the lowering of the country on either side of it by denudation. There are, however, many fragments of old mountain ranges which have now been worn down to their stumps, but still show by their structure that they are the remains of former mountain chains. The most conspicuous mountains in Africa which rise above the plateau are volcanic masses piled up by eruptions. Such are Mount Kilima-Njaro, Mount Kenya, Mount Elgon, and Mount Meru, situated on the plateau of East Africa; Ras Detchen, in Abyssinia; and the Cameroons, to the east of the Gulf of Guinea. Most of the best-known mountains, such as the Drakensberg, the geographical boundary which divides Natal from the Orange River and the Transvaal, and the Kong Mountains, to the north of the Gulf of Guinea, are the worn edges of the plateau. Ruwenzori appears to be a block of ancient rocks left upstanding by the subsidence of the rift valley to the west of it, and of the basin of Victoria Nyanza to the east.

The surface of the African plateau is interrupted by a series of wide and often deep depressions; some of them are basins of internal drainage, for, owing to their slight rainfall and the high rate of evaporation, their rivers are too weak to keep open or to cut channels to the sea. The Shotts in Tunis and in the basin of Oran, Lake Chad, Lake Rudolf, and most of the smaller lakes in the Great Rift Valley, and Lake Ngami, in the Kalahari Desert—all these serve for basins of internal drainage. In most other African basins the rainfall is sufficient to enable the rivers to cut their way to sea. The rivers usually escape through the mountainous rims of their basins by deep gorges cut back by waterfalls. Thus the great depression of the middle Congo discharges its surplus drainage through the rapids of the Lower Congo below Stanley Pool. The basins of the Bahr-el-Ghazal and of the Victoria Nyanza both discharge through the Nile, which, as it leaves the plateau, rushes down the Nile cataracts. The Zambesi escapes from its upper basins over the famous Victoria Falls, and flows in a long, deep canyon cut by the river through the highland rim that once separated the upper basin of the Zambesi from the Indian Ocean. The basin of the Karoo is drained by the Orange River.

The great plateau contains a second series of basins which have now become lakes. These are of two types. Lakes of the first type are round with low shores, and usually rather shallow; such as the Victoria Nyanza, Lake Chad, Lake Bangweulu, and Lake Ngami. Where they occur in arid regions their waters are salt and the lakes are mere shallow sheets of brine lying in the deeper hollows of salt-encrusted plains. Such are the great Makarikari salt-pan, and the "vleis",[1] or shallow clay pans which hold water after rain, of the Kalahari Desert; they are in places so numerous that one district bears the name of the "Land of the Thousand Vleis".

[1] The word is pronounced something like "flay".

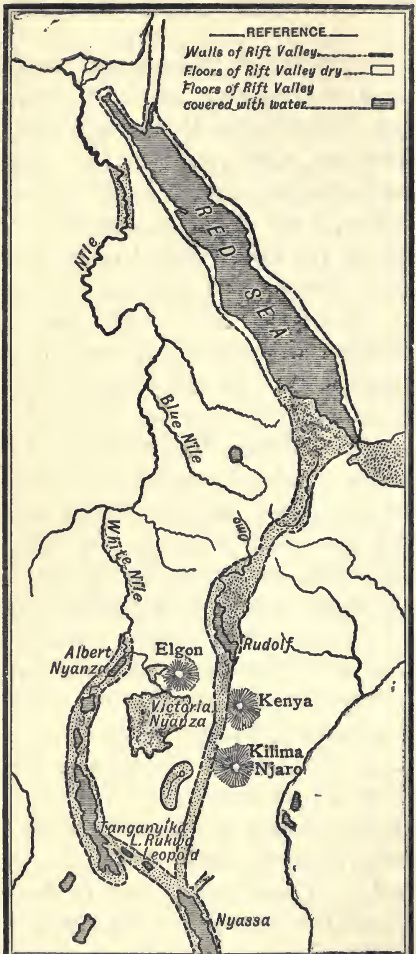


Fig. 89

Lakes of the second type are long and narrow, and lie between parallel precipitous cliffs like fiords; they are confined to eastern Africa, and extend north and south along two lines. They occupy depressions on the floors of the Great Rift Valley, which has been formed by the subsidence of a long tract of the earth's crust between two parallel sets of fractures. This Great Rift Valley begins on the north, in the valley of the Jordan and the Dead Sea (fig. 89). It widens out to form the Red Sea, which is bounded to the east by the high plateau of Arabia, and to the west by the plateau of Egypt and Nubia. At the southern end of the Red Sea the Great Rift Valley sweeps inland, at the foot of the Abyssinian plateau, and is continued by the chain of lakes including Lake Rudolf—190 miles long and 25 miles wide,—Baringo, Elmetaita, Naivasha, Manyara, and Nyasa. From the northern end of Lake Nyasa a branch of this Great

Rift Valley passes westward along Lake Rukwa towards Tanganyika, the greatest of the African rift-valley lakes. Through Lake Tanganyika the valley continues to the north and passes along the Albert Edward Nyanza and the Albert Nyanza into the valley of the White Nile.

WINDS AND RAINFALL

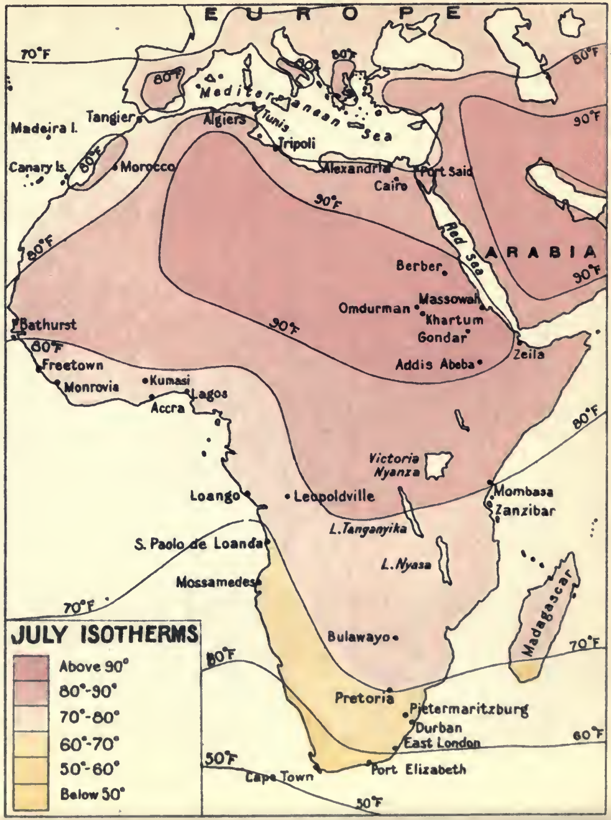
The distribution of the rivers in Africa depends upon the distribution of the rainfall, and that again depends upon the winds and the circulation of the waters in the surrounding oceans. The distribution of the winds in Africa is shown in Pl. XXII, wherein the prevalent direction of the winds in January is shown by thick arrows and in July by thinner arrows. The most striking feature of the winds in eastern Equatorial Africa is their monsoonal reversal of direction twice a year. In January the wind blows along the coast from north-east to south-west, as far as the neighbourhood of Zanzibar. In July, on the other hand, the winds are reversed, and from Zanzibar northward they blow from south-west to north-east. Around the rest of the African coasts the winds are more constant. The prevalent direction along the south-eastern coast near Madagascar and Mozambique is from the south and south-east. Off the coast of Natal east winds blow from the Southern Ocean over the land. All along the western coast, from Cape Colony to the Gulf of Guinea, the prevalent wind is from the south, bending eastward, however, on to the land. Along the coasts of Morocco and the Sahara the prevalent wind blows along the coast from north-east to south-west. The meeting line between the north wind of north-western Africa and the south wind of south-western Africa varies through the year according to the position of the sun. The line in January falls farthest south, and is only about 6° north of the Equator; but as the sun moves northward the south winds follow it, until in July they extend 12° north of the Equator, to the neighbourhood of Cape Verde.

The most important climatic effect of the winds is on the western coast, where they cause a current of cold water, which is blown northward from the Southern Ocean. Hence, as is shown by Plate XI (the World, showing circulation of ocean currents), the west African coast as far north as Angola is chilled by a cold-water current. In the Gulf of Guinea there is an area of warm water, but farther north along the coast of Morocco and the Sahara, as far south as Cape Verde, there is a narrow belt of cold water. This water is due to the action of the off-shore winds, which drive the warm surface-water out to sea, and it is replaced by an up current of cold water from below. Hence, when winds blow ashore along the coasts of north-western Africa, they pass from a cold sea to a warm land. The temperature of the air is raised on coming ashore; so instead of dropping its moisture as rain, it can carry more moisture. Hence it travels over the land as a drying wind, and the parts of the African coast washed by cold currents have arid climates. In Walfisch Bay the average rainfall is said to be only $\frac{1}{3}$ in. in the year, and the climate is one of the driest in the world. Where, on the other hand, the coasts are washed by warm currents, the winds that blow ashore are laden with moisture, which is condensed and falls as rain upon the colder land; and the precipitation is most rapid where the winds on reaching the land are cooled by being forced to rise over high ground.

On the eastern coast the winds from the north-east in January drive the warm waters of the Arabian Sea south-westward along the African coast, and the heavy rains in that part of Africa occur between March and August. When the monsoon is reversed the warm water is blown from the land, cold deep water rises up near the shore, and the rainfall ceases (fig. 67, p. 96). The off-shore winds from the plateau of Somaliland suck up the deep waters, and thus maintain a cold belt along the shore throughout the year; they thus give that part of Africa its arid climate.

Most of East Africa has a fair though apparently uncertain


JANUARY ISOTHERMS
Above 90°
80°-90°
70°-80°
60°-70°
Below 60°
EUROPE
ARABIA
Mediterranean Sea
Red Sea
Madeira I.
Canary Is.
Tangier
Algiers
Tunis
Tripoli
Morocco
Alexandria
Port Said
Cairo
Berber
Massowah
Omdurman
Khartum
Gondar
Zeila
Addis Abeba
Bathurst
Freetown
Monrovia
Kumasi
Lagos
Accra
Victoria Nyanza
Leopoldville
Loango
L. Tanganyika
L. Nyasa
Mombasa
Zanzibar
S. Paolo de Loanda
Mossamedes
Bulawayo
Pretoria
Madagascar
Pietermaritzburg
Durban
East London
Port Elizabeth
Cape Town
50°F
60°F
30°F
40°F
20°F
70°F
80°F
90°


JULY ISOTHERMS
Above 90°
80°-90°
70°-80°
60°-70°
50°-60°
Below 50°
EUROPE
ARABIA
Mediterranean Sea
Red Sea
Madeira I.
Canary Is.
Tangier
Algiers
Tunis
Tripoli
Morocco
Alexandria
Port Said
Cairo
Berber
Massowah
Omdurman
Khartum
Gondar
Zeila
Addis Abeba
Bathurst
Freetown
Monrovia
Kumasi
Lagos
Accra
Victoria Nyanza
Leopoldville
Loango
L. Tanganyika
L. Nyasa
Mombasa
Zanzibar
S. Paolo de Loanda
Mossamedes
Bulawayo
Pretoria
Madagascar
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Durban
East London
Port Elizabeth
Cape Town
70°F
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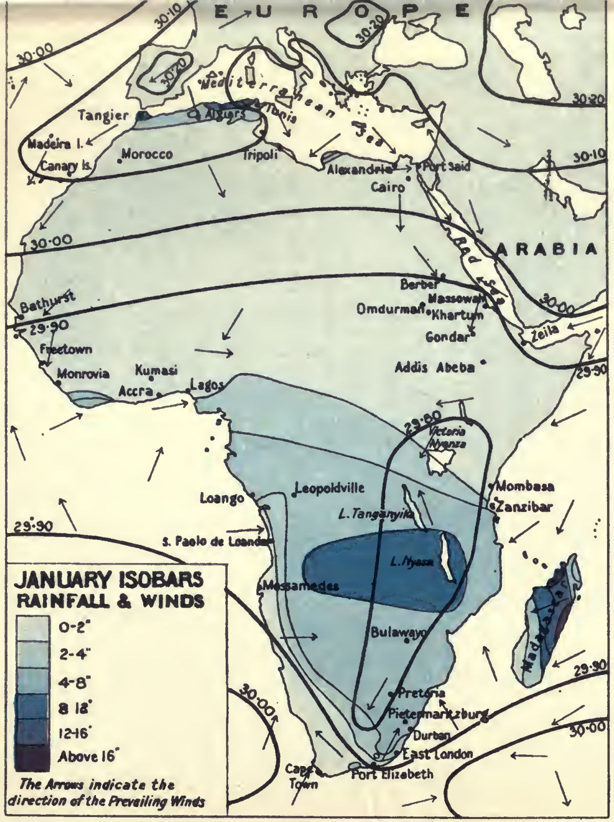
JANUARY ISOBARS
RAINFALL & WINDS
0-2"
2-4"
4-8"
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12-16"
Above 16"
The Arrows indicate the direction of the Prevailing Winds
EUROPE
ARABIA
Mediterranean Sea
Red Sea
Tangier
Madeira I.
Canary Is.
Morocco
Algiers
Tunis
Tripoli
Alexandria
Port Said
Cairo
Berber
Massowah
Omdurman
Khartum
Gondar
Zeila
Addis Abeba
Bathurst
Freetown
Monrovia
Kumasi
Accra
Lagos
Victoria Nyanza
Leopoldville
Loango
L. Tanganyika
Mombasa
Zanzibar
S. Paolo de Loanda
L. Nyasa
Mossamedes
Madagascar
Bulawayo
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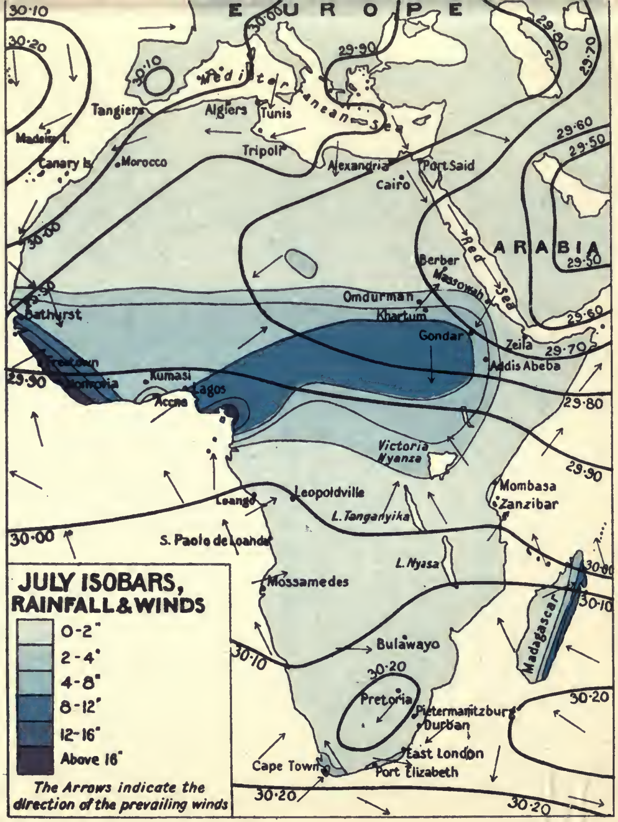
JULY ISOBARS,
RAINFALL & WINDS
0-2"
2-4"
4-8"
8-12"
12-16"
Above 16"
The Arrows indicate the direction of the prevailing winds
EUROPE
ARABIA
Mediterranean Sea
Red Sea
Tangiers
Madeira I.
Canary Is.
Morocco
Algiers
Tunis
Tripoli
Alexandria
Port Said
Cairo
Berber
Massowah
Omdurman
Khartum
Gondar
Zeila
Addis Abeba
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rainfall, owing to the influence of the warm waters of the Indian Ocean, which are blown westward against the coast by the trade winds. To sum up, the rainfall of Africa is heavy on the high lands around the Gulf of Guinea, over the forests of the Congo, and on the high lands of East Africa, from the Equator southward to the Cape and northward through Abyssinia. The Sahara has a low rainfall, and so also has south-western Africa north of Cape Colony, and the "Eastern Horn" of Africa, south of the Gulf of Aden.

THE AFRICAN RIVERS

The chief rivers of Africa naturally rise in the regions of heaviest rainfall. The arid regions have no permanent rivers, although they may be traversed by dry valleys or "nullahs", which are occupied by torrents after heavy storms, and during periods of drought may have lines of water-holes. The chief rivers rise on the high lands of eastern Africa, from Abyssinia to Natal, and on the mountains of the western Soudan to the north of the Gulf of Guinea; the Zambesi rises on the mountains of Barotseland and Angola.

The *Nile* is the most remarkable river of Africa, and is historically the most famous river in the world. The rich soils of its delta, watered every year by unfailing seasonable floods, easily and certainly provided the food for a large population; and the people were able to develop their civilization in peace, as they were sheltered from attack by deserts, then impassable to large armies.

The Nile rises in the high lands of eastern equatorial Africa. The length, from its mouth to its exit from the Victoria Nyanza at the Ripon Falls, is, according to Captain H. G. Lyons, 3473 miles, while the full length of the Nile waterway, across the Victoria Nyanza to its remotest source, the head stream of Kagera River in German East Africa, near the eastern shore of Lake Tanganyika, is 4037 miles.

The Nile has three main head branches. The main trunk stream rises in the Victoria Nyanza, the greatest of African lakes; it collects the waters of the many rivers, which carry into it the heavy rainfall on the surrounding plateau. Most of the water is lost by evaporation from the surface of the lake, but thirteen per cent of it escapes over the Ripon Falls as the Victoria Nile, which, after flowing through a region of lakes and swamps, plunges over the Murchison Falls, and enters the Albert Nyanza. This lake also receives the Semliki branch of the Nile, which comes from the south through the Albert Edward Nyanza. The Nile, after leaving the Albert Nyanza, flows northward as the Bahr-el-Gebel, which descends from the high equatorial plateau down the cataracts which extend for a length of nearly 100 miles from Dufile almost to Gondokoro; there it reaches more level country, and its waters spread out in swamps, while the sluggish current of the river is often blocked by a dense growth of vegetation, known as the "sudd". This region is warm, and evaporation is so high that practically all the waters that escape from the Victoria Nyanza are lost there, and less than one per cent[1] escapes into the White Nile.

The second branch of the Nile is the Bahr-el-Ghazal, which rises in the high lands between the Nile and the Congo; its sources are in a region of heavy rainfall, over 35 in. a year; but its waters are also nearly all lost by evaporation in the swamps around Lake No. The Bahr-el-Ghazal unites with the main trunk of the Nile, and they together form the White Nile.

The third river which helps to form the White Nile is the Sobat, which comes down from the western high lands of Abyssinia and is the main source of the floods in the White Nile.

The fourth branch of the Nile rises in the mountains of Abyssinia, the largest region in north-eastern Africa with an annual rainfall of probably about 50 in. Its rivers unite to form the Blue Nile, which joins the White Nile at Khartum.

[1] According to Captain H. G. Lyons, the exact amount is 0.95 per cent.

The Nile here discharges sometimes as much as 170,000 cu. ft. a second, but henceforth with the exception of the Atbara, it is not joined by a single constant-flowing tributary, as it flows through the arid regions of Nubia and Egypt. At Khartum it is at the height of 1200 ft. above sea-level, and there is a mean fall thence to the Mediterranean of 8 in. in the mile. Its bed is obstructed in Nubia by reefs of rock, forming the "Six Cataracts of the Nile".[1]

The great mystery of the Nile was its annual floods. Every June, independently of local rains, and at the very hottest and driest time of the year, the level of the river begins to rise; it continues to rise till October, when its level at Cairo is 26 ft. above that of low water; the flow of the highest flood at Cairo is about 400,000 cu. ft. per second. The Lower Nile flows between banks which have been raised by the river above the surrounding country, and the flood waters are carried by canals across the low lands and allowed to spread over the fields, which they irrigate with water and silt. After October the river falls; in May the level is so low that a child may walk across it below the Barrage near Cairo.

As Egypt is practically rainless, the cultivation of its soils has always been dependent on the Nile floods; and why they rose at the driest season was a mystery. They are now

[1] The contributions to the Nile by its chief tributaries, according to Sir William Garstin (*Report upon the Basin of the Upper Nile with Proposals for the Improvement of that River*, Cairo, National Printing Department, 1904), are as follows. (The figures have been changed from cubic metres to the nearest even number in cubic feet.) The Victoria Nile outflows from the Victoria Nyanza at the Ripon Falls at the rate of from 5400 to 7000 cu. ft. per second. The Bahr-el-Gebel at Wadelai varies from 5900 to 10,000 cu. ft. per second, and at Lado from 6500 to 21,500 cu. ft. per second, but farther north it is reduced by evaporation till at Lake No the flow is only from 1900 to 3250 cu. ft. per second. The Bahr-el-Ghazal gives no contribution to the floods of even the White Nile, which is mainly supplied by the Sobat, that varies in flow from 0 to 10,750 cu. ft. per second. The White Nile, below the entrance of the Sobat, varies from 3250 to 18,000 cu. ft. per second. The Nile floods in Egypt come practically all from the Blue Nile, of which the flow is up to 130,000 cu. ft. per second, and from the Atbara, of which the flow is up to 32,500 cu. ft. per second. Below Berber the river has a flow rising to 172,000 cu. ft. per second. The average flood at Cairo, according to Sir Colin Scott-Moncrieff, is 280,000 cu. ft. per second with a maximum of 400,000 cu. ft. per second.

known to be due to the rainfall on the mountains 1500 and 2000 miles away; this rainfall comes in the spring, and takes months to reach Egypt.

The *Congo* is the greatest, but not the longest, river in Africa; its length is about 2800 miles. It rises to the west of the head sources of the Nile, and flows westward down the western slope of the east African plateau. Its most remote source is in the streams that flow into Lake Bangweulu. It sometimes receives an overflow from Lake Tanganyika through the Lukuga River, though in dry years, when the level of the water is low, that lake has no outlet. The main direction of the Upper Congo is northward; after falling over the Stanley Falls, close beside the Equator, it turns westward and receives many large tributaries, and is navigable for 1000 miles to Stanley Pool. Here it approaches the western edge of the African plateau, and its further course to the Atlantic is down the wild rapids of the Lower Congo.

The *Niger*, the third great river of Africa, rises to the north of the Kong Mountains of the western Soudan, and is nourished by the heavy rainfall of that region. Its source is about 170 miles from the Atlantic coast, at the height of 2800 ft. above the sea, but it flows inland into French Guinea, and, after a roughly semicircular course of about 2600 miles, reaches the Atlantic in the Gulf of Guinea. The river is of great value as a commercial highway, for its main fall, from 2800 ft. to 1000 ft. above sea-level, takes place in the first 250 miles of its course. The river is navigable for most of its length, though interrupted by rapids at Bussa, where Mungo Park, the early explorer of the Niger basin, lost his life. The river is joined by the Benue, its chief tributary, which drains the high lands to the south-west of Lake Chad. The Niger discharges a larger volume of water than the Nile; but, as it reaches the Atlantic by many outlets scattered along 250 miles of coast, its true mouth was uncertain, until the two brothers Lander, in 1830, descended the river from Bussa to the sea.

The city of Timbuctoo is situated on the great northern bend of the river, but now, owing to a change in the course of the river, is some miles from its bank. It is the great centre of the caravan trade of the Sahara, whence camel caravans go northward across the deserts to Algeria and the Mediterranean States.

The rivers that discharge on the eastern coast of Africa are of secondary importance, with the exception of the Zambesi. They are, proceeding from north to south, the Juba, the Tana, the Sabaki, and the Rovuma. They rise on the eastern border of the Great Rift Valley, and flow across the eastern plateau, till they plunge in successive waterfalls or rapids over its edge on to the plains near the sea. The Tana has the largest volume of water, receiving the drainage from Mount Kenya; the banks of the river in its delta have been raised by the river above the level of the adjacent country, and twice a year the river rises in flood, and, like the Nile, irrigates the plains beside it.

The Zambesi, the chief river that discharges on the eastern coast of Africa, is the only large river which rises on the western side of the continent and flows eastward. The source of the Zambesi is a swamp close by the Congo watershed, about 5000 ft. above sea-level. Its westernmost tributary is the Kwando, which rises on the slopes of the Bihé Plateau in Benguela; while the Kubango, which normally flows into Lake Ngami and has no outlet to the sea, sometimes overflows through the Chobe river into the Zambesi. The Zambesi is some 2000 miles in length and consists of three sections. The Upper Zambesi flows over a high plateau in a broad, shallow channel. At the Victoria Falls (alt. 2850 ft. above the sea) the river is over 1¼ mile in width, and plunges into a gorge in places 400 ft. wide and 420 ft. deep. Below the falls the Middle Zambesi flows through a long canyon, which it has cut through the plateau, to the Kebrabasa Rapids. From these falls the Lower Zambesi is navigable for 400 miles to its mouth, and it is joined by the Shire from Lake Nyasa.

The striking contrast between the Upper Zambesi, flowing in a wide, shallow channel on the surface of the plateau, and the Middle Zambesi in its deep canyon, shows that the history of the river in the two areas has been different, and there seems reason to believe that the Zambesi once rose even farther west than at present, and that it discharged to the Indian Ocean through the broad valley of the Limpopo; but the formation of the valley of the Middle Zambesi, which trends from south-west to north-east, and is continued south-westward up the valley of the Gwai River, and north-eastward up the Loangwa valley, allowed the drainage of the Upper Zambesi to escape north-eastward between the high lands to the west of Lake Nyasa and Mashonaland.

The *Limpopo*, the second important river that discharges on the eastern coast of Africa, has many points of resemblance to the Lower and Middle Zambesi. It has the same crescentic course, and is of nearly the same length; it also rises to the west of the main line of high lands, and carries the drainage of their western slopes eastward to the Indian Ocean; its valley passes between the high lands of the northern Transvaal (the Zoutspanberg) to the south and the Matabeleland Plateau to the north. The region to the west of the Limpopo, however, is arid, and there is no big river for it to capture. So the Limpopo has nothing corresponding to the Zambesi above the Victoria Falls.

The last important African river is the *Orange River*, the head streams of which rise on the western flanks of the Drakensberg to the south of the Limpopo, and on the northern slopes of the mountains of Cape Colony. The main stream rises in Basutoland and forms the boundary between the Orange River Colony and Cape Colony. The most important tributary of the Orange River is the Vaal, which forms the southern boundary of the Transvaal. During its descent from the plateau to the lower lands along the Atlantic coast, the river plunges, at the "Great Falls of the Orange River" or Aughrabies Falls, over a cliff 300 ft. in height into a deep gorge.

ECONOMIC GEOGRAPHY

The economic geography of Africa chiefly depends on its climate, natural resources, people, and situation.

The contrasts of climate are less marked than in other continents, for Africa is situated across the Equator, and extends thence nearly to lat. 37° N. and to lat 35° S.; so that most of the continent lies within the tropics, and the rest is subtropical. The southern end of Africa has the most temperate climate, with the mean annual temperature of 59° Fahr., because it is surrounded by a cold sea and is exposed to cold south-west winds. The cool region of Cape Colony runs northward in a narrow belt along the West African coast, owing to the presence of a cold ocean current.

The temperature of Africa is moderate for its latitude, owing to the elevation of most of the land. The coast lands are humid and relaxing, but their temperatures are never as high as those at mid-day in the dry regions of the Sahara, where the mean annual temperature is over 86° Fahr. The mean temperature of most of Equatorial Africa, reduced to sea-level, is between 78° and 82°; but owing to the elevation of the plateau the night temperatures are often low, and permanent snow-fields and glaciers exist on Mounts Kilima Njaro, Kenya, and Ruwenzori.

The rainfall is the most important climatic factor, and its distribution has already been considered; it nourishes the tropical forests and jungles of the Congo, and the tropical river valleys of the western Soudan. Many of the plateaus are covered with turf and scattered groups of trees; in the drier regions the vegetation is reduced to scanty turf and trees with needle-shaped leaves like the acacia, or it disappears almost entirely in the deserts of the Sahara and German South-west Africa. Amongst the trees of the arid regions are the huge baobabs, with their soft trunks, and a euphorbia growing like a candelabra. The coastal regions have abundant palms, some of which yield oil, and the forests produce valuable timber, including mahogany and ebony, and vines yielding rubber.

The animals of Africa include the largest wild game left upon the earth. First among the typical animals comes the African elephant, which once ranged from north tropical Africa to the coast of Cape Colony. A protected herd still lives in Cape Colony, but in a wild state they are now confined to tropical Africa, and are restricted within much narrower limits than even thirty years ago. The giraffe, the African rhinoceros, the zebra, the eland, and vast herds of antelope live on the open plains or in the open woods beside them; these animals are preyed on by lions and leopards, while hyenas and jackals kill the smaller creatures. The crocodile and the hippopotamus live in the rivers and estuaries. In the Atlas region the animals are allied to those of Europe and Asia, and the characteristic African animals are not now found there.[1]

The mineral resources of Africa are large, but unequally distributed. Africa now yields more gold than any other continent, and it has probably provided man with supplies of gold from prehistoric times. The chief gold-field is that of the Witwatersrand (White Waters Ridge) in the Transvaal, which yields some £30,000,000 of gold a year. The other gold-fields occur in Rhodesia, the Gold Coast of West Africa, western Abyssinia, and Nubia.

Africa contains some valuable coal-fields, at present only worked in South Africa, and there are masses of iron ore which are not yet used. The other mineral resources of Africa include phosphates, obtained from the guano-islands in the rainless area of south-western Africa and from limestones in Algeria and Tunis. Copper occurs in south-western Africa and Cape Colony, and in central Africa in Katanga, and Rhodesia. Tin is found in various districts, especially in northern Nigeria. The diamond-mines of Kimberley in Cape Colony, of the Transvaal, and the Orange River, give the largest yield of these jewels.

[1] The monkeys, however, still live as far north as Gibraltar.

The other economic products of Africa are wool and hides from Cape Colony, grain and cotton from Egypt, oil from the West Coast, india-rubber from the Congo and East Africa, ostrich feathers from the Cape and Somaliland, fibres and ivory from tropical Africa, cocoa from West Africa.

The exports from Africa are small in comparison with its size, fertility, and commercial possibilities. Its backward commerce is due to the primitive civilization of its people. The typical African people are Negroes, who are brown or black in colour, have short curly hair, broad flat noses, projecting massive jaws, thick lips, and receding foreheads (fig. 90). The Negroes occupy all Africa south of the Sahara, Abyssinia, and the Tana River. There are colonies of other races farther south, and remnants of Negro people farther north.

In the far south-western corner of Africa live the survivors of a chocolate-coloured, round-headed people, with prominent cheek-bones and hair growing in tiny pellets scattered over the head; these tufts of hair have been compared, from their size and colour, to peppercorns. These people use clicks in their speech, which are sounds made in the middle of words, somewhat resembling those made by drivers to their horses. Such are the Bushmen, the most primitive of African races. The intermarriage of Bushmen with Negroes gave rise to Hottentots. In the tropical forests there are a small race of men, 4 ft. 6 in. high, known as the pygmies. They too are a very primitive race, and may be allied to the Bushmen, or may be degenerate Negroes, dwarfed by life in the dark forests, just as the pygmy elephants were dwarfed by restriction in the dwindling island of Malta.

The two other groups of people living on the mainland of Africa are sections of the black Caucasians. They may be distinguished from the Negroes by their long hair, thin lips, and straight noses. The black Caucasians in Africa consist of two sub-races: the Semites, including the Arabs and the Jews, are represented in northern Africa by the people of Algeria, Tunis, Egypt, and most of the Nile

Valley, and Abyssinia. The second sub-race, the Hamites, include the Somali, Gallas, Nubians (not to be confused with the Negro Nubas), the tribes of the western Sahara, and many of the tribes of Abyssinia. Where the Hamites meet the Negroes there are mixed races combining the characters of the two.

The inhabitants of the island of Madagascar belong to another race of mankind, the Malays, who sailed from over sea, conquered, and now occupy most of the island, though it is also inhabited by some Negro, and hybrid Negro-Malay tribes.

Fig. 90.—Nuba of Kordofan (a typical negro)

The character of the Negro who occupies the largest, most fertile, and richest regions of Africa is the chief cause of the inadequate use hitherto made of the continent. The Negroes are a powerful, muscular race, and when sympathetically treated work well. "To work like a nigger" is a proverb which illustrates their strength and activity. They are, however, lacking in originality, invention, and in power of independent organization. They raise their food by agriculture or from herding cattle, hunting, or fishing; their chief weapons are of iron, which they obtain by collecting grains of iron ore from river-beds and smelting them in a charcoal furnace with hand-blown bellows. But they have no extensive trade or manufactories, and do not form powerful organized communities except under the influence of the Arab settlers on the eastern coast, or of the Hamites and Semites, who founded the states of Abyssinia, Uganda, and the western Soudan.

Through all its history Negro Africa has remained unorganized and undeveloped, except when controlled by other people. The whole of Africa is now partitioned among the states of Europe, with the exception of Abyssinia, which, protected by its mountains and organized by Semitic conquerors (although the present ruler is a Hamite), has maintained its independence.

The first African civilization developed in Egypt owing to the immigration of a Hamitic people from Arabia. The Egyptian influence spread southward up the Nile valley, and apparently south-westward into the Soudan. The Arabs, perhaps aided by the Phœnicians, found their way down the East African coast long before the Christian era, and founded colonies there, whence they appear to have traded inland, and may have worked the gold-fields of Abyssinia and Rhodesia. Arab invaders after the time of Mahomet conquered northern Africa, which had been already occupied by black Caucasian people.

The European settlement of Africa began after the discovery by Vasco da Gama, in 1492, of the route to India around the Cape of Good Hope. The Portuguese established stations along the east African coast at Mombasa, Mozambique, and Delagoa Bay, to be used during the voyage to stations in India. The Dutch colonized the Cape; but it was taken by the British during the wars with Napoleon, and our right to it confirmed by purchase from Holland after the final overthrow of Napoleon.

European occupation spread slowly from Cape Colony over most of South Africa. In 1884 the Congo Free State was founded by Stanley to protect the agricultural negroes of the Congo from the Arab slave-raiders, and to open the country to European trade. The discovery there of the commercial value of tropical Africa led to the partition of the rest of the continent among the powers of Europe. The great partition was effected between 1885 and 1892.

Railways have been constructed into the interior of Africa; they go up the Nile valley and into Abyssinia; to the Victoria Nyanza across British East Africa; through South Africa from Beira, Delagoa Bay, Natal, Port Elizabeth, and Cape Town, across Southern Rhodesia and into Northern Rhodesia.

There is also a railway up the Congo to Stanley Pool, and another is being built from Benguela to join the Rhodesian Railways.

CHAPTER XVI

NORTH AMERICA

The continent of North America (including Central America) is roughly triangular in shape, its greatest width being in the north, whence it tapers southward to the isthmus of Panama, the narrow link with South America, where it is only 45 miles wide.

The continent consists of three main elements. 1. On the west is a broad area of high mountain country, known as the Western or Pacific Mountains, which extends the whole length of the continent from north to south, and is 1000 miles wide in the United States. 2. In eastern America there is a second band of mountain country composed of plateaus and dissected plateaus, forming Greenland, Labrador, the mountains of eastern Canada, and the Appalachian Mountains and Alleghany Plateau, in the United States; the latter are known as the Appalachian Mountain System, or the Atlantic Mountains.

3. Between the eastern and western mountains is a broad area of comparatively low-lying country composed of plains which extend with unbroken surface from the Arctic Ocean on the north to the Gulf of Mexico on the south; the divide between these two seas is only 800 ft. above sea-level. These level lands, known as the Great Plains, include the basins of the chief North American rivers, the Mississippi, Missouri, the Mackenzie, and the Nelson rivers, as well as the Great Lakes of the Lake Superior group, and the lakes of north-western Canada.

The Western Mountains have been formed by earth movements connected with the formation of the Pacific, and their chief mountain lines are parallel to the Pacific coast. The

Eastern Mountains are the remains of a land that once extended eastward into the Atlantic, and the materials of which they have been built have been obtained by the destruction of this Atlantic land. The Western and Eastern Mountains were once separated by a shallow sea, like the German Ocean, which stretched from the Mackenzie River to the Missouri, and thence southward along the valley of the Mississippi. This sea has been slowly filled up by sediment washed into it from the mountainous lands on either side. The sea shrank into two disconnected gulfs, which have been gradually reduced to Hudson Bay and the Gulf of Mexico.

The geographical history of North America consists, therefore of two parts. There is the joining of two originally disconnected lands by the silting up of the inland sea that once divided them; and there is the separation of the Eastern Highlands from the Atlantic continent, of which they were once the western border.

The coast of North America is long and irregular, as the land projects into the sea in many great peninsulas, which are wide and irregular like Labrador, or long and narrow like Florida and Lower California. The sea in its turn runs far inland over drowned portions of the Great Plains — the Gulf of Mexico and Hudson Bay; it flows into drowned land valleys, such as the Gulf of California, the estuary of the St. Lawrence, and the estuaries along the eastern coasts of the United States; and it fills the fiords in the fractured table-lands along the Pacific. The arms of the sea in places join inland, cutting off islands, of which the chief groups are the Arctic Archipelago and Greenland, Newfoundland, and the fringe of islands along the Canadian coast of the Pacific.

The coastal structure of the Pacific and Atlantic illustrates the typical features of these coastal types. The Pacific coast is parallel to the chief geographical elements in western America; and where the old coast-line has been shattered and the valleys submerged, the remnants of the coast range remain in lines of islands off the shore, or in long peninsulas parallel to the coast, like the Peninsula of Lower California and the Olympic Mountains Peninsula, west of Puget Sound. Where the sea has occupied a simple breach through the coast range, it spreads out north and south in the valley behind, like the branched harbour of San Francisco (fig. 42, p. 58).

The Atlantic coast, on the other hand, has no such marked parallelism with the geographical features of the shore. The southern harbours are estuaries or rias, which gradually contract in width and depth inland; they are the lower ends of drowned land-valleys that have been cut by rivers across the geographical grain of the country and then flooded by the sea; and the mountain lines run out into the Atlantic in Nova Scotia, where their trend is oblique to that of the Atlantic coast.

THE EASTERN MOUNTAINS

The Appalachian Mountain System, or the Atlantic Mountains, are 2000 miles in length, and they vary in width from 130 miles in the Appalachian Mountains themselves to over 500 miles in Labrador. This mountain system extends from Labrador to Alabama, while Greenland may be regarded as a northern extension of it. The mountains are separated from the Atlantic by a low coastal plain, which rises gradually inland from the Atlantic shore to the height of 200 or 300 ft. above sea-level. This coastal plain is composed of marine sediments, often covered with sheets of alluvium deposited by rivers or in lakes. The coastal plains are narrowest to the north, and they widen to the south, where in North Carolina and Virginia they include the region of the Great Dismal Swamp. Still farther south they sweep round the southern end of the Appalachian Mountains and form nearly the whole of the peninsula of Florida. In the far north, around Hudson Bay, the coastal plains are wide and young, having only recently emerged from the sea; there they form the tundra or frozen swamps, and support little vegetation, except a rank growth of mosses and lichens. The coastal plain, most typically developed in the United States, ends inland against a plateau of very ancient rocks, which can be traced from the maritime provinces of Canada southward along the coast of the United States. These rocks are of Archean age, and are exposed for a width of 50 miles at their northern and southern ends, and of 150 miles in the middle. They rise inland to the height of about 1000 ft., where they reach the foot of the Appalachian Mountains; hence they are named the Piedmont Plateau, *i.e.* the plateau at the foot of the mountains.

The main mass of the Appalachian Mountain System consists of high ranges of mountains, arranged in parallel lines from north-east to south-west. The most typical member is the chain which gives its name to the group, the Appalachian Mountains. This chain extends from New Jersey 900 miles to the south-west, across the states of Pennsylvania, Virginia, Tennessee, North Carolina, and sinks beneath the coastal plains in Alabama and Georgia. The mountains vary from 50 to 130 miles in width. They are formed of sedimentary rocks, much younger than those of the Piedmont Plateau. The rocks have been crumpled into folds by pressure, which must have come from the interior of the United States, since

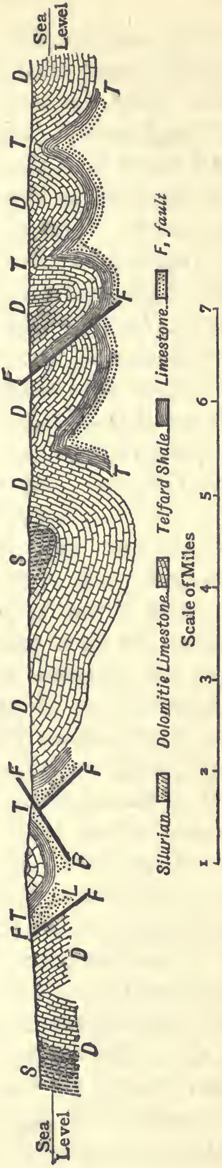


Fig. 91.—Section across part of the Appalachian Mountains in Grenville, Tennessee (after Bailey Willis), showing their structure as a plateau of which the surface is independent of the folds and fractures in the rocks.

the folds are steepest on their western sides (fig. 91). The mountains must once have been much higher than they are at present, when the arch-like ridges formed by the folding were still in existence. The whole of the original mountains were planed down to a plateau, the surface of which was 4000 ft. above sea-level in Virginia, and 2000 ft. in Pennsylvania and New Jersey. The plateau has been in turn destroyed by the formation of river valleys, which have been cut parallel to the chain owing to the wearing away of the softer bands of rock. Fresh mountain ridges have thus been formed by the resistance of the harder rocks. There must once have been higher land to the west, whence the rivers that flowed south-eastward into the Atlantic had their source. The Appalachians were not then fully uplifted, so that such rivers as the Delaware and the Potomac are older than the mountains. As the Appalachian Mountains were slowly uplifted, the rivers cut their channels deeper and deeper, and thus maintained their original course; hence the rivers that rise to the west of the Appalachians, instead of taking what would appear to be their easiest course by joining the Mississippi, flow to the Atlantic through deep trenches cut right across the Appalachian Mountains.

The Appalachian Mountains end to the west in the Alleghany Plateau, which extends from New York to Alabama, and is to be regarded only as the disturbed western side of the Appalachian folds.

The Appalachian Mountains are usually regarded as ending to the north-east at the Hudson River; but the mountains of New England on the eastern side of the river, in the states of New York, Massachusetts, and Vermont, may be regarded as the continuation of the Appalachian belt. Their highest peak, Mount Washington, 6293 ft., is in the White Mountains, which, with the Adirondacks, provide some of the most popular summer resorts for the northern cities of the Atlantic coast. Farther north the Appalachian belt can be traced across the maritime provinces of Canada, and beyond the St. Lawrence it forms the high, weathered plateau of Labrador, where, near Hudson Strait, it rises into peaks 8000 ft. in height, the highest summits of the Appalachian System.

Though the New England and Canadian mountains may be regarded as the geological continuation of the Appalachian Mountains, they are very different in their scenery and superficial characters. North-east of the Hudson River the mountain valleys contain many beautiful lakes, and the rivers leap over waterfalls and rush down cataracts into young valleys. In the southern Appalachians, on the contrary, there are no lakes, and the rivers flow in valleys which have the aspect of great age. This difference is due to the fact that the north-eastern part of the Appalachian belt was covered by ice, and the flow of a great ice-sheet across it has altered the shape of the country, swept the decayed rocks out of the hollows, and left many lake basins. Since the disappearance of the ice the rivers have had to flow in fresh directions, and carve out new channels, so that their valleys are young, and they have not yet had time to destroy the lakes by filling up the basins with sediment or cutting through the barriers. In the southern Appalachians the mountains were not covered by ice; so there have been no recent disturbances of the river system, and the existing rivers are so ancient that they have had time to drain the lake basins and wear away all the waterfalls; thus they flow to the sea down a regular, even slope.

THE GREAT PLAINS

The Great Plains are the largest and most marked feature in the structure of the North American continent. Their essential characters are a level surface and a continuity, from the Gulf of Mexico to the shores of Hudson Bay and the Arctic Ocean, unbroken by any mountain structure save in three places. The main drainage from the plains is southward into the Gulf of Mexico and northward into the Hudson Bay and the Arctic Ocean. The one exception is the

St. Lawrence River, which rises in the Great Lakes, and has cut its way through the eastern mountains to the Atlantic.

The Great Plains may be divided into five main divisions, the Gulf Plains, the Prairies, the High Plains, the sub-Arctic Plains, and the Lake Plains.

The *Gulf Plains* lie along the Gulf of Mexico, and extend inland up the basin of the Lower Mississippi, till they reach the height of about 500 ft. above sea-level. On the east they pass into the Atlantic coastal plain.

The *Prairies* are wide, open, treeless plains, and are perhaps the most typical element in North America. They extend from Mexico to the neighbourhood of the Great Lakes, being about 1400 miles in length from north to south, and 500,000 sq. miles in area. They are treeless, in contrast to the densely-wooded Appalachian Mountains, which were therefore known as the "backwoods" to the settlers on the coastal plains. The rocks beneath the prairies are mainly horizontal sediments and limestones, deposited beneath the sea. The plains rise up to the height of 800 ft. in Minnesota at the flat ill-defined divide, which forms the watershed between Hudson Bay and the Gulf of Mexico. The prairies were first used for grazing, but owing to the abundance of lime in their soils, and their warm, dry, summer climate, they yield prolific crops of wheat. The prairies are the great wheat-growing area of the United States, and great cities have grown upon them as trading and manufacturing centres to supply the requirements of the agriculturists. The chief of these cities are Chicago on Lake Michigan, St. Louis, the port on the Mississippi River, and Cincinnati on the Ohio.

The High Plains.—The prairies rise gradually westward into higher plains, and as they are to the west of the region that receives rain from the Gulf of Mexico, they have a drier climate. They have, therefore, less vegetation and are less fertile than the prairies. The High Plains extend for a length of over 2000 miles, from the Mackenzie River to the Rio

Grande, and have an average width of about 300 miles. Their most typical development may be seen to the west of the Missouri River, between the Arkansas and the Platte Rivers, where they rise gradually to the height of 6500 ft. above the sea, and end abruptly at the foot of the Rocky Mountains (Pl. XXV). The western part of these plains is therefore higher than the summits of the Appalachian Mountains, but as they rise gradually, and do not overtop lower areas, they may be regarded as true plains. Their character as plains is clearly visible in Nebraska and Kansas, where the transcontinental railways take advantage of the easy grades to mount from the Missouri to the Rocky Mountains. In this region the river valleys are broad and shallow, and give a slightly undulating character to the country. Farther north, however, the rivers have cut out deep valleys, and have thus separated the plains into well-marked divisions. The dissection of the High Plains has reached its extreme development in what are known as the "Bad Lands" of Dakota; the White River and its tributaries have cut their valleys so deep that the land between them is left in plateau-blocks, the surface of which is sometimes inaccessible. The valleys, moreover, have drained the high ground so thoroughly that the surface of the plateaus is barren desert. But in Canada the High Plains can be used as grazing lands, though they have not a sufficiently regular rainfall for agricultural purposes.

The Sub-Arctic Plains.—To the north of the prairies and the high plains are the sub-Arctic Plains, which repeat many of the structural features of the prairies, but differ in their economic value and the nature of their vegetation. The difference is due to climate. The soil is much the same as that of the prairies, and there is a similar rainfall; but, owing to their more northern position, the climate is colder and the rate of evaporation much slower. The hollows are occupied by lakes and swamps, and the soil is cold and water-logged. Hence, instead of the country being covered by a rich turf or producing valuable crops of wheat, it is covered with forests, swamps, and rank vegetation. Still farther north the climate is too cold for trees, and these Arctic plains or tundra are covered by swamps and a growth of mosses and lichens.

The Mountain Structures in the Great Plains.—The divide between the Gulf of Mexico and the Arctic Ocean is only 800 ft. above sea-level, and in the vast expanse of plains, over 2500 miles in length, between the Gulf of Mexico and the Arctic Ocean, there are only three areas showing mountain structures. The first of them is the Ozark Mountains, to the west of the Mississippi and to the north of its tributary, the Arkansas. These mountains extend for 500 miles in a course approximately east and west. Their highest peak, the Iron Mountain, is 2100 ft. above the sea-level, and 1800 ft. above the Gulf Plains at their southern edge. The Ozark Mountains are formed by the outcrop of a belt of very ancient rocks, and represent the last stump of an old mountain line, far older than either the Appalachian or the Rocky Mountains.

The second area having mountain structures is that of the Lake Plains, which are formed by a projection from the highlands of eastern Canada into the Great Plains. They are formed of very old rocks, which, like those of the Ozark Mountains, are much older than those of the Appalachian and Rocky Mountains. But instead of rising into mountains like Labrador, they have been planed down into a plateau, though, owing to the hardness of the rocks, these Lake Plains have an irregular surface. They are generally tree-covered, and their soil bears no close relation to the underlying rocks, as it is a transported soil, deposited by the melting of an ice-sheet which once covered this district. On these highlands are the Great Lakes—Lakes Superior, Michigan, and Huron.

The third mountain area, which breaks the continuity of the Great Plains, consists of the Black Hills of southern Dakota, of which the highest summit, Harney Peak, is 7216 ft. above sea-level, and rises 3000 ft. above the surrounding plains. The Black Hills consist of a nucleus of ancient rocks (Archean and granite). The dome of the Black Hills was originally formed, however, of the ordinary rocks of the Great Plains uplifted by the elevation of the old rocks beneath them.

THE WESTERN MOUNTAINS

The western part of the North American continent consists of a vast mountain region which extends from central Mexico on the south, to Alaska on the north. It is widest in the latitude of 40°, between Denver and San Francisco, where it is 1000 miles across. It embraces two mountain systems; each system is composed of many chains, and each chain of many ranges. The eastern or Rocky Mountain system is formed of the Rocky Mountains, and the western of the Sierra Nevada and the Coast Ranges. The two mountain systems are separated by a great basin.

The Rocky Mountain System.—The name Rocky Mountains is sometimes applied to the whole of the Western Mountains. The name was first given to the mountains on the eastern edge of that region which rises above the High Plains near Denver, and it is still most conveniently restricted to those mountains and their continuations to the north and south.

The Western Mountain area in Canada consists of four mountain lines, and the name Rocky Mountains is usually given only to the easternmost of the four. It is a lofty chain; its highest peak, Mount Robson, is 13,700 ft. in height, while many of its mountains are over 10,000 ft. high. This chain is bounded to the west by a long valley containing the head waters of the Fraser River, the Columbia River, and the Kootenay River. The western side of this long valley is formed by the mountains named, by the Geological Survey of Canada, the Gold Mountains; they include the Selkirks and Caribou Ranges, which are famous for their glaciers, their deep canyons, and probably the most magnificent mountain scenery in America. These chains pass to the south into the high Laramie Plateau, on which stand a number of ranges and peaks, including the weathered volcanic domes of the Yellowstone Park and the Teton range, with small glaciers still existing on its highest peaks. South of the Laramie Plateau the Rocky Mountains rise again to greater heights, around the depressions known as the Parks of Colorado. These are the mountains to which the name of Rocky Mountains was first given; their highest summits are Gray's Peak (14,300 ft.), Long's Peak (14,270 ft.), and Pike's Peak (14,146 ft.). Pike's Peak is a huge dome that rises above the mountain wall, that sharply separates the Western Mountains from the Great Plains. The Rocky Mountains of Colorado are famous for their rich ore deposits, and they contain the chief gold, silver, and lead mines of Colorado.

To the south-west of this part of the Rocky Mountains is the high plateau of Colorado, New Mexico, and Arizona; the eastern part is 6000 ft. and more above sea-level, and it sinks gradually south-westward. The climate in most of the district is arid, but there is a good rainfall on the western slopes of the Rocky Mountains, which is discharged by the Colorado River. This river flows to the Pacific through the famous "Grand Canyon of the Colorado". It is a narrow gorge, a mile deep and sometimes less than a mile in width; it has been cut by the river through the horizontal sedimentary rocks of the plateau to the foundation of much older rocks beneath them. Owing to the slight rainfall and the thorough drainage of the plateau by the deep canyon, the soil is barren; and, there being little rain to attack the banks, they stand, in spite of the comparative softness of their rocks, in cliffs which are probably steeper and higher than those of any other river valley in the world.

The Sierra Nevada and Canadian Coast Range.—This Mountain System consists of a series of chains, which run north and south along the Pacific coast. There is no one general name for this mountain system. In California it is called the Sierra Nevada; in the northern part of the United States it is the Cascade Range; and in the Dominion of

Canada it is known as the Coast Ranges. The Sierra Nevada is a mountain chain, 500 miles in length and from 70 to 100 miles in width. It consists of a great up-raised earth-block; its eastern face is a steep scarp bounding the Great Basin, and from its crest there is a long gradual slope to the west. The rivers flowing down this western slope have cut deep canyons, of which the most famous is the Yosemite valley, celebrated for its depth, its vertical cliffs, and its great trees. The highest mountain of the Sierra Nevada is Mount Whitney, 14,898 ft. high; it is the highest in the United States, excluding Alaska. North of the Sierra Nevada is the Cascade Range, a line of extinct volcanic domes, of which the highest is Mount Rainier (14,525 ft.); Mount Hood (11,225 ft.) and Mount Shasta are other extinct volcanoes.

The volcanic rocks of the Cascade Range appear to rest on a foundation having the same structure as the Sierra Nevada; for when the volcanic rocks disappear to the north, the old rocks are again exposed on the surface, and they form the Coast Ranges of Canada and repeat the typical structure of the Sierra Nevada. The Canadian Coast Ranges rise to from 7000 to 9000 ft. in height.

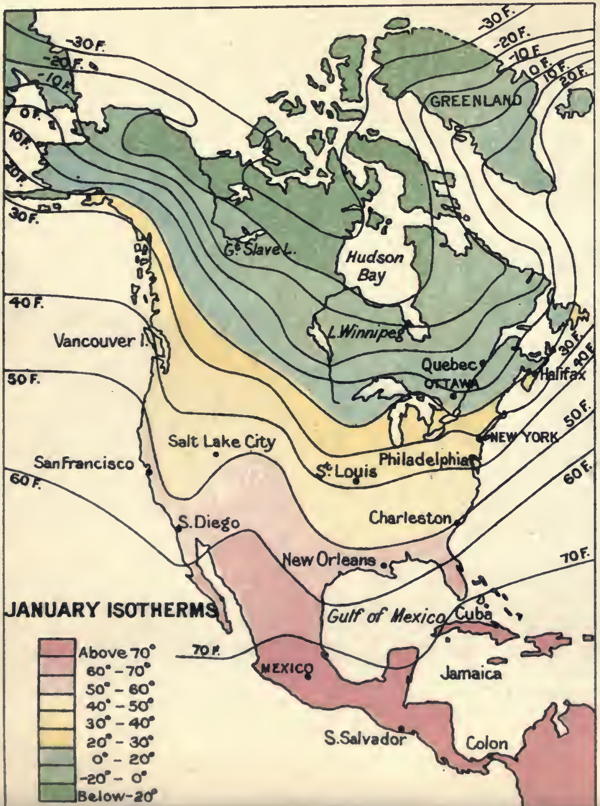
To the west of the Sierra Nevada is the Great Valley of California, which is 500 miles in length; its southern representative is the long Gulf of California; the northern end is drained by the Sacramento River, which discharges into San Francisco Harbour. Farther north, Puget Sound and Queen Charlotte Sound, between Vancouver Island and the mainland, are the representatives of the Great Valley; still farther north it can be traced, by the line of straits and fiords, along the North Pacific coast.

The Great Valley of California and its northern extension are bounded to the west by the Coast Ranges, which in the United States are comparatively low in height. They consist of very old rocks, granite, gneiss, and schists of the same age as the rocks of the Piedmont Plateau on the Atlantic border.

They form the hills of the Golden Gate, the entrance to San Francisco Harbour, and the Olympic Mountains to the west of Puget Sound. In Alaska these rocks rise to a much greater elevation, forming the famous peaks of Mount St. Elias and of Mount MacKinley (20,400 ft.), the highest summit in North America.

The Great Basin.—Between the Rocky Mountains and the Sierra Nevada there is an area of over 210,000 sq. miles, containing parts of the states of Utah, Nevada, California, Idaho, and Oregon, and a small part of Mexico. The northern districts vary in level from 5000 to 6000 ft., some of the peaks upon the border rise to the height of 11,000 ft., but to the south-west in California the plateau level sinks, till in the Death Valley it is 480 feet below sea-level. It is an arid region; the rainfall in places is on the average only 5 in. in the year and all is lost by evaporation. The rivers of the Great Basin have not been able to maintain for themselves any outlet to the sea, and it is therefore an area of internal drainage. Its vegetation is scanty, and its most typical plant is the sage bush, that grows in scattered grey tufts over the plains. The basin contains many lakes. Those along the course of rivers are filled with fresh water, but the lakes that have no outlet lose their water only by evaporation; hence there is a slow concentration of the salts carried into the lakes, and the water becomes intensely salt. The best known of these lakes is the Great Salt Lake in Utah; this is now but a small remnant of the inland sea known to geologists as Lake Bonneville.

The Great Basin is represented in Canada by a depression, 100 miles in width, between the Gold Ranges to the east and the Coast Ranges to the west; but, this being an area of higher rainfall and lower evaporation, the rivers have been able to cut for themselves outlets westward to the Pacific.


JANUARY ISOTHERMS
Above 70°
60° – 70°
50° – 60°
40° – 50°
30° – 40°
20° – 30°
0° – 20°
-20° – 0°
Below -20°
GREENLAND
Hudson Bay
Gt Slave L.
L. Winnipeg
Quebec
OTTAWA
Halifax
NEW YORK
Philadelphia
St Louis
Salt Lake City
San Francisco
Vancouver I.
S. Diego
Charleston
New Orleans
Gulf of Mexico
Cuba
Jamaica
MEXICO
S. Salvador
Colon
-30 F.
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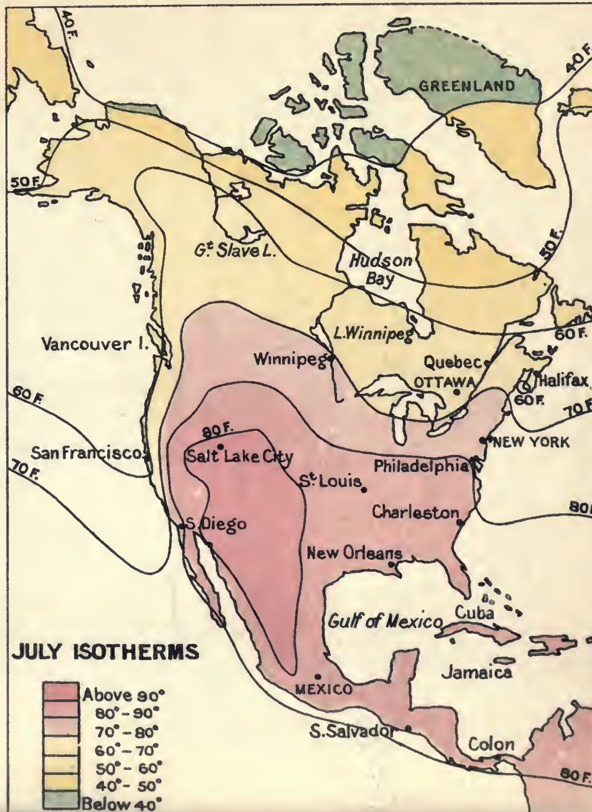
70 F.


JULY ISOTHERMS
Above 90°
80° – 90°
70° – 80°
60° – 70°
50° – 60°
40° – 50°
Below 40°
GREENLAND
Hudson Bay
Gt Slave L.
L. Winnipeg
Winnipeg
Quebec
OTTAWA
Halifax
NEW YORK
Philadelphia
St Louis
Salt Lake City
San Francisco
Vancouver I.
S. Diego
Charleston
New Orleans
Gulf of Mexico
Cuba
Jamaica
MEXICO
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40 F.
50 F.
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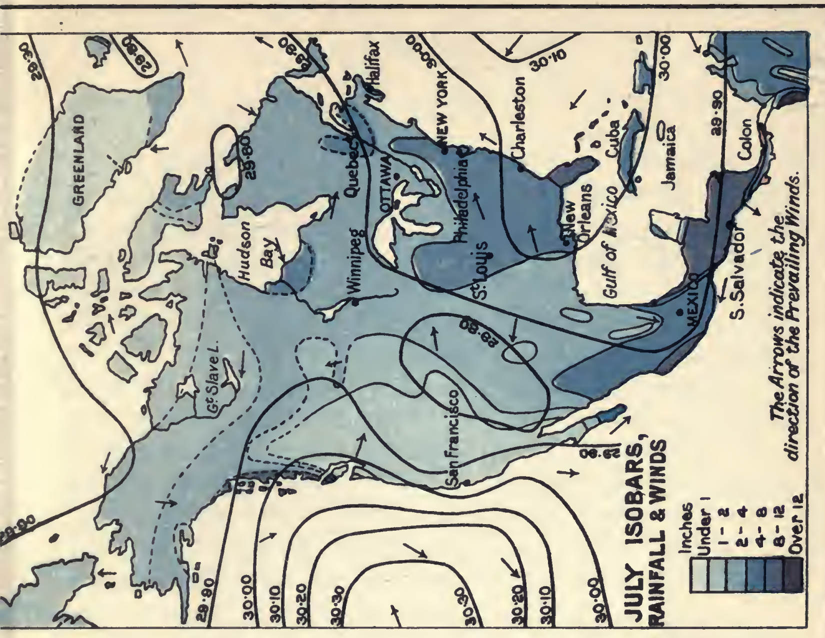
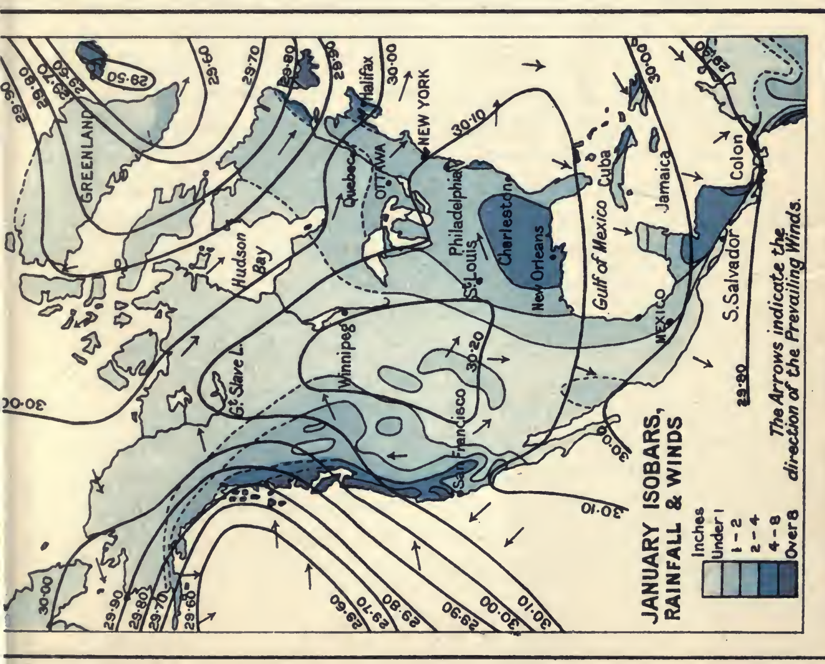
70 F.
80 F.
90 F.


JULY ISOBARS, RAINFALL & WINDS
Inches
Under 1
1 - 2
2 - 4
4 - 8
8 - 12
Over 12
The Arrows indicate the direction of the Prevailing Winds.
GREENLAND
Hudson Bay
Gt Slave L.
Winnipeg
Quebec
OTTAWA
Halifax
NEW YORK
Philadelphia
Charleston
St Louis
New Orleans
Gulf of Mexico
Cuba
Jamaica
Colon
MEXICO
S. Salvador
San Francisco
29·30
29·60
29·80
29·90
30·00
30·10
30·20
30·30


JANUARY ISOBARS, RAINFALL & WINDS
Inches
Under 1
1 - 2
2 - 4
4 - 8
Over 8
The Arrows indicate the direction of the Prevailing Winds.
GREENLAND
Hudson Bay
Gt Slave L.
Winnipeg
Quebec
OTTAWA
Halifax
NEW YORK
Philadelphia
Charleston
St Louis
New Orleans
Gulf of Mexico
Cuba
Jamaica
Colon
MEXICO
S. Salvador
San Francisco
29·50
29·60
29·70
29·80
29·90
30·00
30·10
30·20

CLIMATE

The climate of North America depends on the influence of the adjacent oceans, on the heat received from the sun, and on the arrangement of the land forms. The most influential ocean currents flow along the Atlantic and Pacific coasts. Water is piled up within the West Indian seas owing to the drift of water across the Atlantic by the trade winds. The overflow from this accumulation of water pours northward along the eastern coast of America as the Gulf Stream, and, as it comes from the tropics, it is a warm current. The Gulf Stream ends off Newfoundland, where it meets with a cold current coming through Davis Strait from Baffin Bay, and another current coming down the eastern coast of Greenland. The meeting off Newfoundland of the colder currents with the moist air from the Gulf Stream produces the dense fogs that so often occur in that region.

The prevalent winds of the North Pacific drive the water against the Canadian coast. Some of this water escapes northward in a current which is diverted southward by the peninsula of Alaska. Most of the water, however, flows southward along the coast to the neighbourhood of California, whence it passes westward again into the Pacific. The coasts of Central America are warmed by water drifting eastward along the Equator. The effect of ocean currents is therefore to give a warmer temperature, than they would otherwise have, to the eastern coasts of the United States and Nova Scotia, and to British Columbia. On the other hand, most of the Canadian coast in the Atlantic is chilled by its currents.

The main feature in the distribution of temperature is the occurrence of a series of simple zones, extending east and west across America, and showing a steady decrease in temperature from south to north. The temperature is tropical in Mexico, with a mean sea-level temperature of 80° F., and also in southern Florida and the coasts of the Gulf of California, which, though outside the tropics, have a mean annual temperature of 75° Fahr. The mean temperature falls steadily to the north, till it is 55° at Philadelphia and San Francisco, 45° at Ottawa and British Columbia, and only 5° or 27° below freezing-point in Baffin Land and the Boothia Peninsula. The northern areas receive less warmth, because the sun's rays fall upon them obliquely, the winter nights are long, and, north of the Arctic circle, the sun does not rise at all in midwinter.

The zones of temperature, however, do not cross the continent along the parallels of latitude; for the north-western part of America is warmed by the Pacific current, while the north-eastern region is chilled by the Arctic current. The isothermal line of 40°, and the northern limit of forest trees, run obliquely across the continent from north-west to south-east. There is a difference of 10° in latitude between places on the eastern and western coast that have the same mean annual temperature; thus the isothermal line which is at 45° north latitude on the Atlantic rises to latitude 55° on the Pacific.

Owing to the great size of North America, the inland districts suffer a very marked change between the temperatures of summer and winter. This seasonal variation is especially marked in the interior of Canada, where the summers are warm and the winters intensely cold. It is said of some Canadian cities that in winter they sell their milk by the pound and in summer their butter by the pint.

Rainfall.—The rainfall, that very important factor in climate, depends on the land forms. The winds that blow eastward from the Pacific drop their moisture as rain on the Western Mountains, and reach the Great Basin as dry winds. Forced to rise again over the Rocky Mountains, they are further chilled by the increased elevation, and drop the rest of their moisture; hence they sweep down on the Great Plains as dry winds. Thus along the Pacific coast the rainfall is in places over 60 in. per annum; on the Sierra Nevada it amounts to 40 in.; in the Great Basin it falls under 10 in.; along the Rocky Mountains it is about 30 in.; and on the High Plains at the western foot of the Rockies it falls to between 10 and 20 in. Farther east, in the Mississippi valley, the winds that blow northward from the Gulf of Mexico contribute to the rainfall. It gradually increases eastward till the whole of the Appalachian belt has a rainfall of from 50 to 60 in., and all the Atlantic coast has a rainfall of over 40 in. The coastal regions of Canada share this heavier rainfall, but it is low in central Canada, and the eastern half of the Dominion has a heavier rainfall than the western. The heaviest rainfall of all, however, is along the Pacific coast in Alaska and the Canadian mountains behind Alaska, where, under the influence of an ocean current coming from the south, the rainfall rises to about 100 in.

THE RIVERS AND LAKES

The distribution of the rain controls the development of the rivers. The chief rivers of North America carry the main drainage of the Great Plains in either a northerly or southerly direction to the Arctic Ocean or the Gulf of Mexico. The Mississippi is the greatest river of the continent; it rises at a height of about 800 ft. on the Lake Plain, and flows southward to the Gulf of Mexico. There the sediment brought down by the river has been deposited as a delta; but owing to the absence of currents in that gulf, each mouth of the Mississippi has been projected into the sea by river-built silt jetties (fig. 50, p. 71). The longest tributary of the Mississippi, the Missouri, rises on the eastern face of the Rocky Mountains, while its own tributaries have a similar source farther to the south. These rivers flow through an area of small rainfall, and their volumes are small in proportion to their length and the areas that they drain. The Arkansas and the Red River, both western tributaries of the Mississippi, also flow from the Rocky Mountains across the High Plains. The main eastern tributary of the Mississippi, the Ohio, rises in the region of heavy rainfall on the west of the Appalachian Mountains.

The St. Lawrence, the chief river of Canada, rises in the Great Lakes. Lake Superior, the largest (area, 31,200 sq. miles; alt. 602 ft.; depth, 1008 ft.), and Lake Michigan (area, 22,450 sq. miles; alt. 580 ft.; depth, 870 ft.), both discharge by the rapids of Sault Sainte Marie into Lake Huron (area, 23,780 sq. miles; alt. 580 ft.; depth, 700 ft.). The drainage of the three lakes passes by the Detroit River into Lake Erie. The level of Lake Erie (area, 9960 sq. miles; depth, 210 ft.) is still 573 ft. above sea-level; but when Lake Ontario (area, 7240 sq. miles; depth, 738 ft.) is reached, its level is only 246 ft., because the water from Lake Erie has poured over the Niagara Falls (158 ft. high) into a deep gorge made by the waterfall cutting its way backward through the plateau. The recession of the fall on the Canadian side of the river averages 4 ft. a year.

The Canadian Rocky Mountains nourish many powerful rivers, of which the Yukon and the Mackenzie flow into the Arctic Ocean. The numerous rivers which unite to form the Nelson discharge into Hudson Bay, while the rivers that flow into the Pacific from the Western Mountains of Canada have a very large discharge in proportion to their length.

The lakes in Canada are innumerable. In addition to the great lakes along the frontier, between the United States and Canada, there are many large lakes in the north-west. Lake Winnipeg, in Manitoba (alt. 710 ft.), though its area is still 9400 sq. miles, is only the last remnant of a much greater lake known as Lake Agassiz, which also included Lake Winnipegosis. Lake Athabasca (area, 2850 sq. miles), the Great Slave Lake (area, 10,100 sq. miles; alt., 391 ft.), and the Great Bear Lake (area, 11,200 sq. miles), occupy deep depressions in the Arctic Plains, and discharge their surplus waters into the Mackenzie River.

The Great Basin of the United States has many salt lakes upon its lowest depressions; these are the relics of much greater fresh-water lakes, which have been reduced by evaporation. In the Cascade Mountains are some interesting volcanic lakes formed in volcanic caldrons, due to the subsidence of the ground after volcanic eruptions. The most famous of these volcanic lakes is that known as Crater Lake on Mount Mazama in Oregon.

VEGETATION AND WILD ANIMALS

The vegetation of North America has been generally mentioned under its physical divisions, and it is controlled by the temperature and the rainfall. The forests are of great importance, as the lumber trade is still one of the chief American industries. The forests which maintain it grow in the backwoods of the Appalachian belt. The forests of the lake plains of Wisconsin and Minnesota, of the Upper Mississippi, and of the lake provinces of Canada are other important centres of the timber trade.

The chief agricultural products of America are wheat, cotton, and sugar. Wheat is grown on the rich soils of the prairies, and, owing to the warm dry summer, its cultivation extends on the plains as far north as Manitoba. Cotton is raised in the states of Virginia and Carolina, while still farther south, in Georgia and Florida, are the chief plantations of sugar-cane.

The wild animals of North America are scanty and of comparatively little value. Those of most economic value are the fur animals of the northern forests, including especially the beaver, the sable, the ermine, and the musquah; the trapping of these animals led to the first development of the northern interior of the continent. The most interesting of the wild animals of America is the bison, which once roamed over the high plains in countless herds. In 1872 there were two herds left, numbering some 8,000,000 animals; the southern herd was destroyed between 1872 and 1874, when 3,500,000 bison skins were sent eastward by railway; the northern herd was destroyed a few years later, and the total number left in the United States—about 800—live in a few protected herds. Some wild bisons are still alive in Canada.

The reindeer, known as the caribou, was once plentiful in Newfoundland and Canada; but they were not domesticated, as in Lapland, and have been destroyed by hunting. To replace them, European reindeer were introduced into Alaska in 1881, and have been imported into Labrador in 1907. The moose, the largest of living deer, and the wapiti or American elk, both live in the Canadian forests. The musk-ox is found in the far north on the barren tundra along the Arctic shore, in Greenland, and in Grinnell Land. The mountain sheep lives in the Rocky Mountains. The Eskimo dog was domesticated by the Eskimo who live in Greenland and the islands of the Arctic Archipelago. Bears, of which the best known is the grizzly, live in the Western Mountains. Rattle-snakes were once abundant, both in the south-west of the United States and ranging northward along the Atlantic coasts as far as the state of Maine. Horses and cattle have been introduced since the European occupation, and are now of great industrial importance.

THE ABORIGINAL INHABITANTS

America when first discovered was occupied by an aboriginal race whom Columbus, owing to his mistaking the West Indies for part of India, called Indians. The people are brown in colour, have long black hair, high cheek-bones, and slit-like eyes (fig. 92), and are generally regarded as Mongolians, who must have entered America from Asia. They were a brave and intelligent race, and skilful hunters; they used copper as well as stone for their tools and weapons. The population was always scanty, as it was nomadic and lived by hunting, and the numbers were kept down by war and famine and by their necessarily large requirements of land. The number at present is about 270,000, and it is claimed that, owing to the protection granted them in reserves, they are no longer diminishing in numbers. Ancient settlements made by the "mound builders", and deserted cities among the western canyons, are relics of a people who used only stone tools and weapons, and of whom there is no historical knowledge. These extinct tribes appear to have been the ancestors of the Indians, or at least to have been allied to them in race. The Eskimo of the Arctic Archipelago and Greenland are also of Mongolian origin, but they have been modified by the arduous conditions of their life in the frozen north.

Fig. 92.—Chippeway Indian (Algonquin type)

EUROPEAN SETTLEMENT

The few North-American Indians are of no political importance, and the present population has entered from Europe. North America was discovered apparently in the eleventh century by Scandinavians working around the North Atlantic from Iceland and Greenland, and a stone with a supposed Runic inscription is held to be a contemporary record of these Norse discoverers.

The practical discovery of America dates from the voyage of Columbus to the West Indies in 1492. The active occupation of the mainland began with the landing of the Pilgrim

Fathers in New England in 1620.[1] French settlers, following in the wake of Cartier, who had visited the site of Quebec in 1534, founded a station there in 1608, whence they began the fur trade. In 1623 the Dutch settled at New York, which they called New Amsterdam. Pennsylvania was founded by the Quakers under Penn in 1681. The French settlements at first made the most rapid progress. They pushed out westward from Canada and occupied the Mississippi valley. But in 1759 the British conquered Canada, and had secured possession of New York in exchange for part of Guiana in 1667. Thus the whole of the Atlantic seaboard became British. The colonists quarrelled with the British Government, as they objected to pay taxes without representation, while the Government insisted that the colonists should contribute to the cost of the wars against the French in Canada, which had been undertaken mainly in their defence. The dispute led to a war from 1775 to 1782, which ended in the complete defeat of the British forces, the establishment of the United States, and the recognition of its independence in 1782.

The growth of the population of America has been accelerated by constant immigration. Parts of eastern Canada are largely inhabited by people of French descent, 85 per cent of the population in the province of Quebec being French in race and language. Parts of Texas, New Mexico, and California have many descendants of the old Spanish settlers. Negro slaves were introduced into the southern parts of the United States to work the sugar and cotton plantations. Since the stoppage of the slave trade many immigrants from the south of Europe have settled in the southern states. The lumber trade is largely worked by Scandinavians. Until the development of Germany as a great manufacturing nation, there was a steady German immigration into the States. In spite of the mixture of many other nationalities, the bulk of the North American population is of British origin.

[1] Spaniards had invaded Mexico in 1519, and settled in California in 1697.

POLITICAL DIVISIONS

North America is divided politically between the United States, including Alaska, and British North America, including the Dominion of Canada and Newfoundland.[1] The United States were originally founded as a series of British colonies along the Atlantic coast; after the War of Independence they formed the Republic of the United States. Florida was subsequently acquired by purchase from Spain, the Mississippi Valley from France, and Alaska from Russia. The Republic extended its dominions westward to the Pacific, acquiring Oregon by settlement, and New Mexico and California by cession from Mexico, and Texas by its own consent.

The Government is a Republic, at first of thirteen, but now of forty-five federated states, which have a large amount of local self-government. There are in addition the District of Columbia, including Washington, the seat of the Federal Government; four territories occupied by whites, and one reserved for Indians, who are directly under the control of the Federal Government. The Government consists of a President, who is elected indirectly by a public vote; for the public elect a number of electors, and they elect the President. It has happened more than once that the electoral body chose a President whose party received a minority of the total votes polled at the Presidential election. The President appoints the heads of the various Government departments. The Parliament or Congress is composed of two chambers—the Senate, and a House of Representatives. The former is composed of two members elected by each state; consequently the state of New York, with its 6,000,000 inhabitants, has no larger representation in the Senate than Nevada, with its population of 50,000. The Congress is so elected that it takes years to change the balance of party, and so the political policy of the United States is protected

[1] For Mexico, see Central America, p. 233.

from a sudden wave of public feeling. New acts have to pass both Houses of Congress, and then have to be approved by the President. But the President cannot veto an act if it has been approved by a two-thirds majority of both chambers. The Constitution is democratic, and it was carefully designed to avoid the chief danger of democratic Governments, by safeguarding the administration from rash impulses and panics.

In Canada the older established provinces about Quebec have a large majority of people of the French race, but the inhabitants of the newer western provinces are mainly British. The provinces have (since 1867) been united into a Federal Government—the Dominion of Canada,—which includes all British North America, except Newfoundland and Labrador.

Alaska was originally a Russian province colonized from Siberia; it was sold by Russia to the United States, and is now governed from Washington as a territory.

Exports and Imports.—The United States developed first on its agricultural resources; but during the last half-century it has become one of the greatest manufacturing countries of the world. In 1850 its manufactories employed 957,000 hands, with a capital of £109,000,000. In 1890 the numbers had grown to 4,700,000 hands, with a capital of £1,350,000,000, and by 1900 to 5,700,000 hands, and a capital of £2,024,000,000. Its chief manufacturing industries are those of timber, tinning meat, flour milling, and the making of clothes, iron, steel, and machinery. Its internal trade has been developed by a great system of railways, of which the most important run across the continent from the Atlantic to the Pacific. The rivers and lakes are used for internal navigation. Ships of over 10,000 tons burden bring ore and wheat from the Port of Duluth, at the western end of Lake Superior, for 1000 miles to Lake Ontario. The rapids of Sault Sainte Marie are avoided by a canal, and the Niagara Falls and Rapids by the Welland Canal, in which vessels are lowered 326 ft. by twenty-seven locks in 28 miles. The Erie Canal, for boats and barges, early connected Buffalo, on Lake Erie, with the Hudson River and New York.

The commercial development of the United States has been aided by its vast mineral resources. The discovery of the gold-fields of California led to the occupation of the western States and to the construction of the railway system between east and west. Nevada, with an arid climate and in a remote position, owes its development to its rich mines of gold and silver. The chief gold-fields are in California and Colorado, and the more recently opened fields in Alaska. Still more important than the gold-mines are the rich fields of coal and iron ores. The most important coal-fields are in the eastern states in Pennsylvania. Iron ores are widely distributed, but chiefly around Lake Superior; the ores are transported thence by steamer and rail to be smelted on the Pennsylvania coal-fields. In addition to its vast stores of coal, America has ample stores of oil and natural gas. These have been formed by the distillation of organic matter enclosed in the rocks; the oils and gases given off have accumulated in porous beds lying beneath beds of impermeable rock (fig. 26, p. 30). The sinking of an oil-well through the covering rocks enables the imprisoned gases and oils to rush to the surface. The natural gas-wells have yielded a large supply, which has been used for lighting towns and working machinery in factories. But the supply of natural gas is not permanent, and many of the factories have been obliged to return to the use of coal.

The manufacturing industries of the United States owe their success to the ingenuity of the American people, and to the low price at which they have been able to produce their goods, owing to the great scale of their operations. The country is as large as Europe, and has a continental supply of raw materials; it has a vast home market, with no internal barrier to trade. The wealth of the country is not absorbed by heavy taxation for great military expenses, or to pay the interest of a large national debt left by former wars; and there is no necessity for the withdrawal of a great proportion of the population from industrial pursuits to form a large standing army. With these advantages the United States is advancing rapidly in prosperity, and to a wealth beyond the dreams of avarice.

The development of Canada has been slower, as its more northern position gives it a less favourable climate. Its prosperity is mainly dependent upon its agriculture, and on the working of the timber of the Eastern Highlands. It has gold mines in the Klondyke, British Columbia, and Nova Scotia; the nickel mines of Sudbury; the cobalt and silver ores of Ontario; and the furs trapped on the sub-Arctic plains. The working of the rich gold-fields of the Yukon district, in the far northwest, is hampered by the Arctic climate. Western Canada has enormous coal deposits.

CHAPTER XVII

CENTRAL AMERICA AND THE WEST INDIES

Central America and the West Indies may be grouped together as a part of America geographically independent either of North America or of South America, although actually connected to both. The chief geographical lines of both North and South America run north and south, whereas in Central America and in the West Indies they trend from east to west. This trend is of great antiquity. It dates from the time when the West Indies and Central America were part of a continent—the Antillean Continent—which covered the whole of the Gulf of Mexico and the Caribbean Sea, and extended westward into the Pacific and eastward into the Atlantic, until, perhaps, "Antillia" was united to Europe. At the same time large parts of North and South America were covered by the sea. The mountains of the Antillean continent ran from east to west, and the geographical structure of this old land can still be recognized in the geo-


CENTRAL AMERICA
AND
WEST INDIES
GEOGRAPHICAL DIVISIONS
English Miles
0 100 200 300 400 500 600
UNITED ST
MEXICAN
PLATEAU
Rio Grande
Gulf of California
Sª de la Giganta
Western Sierra Madre
Eastern Sierra Madre
Gulf Plains
GULF O
L. Chapala
Colima
Jorullo
Mexico
Toluca
Basin of Anahuac
Popocatepetl
Orizaba
Vera Cruz
Tuxtla
R Mexcala
Cockscomb Mts
(Recent Fold Mts)
Sª de las Minas
Gigedo Is.
Clipperton Atoll
PACIFIC
OCEAN
Galapagos Is.
120
110
100
90
30
20
10
0
Long. West


ATLANTIC
OCEAN
BAHAMA ISLANDS
Bahama Bank
Florida
Tropic of Cancer
CUBA
GREATER ANTILLES
Gr. Cayman
Bartlett Deep
Jamaica
Kingston
Pedro Bank
S. DOMINGO
Porto Rico
St Thomas
Sombrero
Anguilla
Barbuda
St Kitts
Antigua
Montserrat
Guadeloupe
Dominica
Mt Pelée
Martinique
St Lucia
Barbados
St Vincent
Soufrière
Grenada
Tobago
Trinidad
LESSER ANTILLES
CARIBBEAN SEA
15,000
Below 15,000 ft. deep
Oruba
Curaçoa
Paraguana Penin
Margarita
Guajira Penin
Gulf of Maracaybo
VENEZUELA
COLOMBIA
ECUADOR
MEXICO
TES
Gulf of Honduras
Folded Limestone Mts
Volc. chains of Alajuela and Heredia
Mosquito Coast
Mosquito Bank
Masaya
L. Nicaragua
Ometepe
Orosi
Rio S. Juan
Tenorio
Irazu
Sa de Curiqua
Sa de Veraqua
Cocos I.
Malpelo I.
Equator
eenwich
80
70
60
30
20
10
0
Plateau of Ancient Rocks
Folded Limestone Mountains
Volcanic
Volcanoes
Sedimentary Mountain Chains:-
Remnants of the old Antillean Land

graphical grain of its existing fragments, as shown by the course of the mountains, the strike of the rocks, the trend of the volcanic lines and of the "deeps" of the sea-floor. This Antillean continent is now represented by two fragments, the mainland of Central America, and the archipelago of the West Indies. The mainland of Central America consists of the colony of British Honduras and the states of Mexico, Guatemala, Honduras, San Salvador, Nicaragua, Costa Rica, and Panama.

Mexico is the largest of the Central American states, and it was once much greater still. It inherited all the Spanish possessions in North America, but it has lost California, Arizona, New Mexico, and Texas.

The geographical structure of Mexico differs essentially from that of North America. There is a continuation of the Gulf Plains along the shore of the Gulf of Mexico; these coastal plains, 100 miles wide in the north in the valley of the Rio Grande, gradually narrow southward, till they end to the south of Vera Cruz. The rest of the country consists of a table-land bounded by two scarps, the Eastern Sierra Madre on the Atlantic side, and the Western Sierra Madre on the Pacific side. The surface of the plateau is mostly between 7000 and 8000 ft. in height. The capital, the city of Mexico, is 7430 ft. above sea-level, although only 264 miles by railway from the sea at Vera Cruz. The Eastern Sierra Madre are about 6000 ft. above sea-level; they are merely the worn eastern face of the table-land, which rises steadily inland from their edge. The ascent to it from the sea is over a series of terraced platforms. The height of the Pacific edge of the plateau is from 10,000 to 12,000 ft., and the scarp of the Western Sierra Madre falls steeply to the Pacific coast.

The long, narrow peninsula of Lower California is parallel to the Western Sierra Madre, and its mountains, the Sierra de la Gigantea, are 4000 ft. in height.

The table-land of Mexico may be regarded as a southern continuation of the table-land of Colorado, while the Sierra

Nevada are continued in the peninsula of Lower California, and farther southward by the few scattered islands, including the Gigedo Islands and Clipperton Atoll, which, with the Galapagos, are probably the remnants of a former island festoon off the Pacific coast.

The most famous mountains in Mexico are its volcanoes, now mostly extinct. Roughly speaking, they run in chains east and west across the country from the Gulf of Mexico to the Pacific. The most active volcanoes are always on the Pacific end of each chain. The Mexican chain begins with Tuxtla, 4920 ft. high, on the shore of the Gulf of Mexico; next to the west is Orizaba, the highest summit in Mexico, rising above the central plateau to 18,200 ft. Beyond it is Popocatepetl, 17,540 ft. high, it is 44 miles south-east of the capital, and is now dormant; but it was in active eruption during the Spanish invasion of 1520. The next important volcano on this line is Toluco, 15,019 ft. high, and beyond it lies Jorullo, 4265 ft. high, on the Pacific side. Jorullo is famous from the legend that it rose like a bladder, uplifting 4 sq. miles of a cultivated plain during one night in September, 1759.

The rivers of Mexico are few and unimportant. The only important one is the Rio Grande, which forms the frontier between eastern Mexico and the United States. The Atlantic coast is bordered by lagoons. The most interesting waters in Mexico are the lakes on the plateau. The capital is situated on the site of a lake the waters of which have gradually dwindled. The Aztec name of the city, Anahuac, "Amid the waters", refers to its position in the midst of the lake, which was crossed by a series of narrow causeways. The sinking of the lake and the exposure of the silt on its floor, sodden with the sewerage of centuries, rendered Mexico formerly one of the most unhealthy cities in the world. It has now been drained by a tunnel through the rim of the lake basin. The chief source of the wealth of Mexico is its mines. It is the greatest silver-producing country in the world, and has supplies of gold, copper, and lead.

The northernmost of the smaller States of Central America resemble Mexico in geographical structure, for they consist of an inland plateau, faced to the east and west by scarps, which in Guatemala have the same name as in Mexico—the Sierra de Madre. Also, as in Mexico, the Pacific scarp is the steeper and the Atlantic scarp rises above a coast plain, while on the plateau there are wide sheets or lofty domes of volcanic rocks. But, unlike Mexico, in all the southern states the table-land is broken up by fold-mountains, trending generally from east to west, and separated by deep depressions. Owing to the influence of this feature, the southernmost state, Panama, runs almost due east and west, with the sea to the north and south of it.

The northern states are Guatemala, San Salvador, and Honduras, with the colony of British Honduras. They consist in the north of plains of horizontal limestones, which are well shown in British Honduras, and in the Plains of Peten in Guatemala. To the south are some mountains which in British Honduras are known from their jagged crest as the Cockscomb Mountains. To the south-east, in Guatemala, are limestone mountains, raised by earth crumplings at the same date as the formation of the Alps. The limestone mountains of Guatemala are succeeded to the south by parallel ranges of much older rocks, containing rich ore deposits, to which they owe their name of the Sierra de las Minas. Still farther south, a chain of volcanoes includes the best-known mountains of Guatemala. The volcanoes are most active on the western side of Central America, and the rich soils formed by the decay of the volcanic rocks are the chief source of the wealth of these states; hence most of the cities are on the Pacific side.

Quezaltenango, the commercial capital of western Guatemala, is near the volcano Santa Maria, which was believed to be extinct; but it burst into eruption in 1902, and devastated the agricultural country at its foot, and an earthquake overthrew the city. These disasters were the first incidents in the disturbances, which culminated in the terribly fatal eruptions of Martinique and St. Vincent, on the eastern side of the West Indian area.

The southern republics repeat the same essential geographical structure. Nicaragua has a wide coast plain known as the Mosquito Coast along the shore of the Caribbean Sea; in spite of the low level and tropical position, the climate is said to be remarkably healthy. Most of northern Nicaragua is from 2000 to 3000 ft. above sea-level, and on it rises a series of volcanoes of which Consequina is famous for its tremendous eruption in 1835. The uplands of Nicaragua end to the south and south-west on the edge of a depression which begins on the Pacific side in the Gulf of Fonseca; it is continued by the valleys where lie Lake Nicaragua and the Rio San Juan, which discharges into the Caribbean Sea. This depression forms the lowest valley across America. Lake Nicaragua, near the divide, is only at the height of 108 ft. above sea-level.

South of the Nicaraguan valley is Costa Rica; the northern part is a plateau situated from 3000 to 4000 ft. above sea-level, and above the plateau volcanoes rise to the height of 11,200 ft. The highest of the volcanic cones is Irazu; an eruption in 1723 ruined the old capital Cartago, and the seat of Government was subsequently removed to San José on the Pacific side. All northern Costa Rica is covered by volcanic rocks; but the southern part of the state is composed of old sedimentary rocks, which trend from east to west and are the continuation of the high mountain ridge that forms the isthmus of Panama. The best known of these mountains in Costa Rica are the Sierra de Chiriqua, continued by the Sierra Veraqua and the Cordillera de San Blas in Panama.

POLITICAL GEOGRAPHY

The states of Central America were formerly provinces of the Spanish Empire; one after another they gained their independence and are now republics. The original population consisted of American Indians, and most of the European settlers are of Spanish race. Owing to its elevation, the larger part of the region is said to have a healthy climate.

The chief economic industry is agriculture, owing to the rich and easily tilled volcanic soils. The older rocks which form the Sierras contain many ore deposits, and are especially rich in silver, with smaller deposits of gold.

In recent years the main political interest of these states has been connected with the ship canals, which have been proposed to connect the Atlantic and the Pacific. The route (187 miles) which offers the fewest engineering difficulties, and could be made most cheaply, follows the San Juan valley and traverses Lake Nicaragua; by a few locks and comparatively shallow cuttings the divide could be crossed at a height of 110 ft. Political differences between Britain and the United States prejudiced this route, and it was finally abandoned on the ground that it was unwise to undertake a work so expensive, and so easily liable to damage by earthquakes, in such an unstable volcanic country. The route therefore adopted by the United States Government is across Panama. The political difficulties have been removed by an insurrection, and the establishment of Panama as an independent republic in 1903. The canal will be shorter than that proposed through Nicaragua, the length being about 50 miles; but as the canal is being cut through a thick ridge 328 ft. in height, the expense of excavation will be greater. A canal on this route was begun by a French syndicate under De Lesseps, but, owing to mismanagement, it was abandoned after an expenditure of £60,000,000.

Physical

The West Indies form an archipelago on the east of Central America; they are the scattered island remains of the Antillean continent. The earth movements which produced the Gulf of Mexico in the north, the Caribbean Sea to the south, and the numerous straits, broke up the remaining land into scattered islands; these earth movements are probably still in progress, for the whole area is frequently shaken by powerful earthquakes. The sinking of the surface places intense pressure on parts of the lower layers of the earth's crust, and thus leads to the outflow of the compressed material in volcanic eruptions. The volcanic vents occur along the fractures around the sinking area, and the volcanic eruptions may be compared to the oozing forth of water along the seams of a closed, full tin when the surface is pressed in. Thus the earthquake which devastated Quezaltenango in Guatemala was no doubt a result of the same subterranean movements that caused the volcanic eruptions of Mont Pelée in Martinique, and of the Souffrière in St. Vincent. The eruptions of Mont Pelée destroyed the town of St. Pierre and its 35,000 inhabitants, while that of the Souffrière of St. Vincent was only less fatal as it happened in a less populous district.

The structure of the old Antillean land, and the nature of the movements which destroyed it, are indicated by the east-and-west course of the chief West Indian Islands; the same structure is also shown by the position of the "deeps" that appear as furrows on the floor of the Caribbean Sea (Plate XXVI). Thus the Bartlett Deep, that extends eastward from the Gulf of Honduras, between Cuba and Jamaica, is so long and narrow that it has been regarded as a submerged river valley, though it is more probably a submarine rift valley. The largest of the West Indian Islands, known as the Greater Antilles, are arranged on lines which, like the structural lines of Central America, trend from east to west. Cuba and Jamaica are both on east-and-west lines, separated by the Bartlett Deep. The sea floor falls from the islands to the deeps in slopes so steep that they are unstable, and the materials frequently slip down the sides, producing violent local earthquakes, such as that which devastated Kingston, the chief town of Jamaica, in January, 1907. The two lines form the two peninsulas at the western end of the island of San Domingo; but they are united at its eastern end and in Porto Rico. The last trace of the old rocks of the Greater Antilles is seen in the small island of St. Thomas.

The smaller West Indian Islands, or Lesser Antilles, belong to three groups—the Bahamas, the island chain of the Caribbees, and the islands off South America. The Bahamas are a group of some 3000 coral islands and sand-banks, which rest on a bank in continuation of the peninsula of Florida. They are all low and have a sandy soil.

The island chain of the Caribbees is formed by the peaks of a submerged ridge, which separates the Caribbean Sea from the Atlantic Ocean. These islands are of two distinct types, volcanic and sedimentary. The volcanic islands are the western members of the chain, facing the foundered depression of the Caribbean Sea. The volcanic islands are lofty, and are usually covered with dense forests. Their soils are varied and fertile, and they have an abundant rainfall. The best known of these volcanic islands are St. Kitts, Montserrat, western Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, and Grenada.

The eastern islands of the Caribbees are composed of sedimentary rocks, chiefly limestones, resting on a foundation of more ancient rocks, which are only occasionally exposed. These limestone islands occur on the Atlantic side of the chain. They are generally low, with a fairly level surface, and they are more easily brought under cultivation than the jungle- and forest-covered volcanic soils. The chief islands of this chain, again following them from north to south, are Anguilla, Barbuda, Antigua, eastern Guadeloupe, Barbados, Tobago, and Trinidad. Occasionally both volcanic rocks and limestones occur in the same island, as in Antigua, where the contrast between the level eastern limestone districts and the western mountainous volcanic hills is especially well shown. Antigua also contains representatives of the older rocks of the Antillean continent. The same contrast is very striking in the dumb-bell-shaped island of Guadeloupe; a lofty and volcanic western area and a low limestone island to the east are joined by a narrow isthmus. The rocks beneath the limestones are exposed in Barbados, where they yield petroleum, derived from organic materials laid down in the estuarine deposits; while above them are oozes, which show that during the breaking up of the Antillean continent, the site of Barbados and part of Cuba must have sunk to a depth of over 10,000 ft. beneath the sea and then again been upraised.

Trinidad connects the Caribbean chain with the islands off the South American coast. It is structurally part of the mainland of South America, being separated only by the strait known as the Serpent's Mouth; its northern hills are a direct continuation of those which form the Paria Peninsula of Venezuela. It contains a rich deposit of pitch about 90 acres in extent, known as the Pitch Lake; its surface is not liquid, but is soft in places. The pitch exudes from rocks of the same age as those which form the foundation of Barbados and yield its petroleum springs.

Tobago, between Barbados and Trinidad, also belongs to the non-volcanic chain. It is well known in fiction as Robinson Crusoe's Island, and the man Friday is supposed to be a Carib slave who had escaped from the plantations on the adjacent island of Trinidad.

Off the Venezuelan coast there are the islands of Margarita, Curaçao, and Oruba, which, like Trinidad, are physically fragments of the South American mainland. The peninsulas of Guajira and Paraguana, beside the Gulf of Maracaybo, have the same structure as these islands, but they have not yet been completely separated from the mainland.

POLITICAL AND ECONOMIC GEOGRAPHY

The West Indies were discovered by Christopher Columbus on his epoch-making voyage to America in 1492, when he first landed on the island of Marie Galante, off Guadeloupe. He regarded the islands as connected with India, and so called them the West Indies and their natives Indians. They were then inhabited by an American race, the Caribs or Caribals, who were man-eaters, and from this name by an easy transition came the word "cannibal". The Caribs would not work in the sugar plantations, subsequently established on the islands, so Negro slaves were imported from Africa, and the Caribs have disappeared except in the reserves on the islands of Dominica and St. Vincent.

The islands have rich soils; they have an ample rainfall and a fine climate. At one time they were the most flourishing of tropical colonies, and produced most of the sugar for the European market. But during the nineteenth century they have been less prosperous, owing to the failure of the labour supply after the emancipation of the slaves in 1832, and the competition of sugar produced in Europe from beet-root. They are now yielding, in addition to sugar, quantities of cocoa, coffee, limes, and tropical fruits, especially bananas, which are shipped from Jamaica to the United States and Great Britain.

The development of the islands is hampered by the political differences between them. San Domingo is an independent Negro republic; Cuba is a republic under the protection of the United States; Port Rico belongs to the United States; Jamaica, Anguilla, Barbuda, Antigua, the Bahamas, Dominica, St. Lucia, St. Vincent, Barbados, Grenada, Tobago, Trinidad, and many smaller islands are British; Curaçao and Aruba, off the coast of Venezuela, and St. Eustatius and Saba are Dutch; Guadeloupe and Martinique and St. Bartholomew (bought from Sweden in 1878 for £10,000) are French; the Virgin Islands, including St. Thomas, St. John, and St. Croix, are Danish. The little island of St. Martin is divided between France and Holland. The islands belonging to so many different nations, it is impossible to develop one common policy for them; and the cost of their political administration is necessarily high. Owing to the great geographical contrasts between those of the volcanic and those of the limestone series, these neighbouring islands could interchange their products with especial benefit; yet they are separated by artificial barriers in the matter of trade, and cannot easily combine in investigations which would help their agricultural development.

Among the main products of the islands are sugar, rum, molasses, and fruits from Jamaica; tobacco from Cuba; coffee, cocoa, lime-juice, spices, and sugar from the smaller islands, and asphalte from Trinidad. Phosphate, now exhausted, was worked in Sombrero and Oruba. The chief industries of the Bahamas are sponge-fishing, at sea, and the growth of fibre plants, such as the aloe-like agave, on shore.

CHAPTER XVIII

SOUTH AMERICA

The continent of South America resembles North America in its general shape and structure. Both continents are triangular, and are widest to the north, tapering gradually to the south. The two continents both consist of three similar structural divisions: (1) A western mountain land extending the full length of the continent from north to south; (2) a less extensive eastern highland; and (3) a vast intermediate tract of plains.

The western mountain land of South America contains mountains of recent formation, and has some resemblances in structure to the corresponding mountains of North America. The western mountains stand in parallel ranges, which have a general trend from north to south; at their widest part these mountains enclose the basin of Lake Titicaca, which is analogous to the "Great Basin" of the United States.

The second geographical element in South America consists of the eastern mountains on the Atlantic side of the continent. They form the old highlands of Brazil, which must once have extended eastward into the Atlantic, and, according to Katzer, were built largely of materials derived from the destruction of an old Atlantic land. The actual


CARIBBEAN SEA
Gulf of Darien
Isthmus of Panama
Caribbean
CARACAS
Cordillera
Trinidad
Venezuelan Cordillera
Western Cordillera
Magdalena
Interandean Volcanic Line
Eastern Cordillera
V. de Tolima
V. Purace
QUITO
Antisana
Cotopaxi
Chimborazo
Cordillera Nevada
Cordillera Negra
Huascan
Callao
LIMA
Huancavelica
Basin of
Lake Titicaca
Illampu (Sorata)
Illimani
V. Tutupaca
Coast Cordillera
Arica
Sucre or Chuquisaca
Camargo
Orinoco
Bolivar
Georgetown
Paramaribo
Cayenne
HIGHLANDS OF GUIANA
NORTH ATLANTIC
OCEAN
Rio Negro
Amazon
Yapura
Teffe
Ica
Marañon
Jurua
Purus
Madeira
Borba
Tapajos
Xingu
Belem
Araguaya
Fortaleza or Ceara
Natal
Pernambuco
São Francisco
BRAZILIAN
HIGHLANDS
Guapore
Trinidad
Chiquitos
Paraguay
Cuyaba
Goyaz
GREAT CORDILLERAS
MOUNTAIN SYSTEM
80
70
60
50
40
10
0
10


SOUTH AMERICA
GEOGRAPHICAL DIVISIONS
English Miles
0 200 400 600 800
Uplands
Lowlands
Grain of the older Mountain System
Western Cordillera
Eastern Cordillera
Coast Cordillera
Volcanic Areas
SOUTH ATLANTIC OCEAN
RIO DE JANEIRO
Rio Grande
ASUNCION
Rio Parana
Uruguay
MONTEVIDEO
Rio de la Plata
BUENOS AYRES
Sierra de la Tandil
Sa. de la Ventana
Rio Negro
Verraejo
Salado
Sierra de Famatina
Sierra de Cordoba
Cor. de Aconcagua
ANDES
OF THE ANDES
V. Copiapo
Valparaiso
SANTIAGO
Coast Cordillera
Concepcion
V. Antuco
Valdivia
V. Chalten
Falkland Is.
S. Georgia
St. of Magellan
Tierra del Fuego
Cape Horn
Tropic of Capricorn
OCEAN
St. Felix
Juan Fernandez
Longitude West of Greenwich
30
40
50
60
70
80
90
20

composition of these Brazilian highlands is strikingly different from the Appalachian belt of North America; but their geographical correspondence, in spite of the differences of composition, emphasizes the structural resemblance between the two continents.

The third element in South America consists of the wide lowland plains that lie between the eastern and western mountains. The area of these plains was doubtless once occupied by the sea, which then divided South America into two distinct lands. These lowland plains hold the basin of the Amazon, the Orinoco, and the La Plata. The Amazon, corresponding to the St. Lawrence in North America, flows through a valley in the eastern mountains, and has thus separated the highlands of Brazil from those of Guiana, just as the St. Lawrence separates the highlands of Labrador from those of the Appalachians. The La Plata corresponds to the Mississippi, the Orinoco to the Nelson River. The Mackenzie is represented on a smaller scale by the Magdalena River.

South America presents one striking contrast to Africa, which it resembles in many respects, as in position and shape. Apart from the Atlas region, which, as already mentioned (pp. 138, 184–185), belongs geographically to Europe, Africa consists of an ancient plateau, and its whole mass has remained geographically united since the earliest geological times. South America, on the contrary, consists of two distinct lands, geographically united by the formation of connecting lowland plains in comparatively recent times. The high African plateau has a fairly uniform surface, with little lowland country, and only a few peaks rising above the height of 10,000 ft., and no recent chains of fold-mountains except in the Atlas region. Most of South America is low land, less than 600 ft. above sea-level, but large tracts are at the height of over 10,000 ft., and the most conspicuous feature in its geography is a great chain of fold-mountains down its western side. South America is therefore characterized by very marked extremes in elevation, which contrast with the comparative uniformity in level of most of Africa.

The coasts of South America are regular; the western coast has the typical structure of a Pacific coast with mountain lines parallel to the shore, and apparently also parallel faults by which the land sinks in bold terraces to the sea. It has, however, but few relics of the island festoons which are so conspicuous on the Asiatic shores of the Pacific. Traces of the former existence of such festoons are indicated by the lines of scattered islets off Central America between California and the Galapagos, while another festoon may be represented by Juan Fernandez and St. Felix, off the coast of Chili. The archipelago off southern Chili has been produced by the submergence of the coast lands under the sea, the Coast Cordillera occurring along the islands, which are separated by fiords that run far inland and give this coast its extreme complexity. The eastern coast has the typical Atlantic structure, being bordered by plateaus, and where the fold-mountain lines reach the shore they strike across it quite indifferent to its trend. The east coast estuaries are true rias or drowned valleys deepening steadily seaward.

The most important geographical feature in the structure of South America is its western mountain belt; this extends north and south along the whole of its Pacific coast. The base is a vast mountain mass, the surface of which has a mean elevation of 14,000 ft.; volcanic domes have been piled upon this mountain mass, and they form the highest peaks of the Andes. The western mountain land—the Cordillera of the Andes — is sometimes represented as a continuous volcanic chain; its highest mountains, Aconcagua (23,080 ft.) in Chili, and Chimborazo in Ecuador, are extinct volcanic domes; but Mount Sorata in Peru (over 22,000 ft.) is not volcanic. The volcanoes are formed at intervals, separated by wide mountain belts which are not volcanic; the volcanoes occur along a broken line parallel to the Pacific coast, and are independent of the structure of the Andes, on which they rest. The Cordilleras as a whole are due to earth movements which have left them standing over 14,000 ft. above sea-level, and over 30,000 ft. above the level of adjacent parts of the Pacific floor. These earth movements have happened along lines which trend from north to south; and they have caused the uplift in the Andes of areas which have different structures. The grain of an older mountain system can be recognized along the Andes; it has produced the sharp bend of the coast of southern Peru, and the branching from the main chain of various ranges, such as the Sierra de Famatina and the Sierra de Cordoba, which run south-eastward across Argentina; these branches finally bend round till they take a course from west-north-west to east-south-east; and their easternmost representatives, the Sierra de Tandil to the south of Buenos Ayres and the Sierra de la Ventana, are cut off by the Atlantic. Still farther south the structural lines sweep eastward in Tierra del Fuego, corresponding to the eastward trend of the structural lines of the Antilles at the southern end of North America.

The Cordilleras are composed of parallel ranges of different structures and ages. Transverse sections across the Cordilleras in different latitudes show how greatly they vary in structure during their course along South America (fig. 93). The most constant feature in their composition are the Coast Ranges, which consist of hills of very ancient rocks running nearly the whole length of the Pacific coast. They correspond to the Coast Ranges of California, which at San Francisco are composed of rocks of the same age and character as those of South America. Behind the Coast Cordillera rises the Western Cordillera. It consists in the main of sedimentary rocks, and its summit is described as presenting from the sea a long wall-like aspect, with a level surface of a mean height of 14,000 ft. above sea-level. The mountains are made of sediments laid down beneath the sea at the same time as the formation of the oolites and the chalk of the British Isles. They are associated, however, with sheets of igneous rocks interbedded with the sediments. The highest of the Andes are volcanic peaks upon the Western Cordillera, and they form most of the existing watershed between the Atlantic and the Pacific. South of Lima the Western Cordillera, or Cordillera Negra, is composed only of sedimentary rocks, and the volcanic line lies farther to the east (fig. 93, *c*). The Eastern Cordillera, along most of the Andes, consists of very ancient rocks which are not volcanic; and beds of limestone, probably deposited during the same period as the English chalk, rest upon their eastern flanks. North of Lima the main Eastern Cordillera, or Cordillera Nevada, is volcanic; while still farther east another parallel line represents the old rocks of the Eastern Cordillera of Chili and Ecuador. Farther north again, in Colombia (fig. 93, *b*) the volcanic region is in a valley between the Eastern and Western Cordilleras. The sections representing the differences in the Andes are shown on fig. 93.

The main structural lines of the Cordilleras trend generally from north to south, though they may be deflected, as on the coast of Peru, by the influence of the older mountain system. But to the south, in addition to sending off mountain ranges south-eastward across the Argentine, the chain itself turns eastward, till in Tierra del Fuego it runs from west to east. At the northern end of South America there is a similar change in direction. The mountains turn north-eastward in the State of Colombia, and the continuation of the Andes is to be sought in the east-and-west ranges of Venezuela. The Venezuelan mountains strike eastward into the Atlantic, where their line, if continued, would join that of the Atlas. The Venezuelan mountains present a striking resemblance in structure to the Atlas. They are fringed to the north by volcanic masses which were erupted on the edge of the sunken Caribbean Sea, just as those along the Algerian coast were discharged on the edge of the sunken Mediterranean. The northern ranges of Venezuela are made of ancient rocks corresponding to the old rocks of the Alpine loop in the

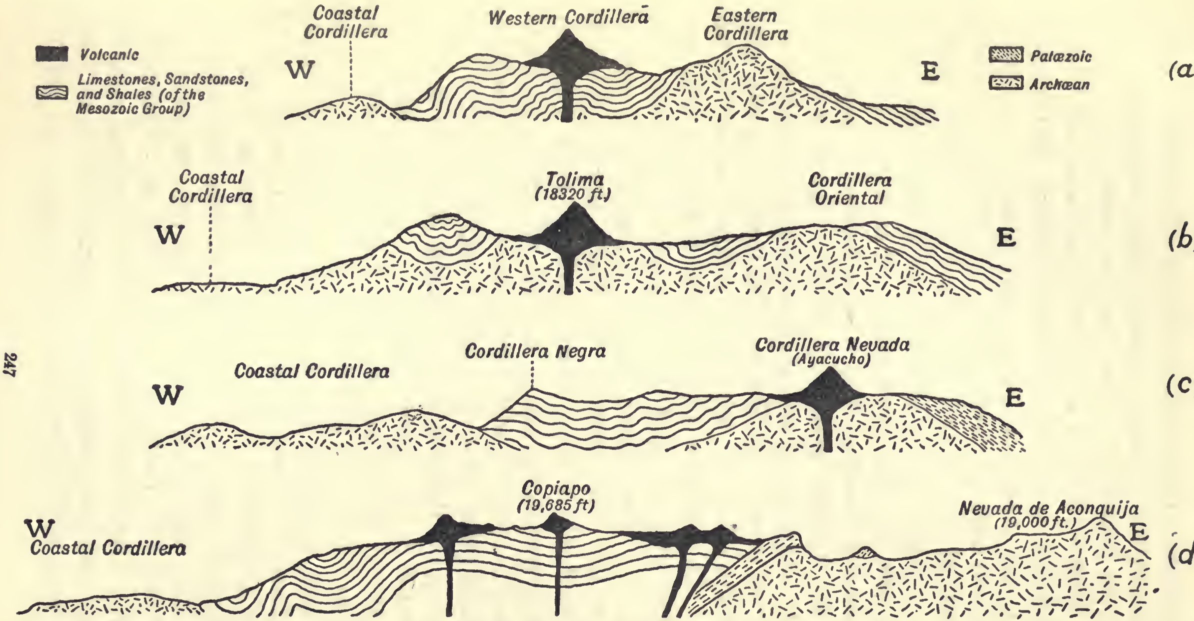


Fig. 93.—Diagrammatic Sections illustrating the Structure of the Andes

a, Generalized section showing relation of the Coastal Cordillera and the Eastern Cordillera composed of Archean rocks; the main mass of the Western Cordillera is a foundation of folded Mesozoic rocks, supporting in places the volcanic domes of the Andes. *b*, Section across Colombia, where the volcanic chain rises from a valley between folded sedimentary and Archean rocks. *c*, Section near Lima. The Western Cordillera consist of folded sedimentary rocks, and the volcanoes are in the Eastern Cordillera. *d*, Section across the Andes of Chile through Volcano Copiapo; the Western Cordillera includes the volcanoes, and the Eastern Cordillera consists of Archean rocks.

northern Atlas. The southern ranges of Venezuela consist of folded sheets of limestone corresponding in age and structure with the folded limestones of the Great Atlas. Both areas are separated by a broad valley from an old plateau, which in Africa is the massif of the Sahara, and in South America is the massif of Guiana and Brazil.

The eastern high lands of South America are now divided by the basin of the Amazon into the two detached areas of Guiana and Brazil. The highlands of Brazil consist essentially of a plateau of ancient rocks; it once extended eastward across the Atlantic, and was probably connected with the opposite Archean plateau of Africa. Brazil is therefore the western fragment of the ancient Brazilio-Ethiopian continent. It is covered by sheets of sedimentary rocks, which were deposited on the land or in lakes; some of them belong to the rocks of Gondwanaland, and include some deposits left by glaciers, of the same age as in South Africa and Australia. The average level of the plateau is probably about 3500 ft. The province of Minas Geraes, in south-eastern Brazil, is at the general level of 3500 ft.; Matto Grosso, the western province of the Brazilian highlands, has a level of 2500 ft., while the plateau to the north-west along the Atlantic coast rises to the height of 4000 ft., and its highest peak, Itatiaya, to the height of 10,340 ft. The old plateau has now been broken up, as the rivers have cut their valleys deeply into it. These rivers flow at a comparatively low level, and afford navigable waterways into the heart of the highlands along the Parana from the south-west, the San Francisco River from the north-east, and the Tocantins, a tributary of the Amazon, from the north.

The lowland basin of South America lies to the west of the Brazilian highlands. It includes the basins of the Amazon, the La Plata, and the Orinoco. These river basins form a continuous band of low country, extending across the continent, where the watershed is even lower than the watershed between the Mississippi and Hudson

Bay. The Amazon and La Plata basins were once occupied by the sea, but they have now been filled up by the deposition of sediment. The Amazon basin was occupied by the sea in the time both of the British Coal Measures and of the Chalk, and the marine rocks then deposited are now exposed around the Amazon basin. Some of the same rocks are exposed along the western edge of the La Plata basin; so that the sea probably once extended from the Amazon to the La Plata, and completely separated the mountain areas on the two sides of the continent.

The watersheds between the Amazon and the La Plata are so low and flat that a lake or swamp sometimes discharges into the one river and sometimes into the other; it is even said that the fall of a tree across a stream may divert the water from the La Plata to the Amazon. Owing to the great antiquity and power of the South American rivers, they have cut their beds into a long even slope, so that they are not interrupted by rapids or waterfalls except at a great distance inland. The rivers are navigable from the sea for a greater length than any other rivers in the world. Owing to the heavy rainfall in its basin, the Amazon, though not the longest river known, discharges a larger volume of water than any other river. Ocean-going ships ascend the Amazon to Iquitos, 2300 miles from its mouth.

CLIMATE

The origin of the great South American rivers, as is commonly the case, depends on the distribution of the rainfall, which is in its turn dependent on the temperature of the surrounding oceans. There are three chief ocean currents around South America. The water that is drifted across the southern Pacific by the westerly winds is piled up against the coast of southern Chili, and gives rise to the cold "Peruvian Current", that flows northwards along the coast almost to the Equator. At the same time the off-shore winds along the Pacific coast suck up cold water from the ocean deeps, and help the southern waters to lower the temperature all along the western coast. The Atlantic coasts, on the other hand, are warmed by the ocean currents. The trade winds blow water across the equatorial Atlantic, producing a warm current which flows north-westward along the northern coasts of Brazil and of Guiana. The same cause produces the current which flows southward along the south-eastern coasts of Brazil and the Argentine, and helps to give them a warm climate.

The winds of South America are controlled by the distribution of atmospheric pressure (see pp. 85–88). The north-eastern part of the continent is covered by a prevalent cyclone or low-pressure area, and a second cyclone covers southern Argentina and Patagonia. Between these cyclones is a belt of high atmospheric pressure connecting the prevalent anticyclones in the south Atlantic and the south Pacific. According to the well-known law stating the circulation of winds around such anticyclones, if a man in the Southern Hemisphere stand with the low-pressure area on his left, the wind will blow in his face. Hence the circulation of the air around both the cyclonic areas of South America is in the same direction as the hands of a watch. The winds strike the north-eastern coast of Brazil from the north-east, while along the south-eastern coast they blow in from the south-east. The prevalent winds on the Pacific coast blow from the south-west against the coasts of southern Chili, due northward along Chili, and south-eastward to north-westward in southern Peru. In the vast cyclonic region that covers all the north-east of South America, the wind generally blows from north-east to south-west. In central Brazil the direction is more nearly from east to west. Warm, wet winds are therefore blown from the equatorial Atlantic into the Amazon basin; they there drop their moisture as they are lifted upward to higher and colder levels by the cyclonic circulation of that region; and they


JANUARY ISOTHERMS
Above 80°
70°-80°
60°-70°
50°-60°
Below 50°
Trinidad
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Georgetown
Paramaribo
Cayenne
Bogota
Quito
Para
Pernambuco
Lima
Bahia
Sucre
Asuncion
Rio Janeiro
Valparaiso
Santiago
Monte Video
Buenos Ayres
Falkland Is
S.Georgia I.
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70F
60F
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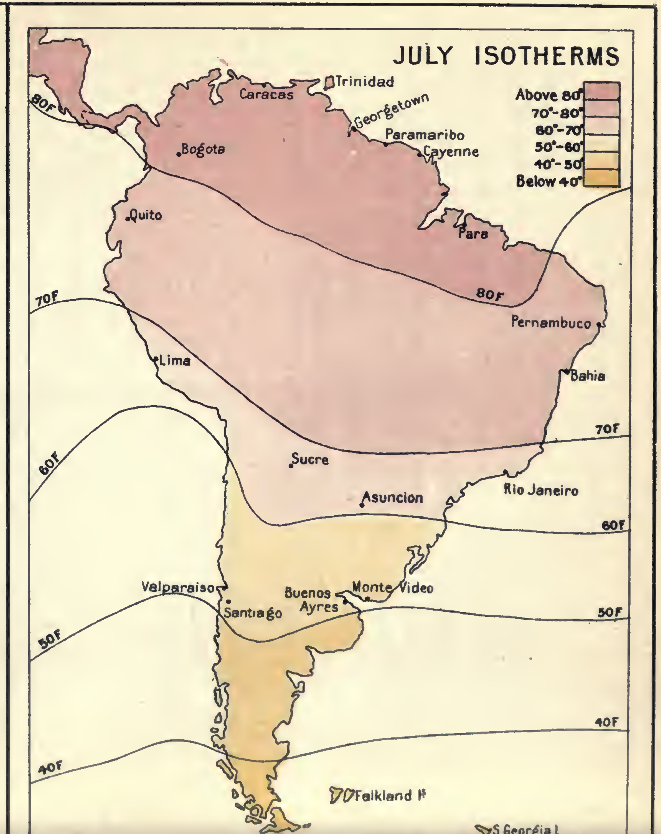
JULY ISOTHERMS
Above 80°
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60°-70°
50°-60°
40°-50°
Below 40°
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Cayenne
Bogota
Quito
Para
Pernambuco
Lima
Bahia
Sucre
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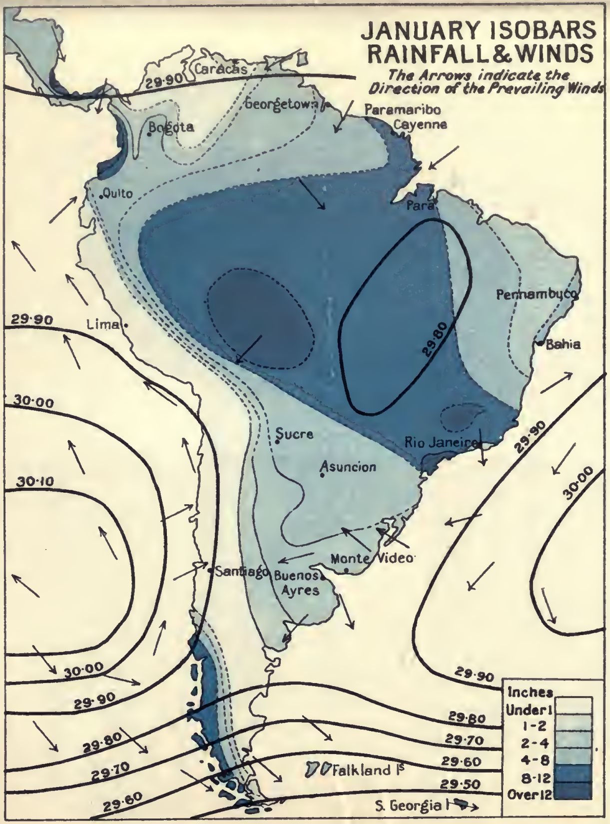
JANUARY ISOBARS
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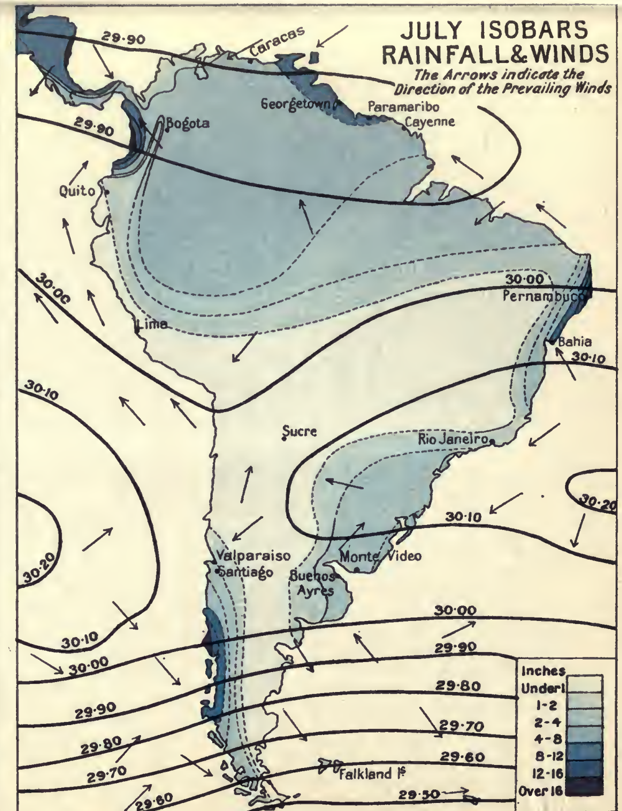
Over 12


JULY ISOBARS
RAINFALL & WINDS
The Arrows indicate the Direction of the Prevailing Winds
Caracas
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Inches
Under 1
1-2
2-4
4-8
8-12
12-16
Over 16

yield the heavy rainfall of 100 in. a year. The winds drop the last of their moisture on the eastern slopes of the Andes, so that they are quite dry when they reach the western slopes of those mountains. In southern Chili and Patagonia there is another region with a high rainfall—over 80 in. a year; for as the land is colder than the winds which strike in from the sea, their moisture is precipitated on the seaward face of the Andes. These two areas of heavy rainfall are separated by a dry belt extending from southern Peru obliquely across the continent to south-eastern Patagonia; this dry belt crosses the anticyclonic area. The western coast has a scanty rainfall, because the land is warmer than the adjacent sea.

The ocean currents affect the distribution of temperature in South America as well as the rainfall. Off Cape Horn the mean annual temperature is 40°. Patagonia is crossed on a nearly east-and-west course by the isotherm of 45°. Farther north, owing to the influence of the cold current along the western coast, the isothermal lines bend northward on the western side of the continent, and run for some distance nearly parallel to the coast. Thus the isotherm of 70° crosses the Atlantic coast at 30° S.; it lies even farther southward in western Argentina, but there turns sharply to the north, and reaches the Pacific coast in the latitude of 10° S. to the north of Lima. All the north-eastern region has the tropical temperature of over 80°.

ECONOMIC AND POLITICAL GEOGRAPHY

There are traditions of a pre-Columbian discovery of South America by Portuguese sailors, who, sailing to the Cape of Good Hope, were blown off their course to the west, and thus reached Brazil. The first discovery of practical importance was made after the voyage of Columbus to the West Indies in 1492. After his return to Europe in 1493 the newly-found western lands were divided by a Papal Bull between Spain and Portugal. The bull chose a shifting line as the frontier.

It gave Portugal all the land to the east, and Spain all to the west, of the line on which the mariner's compass pointed exactly to the North Pole. This award would, at that date, have given Portugal the eastern promontory of Brazil. This magnetic line, however, is not fixed in position, and it was then travelling eastward, so Portugal would only have been entitled to temporary possession of any part of South America. The Papal decision was revised in 1594, and the Treaty of Tordesillas then gave Portugal the eastern part of the continent and Spain the western. The Portuguese, therefore, subsequently occupied Brazil, of which the language is now Portuguese. The rest of the continent was occupied by Spaniards, where the Spanish language prevails.

The mainland was first explored by a voyage along the northern coast to the Gulf of Darien, in 1496. Columbus himself first reached South America in 1498, when he discovered the mouths of the Orinoco and sailed around the island of Trinidad. Already the Portuguese explorer, Cabral, had unintentionally reached Brazil during a voyage to South Africa, and by 1509 Spanish explorers had worked down the Atlantic coast to the La Plata. South America was still believed to be the eastern end of Asia; nor was this view disproved till 1513, when Vasco de Balboa, "silent upon a peak in Darien", first discovered the ocean to the west. He called it the South Sea, as it lay to the south of the Isthmus of Panama; this name is still retained for the Pacific Islands, which are often called the South Sea Islands, and live in our commercial history in connection with the South Sea Bubble. Four years later a ship was built in the Gulf of Panama, and started the exploration of the coast. The southern termination of the continent was discovered in 1520 by Magellan, who sailed through the Straits of Magellan, and, reaching the ocean to the west, named it the Pacific, as contrasted with the stormy waters through which he had just fought his way.

The rumours of rich stores of gold and silver in the Andes led to the conquest of Peru by Pizarro in 1531, and of Chili by De Valdivia in 1541. Spanish parties travelled boldly through South America, and soon determined the chief features in its internal geography. An expedition sent by Pizarro from Peru reached the upper Amazon, and between 1539 and 1541 sailed down it to the Atlantic; the river was called the Amazon because the native women fought in one of the conflicts with the explorers.

The Spaniards found South America occupied by a race of Indians, who had established in Peru an organized state. These Indians had been preceded by a race of long-headed people whose stone implements are found deeply buried beneath the river deposits of various parts of South America. The origin of these people is unknown, but it has been suggested that they were a Berber race, who crossed from north Africa by the Canaries and the Azores, and possibly other islands now non-existent. The South American Indians show the high cheek-bones, the long, black, straight hair, and somewhat almond-shaped eyes of the Mongolians (fig. 94). They are therefore usually regarded as a branch of the Mongolian race of Asia. Objections have been repeatedly made to this view, on the ground that the South American tribes have been so long isolated from the Asiatics that they have developed into an independent race. Some of the tribes would appear to be among the most primitive of existing peoples. Thus, according to some descriptions, the Chiquitoes of central Bolivia have no ideas of numbers, and have not discovered how to make even stone implements, and their only tools are made of shells, bones, and thorns. They would therefore be in a state of

Fig. 94.—Indian of Central Brazil

culture below that of the Australians or even of the extinct Tasmanians.

Settlement.—The natives of South America, although individually brave and careless of death, had the Mongolian habit of obedience to authority and passive acceptance of conquest. Hence the Spaniards, having once overthrown or deposed the chiefs, had no serious difficulty in ruling the country and forcing the natives to work the mines and plantations. The Portuguese found the natives in Brazil less numerous, and made up the deficiency in the labour supply by the importation of Negroes from Africa. The Spanish and Portuguese dominion over South America lasted till early in the nineteenth century, when the conquest of Spain by Napoleon gave the Spanish colonies an opportunity to secure their independence. The north-western districts were separated as New Granada, after a struggle lasting from 1810 to 1822; this state at first included Colombia, and also Venezuela until 1829, and Ecuador until 1830. After the separation of these states the rest became the nine United States of Colombia, but in 1899 the various states were merged into one republic.

Peru proclaimed its independence of Spain in 1821, and Bolivia gained her freedom in 1824, after a struggle lasting from 1809. Chili revolted in 1810, but was reconquered by Spain. It regained its independence in 1817, after a war in which the Chilians were led by O'Higgins on land and helped by Lord Cochrane at sea. The Argentina became independent in 1810. Uruguay, which had been founded in 1817, was annexed to Brazil in 1821, but recovered its independence, aided by Great Britain, in 1828. Brazil secured its independence from Portugal in 1822, and the empire then founded lasted till the proclamation of the existing republic in 1889. The three colonies of Guiana are the only parts of South America still held by European Powers. British Guiana was originally a Dutch colony. It was conquered in 1781 by the British, again conquered and reconquered, and finally ceded to the British Empire in 1815. French Guiana, or Cayenne, was founded by French colonists between 1624 and 1664. Dutch Guiana was originally a British colony, but was given to Holland in 1667 in exchange for New York.

Since the establishment of the independent states in South America there has been a great immigration of Europeans, principally Italian, British, and German, of whom the last are especially numerous in Brazil.

ECONOMIC DEVELOPMENT

It was the great mineral wealth of South America which attracted the Spanish invaders. The silver-mines in the older rocks of the Cordillera are the most important, and they have maintained a large output since the Spanish occupation. The silver-mines of Potosi have yielded probably the greatest output of silver of any one mining field in the world. Gold is widely distributed in the older rocks, both of the eastern and western mountains. The mining regions of Brazil are also famous for their diamonds. They yielded the chief supply until the discovery of the diamond-mines of South Africa. Another important product of South America is guano, obtained in the islands along the western coast of Chili and Peru. Guano is an accumulation of bird droppings, and is rich in phosphate and ammonia, and makes a very valuable manure. It is formed on these islands, as birds from the mainland resort to them to breed, and it collects on them, as the climate is practically rainless. The nitrate deposits on the mainland of northern Chili also owe their accumulations to the dryness of the climate.

Considering its great economic resources, the commerce of South America is backward, although it is aided by the finest waterways in the world. Their extent delayed the use of railways, of which there are now 44,000 miles. A railway from Callao and Lima climbs over the Andes into the highland basin of eastern Peru, and a trans-continental line from across the Andes connects the two capital cities Buenos Ayres and Valparaiso.

PLANTS AND ANIMALS

The animals of South America are poor and scanty in contrast to its rich vegetation. The mountains of Peru are the home of the alpaca and the vicuna, whose silky hair makes valuable clothing material, and of the llama, the only South American animal that has been at all domesticated, since it is used for transport in the western mountains. The tapir, the peccary, jaguar, and the puma live in the forests, with troops of monkeys in the trees. The most typical animals of South America are the sloths and ant-eaters. The great boa-constrictor or anaconda is the best known of the snakes, and the cayman or South American alligator has its home in the rivers. The rhea or South American ostrich lives on the Pampas; the condor and humming-birds are the most remarkable flying birds. The South American mammals include some small marsupials (*e.g.* Cœnolestes) of a kind previously regarded as confined to Australia, but now found in the forests of Ecuador and Colombia. The opossums are found in both South and North America. There are bones which prove that herds of horses once roamed the plains of South America, but for some reason they became completely extinct, and all the present herds are descendants of horses introduced by the Spaniards at the conquest. The present comparatively small mammal fauna is especially remarkable, for in geologically recent times the South American plains were occupied by herds of giant mammals, such as the great ground-sloth. This animal, too large to climb the trees for its food, tore them up by the roots, and then browsed on their leaves. There were giant armadilloes, and large animals, allied to the marsupials of Australia, lived on the Pampas of Patagonia.

The low lands of South America, owing to their rich thick soils and generally ample rainfall, have a varied and luxuriant vegetation. The Amazon valley is covered with dense forests, the wide-spread "silvas" of the Amazon. In Argentina the rainfall is smaller, and the forests are replaced by open, turf-clad plains or "pampas", which support flocks of sheep and herds of cattle. It is one of the great wool- and meat-raising regions of the world. South America is famous for its exceptional wealth in plants of great economic value. It has supplied the world with the potato, tomato, maize, and yams, besides other food-plants. Among oil-producing plants it has the ground-nut; amongst drugs the cinchona, which yields quinine, and coca, the source of cocaine. It is also the original home of tobacco and cocoa, while the rubber vines of the Amazon valley have been hitherto the chief source of the india-rubber supply of the world.

CHAPTER XIX

AUSTRALIA

The name Australasia means "southern Asia"; it expresses the fact that Australia is a southern extension of Asia. The largest part of Australia is a plateau of very ancient rocks. This bears the same relation to eastern Asia and the fold-arc of Malaysia that the ancient plateau of southern India bears to Central Asia and the Himalaya, and the African plateau to Europe and the fold-arc of the Atlas.

Owing to its remote position, Australia was the last of the continents discovered, except Antarctica. The Malay sailors probably reached it in very early times, and rumours of its existence spread to Europe in the sixteenth century, for many maps of that period refer to a great land to the south of Malaysia, called "Java la Grande", to distinguish it from the smaller island of Java to the north. It was sometimes called "Australis Terra".

The mainland of Australia was first reached by Europeans in 1606, when a Dutch vessel, the *Duyfken*, crossed to Australia from New Guinea, and explored part of the northern coast. It was followed by other Dutch expeditions, which explored the western coasts, and in 1644 Tasman, sailing eastward to the south of Australia, discovered Tasmania and New Zealand. The first British sailor to reach Australia was Dampier, in 1688. Cook's exploration of New Zealand and of eastern Australia, in 1769–1770, was the most important of the early voyages, for it led to the first permanent settlements, which were established by the British Government at Sydney in 1788. The rest of the continent and New Zealand were annexed to the British empire by instalments, and British colonists settled at the chief harbours around the coasts.

The mainland of Australia is about 2400 miles wide and 1970 miles across from north to south. Its area, including Tasmania, is estimated as 2,974,581 sq. miles. It is bounded to the south by the Southern Ocean, to the west by the Indian Ocean, to the east by the Tasman Sea and the Coral Sea (which are parts of the Pacific Ocean), and to the north by the Indian Ocean, the Arafura Sea, and Torres Straits. The coasts are about 12,000 miles in length. The eastern coast is a variety of the Pacific type, in which the fold line of the old continental edge has been left separated from the main mass of the continent by partially enclosed seas. The northern, southern, and western coasts of Australia are on the Atlantic type.

The coasts, as a rule, are regular, except on the north-west, where they are indented by fiords. On the southern coast a long rift valley extends far inland and forms Spencer Gulf. The north-eastern coast, off Queensland, is fringed with the series of reefs and shoals that form the Great Barrier Reef of Australia. On the north is the wide Gulf of Carpentaria, formed by the submergence of the northern end of the Great Plains.

The whole continent may be divided into three main divisions. The western half of the continent is composed of a

115
120
125
130
Sandalwood I.
Melville I.
Bathurst I.
TIMOR SEA
Daly
Victoria
Kimberley Division
Fitzroy
Mc Clintock Ra.
NORTHERN
INDIAN OCEAN
WESTERN
Tropic of Capricorn
Macdo
L.Amadeus
Ashburton
WESTERN
Lyons
Coastal Plain of Westralia
PLATEAU
Gascoyne
AUSTRALIA
Murchison
L.Austin
Salt L.
The Great Victoria Desert
Eucla Artesian Basin
L.Monger
L.Barlee
L.Moore
AUS
Nullarbor Plains
Perth
Darling Ra.
Swan
Great Australian Bight
Stirling Ra.
Albany
10
15
20
25
30
35
40
AUSTRALIA
GEOGRAPHICAL DIVISIONS
English Miles
0 100 200 300 400 500
Uplands
Lowlands
105
110
115
120
125 Longitude East 130 of Gree


C. York
New Guinea
CORAL SEA
Gulf of Carpentaria
Cape York Peninsula
Great Barrier Reef
Mitchell
Geraldton
EAST AUSTRALIAN HIGHLANDS
Burdekin
Flinders
Rankine
Georgina
QUEENSLAND
Marshall
Chain
Hay
Field
Diamantina
THE GREAT PLAINS
Fitzroy
Barcoo or Cooper
Bulloo
Paroo
Warrego
Culgoa
Darling Downs
Brisbane
Clarence
Plains
L. Eyre
Stuart Ra.
L. Torrens
L. Gairdner
Gawler Range
Flinders Ra.
L. Frome
S. Australian Highlands
Eyre Pen.
Spencer G.
St. Vincent G.
Kangaroo I.
NEW SOUTH WALES
Darling
Tamworth
Liverpool Ra.
RIVERINA DISTRICT
Lachlan
Coastal
Hunter
Murray
Mallee Plains
Murrumbidgee
Blue Mts.
SYDNEY
L. Alexandrina
Upper Murray or Hume
Mt. Townsend
Mt. Kosciusko 7256
Grampians
VICTORIA
Victorian Highlands
Australian Alps
Yarra
Snowy
New South Wales
Gt. Valley of Victoria
L. Korangamite
MELBOURNE
P. Phillip
Gippsland Lakes
Wilson's Prom.
Bass Str.
TASMANIA
SOUTH PACIFIC OCEAN
hem Ld.
Roper
TERRITORY
OUTH
RALIA
135
140
145
150
155
160
10
15
20
25
30
35
40

vast plateau, formed of very ancient rocks, and it does not appear to have been below sea-level during geological times. The north-western part, however, is crossed by a band of rocks which show that the plateau was covered by the sea in that district in very early geological times. On the north, west, and south of Australia coast plains skirt the foot of the plateau, and they contain marine rocks of several distinct periods.

Owing to the arid nature of the climate in the interior, the surface of the western plateau is generally level. The ridges have been cut down by wind erosion, and the loose soil has been blown into the valleys, so that they are choked by deposits of silt and clay. A few rivers rise on the border of the plateau and discharge flood waters after rain; but in the intervals between the rains the rivers are nothing but lines of stagnant water-holes. The lower courses of the rivers are on the coastal plains, where the rainfall is higher and the drainage of the country is better, and the rivers may flow throughout the year. Most of the western plateau of Australia is an area of internal drainage, where the rain runs into depressions on the surface, and is thence removed by evaporation.

The second element in the structure of Australia consists of the Great Plains; they extend from the Gulf of Carpentaria across the continent to the Southern Ocean, between the mouth of the Murray and the coast of western Victoria. The Great Plains are covered by a sheet of thick clay deposited beneath a sea which extended from the Gulf of Carpentaria southward to Lake Eyre and Lake Frome. Though from a superficial glance it might appear that the Great Plains were continuous in structure, and that this sea once divided Australia into two great islands, such was never really the case. The marine beds, known as the Rolling Downs Formation, have not been found farther south, as apparently they end against an old shore. The Great Plains are, however, continued by the river silts that form the plains of the Darling. The Great Plains descend gradually to the valley of the

Murray, and continue along it to the southern coast. The plains in the basin of the Lower Murray rest on marine rocks of later formation than those of the Great Plains to the north.

The Great Plains have an arid climate. They are traversed by many rivers, most of which rise on the higher country to the east. Some of them, as the Flinders, flow northward into the Gulf of Carpentaria. Others flow southward to Lake Eyre, where their last waters are lost by evaporation; but most of the rivers are collected by the Darling, Murrumbidgee, and Upper Murray, or Hume, into one great river, the Murray, which discharges into the Southern Ocean. The level of the Great Plains is low, and the shore of Lake Eyre is 39 ft. below sea-level. The basins of Lake Eyre, Lake Frome, and of the rivers Paroo and Bulloo, and wide areas without well-defined rivers, amounting altogether to more than half of the whole continent of Australia, are occupied by areas of internal drainage.

The third element in the composition of Australia consists of the East Australian Highlands, which occur between the Great Plains and the eastern coast; they extend from Cape York Peninsula on the north to Bass Strait on the south, and are continued still farther by the island of Tasmania.

The fold-mountains of Australia are now geographically unimportant; for, owing to their great antiquity, they can only be traced by their ruins. The remains of one series of fold-mountains run across Australia from the Kimberley Gold-field in the north-west, through the Macdonnell Chain in central Australia, to the southern coast, and to Tasmania. The older geographical grain of Victoria ran from north to south, and relics of it can be recognized in comparatively inconspicuous hills, such as the long line of the Colbinabbin Range; while more conspicuous mountains, also trending north and south, such as the Grampians of western Victoria, are due to secondary movements parallel to the older geographical grain of the country. The original structure of Victoria has comparatively little influence on its present relief. For the intrusion of a series of granitic masses, which extend in a broken line across Victoria, formed a later mountain chain that ran east and west and obliterated the older mountains. The later mountains were so lofty that they were covered by perpetual snow-fields, from which glaciers flowed down into the valleys on their flanks. These old mountains have, however, been planed down to a peneplane. This earth block has been dissected by rivers, and now forms the Victorian Highlands, which extend east and west across the state, between the broad plains of the Murray on the north, and the Great Valley of Victoria on the south.

The Victorian Highlands are a projection westward from the East-Australian Highlands, which form the high country of eastern Australia from Cape York Peninsula in Queensland to Tasmania. This high country receives abundant rains, blown in from the South Pacific. The rain falling on the eastern scarp of the Highlands rushes violently down their face to the low coastal plains. Such swift torrents have great powers of digging out their beds, and have cut deep gorges into the Highlands. The East-Australian Highlands are therefore dissected by deep gorges, and the meetings of some of the tributaries have isolated fragments of the old plateau, with walls so steep that some of their level summits have never yet been reached by man. The ascent on to the plateau from the coast plains is so abrupt that every attempt to reach it during the first thirty years of the Australian occupation was unsuccessful. It was not until 1813 that explorers discovered a way on to the Blue Mountains west of Sydney; and it was not till 1828 that Allan Cunningham found a practicable route from the coast of Queensland on to the vast, fertile Darling Downs. The remains of the plateaus and the ridges left between the river valleys have been named as mountain ranges, and their number is legion. The best known, such as the Blue Mountains, to the west of Sydney, and the Darling Downs, to the west of Brisbane, are parts of this dissected plateau.

The highest summits in Australia are humps upon the surface of the eastern highland plateau. Mount Kosciusko, the highest point in Australia, 7256 ft. high, was so named by Strzeleski, as it reminded him of the artificial mound over the grave of Kosciusko. The Australian Alps were so named as they are snow-covered during the winter, and the snow lies in gullies on the southern face of the Alps throughout the summer. The South Australian Highlands form the backbone of the southern part of the state of South Australia. They consist of part of an old plateau that once extended across southern Australia from the Western Plateau to the Victorian Highlands. They have now been left as an isolated earth-block trending north and south, owing to the subsidence of the Spencer and St. Vincent Gulfs to the west, and of the Murray Basin to the east. The best-known ranges in western Australia are the parts of the scarp of the West-Australian plateau, such as the Darling Range to the west of Perth, and the Stirling Range to the north of Albany.

The Great Plains of Australia occupy the vast basin between the East-Australian Highlands and the Western Plateau; they extend inland from the Gulf of Carpentaria, and widen out to include the basin of Lake Eyre; this basin is closed to the south-west by a projection from the great plateau of western Australia. The Great Plains are continued southward by the plain of the Darling and Murray Rivers, and thus reach the southern coast. These plains offer a striking contrast to the Highlands; they have an arid climate, a low rainfall, scanty vegetation, and consist of vast extents of open, level country, forming some of the greatest true plains in the world. Their soils are fertile when watered, and after suitable rains they are covered by rich turf, and support the huge flocks of sheep which are still the greatest source of Australian wealth. The richest part of the Great Plains is along the valley of the Darling and the Murray, and in the district known as the Riverina; the Mallee Plains, in north-western Victoria, are a part of these Great Plains, and were once covered by a dense growth of scrub, consisting mainly of a low-growing tree known as the Mallee (*Eucalyptus dumosa*).

To the south of the Victorian Highlands lies the Great Valley of Victoria; in the west its floor is covered with lava flows discharged from many volcanic vents, some of which show only the worn plug of lava that stopped the pipe of the volcano, while others are still covered by volcanic hills with perfectly preserved craters. The lava plains, which cover about 10,000 sq. miles of western Victoria, have a good rainfall and rich turf, so that the first settlers naturally turned their attention to pastoral pursuits.

The coastal plains of Australia are comparatively narrow as a rule. They lie between the foot of the East-Australian Highlands and the sea along the greater part of the eastern coast. A coast plain fringes most of Victoria, extending northward up the valleys of the Glenelg and the Murray, while in western Australia the Nullarbor Plains, formed of recent limestones, extend far inland from the Great Australian Bight, with their northern limits at present undefined. There is a narrow coast plain at the foot of the scarp of the Great Western Plateau along the coast of Westralia.

Australia has a remarkable structural resemblance to South America; but the arrangement of the parts is reversed. The highland plateau of Brazil, on the east of South America, corresponds to the ancient plateau of western Australia. The lowland basin of the Amazon and La Plata corresponds to the great plains of Australia, which occupy the basin of a former sea that extended from the Gulf of Carpentaria southward to Lake Eyre. The mountainous area on the eastern flanks of the Andes corresponds to the Eastern Highlands of Australia; but the main Cordillera of South America is not represented in Australia, but by the chains of fold-mountains in New Zealand and Melanesia. The original border of the Pacific has been separated from Australia by the foundering of land that now forms the Tasman and Coral

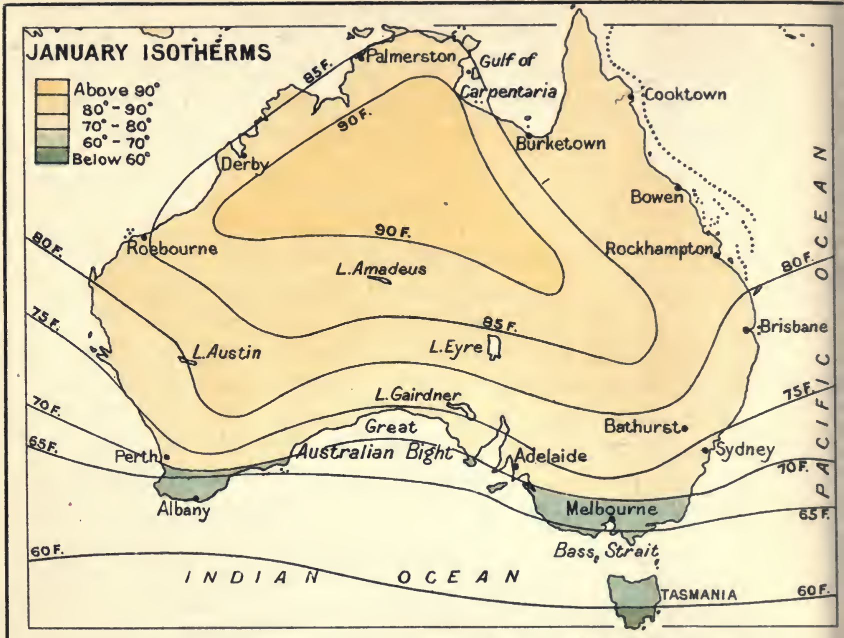
Seas; this movement separated the fold lines of New Zealand farther from the plateau of Australia than is the main Cordillera from the mountainous area of the eastern Andes.

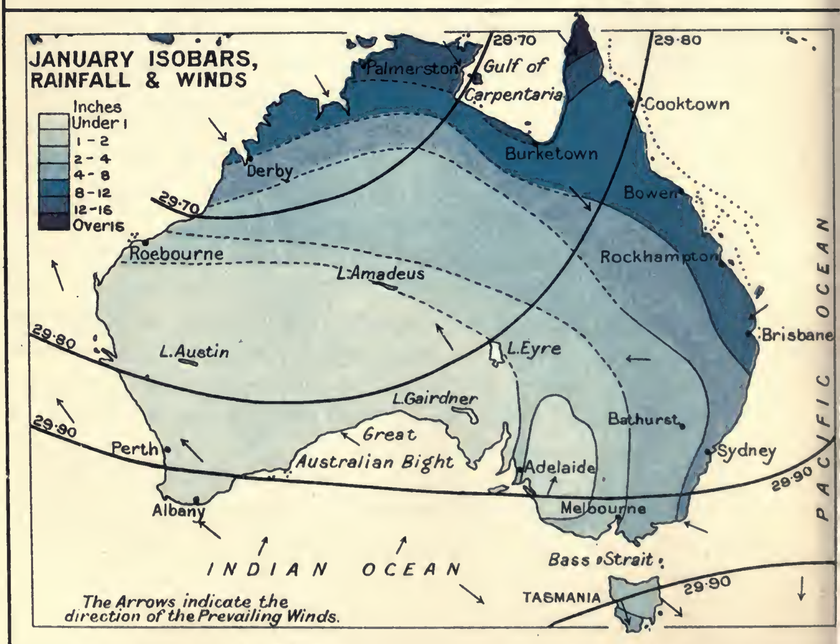
CLIMATE

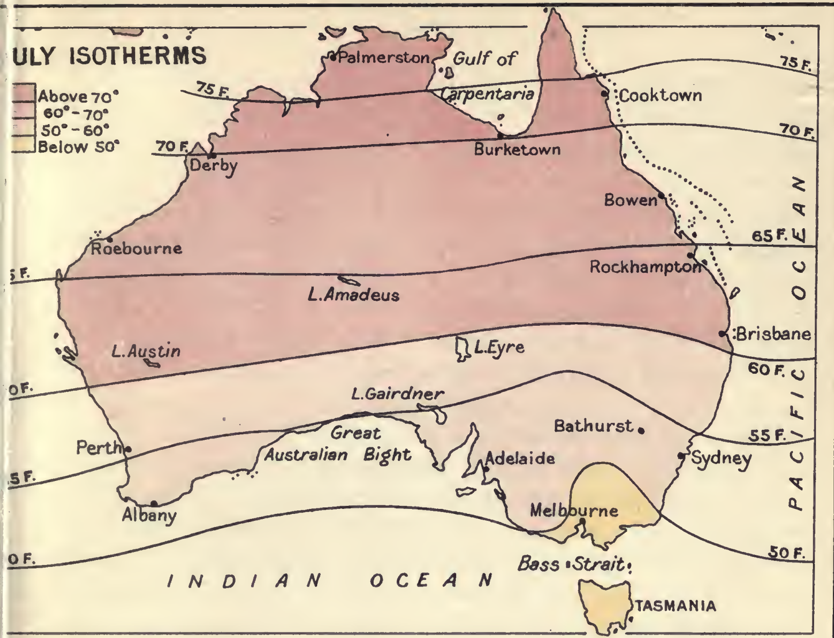
The position of Australia in the warmer part of the south temperate zone endows it with a mild climate. The Tropic of Capricorn crosses the continent at its widest part, and, with the exception of North Africa, it is the broadest mass of land crossed by a Tropic. Three great peninsulas project northward into the warm tropical seas, while most of the land lies south of the Tropic, but confined to latitudes corresponding to those of Egypt, and reaching little farther from the Equator than Sicily. The middle line of the continent is the parallel of 25°; the main mass of it lies between the latitudes of 18° and 35°, and the extreme range of the mainland is only from 10° 38′ S. at Cape York to 39° 11½′ S. at Wilson's Promontory.

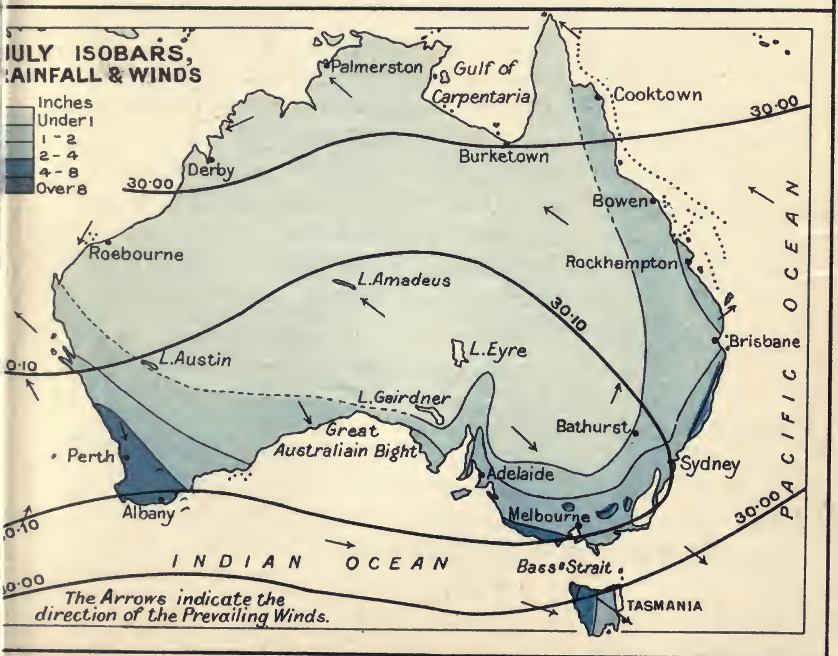
Australia has, for its size, a limited range in latitude. Its extension east and west, its insular nature, its uniform elevation, and its plateau structure give it a simple, regular climate governed by its subtropical position and the circulation of the waters in the surrounding oceans.

The eastern coast is washed by a warm current flowing southward; accordingly the winds that blow ashore from it come in as moist winds, and, as they are forced to rise over the East-Australian Highlands, they drop their moisture there in abundant rains. The western and south-western coasts are subject to winds coming from a cold sea to a warmer land; the air is warmed as it crosses the land, so its capacity for moisture is increased instead of being lowered, and it sweeps inland as a dry and even parching wind. Hence the shores of the Great Australian Bight are arid, with a 10-in. rainfall, while the eastern coast on the same latitude has a rainfall of 60 in.


JANUARY ISOTHERMS
Above 90°
80° - 90°
70° - 80°
60° - 70°
Below 60°
Palmerston
Gulf of Carpentaria
Cooktown
Burketown
Derby
Bowen
Roebourne
Rockhampton
L. Amadeus
Brisbane
L. Austin
L. Eyre
L. Gairdner
Great Australian Bight
Bathurst
Perth
Adelaide
Sydney
Albany
Melbourne
Bass Strait
INDIAN OCEAN
PACIFIC OCEAN
TASMANIA
90 F.
85 F.
80 F.
75 F.
70 F.
65 F.
60 F.


JANUARY ISOBARS, RAINFALL & WINDS
Inches
Under 1
1 - 2
2 - 4
4 - 8
8 - 12
12 - 16
Over 16
29·70
29·80
29·90
Palmerston
Gulf of Carpentaria
Cooktown
Burketown
Derby
Bowen
Roebourne
Rockhampton
L. Amadeus
Brisbane
L. Austin
L. Eyre
L. Gairdner
Great Australian Bight
Bathurst
Perth
Adelaide
Sydney
Albany
Melbourne
Bass Strait
INDIAN OCEAN
PACIFIC OCEAN
TASMANIA
The Arrows indicate the direction of the Prevailing Winds.


ULY ISOTHERMS
Above 70°
60°-70°
50°-60°
Below 50°
75 F.
70 F.
65 F.
60 F.
55 F.
50 F.
Palmerston
Gulf of Carpentaria
Cooktown
Burketown
Derby
Bowen
Roebourne
Rockhampton
L.Amadeus
L.Austin
L.Eyre
Brisbane
L.Gairdner
Bathurst
Great Australian Bight
Perth
Adelaide
Sydney
Albany
Melbourne
Bass Strait
INDIAN OCEAN
PACIFIC OCEAN
TASMANIA


ULY ISOBARS,
AINFALL & WINDS
Inches
Under 1
1 - 2
2 - 4
4 - 8
Over 8
30·00
30·10
Palmerston
Gulf of Carpentaria
Cooktown
Burketown
Derby
Bowen
Roebourne
Rockhampton
L.Amadeus
L.Austin
L.Eyre
Brisbane
L.Gairdner
Bathurst
Great Australiain Bight
Perth
Adelaide
Sydney
Albany
Melbourne
Bass Strait
INDIAN OCEAN
PACIFIC OCEAN
TASMANIA
The Arrows indicate the direction of the Prevailing Winds.

The climate of Australia is governed by the passage of a succession of atmospheric systems. They sometimes cross the continent along a southern path, and leave the interior open to warm moist winds from the tropics. On other occasions they pass along a more northern track, excluding the moist tropical winds, and letting in the cold rough winds from the Southern Ocean. A succession of anticyclones crosses the continent with remarkable regularity. They take on an average eight and a quarter days in their passage, and the variations in their path and progress determine the conditions of the Australian weather.

The rainfall of Australia is therefore heavier over the eastern than over the western half of the continent. The moist winds which blow in from the South Pacific give the East-Australian Highlands an ample rainfall, ranging from the maximum record of 211¼ in. at Inisfail on the Queensland coast in 1894, to 60 in., the average over the eastern slopes of the high lands. The rainfall sinks from from 30 or 40 in. over the western band of highlands, and from 10 to 25 in. over most of the Great Plains down to about 6 in. in the Lake Eyre country. Still farther west, on the interior of the Western Plateau, the mean rainfall is below 5 in. The northern territory and the Kimberley district in northern Westralia both have a rainfall from 40 to 60 in., and the rainfall rises in one or two places in the extreme south-west of Australia to the same amount; but the Westralian coast has a much lower rainfall than corresponding latitudes on the eastern coast.

THE RIVERS

The distribution of the rain naturally controls the rivers. The Australian rivers with the largest volumes, in proportion to their length and catchment areas, are those which discharge from the East-Australian Highlands into the South Pacific. The heavy rains on the high lands nourish numerous powerful rivers, which are liable to rise in devastating floods when the waters from heavy storms on the high lands reach the coastal plains; for the river channels there have too low a fall, and are too small, to discharge the flood waters.

The chief rivers on the eastern coast are the Burdekin and the Fitzroy in Queensland; the Clarence, the Hunter, and the Hawkesbury in New South Wales. The Snowy River discharges the drainage from the southern end of the New South Wales Highlands across Victoria into Bass Strait; and the Yarra flows from the southern slopes of the high lands into Port Philip.

The rainfall on the western slopes of the East-Australian Highlands is discharged in part by the Mitchell and Flinders Rivers into the Gulf of Carpentaria; partly through the Diamantina and Cooper's Creek into Lake Eyre; while the rest is collected into the Darling, the Murrumbidgee, and the Murray. These three rivers were originally independent, each discharging separately into a sea that once occupied the basin of the Lower Murray; but the emergence of the land has engrafted these three rivers on to one trunk, the Lower Murray, and they together discharge into the Southern Ocean through Lake Alexandrina. The basin of the Murray River includes over 414,000 sq. miles, but it is only the mountainous highlands near its head streams that give any effective contribution to the river. The 255,000 sq. miles of the Great Plains beside the Darling, the Murray, and the Lower Murray give no contribution to the river, except that which may arise from springs in their beds. The evaporation from the surface of Lake Alexandrina is sometimes greater than the amount of river water poured into it; then the Murray has no discharge into the sea, and the sea-water flows into Lake Alexandrina and works its way some miles up the Murray.

The remaining rivers of Australia are of secondary importance. The northern territory, with its plateau structure and heavy rainfall, has powerful rivers, including the Roper, Daly, and Victoria; while the Fitzroy, in the Kimberley district of Westralia, is also a large river. The other rivers of Westralia rise upon the western plateau, and they usually consist of chains of water-holes; they only flow after storms of rain. The chief of these rivers are the Ashburton, the Gascoyne, the Murchison, and the Swan River. The great bulk of the western plateau is riverless, as the rain-waters run into hollows, and are lost by evaporation.

The lakes of Australia are few, for in the high lands the rivers are so active that they rapidly cut down their beds, and have thus drained all the lakes that may once have existed along their courses.

In the coastal plains of Victoria there is a group of lakes—the Gippsland Lakes—which, like the Norfolk Broads, are the unfilled remnants of a great estuary. In the volcanic plains of western Victoria there are numerous lakes in hollows formed by the damming up of old valleys by lava streams. Lake Korangamite, the largest of these lakes, is 20 miles long and 6 miles broad; and the number of lakes in that district of Victoria is over 145.

There are, in Victoria, some interesting lakes occupying volcanic caldrons, or basins formed by the subsidence of ground which had been left unsupported in consequence of volcanic eruptions.

ECONOMIC DEVELOPMENT

The Aborigines.—When first discovered, Australia was naturally occupied by a very scanty population, owing to its arid interior, the absence of animals that could be domesticated, and the poverty of native food-plants. The aborigines of Tasmania were a black, round-headed race with short woolly hair, which was distributed in tiny curls over the head. These people were probably a race of primitive Melanesians. According to Huxley—and nothing has yet been discovered to disprove his conclusion—they entered Tasmania by travelling down the eastern coast of Australia, and probably along lands now submerged beneath the Tasman Sea. The Tasmanians were in a very primitive stage of culture, being ignorant of the use of metal. Their tools were made of roughly chipped unpolished stone, like those used by the people of the older stone age in Europe. Their numbers were always small. They were removed to reserves on an island in Bass Strait, and have become extinct.


Fig. 95.—Australian Aborigine, from east side of Lake Eyre

The Australian aborigines are a very different race. They are black Caucasians, having long straight or wavy hair, and a skull which is Caucasian and not Negro in its important characters. They are Caucasians who have been modified by adaptation to life in the arid region of central Australia. When first discovered, they were ignorant of the use of metal, but made their tools of polished stone, of wood and bone. They are an intelligent race, very kindly disposed, and more advanced in culture than some of the tribes of South America are described as being. They were probably always few in number, and they have been replaced on the borders of the continent by Europeans.

British Settlement.—The first British colony was founded at Sydney, where a convict settlement was established in 1788; the second colony was in Tasmania. The discovery of the rich turf-clad plains of Victoria led to its occupation by pastoralists in 1836 and 1837. The state of South Australia was founded by a British company, the South

Australian Colonization Association, in 1836. The practical occupation of Australia was at first for pastoral settlement; but the discovery of the gold-fields of New South Wales and Victoria in 1851 led to a rapid immigration. Agricultural development and the growth of manufactures has followed from the prosperity given by the mines.

The pastoral industry of Australia was founded by John Macarthur, who first imported merino sheep, at great expense and trouble. By careful breeding, the quality of Australian wool has been raised till it is the most valuable in the world. The export of wool began in 1807, and the total quantity sent from Australia is now 800,000,000 lb. a year. The total number of sheep in Australia is about 92,000,000, in addition to 30,000,000 in New Zealand.

The success of the sheep-raising industry is due to the dry, warm climate, and the vast areas of open grassy plains, which are too arid for agriculture, but can support vast flocks of sheep. The sheep are raised on stations some of which are as large as the larger English counties, and have flocks of over 1,000,000 sheep. The station of Tamworth, in New South Wales, had in a recent year over 1,500,000 sheep.

Cattle-rearing is an important industry in the East-Australian Highlands and in the plains of the interior, which are too far from the coast and from railways for the transport of wool. Dairy-farming is the great occupation on the coast plains and the Great Valley of Victoria; much of the butter is exported to Europe.

The agricultural industries include wheat on the southern plains, fruit in Tasmania, sugar in Queensland, and vineyards for wine manufactories in Victoria, New South Wales, and South Australia.

Australia is exceptionally rich in minerals, and especially in gold; it is one of the chief sources of the world's gold-supply. The State of Victoria has produced gold to the value of over £295,000,000 since the discovery of its gold-fields in 1851.

The chief mines of silver and lead are in New South Wales, of copper and tin in Tasmania, of coal—of which Australia has immense quantities—in New South Wales. Iron ores of good quality are abundant and widely distributed, and the iron-smelting industry has recently been founded.

CHAPTER XX

NEW ZEALAND

New Zealand is an archipelago containing three chief islands, usually called North Island, South (or Middle) Island, and Stewart Island, which extend from 34° 23′ S. lat. to 14° 7′ S. lat. The islands are long and narrow, and occur on a ridge which separates the southern Pacific on the east from the Southern Ocean on the west.

The main trend of New Zealand is from south-west to north-east, but the North Island is bent sharply at the latitude of 38°, and the Auckland Peninsula projects north-westward at right angles to the main axis of the archipelago. The three islands are connected by a submerged ridge, no part of which is more than 100 fathoms deep, while the line marking the depth of 500 fathoms has a long extension to the north-west; and in that direction the New Zealand ridge is connected with Melanesia and Queensland by a platform never more than 2000 fathoms deep. The New Zealand platform, however, is cut off abruptly to the east by the 1000-fathom line, which runs close along the eastern coast. The areas of the three chief islands are: North Island, 44,468 sq. miles; South Island, 58,525 sq. miles; and Stewart Island, 665 sq. miles. The total area, including the various off-lying Pacific Islands, is 104,751 sq. miles.

New Zealand was discovered in 1642 by Abel Tasman, who sailed along part of the north-western coast. The land was believed to be part of the great Antarctic continent until it


NEW ZEALAND
GEOGRAPHICAL DIVISIONS
English Miles
0 50 100 150
NOTE
Fold Mountains of Younger Rocks
Folded old rocks of the Southern Alps
Grain of older Mountain System
Volcanic
Plains
NORTH ISLAND
SOUTH ISLAND
PACIFIC OCEAN
PACIFIC OCEAN
C. Reinga
C. Maria Van Diemen
Russell
Ahipara B.
B. of Islands
Whangarei
Whangarei B.
Auckland Penin.
Gt Barrier I.
Kaipara Harb.
Hauraki Gulf
Auckland
Manukau Harb.
Grahamstown
Bay of Plenty
Tauranga
C. Runaway
Kawhia Harb.
Roto Rua
TAUPO VOLCANIC BASIN
L. Taupo
New Plymouth
Mt. Tongariro
Mt. Ruapehu
Mt. Egmont
DISSECTED WANGANUI PLAINS
Wanganui
Wanganui R.
Poverty Bay
Mahia Pen.
Hawke Bay
Napier
Ruahine Mts.
Raukumara Mts.
C. Turnagain
Tararua Mts.
WELLINGTON
C. Palliser
COOK STRAIT
C. Farewell
Golden B.
Tasman B.
Rocks Pt.
Karamea Bight
Nelson
Blenheim
C. Foulwind
Westport
Buller
C. Campbell
Mt. Franklin
Clarence
Kaikoura
Greymouth
Hokitika
SOUTHERN ALPS
Westland Plains
Franz Joseph
Mt. Cook
Mt. Torlesse
Rangiora
CANTERBURY PLAINS
Christchurch
Lyttelton
Banks Peninsula
Cascade Pt.
Timaru
Canterbury Bight
Milford Sd.
L. Wanaka
L. Hawea
Naseby
Oamaru
Clutha
L. Te Anau
Wakatipu
OTAGO PLATEAU
L. Manipori
Port Chalmers
Otago Harbour
DUNEDIN
C. Saunders
Gore
Balclutha
Invercargill
Nugget Pt.
Te Waewae B.
Stewart I.
Longitude East of Greenwich

was circumnavigated and mapped by Captain Cook in 1769. The whalers followed Cook, and erected temporary stations along the coasts. The permanent colonization was begun in 1837.

THE MOUNTAIN SYSTEM

The geographical backbone of New Zealand consists of a system of fold-mountains running from south-west to north-east. The best-known mountain chains of this system are the Southern Alps in the South Island, and the Ruahine-Raukumara chain in the south-eastern part of the North Island. These south-west-to-north-east mountains do not, however, extend the whole length of New Zealand; for Otago, the southern province of the South Island, is an old plateau with its chief structural lines trending from north-west to south-east, nearly at right angles to the folds of the New Zealand Alps, but parallel to the grain of the country in the Auckland Peninsula. The Southern Alps, as they were called by Cook, are a lofty mountain chain, of which Mount Cook (12,350 ft.) is the highest mountain in New Zealand; they have permanent snowfields and great glaciers which flow down both flanks into the low country. The great Tasman glacier, on the eastern side of the chain, is the longest of these glaciers; and the Franz Joseph Glacier, on the western side, is the lowest, as it flows down within 600 ft. of sea-level. The Alps extend along the western side of the South Island, and form, where they are highest, an almost impassable barrier between the low plains on the eastern and western coasts. They are crossed by high passes; over one a road has been made down the famous Otira Gorge to the province of Westland.

The rocks of the Southern Alps end to the north on the shores of Cook Strait, which divides the North and South Islands. The trend of the rocks would suggest their recurrence across Cook Strait in North Island; but, so far as is known, that island contains no representatives of the ancient rocks of the Southern Alps. The line along which the rocks were once continued is occupied by the basin of the Wanganui River, and by the great Taupo volcanic district of New Zealand, remarkable for its hot springs, its geysers, and the disastrous explosive eruption of the volcano Tarawera in 1886. The explosion blew up the famous Pink and White Terraces, and formed a deep volcanic rift 9 miles in length. In all probability the rocks of the Southern Alps once extended across the volcanic area, but they have foundered, and been covered by volcanic accumulations.

The chief volcanic mountains of New Zealand are found in the Taupo volcanic area, which consists of wide plains of lava and volcanic ash; the hollows in these plains are filled by lakes, such as Lakes Taupo and Rotorua. Above these plains rise many hills formed by volcanoes, including Ruapehu (9175 ft.), Ngauruhoe (7515 ft.), and Tongariro (6485 ft.). The other chief volcanic mountains occur along the coasts on the edges of foundered areas. Such are Mount Egmont, which rises from the coast of Taranaki in a graceful snow-capped cone 8250 ft. high. On the eastern side of the South Island there are masses of older volcanic rocks forming Banks Peninsula, near Christchurch, and the hills beside the harbour of Otago at Dunedin.

RIVERS AND LAKES

The chief rivers of New Zealand rise on the Southern Alps and flow thence eastward or westward to the sea. The rivers of the western coast are short and powerful; they are subject to great floods after heavy rains, and after the melting of the snow in the spring. The rivers of the eastern slopes of the Alps have a longer course to the sea, and flow across the wide Canterbury Plains; these plains largely consist of fan-shaped sheets of sand and gravel, deposited by the rivers where they have escaped from the mountain gorges. The plains have a gradual slope from the hills to the sea.

The lakes of New Zealand are famous for the beauty of their scenery. The chief lakes of the North Island, such as Lake Taupo and Rotorua, occur in basins on the volcanic plains. The "Cold Lakes" of the South Island lie in deep, fiord-like valleys, the floors of which sink below the level of the sea; thus Lake Manapouri, the surface of which is 597 ft. above sea-level, is 1462 ft. deep. These lakes occupy valleys that have been formed in the same way as the fiords of the south-western coast of New Zealand, and they differ from the fiords only by the fact that they are not connected with the sea, and are thus occupied by fresh instead of by salt water.

CLIMATE

The climate of New Zealand is healthy and equable, and, in spite of the great length of the islands from north to south, the influence of the adjacent seas renders the climate remarkably uniform. The average temperature for the latitude is low, as the country is surrounded by seas chilled by currents from the south. Owing to its insular position, and the high elevation of its mountains, the rainfall is generally ample. It amounts to 228 in. in the south-western corner of the South Island; and the western coasts, being exposed to prevalent winds from the Southern Ocean, have a rainfall which is generally over 100 in. a year. The eastern coasts have a more moderate rainfall, and some localities in the interior, such as Mount Torlesse, show by their aspect that they have an arid climate; for the winds which reach them have lost their moisture in their passage over the Southern Alps, and sweep on as hot, drying winds.

ECONOMIC DEVELOPMENT

The aboriginal inhabitants of New Zealand are the Maoris. They are a race of brown Polynesians, and are members of the dark-coloured section of the Caucasians. Their ancestors crossed the Pacific in great sea-going canoes, and made their chief settlement in New Zealand about six centuries ago. The Maoris are a brave, able race, skilled in several arts, especially in wood-carving; they were, however, quite ignorant of the use of metals, and their chief tools and weapons were made of polished stone.

The British colonists of New Zealand occupied the country for pastoral and agricultural pursuits. They settled along the coasts, founding the towns of Dunedin, Christchurch, Wellington, Auckland, and Nelson. Each of these towns is now the capital of its province. The very mountainous nature of the interior of New Zealand placed great difficulties in the way of internal communications; hence the provinces developed independently, and the chief connection beween them is still by sea. The construction of railways is unusually costly. There are railways from Invercargill, the port at the southern end of the South Island, through Dunedin, to Christchurch; and in the North Island railways connect Auckland, the chief port, with Wellington, the capital. The railway system includes many disconnected lines going inland from the chief ports.

The chief economic product of New Zealand has been its wool, which is now being supplemented by frozen meat and dairy produce. The agricultural development is less advanced, but it is growing rapidly by the subdivision of the large sheep-stations into farms. The dense forests of Westland maintain an extensive timber industry.

The mineral wealth of New Zealand depends chiefly on its gold- and coal-mines, and on the diggings for Kauri gum, a fossil resin found on the site of ancient forests in Auckland.

The population of New Zealand in 1910, including the Pacific Islands that form part of the Dominion, was 1,008,407.

CHAPTER XXI

OCEANIA OR THE PACIFIC ISLANDS

The surface of the Pacific is studded with innumerable reefs and islands, the distribution of which at first appears irregular. They may, however, be divided into five lines of islands, the course of which is dependent on the geographical structure of the adjacent continents. Three of the lines hang in curved loops from the continents, and are called festoons. The five island lines are:

1. The Australasian Festoon;
2. The Micronesian Festoon;
3. The Pelew-Ladrone Festoon;
4. The North Pacific Chain; and
5. The South Pacific Chain.

Fig. 96.—Melanesian

1. The Australasian Festoon consists of a line of islands to the east of Australia; they are formed of continental rocks, or have a foundation of such materials. The festoon begins on the south with the archipelago of New Zealand, which is formed of continental rocks, covered in places by volcanic domes and sheets of volcanic rocks. The line of the New Zealand islands is continued northward through Norfolk Island, through the archipelagoes of New Caledonia, the New Hebrides, and the Solomon Islands, and it ends in New Guinea. The northern islands are inhabited by people known as the Melanesians, who are a branch of the Negro race; they have the woolly hair, short heads, dark skins, thick lips, and broad noses of the Negro (fig. 96). The islands from New Guinea to New Caledonia are known as Melanesia, and they rest upon the submarine Melanesian plateau. The islands are related to Australia both geologically and by the

characters of the animals and plants that live in them. The Melanesian islands are the remains of a formerly continuous land which once connected New Zealand with both New Guinea and Australia. New Zealand received most of the animals and plants that now inhabit it, by migration across this land.

New Guinea is the largest of the Melanesian islands, and is separated from Australia by the shallow Torres Strait. It is a long island, trending east and west, and containing mountains of which Mount Victoria, in south-eastern New Guinea, is 13,000 ft. in height, while Mount Bismarck, in northern New Guinea, is estimated at from 15,000 to 20,000 ft. high. New Guinea has a heavy rainfall and a fertile soil, and appears to have rich stores of mineral wealth. It belongs in part to Britain; the remainder is shared between Holland and Germany.

New Caledonia, 900 miles east of Queensland, is a long island running from north-west to south-east for over 250 miles. It is 30 miles broad, and its highest peak, Mount Humboldt, is 5000 ft. high. It is composed of old rocks, and its mines are one of the chief sources of the world's nickel supply. To the east of the mainland of New Caledonia stretches the chain of the Loyalty Islands, a line of coral reefs and coral islands.

The outer fringe of the Australasian Festoon includes the Solomon Islands and the New Hebrides. The Solomon Islands are a chain of high volcanic islands about 600 miles in length; they belong to Great Britain and Germany. Their line is continued to the south-east by the New Hebrides in a chain about 500 miles long, which includes both coral and volcanic islands. They were discovered in 1606 by de Quiros, who named them "Tierra Austrialia", as he believed them to be part of the great southern continent. Many of the inhabitants in the New Hebrides are Polynesians, a people with a lighter coloured skin than the Melanesians, and with long, straight, not woolly hair (fig. 97).

105
120
135
150
60
45
30
15
0
15
30
45
A S I A
Aleutian Festoon
Kurile Festoon
Japanese Festoon
TUSCARORA DEEP
Sea of Japan
Liu-kiu Festoon
Formosa
Volcano Is.
Ladrone Is.
Ladrone Chain
Challenger Trench
Ocean Is.
North Pacific Chain
Honolulu
Mauna Loa
Belknap Trough
China Sea
Philippine Islands
Chinese Festoon
Pelew-Ladrone
Pelew Is.
Caroline Is.
P A C I
Marshall Is.
Gilbert Is.
Micronesia
Miller Basin
Hilgard Trench
Borneo
Nares Trench
MICRONESIAN
FESTOON
Phœnix Is.
New Guinea
AUSTRALASIAN FESTOON
Melanesia
Solomon Is.
Ellice Is.
Torres Str.
Samoa Is.
Polynesia
Carpenter Trench
New Hebrides
Fiji Is.
Tonga or Friendly Is.
Tonga Trench
Cook Is.
Coral Sea
New Caledonia
Gazelle Trench
AUSTRALIA
Norfolk I.
Kermadec Is.
Kermadec Trench
Lord Howe I.
Tasman Sea
Jeffrey's Trench
Thomson Trough
Tasmania
NEW ZEALAND
Chatham Is.
Snares
Auckland I.
Campbell I.
Macquarie I.
Long E. 120 of Greenwich 135
150
165
180
165


THE
PACIFIC ISLANDS
with the principal Oceanic Deeps
NORTH AMERICA
SOUTH AMERICA
British Columbian Festoon
Guadalupe
Alijos Rocks
Gigedo I.
Clipperton I.
Duncan I.
Galapagos Is.
Marquesas Is.
Paumotu or Low Archipelago
Sala-y-Gomez
Easter I.
St. Felix
Juan Fernandez
PATAGONIAN PLATFORM
PACIFIC
CHAIN
Tropic of Cancer
Equator
Tropic of Capricorn
Long W. 120 of Greenwich 105
150
135
120
105
90
75
60
45
30
15
0

2. The Micronesian Festoon is roughly concentric with the Australasian Festoon, and lies farther out in the southern Pacific. It includes the small coral islands known as Micronesia, and some of the islands included in Polynesia. It begins to the east of the Philippines with the Caroline and Marshall Islands, which extend from east to west, and belong to Germany. Some of the Caroline Islands contain ruins of massive buildings, erected by an extinct unknown race. The Micronesian line is continued to the south-east by the Gilbert, Ellice, Fiji, Samoan, and Tonga or Friendly Islands. These groups all occur on the edge of a submerged plateau, which extends south-westward to Australia, and they appear from geological, and still more from the zoological, evidence to have been formerly connected with Australia. Thus Woolnough has shown that the foundation of the Fiji Islands consists of continental rocks deeply covered by volcanic accumulations; and Hedley, that they are inhabited by some representatives of the Australian fauna.

Fig. 97.—Polynesian (Chatham Islands)

3. The Pelew-Ladrone Festoon runs northward from the Malay Archipelago, and includes the Pelew Islands, the Ladrone Islands, and the Volcano Islands. It forms the festoon which helps to enclose the Chinese Sea, and links Japan to Formosa and Malaysia. Its relations to the mainland of Asia are similar to that of the Japanese Festoon, which includes the Japan Sea.

4. The North Pacific Chain includes two groups of islands, the Hawaian, or Sandwich Islands, and the Ocean Islands. The Hawaian Islands belong to the United States. The chief

town is Honolulu. They contain the famous volcanoes Kilauea and the lofty Mauna Loa, 13,600 ft. high.

5. The South Pacific Chain includes a long line of islands, which branches from the Micronesian Festoon at the Samoan group, and extends eastward across the southern Pacific. Its islands may be the last survivors of a land which once connected South America and Australasia, and enabled the marsupials and land tortoises found in both regions to migrate from one to the other.

The South Pacific Chain includes the Low Archipelago, or the Paumotus, the Society Islands, the Cook Islands, and the Marquesas Islands: the last is a volcanic group which lies to the north of the coral atolls of the Paumotu. The Society Islands were so named by Captain Cook in honour of the Royal Society, under the auspices of which he established an observatory there in 1769 to observe the transit of Venus, and thus measure the distance of the earth from the sun.

Easter Island is, with one exception, the easternmost member of the South Pacific Chain, and is famous for its gigantic statues cut out of lava. They have been compared to the statues made by the Incas of Peru, but it is more probable that they were made by Polynesians, who reached Easter Island in canoes from the west, and, in the absence of wood, carved statues out of stone. The statues resemble those made in wood by the Maoris of New Zealand. The walls of huge stones found on the Caroline Islands, and some other central Pacific islands, may have been built by the same race.

In addition to these islands far out in the Pacific there are many island lines fringing its shores. They include the Chinese Festoon, the Liu-Kiu Festoon, the Japanese Festoon, the Aleutian Festoon, the British Columbian Festoon, and the series of islands off the coast of Central America, including Gigedo Island, Clipperton Island, Duncan Island, and the Galapagos Islands. St. Felix and Juan Fernandez may be the last fragments of a festoon that may have existed off South America.

CHAPTER XXII

ANTARCTICA

Antipodal to the floe-filled Arctic ocean is the ice-clad continent of Antarctica. Ancient and mediæval geographers believed that the excess of land in the Northern Hemisphere must be counterbalanced by a great land area around the South Pole; and when New Zealand was discovered it was thought to be a northward projection from this Antarctic continent. The possible limits of this hypothetical land were greatly reduced by Cook, who proved New Zealand to consist of islands, and by his voyage around the Antarctic regions showed that the lands there were much smaller than had been thought. He returned, however, with a firm conviction that within the Antarctic ice-floes lay a great land. Its existence has been finally established by the Antarctic expeditions of the last twelve years.

Antarctica is still the least-known part of the earth, but there is sufficient evidence to suggest that it consists of one large plateau, of which the highest part and the steepest scarps rise south of the Pacific. The part of the plateau opposite Australia is known as Wilkes Land, which appears to repeat the structural characteristics of Australia. From the coast of Wilkes Land the land rises inland, and is covered by a vast ice sheet, which extends to the South Pole. There appears to be a long gradual slope from the shores of the Southern Ocean to the South Polar plateau, which faces the South Pacific in a steep mountain scarp around the Ross Sea. Wilkes Land passes eastward into Victoria Land, which is traversed by a great mountain chain, while from the islands at its foot rise the lofty volcanoes of Mounts Erebus and Terror. The Ross Sea appears to occupy a sunkland, and it ends to the south in Ross's Great Ice Barrier, a thick sheet of ice which is partly afloat. It is fed mainly by the snowfall upon its surface, while the glaciers from the adjacent lands force their way into it.

South of the Pacific, between the eastern shore of the Ross Sea and Graham Land, is a wide land the evidence for which was first collected by Cook, but of which nothing is certainly known except on the margin of the Ross Sea and so far as it has been followed westward from Graham Land. Graham Land is a continuation of the Andes, being composed of similar igneous rocks and folded sediments. It has been remarked (p. 246) that the folded chain of the Andes bends eastward at the southern end of South America, across Tierra del Fuego; its former farther continuation appears to have been reflexed westward across Graham Land.

To the south of the Atlantic, between Graham Land and the western end of Wilkes Land, is the Weddell Sea, which projects far southward into the Antarctic continent, having its coasts (in Coats' Land) in latitude 74° S. The geographical structure of the Antarctic continent is problematical, but its coast in Graham Land is of the Pacific type, that of South Victoria Land of the Secondary Pacific type, while that of Wilkes Land is of the Atlantic type.

APPENDIX I

LIST OF THE GEOLOGICAL SYSTEMS AND SOME OF THEIR BRITISH REPRESENTATIVES

Group.	System.	British Representatives.
Kainozoic—Period of Recent Life.	Pleistocene.	River silts and gravels, old sea beaches, glacial deposits, &c.
	Pliocene.	Crags of Norfolk, Suffolk, Essex, &c.
	Miocene.	No certain representative.
	Oligocene.	Marine and fresh water beds in Hampshire; volcanic rocks of Scottish isles.
	Eocene.	Sands and clays of London and Hampshire basins; volcanic rocks and plant beds of Scottish isles.
Mesozoic—Period of Middle Life.	Cretaceous.	Chalk, greensands, and Wealden beds.
	Jurassic.	Oolitic limestones of Portland, Bath, and North-east Yorkshire; ironstones of Cleveland and Midlands; clays of Oxfordshire, Fen Country, &c.
	Trias.	The New Red Sandstones of Cheshire and the Midlands.
Palaeozoic—Period of Ancient Life.	Permian.	Red sandstones and magnesian limestones (Dolomites).
	Carboniferous.	Sandstones containing the British coal-fields; the limestones forming the mountains of the Peak, the Pennines, Mendip Hills, &c.; limestones of the central plains of Ireland; the volcanic plateaus of the Lower Clyde basin.
	Devonian.	Old Red Sandstone of South Wales, South Ireland, and of various districts in Scotland, where they are associated with volcanic rocks.
		Marine rocks, sandstones, limestones, and slates of Devonshire.
	Silurian.	Limestones and sandstones of the Welsh border counties and the southern part of the Southern Uplands of Scotland.
	Ordovician.	Slates, sandstones, and volcanic rocks of Wales, the Lake District, Southern Uplands of Scotland, and northern Ireland.
	Cambrian.	Slates and sandstones of Wales, Warwickshire, and Ireland; quartzites of north-western Scotland.
Azoic—Period with only obscure traces of Life.	Torridonian.	Sandstones of north-western Scotland.
	Archean.	Schists, gneisses, and other crystalline rocks in northern Scotland, Wales, Charnwood Forest, northern Ireland, &c.

APPENDIX II

REFERENCES TO LITERATURE

The literature of Structural Geography is so scattered and extensive that adequate reference to it here is impossible. The following list includes a few of the more readily accessible, and some of the less technical works containing detailed information.

Chapter I

The evidence for the meteoritic theory is given by Sir Norman Lockyer in *The Meteoritic Hypothesis: a Statement of the Results of a Spectroscopic Inquiry into the Origin of Cosmical Systems* (1890).

The planetismal theory is stated in Chamberlin and Salisbury. *Geology*, vol. ii, 1906, pp. 1–81.

Chapter II

A fuller summary of the tetrahedral theory has been given by the author in "The Plan of the Earth and its Causes", *Geographical Journal*, vol. xiii, 1899, pp. 225–251.

The original theory was published by W. L. Green in his *Vestiges of the Molten Globe*, Part I (London, 1875); Part II (published in 1887 at Honolulu), where Green was then American minister, is less important.

In reference to problems considered in this chapter, see also T. Mellard Reade, *Evolution of Earth Structure* (1903).

Chapter III

For fuller information about the materials of the earth's crust reference may be made to any elementary textbook of geology; such as Sir A. Geikie, *Class-book of Geology* (Macmillan); C. Lapworth, *Intermediate Text-Book of Geology* (Blackwood); W. W. Watts, *Geology for Beginners* (Macmillan, 1903); J. E. Marr, *An Introduction to Geology* (Cambridge, 1905); W. J. Harrison, *A Text-Book of Geology*, fifth edition (Blackie, 1903); or L. Fletcher, *Guide to the Rock Collection in the Natural History Museum, South Kensington* (6*d*.).

For a more detailed account of the weathering of rocks and the formation of soils, reference may be made to the following: G. P. Merrill, *A Treatise on Rocks, Rock Weathering, and Soils* (New York, 1897); N. S. Shaler, "Aspects of the Earth" (London, 1890), *The Origin and Nature of Soils*, pp. 300–339; H. E. Stockbridge, *Rocks and Soils: their Origin, Composition, and Characteristics* (New York, 1901); A. D. Hall, *The Soil* (Murray, 1903).

Chapter IV

G. A. J. Cole, *Open Air Studies in Geology* (Griffin, second edition, 1902); W. M. Davis, *Physical Geography* (Boston, 1898); J. E. Marr, *The Scientific Study of Scenery* (London, 1903).

Chapter V

For an account of the methods of deep-sea investigation see A. Agassiz, *Three Cruises of the Blake* (Cambridge, Mass., 1888); or an earlier account in C. Wyville Thomson, *The Depths of the Sea* (London, 1873).

Chapter VI

In connection with this chapter reference may be made to any of the numerous excellent textbooks of physical geography or physiography. H. R. Mill, *The Realm of Nature: an Outline of Physiography* (London, 1892); Huxley, *Physiography:* (edited by R. A. Gregory (Macmillan, 1904); N. S. Shaler, "Aspects of the Earth" (London, 1890); *Rivers and Valleys*, 143–196; G. K. Gilbert and A. P. Brigham, *An Introduction to Physical Geography* (New York, 1907); A. J. Herbertson, *Outlines of Physiography* (Arnold, 1901); W. J. Harrison and H. R. Wakefield, *Earth-Knowledge*, seventh edition (Blackie, 1897). For a larger work, rich in instructive illustrations, see Salisbury, *Physiography* (Murray, 1907).

Chapter VII

The distinction between Pacific and Atlantic Coast types was established in E. Suess, *The Face of the Earth* (English translation by Dr. H. Sollas), vol. ii (Oxford, 1906), chap. iv, pp. 201–207.

For special sections of this chapter reference may be made to J. Milne, *Earthquakes and other Earth Movements* (London, 1898);

J. Milne, *Seismology* (London, 1898); C. E. Dutton, *Earthquakes in the Light of the New Seismology* (Murray, 1904); T. Mellard Reade, *The Origin of Mountain Ranges* (London, 1886); T. G. Bonney, *Ice Work: Present and Past* (London, 1896); James Geikie, *The Great Ice Age*, third edition (1894); J. W. Judd, *Volcanoes*, International Science Series (Kegan Paul, 1881); I. C. Russell, *River Development as illustrated by the Rivers of North America* (London, 1903).

Chapter VIII

For the structure and origin of coral islands see J. D. Dana, *Corals and Coral Islands* (1853); Darwin, *The Structure and Distribution of Coral Reefs* (1842).

Chapter IX

I. C. Russell, *Lakes of North America* (New York, 1894).

Chapter X

W. M. Davis, *Elementary Meteorology* (Boston, 1894); R. M. Scott, *Elementary Meteorology* (London, 1883).

Chapter XI

In addition to the chapters on ocean currents in the textbooks of which the titles are given on p. 283, special reference for the problems of this chapter may be made to W. M. Davis, "Winds and Ocean Currents", *Scottish Geographical Magazine*, 1897, pp. 515–523; H. N. Dickson, "The Circulation of the Surface Waters of the North Atlantic Ocean", *Phil. Trans.*, vol. cxcvi, 1901, pp. 61–203, pl. iv; Dr. Otto Pettersson, "On the Influence of Ice-Melting upon Oceanic Circulation", Part I, *Geographical Journal*, vol. xxiv, 1904, pp. 285–333; Part II, *ibid.*, vol. xxx, 1907, pp. 273–303.

(Dr. Pettersson regards the melting of the Arctic ice as the most important factor in the circulation of the North Atlantic, and he is the most eminent authority on ocean currents who retains the name Gulf Stream for the transatlantic drift.)

Chapter XII

Lord Avebury, *The Scenery of England*, fourth edition (Macmillan, 1906); Sir A. Geikie, *The Scenery of Scotland*, third edition (Macmillan, 1901); A. J. Jukes-Browne, *The Building of the British Isles* (Bell); H. J. Mackinder, *Britain and the British Seas*, second edition (London, 1907); Sir A. C. Ramsay, *Physical Geology and Geography of Great Britain* (London, sixth edition, Stanford, 1894); Geological Map of the British Isles, *Geological Survey of Great Britain* (1906. 2*s*.); Stanford's *Geological Atlas of Great Britain*, edited by H. B. Woodward, 1904.

The uplift of the north-western part of the British area, which formed the slope down to the south-east and gave the consequent rivers their direction, happened so long ago that the original river system has been destroyed. It is only occasionally that the existing rivers coincide with the original consequent rivers. So great has been the change in the geography of the British Isles since the establishment of the main slope from north-west to south-east that some authorities, such as Mr. F. W. Harmer, hold that no trace survives of the consequent rivers. In a paper "On the Origin of certain Canyon-like Valleys associated with Lake-like Areas of Depression", *Quarterly Journal Geological Society*, vol. lxiii, 1907, pp. 470–513, pl. xxxi–xxxv, he opposes the theory that the wind gaps in the Chiltern Hills are due to rivers from the central plateau of England, and explains them as due to overflow channels from a glacial lake. It appears, however, quite possible that, in spite of the venerable antiquity thereby assumed for them, the directions of the rivers and valleys trending from north-west to south-east is due to the ancient uplift of the north-western parts of the British Isles.

The evolution of the English rivers has passed through four stages:—

1. The establishment of a slope from north-west downward to the south-east, which was probably due to earth movements early in Kainozoic times.

2. The diversion of some of the drainage into subsequent rivers flowing to the north-east and south-west by the excavation of valleys along the grain of the country. Many of the chief English rivers rise in the Midlands, within a radius of 30 miles of Rugby, as was pointed out by the author in a paper on "The Evolution of the Thames", *Nat. Science*, vol. v, 1894, pp. 97–108. From this central area some streams flow north-eastward to the Humber and the Wash, others south-westward into the Severn, and others south-eastward into

the Thames. The radial arrangement of the drainage from this district, in spite of its present comparatively low elevation, was probably due to its resting on a buried ridge of old rocks. This ridge has long acted as a firm foundation, which has separated the areas to the north-east and south-west of it, and often given them different geographical histories.

3. The excavation of valleys trending north-east and south-west by subsequent streams left the ridges between them as the oolitic and chalk escarpments; the latter is notched by wind gaps which were probably due to rivers that flowed south-eastward before the excavation of the valley between the escarpments.

4. Finally, during the glacial period in England there were many changes in the river system. Thus a glacial lake was probably formed in the upper basin of the Dee owing to the occupation of the lower part of the Dee valley by glaciers; the overflow from this lake discharged to the south-east and cut the gorge of the Severn at Ironbridge.

According to Mr. Harmer, the gorge of the Thames through the Chiltern Hills at Goring and all the wind gaps through that range were also cut by the overflow from a glacial lake which occupied the English Midlands. The irregularity in height of the floors of these gaps and the absence of lake terraces corresponding in height to the overflow channels appears to the author to render this explanation improbable. Some of the lower wind gaps were probably deepened by glacial drainage, but that view assumes the existence of the gaps in preglacial times; and these preglacial valleys are probably the remains of the old consequent river valleys.

The author, in 1894, in the paper previously quoted, attributed the present distribution of the rivers of southern and central England to radiation from the midland plateau in late Kainozoic times. The consequent river system described in Chapter xii, adopting the views of Professor W. M. Davis ("The Development of certain English Rivers", *Geographical Journal*, vol. v, 1895, pp. 127–146), H. M. Cadell, and H. J. Mackinder was established at a much earlier period than the radial drainage from the Midlands. The existing British river system was probably started in Eocene and Oligocene times, and some traces of the consequent drainage of that period may still be recognizable.

Chapter XIII

H. R. Mill, *The International Geography*, second edition (Macmillan, 1908). [This work may also be consulted for any of the continents.] G. G. Chisholm, *Europe*, 2 vols., 1899, 1902—"Stanford's Compendium of Geography". Avebury (Sir John Lubbock), *The Scenery of Switzerland and the Causes to which it is Due* (London, 1896); J. Partsch, *Central Europe* (London, 1903); E. Suess, *The Face of the Earth*, vol. i, part ii, chap. i–iv.

Chapter XIV

D. G. Hogarth, *The Nearer East* (London, 1902); T. Holdich, *India*; A. H. Keane, *Asia*, 2 vols., 1901—"Stanford's Compendium of Geography". E. Suess, *The Face of the Earth*, vol. i, chaps. vii and viii.

Chapter XV

A. H. Keane, *Africa*, 2 vols.—"Stanford's Compendium of Geography". E. Suess, *The Face of the Earth*, vol. i, chaps. v and vi.

Chapter XVI

S. E. Dawson, *North America*, vol. i, "Canada and Newfoundland" (1897)—"Stanford's Compendium of Geography". H. Gannet, *North America*, vol. ii, "The United States" (1898)—"Stanford's Compendium of Geography". I. C. Russell, *North America* (London, 1904); E. Suess, *The Face of the Earth*, vol. i, chap. xi.

Chapter XVII

A. H. Keane, *Central and South America*, 2 vols., 1901—"Stanford's Compendium of Geography". E. Suess, *The Face of the Earth*, vol. i, chap. ix.

Chapter XVIII

E. Suess, *The Face of the Earth*, vol. i, chap. x.

Chapter XIX

J. W. Gregory, *Australasia*, part i—"Stanford's Compendium of Geography" (1907); J. W. Gregory, *Geography of Victoria* (Melbourne, 1903); E. Suess, *The Face of the Earth*, vol. ii, chap. iii, pp. 149–162.

Chapter XX

P. Marshall, *Geography of New Zealand* (Christchurch and London, 1905); E. Suess, *The Face of the Earth*, vol. ii, chap. iii, "New Zealand", pp, 143–149.

Chapter XXI

F. H. H. Guillemard, *Australasia*, part ii—"Stanford's Compendium of Geography".

Chapter XXII

Fricker, *The Antarctic Regions* (Sonnenschein, 1900). H. R. Mill, *The Siege of the South Pole* (Rivers, 1906).

INDEX